On the acquisition of restrictive and appositive relative clauses

Inauguraldissertation

zur Erlangung des Grades eines Doktors der Philosophie

im Fachbereich Neuere Philologien (10)

der Johann Wolfgang Goethe-Universität

zu Frankfurt am Main

vorgelegt von

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aus Frankfurt am Main

Einreichungsjahr: 2016

Erscheinungsjahr: 2017

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Tag der Promotion: 29. Juni 2016

Acknowledgments

First and foremost, I would like to thank my supervisor Prof. Dr. Petra Schulz for fostering my interest in language acquisition, for her continuous support at all steps of this research project, and for her great expertise in setting up insightful experiments. I am also particularly grateful to Prof. Ede Zimmermann for sharing his vast knowledge on the semantic aspects of nominal modification. Also Tom Roeper's advice was of great value, and without his ideas this thesis would not have been possible.
Furthermore, I especially thank Emanuela Sanfelici for being a great source of knowledge for all questions concerning syntax and for her constant support during and beyond the writing of this dissertation. Many thanks go to my colleagues in the Forschergruppe 1783 *Relativsätze* and the group *Deutsch als Zweitsprache* for the numerous discussions I have enjoyed over the years. In this context I personally want to thank Alex Thiel, Magdalena Wojtecka, Derk Frerichs, Cécile Meier, and Claudia Poschmann.
Moreover, many thanks go to Dieter Koch for setting up the computer games. I am also much obliged to Nina Adam, Sarah Barton, Valeria Bunkov, Rebecca Janas, Caroline Lange, Alex Lowles, Michèle Paul, Franziska Pelka, Silvana Pfuhz, Luzia Rott, Martin Schastak, Daniela Schröder, Sally Schulze, Julia Simon, Isa-Marie Trussina, and Monika Tschense for their assistance in the data acquisition and coding and to Rabea Lemmer for her help with the project management. Moreover, I wish to thank the 274 children, their kindergartens, and the 63 adults for participating in the experiments.
This thesis benefited greatly from the comments of Emanuela Sanfelici, Alex Thiel, Pia Gerhard, Magdalena Wojtecka, Dieter Koch, and Joana van de Löcht. Thank you very much! Last, above all others, my family and my husband Christian deserve my deepest thanks and respect for their infinite emotional and moral support during the writing of this dissertation. I could not have done it without them.

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1. Introduction

Imagine you are spending an afternoon in Frankfurt, Germany and would like to go and explore the city. In a travel guide you may find the following recommendation.

> Vom Hauptbahnhof aus führt der Rundkurs zum markierten Ausgangspunkt an den Main. Überqueren Sie die Friedensbrücke zum südlichen Flussufer. Verlassen Sie die Straße und gehen Sie hinab ans Ufer. Folgen Sie dem Mainufer bis zur zweiten Brücke, die nur für Fußgänger freigegeben ist. Überqueren Sie den Fluss zurück auf die Seite der Innenstadt. Von dort gelangen Sie geradeaus auf den Römerberg. Dort befindet sich der nach historischen Belegen wiederaufgebaute Altstadtkern mit Rathaus und Dom. Nach diesem Abstecher folgen Sie dem Ufer zurück zum Ausgangspunkt. Auf dieser Tour können Sie viel entdecken. Dreizehn Museen und viele Cafés laden unterwegs zum Einkehren ein.

Figure 1.1.: Map of Frankfurt.

> ‘Follow the street from the main station towards the river Main to the marked starting point of the round trip. Cross the bridge to the southern bank of the river. Leave the street and go down to the riverbank. Follow the riverside walk

> until you reach the second bridge that is open only for pedestrians. Cross the river again in direction of the city center. Straight ahead you will find the Römerberg with reconstructions of the historical town hall and the cathedral. After this small detour follow the riverside walk back to the starting point. On this trip you may explore one of the 13 museums along the river or you may enjoy the day in one of the cafés.'

Following the English instructions you will find all the museums, cafés and historical places easily, and you will have a nice walk through the city. Based on the German instructions, you may wonder why you did not see the sights advertised in the travel guide, and why you made the tour in less than half of the time specified in the guide. The interpretation of the fourth sentence of the instructions (*Follow the riverside walk...*) makes the difference. In German, this sentence is ambiguous between two readings that can be distinguished in English. Based on a *restrictive* interpretation of the relative clause, you would follow the riverside walk to the second bridge that is open for pedestrians only. Alternatively, you may interpret the relative clause *appositively*[1]. In this case, you would follow the riverbank to the second bridge overall, which is open only for pedestrians. The former reading will guide you along the river and you will see very nice parts of Frankfurt. The latter reading will result in a short walk and you may think that Frankfurt is not as nice as you would have expected.

These two possibilities to interpret relative clauses are in the focus of this thesis. The contrast between restrictive and appositive interpretations is not only relevant for German. Also in English and other languages, these two semantic functions are sometimes difficult to distinguish. Imagine, for instance, you have a new position and your task is to supervise the trainees in a laboratory. Your colleague may say *"Your trainees$_{(,)}$ who are working in the lab right now$_{(,)}$ are really nice"*. Based on this statement you may not know whether all or only some of your trainees, namely those working in the lab at the moment, are nice. The interpretation of the relative clause may either serve to restrict the set of potential referents, or it may add additional information on an already identified set of referents. The former function of the relative clause is called *restrictive* while the latter function is labeled *appositive*.

Many studies have focused on relative clauses from both a theoretical linguistic perspective and a psycholinguistics point of view, including language acquisition. So far, studies on language acquisition and human language processing mainly investigated syntactic properties of relative clauses such as the different degrees of complexity associated with subject and object relatives. Research in formal semantics and theoretical syntax, in contrast, was mainly involved in a debate about the representation of the restrictive/non-restrictive distinction.

In this thesis I am connecting these two lines of research. Using experimental tasks, I investigate the semantic properties of relative clauses from an acquisition perspective.

[1] Note that in this thesis, the term *appositive* will be used to refer to non-restrictive relative clauses that modify a nominal antecedent and do not have a continuating discourse relation (Holler, 2005). Background on the class of *appositive* relatives, and *non-restrictive* relative clauses in general will be discussed in Chapter 2.

The main research question of this thesis is formulated in (Q).

(Q) How do typically developing German-speaking children acquire the semantic functions *restrictivity* and *appositivity* of relative clauses?

Focusing on the two semantic functions of relative clauses, I aim to find out how children deal with these semantically ambiguous structures. Studies on the acquisition of syntax generally assume that less complex structures will be acquired before more complex ones, e.g., single words before word combinations, before simple main clauses, before complex sentence structures involving subordination (Clahsen, 1990; Tracy, 2002). Whether this general view can be transferred to semantics or to phenomena at the syntax-semantics interface has not been explored in detail. The acquisition of restrictive and appositive relative clauses, however, constitutes such a phenomenon at the syntax-semantics interface. To study the development of the two semantic functions, assumptions about semantic and syntactic complexity need to be connected. Up to date, it is an open question whether a lack of syntactic structure may also represent a less sophisticated semantics within the learner's grammar (Van Geenhoven, 2006). In this thesis, I propose that syntax and semantics together predict the acquisition path for the two semantic functions. I follow Van Geenhoven's idea that semantic theory should be able to explain non-target-like stages in children's interpretations during the acquisition process.

To investigate the acquisition of restrictivity and appositivity, aspects from different linguistic subfields need to be considered. In this thesis, I start out from formal semantic and syntactic approaches for restrictive and appositive relative clauses. The formal background serves to identify the properties of restrictive and appositive readings that children have to acquire in the course of acquisition. In addition to formal approaches, factors influencing the interpretation of relative clauses have to be addressed. In this respect, I focus on the effects of prosody and lexical markers as disambiguating cues for restrictive and appositive readings of relative clauses in language comprehension. Furthermore, properties of human language processing and ambiguity resolution need to be considered. When children encounter relative clauses in their input, they may be faced with a potential semantic ambiguity that has to be resolved.

Based on the formal background and insights from previous studies addressing these aspects, three experiments were designed: two picture selection tasks and one acceptability task. The results of the experiments demonstrate that 4- to 6-year-old German-speaking children and adults prefer restrictive readings over appositive ones. In addition, while the majority of children has acquired restrictive readings at the age of 4, appositive interpretations are mastered only by about half of the children between age 4 and 6. Interestingly, 3-year-old children show a different pattern than their older peers. Appositive but not restrictive interpretations seem to be available to these children.

Although the results may be taken as evidence that appositivity is acquired before restrictivity in relative clauses by German-speaking children, I propose the contrary. Based on assumptions about the complexity of restrictive and appositive derivations, I argue that the appositive interpretations observed at the age of 3 do not result from

a target-like syntactic and semantic representation. Instead, I propose that they are derived from an incorrect attachment of the relative clause higher up in the syntactic tree.

This thesis is structured as follows. In Chapter 2, properties of restrictive and appositive relative clauses are presented. Section 2.1 introduces the terminology to describe the phenomenon under investigation. Then, restrictive and appositive relative clauses are addressed from a syntactic (Section 2.2) and semantic perspective (Section 2.3). Details about relative clauses in German are presented in Section 2.4. In addition, the interaction of syntax and semantics on the one hand and prosody on the other hand is discussed in Section 2.5. Section 2.6 addresses assumptions about how relative clauses are processed on-line, and how general parsing principles may influence the interpretation of relative clauses.

The theoretical background introduced in Chapter 2 shows that restrictive relative clauses are semantically less complex than appositive ones. This assumption is supported by observations from a typological overview on the semantic functions attested across languages. It is shown that the existence of appositive relative clauses implies the availability of restrictive readings in a given language. Furthermore, restrictive readings may be favored due to the functioning of general processing principles.

Chapter 3 summarizes previous research on the acquisition of relative clauses. Section 3.1 focuses on the emergence of relative clauses in spontaneous speech. Subsequently, Section 3.2 presents studies that investigated the acquisition of syntactic aspects of relative clauses. Section 3.3 describes the few studies that investigated semantic aspects of relative clauses in language acquisition. In addition, research on the acquisition of restrictivity and appositivity in adjectival modification is addressed in Section 3.4. Section 3.5 gives an overview of how children process language and, more specific, relative clauses.

Chapter 3 demonstrates that the acquisition of the semantic functions of relative clauses is an understudied area. In contrast, the acquisition of syntactic aspects of relative clauses is well documented. Relative clauses start to be produced in the third year of life and can be interpreted target-like between the age of 4 and 8 depending on their structure. Which semantic interpretation children assign to relative clauses at this age, however, is still an open question.

In Chapter 4, the research questions and corresponding hypotheses guiding the empirical part of the thesis are formulated. Based on the insights from the previous chapters, I assume that both readings may be available to the children. In addition, I predict that restrictive interpretations may be preferred over appositive readings. Subsequently, Section 4.2 introduces the core ideas for the three experiments reported in this thesis. To investigate the acquisition of restrictivity and appositivity experimentally, a design going back to Roeper (1972) and Matthei (1982) for the interpretation of adjective sequences is adapted.

Subsequently, the three experiments are presented. Chapter 5 reports how children and adults interpreted relative clauses in a preference task. Experiment 1 explored the influence of prosody and the influence of the visual context as disambiguating cues for otherwise semantically ambiguous test items. The results showed a strong preference for

restrictive readings in both 4- to 6-year-old children and adults.

Experiment 2 is presented in Chapter 6. The second preference task investigated whether discourse particles marking relative clauses as appositive modifiers influence the interpretation preferences of the participants. A design like in Experiment 1 was used to explore the interaction of prosodic cues with the presence or absence of the lexical marker. The results were similar to those obtained in Experiment 1. Children preferred restrictive interpretations for all conditions. Adults, in contrast, adapted their interpretations according to the presence of the lexical marker for appositivity.

Chapter 7 presents the third experiment of this thesis. Experiment 3 investigated the availability of restrictive and appositive readings in an acceptability task. Participants had to judge whether a picture selection matched the stimulus sentence. Like in Experiment 2, prosody as well as the presence of a lexical marker for appositivity were implemented as disambiguating factors. In this experiment, 3- to 6-year-old children were tested. The results revealed that 3-year-olds differed from the older children accepting appositive but not restrictive interpretations of relative clauses. For children between age 4 and 6, restrictive but not appositive readings were mastered by the majority of children.

The results of the three experiments are discussed in Chapter 8. Based on results of this thesis, Section 8.1 answers the research questions and addresses the hypotheses. In Section 8.2, a developmental path for the acquisition of restrictivity and appositivity is proposed as a first answer to the general research question (Q). Implications of the proposed acquisition path are discussed in Section 8.3. In addition to the results on the interpretation of relative clauses, Section 8.4 discusses findings for ordinal numbers, another type of nominal modifiers used in the experimental design.

In the general discussion, I argue for the acquisition of restrictivity before appositivity. On the basis of the empirical data, I postulate that children at age 3 have problems to integrate relative clauses as subordinated elements within the matrix clause. As soon as relative clauses are integrated within the matrix clause, restrictive readings are found for relative clauses.

Chapter 9 concludes this thesis. Based on the findings from the empirical part open questions and suggestions for further research are addressed.

2. Structure and meaning of relative clauses

The present thesis investigates the semantic properties of relative clauses in German in language acquisition. As a background for the empirical part, this chapter introduces assumptions about restrictive and appositive relative clauses from a theoretical perspective. Section 2.1 introduces some terminology to describe relative clauses syntactically and semantically. In addition, syntactic variants and semantic functions of relative clauses are identified that are not in the scope of this thesis. Sections 2.2 and 2.3 present syntactic and semantic approaches for the two semantic functions of relative clauses. These sections serve to describe the different properties of restrictive and appositive relative clauses syntactically and semantically across languages. In addition, assumptions about the complexity of the two readings are derived as basis for the empirical studies. Subsequently, Section 2.4 presents the characteristics of restrictive and appositive relative clauses in German. This background forms the basis to derive hypotheses regarding the acquisition of restrictive and appositive relative clauses. Sections 2.5 and 2.6 connect the theoretical assumptions to human language processing. Section 2.5 focuses on the interaction of prosody with the syntactic and semantic representation of relative clauses. It investigates whether prosodic information is perceived as a cue disambiguating between restrictive and appositive interpretations. Finally, Section 2.6 concentrates on theoretical assumptions about the processing of relative clauses. The function of general parsing principles and their consequences for relative clause interpretations are addressed.

2.1. Introducing relative clauses

This section introduces the phenomenon under investigation and the terminology used in this thesis. First, syntactic aspects are addressed. The formal characterization of relative clauses forms the basis for the syntactic analyses described in the following sections. The second part of this introduction focuses on the semantic side of relative clauses. The notion of restrictive and appositive relative clauses is addressed. In addition, other types of structures, such as integrated V2 structures, pseudo-relatives, and amount relatives are identified. The discussion of these structural and semantic variants serves to define the focus of the acquisition studies reported in the empirical part of this thesis. In addition, the overview clarifies what the notions *restrictive* and *appositive relative clauses* refer to in the following chapters.

Typological research has shown that relative clause are attested in all languages (Downing, 1978; De Vries, 2002). In general, relative clauses are complex nominal modifiers that involve an "abstraction over an internal position of the clause (the relativization site) and [the] connect[ion] to some constituent it modifies (the relative 'head')." (Bianchi, 2002a, p. 197). An example is given in (1).

(1) Der Junge, [der ein großes Geschenk bekommen hat]$_{RC}$, war sehr glücklich.
The boy who a big present got has was very happy

'The boy$_{(,)}$ who got a big present$_{(,)}$ was very happy.'

The sentence in (1) is an example for a *headed relative clause*. In headed constructions, the relative clause has a lexical antecedent, a *head*, in the host clause. In (1), the NP or DP[1] *(der) Junge* '(the) boy' is the head that is modified by the relative clause. In general, German and other languages distinguish between *headed relative clauses* as in (1) and (2), and *free relative clauses* as in (3).

(2) Anna küsst Peter, [was Maria nicht gefällt]$_{RC}$.
Anna kisses Peter what Maria not likes

'Anna is kissing Peter, which Mary doesn't like.'

(3) [Wer ein großes Geschenk bekommt]$_{RC}$, ist sehr glücklich.
Who a big present gets is very happy

'Whoever is getting a big present is very happy.'

Depending on the constituent being modified, headed relative clauses can be classified as *attributive relative clauses* or *continuative relative clauses*. Attributive relative clauses modify a nominal expression as *der Junge* in (1) (Pittner & Bermann, 2007). Continuative relatives as in (2) may take the whole matrix clause or VP as antecedent (Holler, 2005; Zifonoun, 2001). Headed relatives are part of the constituent of the head. In contrast to the headed relative variant, free relative clauses as in (3) lack an antecedent in the matrix clause. Moreover, free relatives function as a constituent of the matrix clause on their own. In (3) for example, the relative is the subject of the matrix clause.

As demonstrated in (1) and (2), headed relatives follow their head noun in German. The *postnominal* relative clause may be adjacent to its antecedent as in (1), or may be extraposed as in (4). Examples for *prenominal* or *circumnominal* relative clauses are displayed in a typological overview in Section 2.2.1.

(4) Das Mädchen hat einem Jungen ein Geschenk gebracht, [der sich ein Bein
The girl has a boy a present given who himself a leg
gebrochen hatte]$_{RC}$.
broken had

'The girl gave a present to a boy$_{(,)}$ who had broken his leg.'

In general, it is assumed that relative clauses belong to the class of subordinate clauses (but see the discussion for appositive relatives in Section 2.2.2). In German, the subordinated status can be identified based on the position of the finite verb. The examples (1) to (4) show that in German the finite verb in relative clauses is in sentence-final

[1] As described in detail in Section 2.2.3, restrictive relative clauses are analyzed as modifiers of the NP whereas appositive relative clauses are modifiers of the DP. See for instance Partee (1973).

position. In main clauses, the finite verb has to move into the second position due to the V2-property of German (Reis, 1985). Interestingly, a certain type of relative clause structures displays V2 word order. This is exemplified in (5) cf., Gärtner (2001a, p. 98).

(5) Das Blatt hat eine Seite, (/) [<u>die</u> ist ganz schwarz].
The sheet has a page that is completely black

'The sheet has a page that is completely black.'

These so-called *integrated V2* relatives can only be used in a very restricted set of linguistic environments (see, e.g., Gärtner, 2001a, 2001b). With regard to the syntactic analysis of integrated V2 structures, there is disagreement. In contrast to verb-final relative clauses, integrated V2 structures may constitute an instance of embedded root phenomena (Sanfelici, Schulz, & Trabandt, 2017) or are analyzed as discourse-linked main clauses Gärtner (2001a, 2001b). Independently of the analysis, the syntactic attachment and the semantic properties of these clauses differ from those found in verb-final relative clauses. Therefore, integrated V2 relatives will not be scrutinized further. For more details of integrated V2 relatives the reader is referred to Gärtner (2001a, 2001b), Endriss and Gärtner (2004), De Vries (2006), and Sanfelici et al. (2017).

One characteristic property of relative clauses is the "abstraction over an internal position of the clause (the relativization site)" as for instance described by Bianchi (2002a, p. 197). In German, many grammatical functions can be relativized. (6) shows a *subject relative clause*, henceforth referred to as SRC, in which the relative pronoun functions as the subject of the relative clause. Consequently, the relative pronoun bears nominative case. In (7) the indirect object is relativized, in (8) it is the prepositional object. In the following examples, the base position of the relativized element is underlined.

(6) Der Junge, der ___ ein großes Geschenk bekommen hat, war sehr
The boy who-MASC-SG-NOM a big present got has was very
glücklich.
happy

'The boy$_{(,)}$ who got a big present$_{(,)}$ was very happy.'

(7) Der Junge, dem das Mädchen ein Geschenk ___ gegeben hat, war
The boy who-MASC-SG-DAT the girl a present given has was
sehr glücklich.
very happy

'The boy$_{(,)}$ to whom the girl gave a present$_{(,)}$ was very happy.'

(8) Das Geschenk, über das sich der Junge ___ gefreut hat,
The present about which-NEUT-PL-ACC himself the boy rejoiced has
liegt auf dem Tisch.
lie on the table

'The present$_{(,)}$ about which the boy was happy, is on the table.'

Another characteristic property of relative clauses is the nature of the relative element. As seen in the examples (6) to (8) above, relative clauses in German are introduced by a *relative pronoun*. In English, in contrast, relative pronouns like *who* and *which* as well as the *relative complementizer that* can be used.

The syntactic aspects highlighted so far are taken up in the following chapters in more detail. With regard to semantics, the notions of *restrictive* and *appositive* relative clauses are introduced in what follows.

In principle, relative clauses can be classified as *restrictive* or *non-restrictive*, i.e., *appositive*. The term describes the semantic relation of the head noun and the relative clause. Restrictive relative clauses restrict the denotation of the head noun. Thus, they help to identify the referent of the modified noun phrase (e.g., Blühdorn, 2007; Fabricius-Hansen, 2009; Pittner & Bermann, 2007). In contrast, non-restrictive relatives add information on an already identified referent. The relevance of this distinction has been shown in the tour guide example in the introduction of this thesis. Consider Example (1), repeated here as (9). The sentence may be uttered in the context of a christmas party. One boy got a big present, other boys got only small presents or nothing. In this scenario, the relative clause restricts the set of boys present to the one boy that received a big present. Notably, also without knowledge about the presence of other boys, a restrictive interpretation of (9) implies the existence of alternative referents, i.e., boys who did not get a big present.

(9) Der Junge, [der ein großes Geschenk bekommen hat]$_{RC}$, war sehr glücklich.
The boy who a big present got has was very happy
'The boy$_{(,)}$ who got a big present$_{(,)}$ was very happy.'

Example (9) can also be interpreted non-restrictively. In this case we could think of a family celebration where only one boy is present. In this scenario, the reference of the head noun *boy* can be established independently of the relative clause. The relative clause itself adds additional (background) information on this referent.

Several means can be used to mark a relative clause as restrictive or appositive and exclude the other interpretation. In languages like English or French, the use of a comma is a formal cue for the semantics of the sentence. In German, a comma separating the relative clause from its host clause is obligatory independently of the reading. In addition, language-specific cues and lexical markers may serve as disambiguating factors. They will be addressed in subsequent sections of this thesis.

Restrictive and appositive interpretations are not the only readings that are attested for relative clauses. In languages like Italian, Spanish, Dutch and Japanese, relative clauses can also receive a *pseudo-relative* interpretation under perception verbs in the matrix clause. Unlike restrictive relative clauses, the string-identical pseudo-relatives denote propositions and are interpreted as direct perceptions of an event (Grillo, 2012; Grillo & Costa, 2014). The semantic difference between a pseudo-relative and the corresponding restrictive relative clause in Italian is given in (10a) and (11a). A semantic representation is given in (b) and is paraphrased in (c), taken from Grillo and Costa (2014, p. 163).

(10) a) Gianni ha visto [PR la ragazza che correva].
Gianni has seen the girl that runs

'John saw the girl running.'
'John sah ein Mädchen rennen.'

b) $\exists s \exists s'$ [see (s) & AGENT(s)(John) & THEME(s')(s) & run (s') & AGENT(s')(the girl)]

c) There is an event of seeing and the agent of that event is John and the theme of the event is an event of running and the agent of the running-event is the girl.

(11) a) Gianni ha visto [DP la [NP ragazza [CP che correva]]].
Gianni has seen the girl that runs

'John saw the girl that was running.'
'John sah ein Mädchen, das rannte.

b) $\exists s$ [see (s) & AGENT(s)(John) THEME(the unique girl that ran)(s)]

c) There is an event of seeing and the agent of that event is John and the theme of the event is the unique girl that ran.

In German, pseudo-relatives being string-identical to restrictive relative clauses are not available according to Grillo and Costa (2014). In general, these interpretations are banned from languages that obligatorily use relative pronouns (Grillo & Costa, 2014). For more details see Belletti (2012), Belletti (2015), Cinque (1992), Grillo (2012), and Grillo and Costa (2014).

Additional types of interpretations are also available for non-restrictive relative clauses. The class of non-restrictive relatives can be divided into at least three subtypes based on findings from the literature. Non-restrictive relatives may be interpreted *appositively*, as in (12), *continuatively* (Holler, 2005), as in (13) and (14), or with an *amount interpretation*, exemplified in (15) (Carlson, 1977; Grosu & Landman, 1998; Heim, 1987). The following paragraphs focus on these different interpretations in turn.

(12) Peter, [der ein großes Geschenk bekommen hat]$_{RC}$, war sehr glücklich.
Peter who a big present got has was very happy

'Peter, who got a big present, was very happy.'

(13) Anna gewann die Schachpartie, was Peter maßlos ärgerte.
Anna won the chess match what Peter exorbitantly annoyed

'Anna won the chess match, which annoyed Peter exorbitantly.' (Holler, 2005, p. 25)

(14) Otto gab Emil das Buch, das er dann in die Bibliothek brachte.
Otto gave Emil the book which he then in the library brought

'Otto gave Emil the book, which he then brought into the library.' (Holler, 2005, p. 25)

It is frequently assumed that appositive and continuative relative clauses have to be differentiated (Lehmann, 1984; De Vries, 2002; Holler, 2005). The distinction is linked to the discourse relation that is expressed by the relative clause (Asher & Vieu, 2005). In Holler's terminology appositive relative clauses modify a nominal antecedent as in (12). In addition, appositive relatives have a backgrounding function (see also Huddleston & Pullum, 2002, 1064). Continuating relatives, on the other hand, syntactically modify sentential antecedents. Moreover, they are in a symmetric, non-subordinating discourse relation with regard to the matrix clause (Asher & Vieu, 2005; Holler, 2005). From a semantic perspective, continuating relative clauses, as displayed in (13) and (14), can refer to a variety of entities (individuals, events, propositions). In general, they establish a (temporal) adverbial relation to the semantic antecedent.

Non-restrictive relative clauses may also have an amount or maximalizing interpretation depending on the language (Carlson, 1977; Grosu & Landman, 1998; Heim, 1987). This reading is illustrated in (15).

(15) It will take us the rest of our lives to drink the champagne that they spilled that evening. (Heim, 1987, p. 38)

As Grosu and Landman (1998) point out, (15) can be either interpreted as a restrictive relative or with an amount reading. In the amount reading it is not the case that the speaker will have to drink exactly the same champagne that was spilled that evening. Instead the speaker expresses that drinking the same *amount* or *quantity* of champagne as was spilled that evening will take him the rest of his life. Like in restrictive relatives, the relative clause restricts the denotation of the head noun. Contrary to typical restrictive relatives, the denotation of the modified noun phrase is the quantity of a set specified by the head noun and the relative clause.

Importantly, in what follows the term *appositive relative clause* will be used as defined by Holler (2005) unless specified differently. Thus, the term refers exclusively to non-restrictive relative clauses with a nominal antecedent that do not establish a continuating discourse relation with regard to their antecedents. Maximalizing relative clauses and continuating relative clauses are subsumed under the label of *non-restrictive* relative clauses, but they are not referred to as appositive relatives.

The following section focuses in more depth on syntactic properties of relative clauses.

2.2. On the structure of relative clauses

During the last 50 years the central questions of syntactic research on relative clauses centered around two aspects. On the one hand, the nature of the structural relation between the relative clause and the DP hosting it has been discussed. On the other hand, the nature of the link between the head noun and the relativized element within the relative clause has been explored (see e.g., the introduction in Alexiadou, Law, Meinunger, & Wilder, 2000; Bianchi, 2002a, 2002b; or De Vries, 2002). The debate focused on the question where relative clauses are attached in the syntactic representation. Furthermore, it is unclear whether relative clauses are arguments of a head, D or N, or whether

they are adjuncts (arguing for D: e.g., Kayne, 1994; Sternefeld, 2006; N: Platzack, 2000; adjunct: e.g., Del Gobbo, 2003; Demirdache, 1991; Partee, 1973). Moreover, analyses differ in their assumptions about the origin of the head noun, i.e., whether it is part of the matrix clause or base-generated within the relative clause. Competing approaches are presented in Section 2.2.3 as a basis to derive implications of these models with respect to the acquisition of relative clauses. Before going into detail, Sections 2.2.1 and 2.2.2 introduce the background for the structural analyses. First, a short typological overview presents properties of relative clauses across languages (2.2.1). This is followed in Section 2.2.2 by a discussion of the status of appositive and restrictive relatives as subordinate clauses.

2.2.1. The syntax of relative clauses across languages

According to typological research, sentential modification of nominals occurs universally. "All languages use relative clauses" (De Vries, 2002, p. 35). This *absolute universal* dates back to Downing (1978) and is supported by typological data of Lehmann (1984). A universal definition of relative clauses is difficult to phrase. The definition that a relative clause involves an "abstraction over an internal position of the clause (the relativization site) and [the] connect[ion] to some constituent it modifies (the relative 'head')." (Bianchi, 2002a, p. 197) does not hold universally since not all relative clauses contain a gap and an external head. The head may also be internal to the relative clause although it is interpreted at a position within the main clause, as for instance in Hindi (Downing, 1978), Example (16).

(16) [yo **laRke** KhaRe hai], **ve** lambe haiN.
wh boys standing are those tall are

lit. 'Which boys are standing, they are tall.' (Hindi, Grosu & Landman, 1998, p. 164)

A more general definition to cover the properties of relative clauses cross-linguistically is formulated by De Vries (2002, p. 14) in (17).

(17) Defining properties of relative constructions:
a) A relative clause is subordinated.
b) A relative clause is connected to surrounding material by a pivot constituent.

The pivotal element is understood as "a constituent semantically shared by the matrix clause and the relative clause" (De Vries, 2002, p. 14). This definition is rather vague but it teases apart relative clauses from other subordinate sentences. The vagueness is necessary because languages differ with regard to the means they use to mark relative clause structures.

Cross-linguistically, four main types of relative clauses have been identified: *prenominal relatives* as in Basque, Japanese or Chinese (see Example (18)), *postnominal relatives* as in English (Example (19), as well as in Germanic and Romance languages, *circumnominal*

relatives as in Mohave (see Example (20)) or Ancash Quechua, and *correlatives* as in Hindi in (16) (De Vries, 2002). Across languages, each of these variants is attested as both a *headed relative*, in which an overt lexical noun is modified, and as a *free relative*, i.e., a relative clause without an overt lexical head. In the examples below, the head noun is marked in bold and the relative clauses are written in brackets.

(18) Aitak irakurrii nai du [amak erre du-en] **liburua**.
Father read want mother burned-has-REL book.

'Father wants to read the book that mother has burned' (Basque, Downing, 1978, p. 393)

(19) The **girl**, [who got a big birthday present], was very happy.

(20) [**Hatčoq ʔavi:-m** ʔ-u:ta:v]-n^{y}-č n^{y}əʔi:l^{y}-pč.
[dog stone-INST SBJ.1-hit]-DEF-NOM black-REAL

'The stone with which I hit the dog was black.' *or*
'The dog which I hit with the stone was black.' (Mohave, Lehmann, 1984, p. 111)

Following De Vries (2002, p. 20), the syntactic structures of the four relative constructions can be formally described as in (21).

(21) a) prenominal relatives [S-matrix ... [RC N] ...]
b) postnominal relatives [S-matrix ... [N RC] ...]
c) circumnominal relatives [S-matrix ... [[RC ... N ...]] ...]
d) correlatives [S-matrix ... [[RC (...) N ...] [S-matrix ... (Dem) ...]

As can be seen from the syntactic structures in (21), in pre- and postnominal relative clauses the head noun N is external to the relative clause. In contrast, circumnominal relatives and correlatives are head-internal and a gap in the matrix clause is linked to this noun phrase. At first, correlatives look like left-dislocated circumnominal relative clauses. The left-dislocated relative is taken up again by a correlate, frequently a demonstrative pronoun in the second part of the main clause. This analysis, however, is not appropriate. De Vries (2002) summarizes findings on correlatives and shows that they indeed differ from circumnominal (and other adnominal) relatives. According to De Vries, correlatives are not embedded in a DP of the matrix clause together with their head noun. Instead, they should be analyzed as bare CPs, an analysis going back to Keenan (1985).

A comparison of the four syntactic types of relative clauses with regard to other properties, e.g., the basic word order of a language, led to the formulation of typological generalizations (Downing, 1978). In contrast to previous assumptions, however, De Vries (2002) concludes that the four syntactic types of relative clauses cannot be directly linked to the basic word order (VO vs. OV) of a language. Implications formerly described by Downing (1978) do not hold. It is not the case that postnominal relative clauses are found in VO-languages, and that prenominal relatives are found in OV-languages. German for instance is a counterexample to the first generalization since it is an OV-language with postnominal relative clauses.

A further generalization focuses on the syntactic functions that can be relativized across languages. Typological studies have shown that the syntactic function of the relative clause head within the matrix clause seems to be unrestricted (De Vries, 2002). Relative clauses can be attached to head nouns independently of their syntactic function as subject, (in)direct object, or adverbial. In contrast, languages differ with regard to which syntactic roles within the relative clause can be relativized (Keenan & Comrie, 1977; Lehmann, 1984). On the basis of about fifty languages, Keenan and Comrie (1977, p. 66) formulate the *Accessibility Hierarchy* in Figure 2.1. In their schema '>' means that the function to the left is more accessible than the function to the right; OCOMP stands for 'Object of comparison', i.e., a noun phrase within a comparative form as *'taller than the man'*.

SU > DO > IO > OBL > GEN > OCOMP

Figure 2.1.: Accessibility Hierarchy (Keenan and Comrie, 1977, p. 66).

According to the hierarchy in Figure 2.1, there is an implication that if in a given language for instance a genitive object can be relativized within the relative clause, it will also be possible to relativize all functions to the left of GEN. For more detailed analyses see Lehmann (1984, pp. 209ff.) or De Vries (2002, chapter 2).

The four different types of relative clauses seem to vary systematically with regard to relative clause elements such as relative pronouns, complementizers, resumptive pronouns, and verbal affixes. Cross-linguistically, prenominal relative clauses may be unmarked, or they may contain a verbal relative affix. In the unmarked case (like e.g., in Japanese), a relative clause can be identified by its word order or position relative to the matrix clause. According to De Vries (2002, p. 37), prenominal relative clauses never contain a relative pronoun or a relative complementizer. This also holds for circumnominal relatives. Postnominal relative clauses are more flexible with regard to their relative elements. If a relative pronoun is present, it is located sentence-initial and it is typically identical to the set of interrogative or demonstrative pronouns used in the language (Downing, 1978). Correlatives are more limited and do not use relative affixes. Moreover, most of the languages that have correlatives use relative pronouns instead of relative complementizers (De Vries, 2002, p. 38).

Depending on the specific language and its structural type, relative clauses may have resumptive pronouns that mark the base position of the relativized element. According to observed universals derived from a thorough typological overview, resumption is not possible in circumnominal relative clauses (De Vries, 2002, p. 38). As De Vries notes, resumptive pronouns are rare in prenominal relatives. In postnominal relative clauses, the presence of a relative pronoun excludes the presence of resumptive pronouns or clitics. The same observation led Demirdache (1991) to conclude that resumptive pronouns are the consequence of in-situ relativization in languages where resumption is not restricted to islands. Demirdache argues that if the relative pronoun stays in its base-position, it is spelled out as a resumptive. This is the case in Hebrew, a language with postnominal relative clauses.

The four syntactic variants, also vary systematically with regard to the semantic functions that can be expressed (De Vries, 2002, p. 29). The interplay of syntax and semantic functions is displayed in Table 2.1. '+' indicates that the semantic function is available for a language of the respective syntactic type.

Table 2.1.: Mapping between syntactic and semantic types of relative clauses following De Vries (2002)

	Semantic type		
Syntactic type	Appositive	Restrictive	Maximalizing
Postnominal	+	+	+
Prenominal	–	+	+
Circumnominal	–	+	+
Correlative	–	–	+
Free relatives	–	–	+

Note. + denotes availability of semantic function in a language of the syntactic type; – denotes unavailability of semantic function in any language of the syntactic type.

As can be seen from Table 2.1, only postnominal relative clauses allow an appositive[2] reading. In contrast, all adnominal constructions allow restrictive readings. Interpretations that involve a maximalization operation described above (cf., Grosu & Landman, 1998) are most widely attested and are possible in all four syntactic structures. In addition, only a maximalization reading is possible in correlatives. It is also the only interpretation that is available for free relatives, which can be found in all of the four syntactic variants.

Some generalizations regarding the properties of the four syntactic structures of relative clauses can also be transferred to individual languages. The observations in Table 2.1 can be formulated as universal implications. De Vries (2002, p. 35) states that "if a language has relatives, it has restrictive or maximalizing relatives". Moreover it can be generalized that "if a language has appositives, it also has restrictives – but not necessarily the other way around" (De Vries, 2002, p. 35). This implication captures the idea of Downing (1978) that appositives are less basic than restrictive relatives. Note that according to Table (2.1), appositive interpretations are only attested for languages with postnominal relative clauses. Therefore, the implicature has the consequence that only languages with a postnominal relativization strategy allow appositive interpretations. In this case, the respective language will also have restrictive and/or maximalizing relative clauses.

A different line of cross-linguistic research focuses on structural properties of non-restrictive relative clauses in contrast to restrictive ones (Cinque, 2008b). Cinque argues that there are two types of non-restrictive relative clauses across languages to be differen-

[2]De Vries (2002) does not distinguish between different types of appositive relative clauses. Continuating relatives as defined in Holler (2005) are subsumed under the label of appositive relative clauses.

tiated: integrated and non-integrated non-restrictives.[3] Based on examples from Italian, Cinque proposes that integrated non-restrictive relative clauses are similar to restrictive relative clauses with regard to their syntactic properties. Like restrictive relatives, integrated non-restrictive relatives are introduced by a relative complementizer (*che/cui* in Italian). They can only have declarative force as displayed in (22a). Furthermore, they have to be adjacent to their heads. In addition, the head can only be a nominal antecedent as in (22b)[4]. In contrast to the attachment of restrictive relatives, Cinque assumes that integrated appositives are attached at a higher position in the syntactic tree.

(22) a) L'unico che potrebbe è tuo padre, **il quale** / *?**che**
The only one who could is your father, the who / who (lit. that)
potrà, credi, perdonarci per quello che abbiamo fatto?
will ever, you think, forgive us for what that we have done

'The only one who could is your father, who will ever forgive us, you think, for what we have done?' (Cinque, 2008b, p. 102)

b) Carlo lavora troppo poco. **La qual cosa** / ***Che** verrà certamente
Carlo works too little. The which thing / That will come certainly
notato.
observed

'Carlo works too little. This will certainly be recognized' (Cinque, 2008b, p. 106)

Non-integrated relative clauses are introduced by a relative pronoun (*il quale* in Italian). Non-integrated relatives differ from integrated ones in that they allow pied piping of different kind of phrases with the relative pronoun. In addition, they can have interrogative or imperative illocutionary force and can be extraposed. Moreover, they can modify various phrasal categories in addition to nominal ones. With regard to other properties, integrated and non-integrated non-restrictive relative clauses do not differ: Both types allow for proper names and pronouns as antecedents, sentential adverbs are licensed and weak-crossover effects are absent in these constructions.

Cinque (2008b) states that languages differ in whether they allow both types, like Romance languages, or whether they use only one of the types. Languages like English only allow non-integrated non-restrictive relatives. Some Northern Italian dialects or Chinese[5] allow only integrated relatives.

[3] Like De Vries (2002), Cinque does not address the distinction between appositive relative clauses and continuative relatives raised by Holler (2005), only maximalizing relatives are excluded as a different class of appositives.

[4] For additional defining properties of the two types of non-restrictive relative clauses see Cinque (2008b).

[5] According to Cinque (2008b) Mandarin Chinese has integrated non-restrictive relative clauses. This assumption conflicts with the fact that relative clauses in Mandarin Chinese belong to the class of prenominal relative clauses, which should not be appositive according to the typological findings reported above by De Vries (2002). In a detailed discussion, Del Gobbo (2003) shows that relative

German appositive relative clauses, as illustrated in Section 2.1 cannot be classified uniformly according to the criteria of Cinque (2008b). In German, both restrictive and appositive relative clauses are introduced by a relative pronoun and allow extraposition of the subordinate clause. This has been illustrated in (1) and (4) above. Thus, restrictive relative clauses in German show properties different from those reported for Italian. Since Cinque's definition of integrated and non-integrated relatives is based on a comparison of Italian non-restrictives with the properties of restrictive relative clauses in question, a direct transfer to German is not possible.

Therefore it is open to further research, whether the cross-linguistic characterization of non-restrictive relatives as proposed in Cinque (2008b) can be maintained as such. Alternatively, integrated and non-integrated appositives as described in Cinque (2008b) could define the end points on a scale. Languages then may differ with regard to the properties that are implemented in appositives, such as the presence of relative complementizers versus relative pronouns.

As this short typological overview shows, there is variation with regard to relative clause formation and the occurrence of appositive relative clauses across languages. Nevertheless, some systematic links between the syntactic properties of relative clauses and their interpretation have been identified, as summarized by De Vries (2002). These correlations have to be captured by syntactic and semantic analyses. In addition, the correlations help to form hypotheses for the acquisition of relative clause semantics. In this regard the observation that appositive interpretations are limited to postnominal relative clauses is relevant. Together with the implication that a language with appositive relative clauses will also allow for restrictive relative clauses, these correlations may imply a certain order of acquisition. The semantics of restrictive relatives, as the option that is more widely available across languages, may be acquired before the less available appositive interpretation. This will be addressed in more detail in the empirical part of this thesis (see discussion in Section 4.1).

In the following, Section 2.2.2 addresses the interplay of semantic and syntactic properties of relative clauses with regard to the question whether both, restrictive and appositive relative clauses should be analyzed as instances of subordination.

2.2.2. Relative clauses as an instance of subordination

In traditional reference grammars, relative clauses are categorized as subordinated clauses (e.g., German: Dudenredaktion, 2005, English: Huddleston & Pullum, 2002). Taking a typological perspective, Lehmann (1984, pp. 145ff.) states that all relative clauses are subordinated. Lehmann argues that, in general, relative clauses cannot be used like main

clauses in Mandarin Chinese can modify a proper name or a pronoun. Contrary to 'true' appositives, they typically receive a restrictive interpretation as in '*The John that did X*' in instances as such. In addition, these relative clauses pattern with restrictive relatives and appositive adjectives with regard to ellipsis. Furthermore, sentential adverbs are not allowed, whereas binding from the matrix clause into these relatives is possible. Thus, Chinese relative clauses do not fulfill the requirements listed in Cinque (2008b) for appositive relatives. According to more recent proposals by Del Gobbo (2004, 2006), all relative clauses of Mandarin Chinese should be analyzed as adjectival forms. For a detailed discussion see Del Gobbo (2003) and subsequent works.

clause across languages. For Downing (1978) the (semantic) linking of relative clauses to another clause is a defining characteristic of relative clauses. He states: "A relative clause never stands alone as a complete sentence: it is always linked, semantically at least, to a noun phrase that is part of another clause" (Downing, 1978, p. 378). Lehmann demonstrates that cross-linguistically, a variety of cues mark relative clauses as instances of subordination (Lehmann, 1984, pp. 158ff.). Among them are the relative clause position in relation to the main clause (e.g., Madagassian), subordination markers as in Chinese, and verbal affixes as in Turkish.

In some languages, verb placement can be taken as evidence for a subordinated status of relative clauses (De Vries, 2002). In languages that use different verb positions for embedded and non-embedded clauses, the verb placement in relative clauses patterns with that of other subordinate clauses. In German, main clauses display verb-second word order for the finite verb, see (23). In contrast, in subordinate clauses, the finite verb stays in final position in German as in (24). Since German relative clauses display verb final word order as shown in (25), De Vries argues that relative clauses are clear instances of subordination in this language.[6] Based on the German data De Vries generalizes this property to relative clauses in general.

(23) Das Mädchen *hat* heute Geburtstag.
The girl has today birthday.

'Today is the child's birthday.'

(24) Das Mädchen glaubt daran, dass es ein Geschenk *bekommt.*
The girl believes in-it, that she a present gets.

'The girl thinks, that she will get a present.'

(25) Das Mädchen, das ein Geschenk bekommen *hat*, war sehr glücklich.
The girl, who a present got has, was very happy.

The girl, that/who got a present, was very happy.

[6] Holler (2005) argues that this argument is not valid for German because the correspondence of verb-second for unembedded main clauses and verb final placement for subordinated clauses is not as strict as frequently reported. As demonstrated in (Ia), sentences with verb final word order can be used independently. In addition, some subordinate clauses can have verb second word order as shown in (Ib) and (Ic).

(I) a) Ob Max das Auto gewaschen hat?
Whether Max the car washed has

'Whether Max washed the car?' (Holler, 2005, p. 31)

b) Peter weiß, die Sonne geht im Osten auf.
Peter knows the sun goes in-the east up

'Peter knows that the sun rises in the east.' (Holler, 2005, p. 31)

c) Das Buch hat eine Seite, die ist ganz schwarz.
The book has a page that is totally black

'The book has a page that is totally black.' (Gärtner, 2001a, p. 98)

However, there are challenges to the view that all relative clauses are dependent, subordinated clauses when restrictive and appositive relative clauses are investigated in detail (Emonds, 1979; Frosch, 1996; Lehmann, 1984; McCawley, 1981). As the examples in (26) and (27) demonstrate, restrictive and appositive relative clauses have different properties with regard to certain root phenomena that are typically associated with independent main clauses.

The examples in (26) show that declarative illocutionary force is possible with both semantic functions of relative clauses as shown in Example (26a) by McCawley (1981, p. 116). An imperative reading of the relative clause, as in (26b) by Huddleston and Pullum (2002, p. 1061), is limited to appositive interpretations of the relative clause. The German example in (26c) taken from Holler (2005, p. 31) demonstrates that also an interrogative force is possible for appositive but not for restrictive relatives. Thus, in contrast to appositive relatives, restrictive relative clauses cannot have independent (non-declarative) illocutionary force.

(26) a) Have you seen the strange-looking man, who was here a minute ago?
[restrictive / appositive]

b) He said he'd show a few slides towards the end of the talk, at which point please remember to dim the lights. [*restrictive / appositive]

c) Finde endlich Müller, den du doch auch noch von damals kennst?
Find finally Müller, who you PRT also still from back then know
'Find Müller, who you still know from back then?' [*restrictive / appositive]

Furthermore, appositives but not restrictive relatives can contain sentential adverbs or other proposition-modifying elements (Holler, 2005, among others).[7] This is shown in the examples in (27). Example (27a) is from Emonds (1979, p. 239). The relative in (27b) can only receive a restrictive interpretation due to the determiner *diejenigen* 'these ones' of the head noun. (27b) and (27c) are taken from Holler (2005, p. 30).

[7]Note that modal particles in German are not restricted to main clauses. As Thurmair (1989, p. 54) observes, modal particles can also occur in independently used verb-final clauses as in (I). In addition, certain types of adverbial clauses allow modal particles. The examples given in (II) are taken from Thurmair (1989, p. 77). Following Thurmair, these subordinate clauses are illocutionary independent subordinate clauses and pattern therefore together with non-restrictive relative clauses.

(I) Dass du dich JA anständig benimmst!
That you yourself PRT properly behave
'Behave properly!'

(II) a) Wie es halt so ist, hat man uns immer wieder vertröstet.
As it PRT like that is has one us always again put off
'As it is usually, they put us off again and again.'

b) Ich dachte, es war schönes Wetter, weil es im Augenblick doch sehr schön ist.
I thought it was nice weather because it in the moment PRT very nice is
'I thought the weather had been nice because it is so nice at the moment.'

(27) a) The boys, who have frankly lost their case, should give up.

[*restrictive / appositive]

b) Diejenigen, die (*ja/*doch) politisch interessiert sind, gehen auch zur
The-ones, who (PRT) politically interested are, go also to-the
Wahl.
election

'Those that are interested in politics will attend the elections.'

[restrictive / *appositive]

c) Reformen, die ja/doch unumgänglich sind, müssen so bald als möglich
Reforms, which PRT inevitable are, must as soon as possible
durchgeführt werden.
realized become

'Reforms, which are as you know inevitable, have to be realized as soon as possible.' [*restrictive / appositive]

The presence of sentential adverbs or proposition-modifying elements in appositives leads Holler (2005) to assume that appositive relative clauses have a root status. As a consequence, Holler (2005) states, appositive relatives can be transformed into independent clauses, as is illustrated in (28). (29) demonstrates that this type of paraphrase is not possible for restrictive relative clauses.

(28) The girl, who got a present, was very happy. ⇒ The girl was very happy. She got a present.

(29) The girl that got a present was very happy. ⇏ The girl was very happy. She got a present.

Moreover, appositive relative clauses are similar to root clauses as they cannot be infinitival (Demirdache, 1991). In addition, as pointed out by Demirdache (1991), appositives differ from restrictive relative clauses in further aspects concerning their status as root or dependent clauses. Restrictive relative clauses in English can be introduced by the complementizer *that*, which also introduces embedded (tensed) clauses. This complementizer cannot be used in appositive relatives. In addition, in languages that distinguish embedded and non-embedded tenses such as Spanish, the subjunctive as an embedded tense cannot be used in appositive relative clauses.

The observations for restrictive and appositive relative clauses with regard to root phenomena led to a variety of proposals representing these clauses syntactically. Appositives should be analyzed as main clauses (Emonds, 1979; Ross, 1967), as subordinate clauses (Smith, 1964; Jackendoff, 1977) or as a hybrid phenomenon (Demirdache, 1991; Del Gobbo, 2003, 2007).

Emonds (1979), referring to Ross (1967), proposes that whereas restrictive relative clauses are subordinated, appositive relatives have to be analyzed as main clauses (*main*

clause hypothesis). Starting out as coordinated clauses, parts of the first conjunct (the matrix clause) will be moved to the right of the appositive relative clause to achieve the target word order if the appositive is embedded in the matrix clause. Since the appositive relative clause in this view is a main clause, the main clause properties are naturally accounted for. However, under the main clause hypothesis the relative clause does not form a syntactic constituent with its head in the course of derivation. This assumption contradicts the fact that in German, a verb-second language that allows only for one constituent in front of the finite verb in main clauses, a nominal that is modified by an appositive relative clause can appear sentence-initially (cf., (25)).

The competing approach, the *subordinate clause hypothesis*, was put forward among others by Smith (1964) and Jackendoff (1977). According to this hypothesis, all relative clauses are subordinated and differ only in their position of attachment within the syntactic tree. Contrary to the main clause hypothesis, the subordinate clause hypothesis can explain the constituency of the head noun and the relative clause as its modifier. Nevertheless, the subordinate clause hypothesis cannot explain the root phenomena observable in appositive relative clauses.

More recent proposals combine both hypotheses. Demirdache (1991), Del Gobbo (2003, 2007) and Potts (2005) assume that with regard to syntax, relative clauses are embedded and will be represented as subordinate clauses independently of their semantics. At a semantic level in contrast, appositive relative clauses but not restrictive relatives will be interpreted as independent (main) clauses. These proposals will be discussed in more detail in Section 2.3.

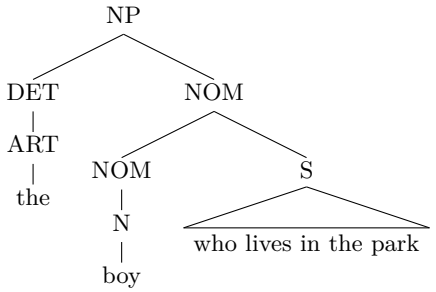
In the following, syntactic approaches to relative clauses and their semantic functions are spelled out in more detail.

2.2.3. Syntactic approaches to relative clauses

This section focuses on different approaches to represent restrictive and appositive relative clauses syntactically. First, assumptions about attachment positions of relative clauses are addressed as well as considerations about the relation between relative clause and matrix clause. Subsequently, assumptions with regard to the internal structure of relative clauses are discussed.

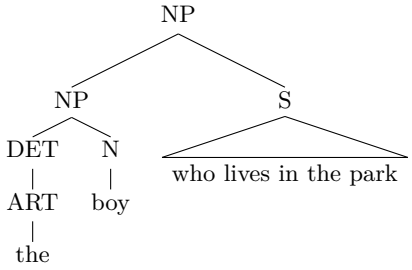
One of the first proposals in the generative framework to distinguish restrictive and appositive relative clauses on a syntactic level was put forward by Partee (1973). Partee follows Montague's approach that semantics should be compositional (Montague, 1973). She proposes that there should be a fundamental connection between syntactic and semantic rules. Moreover, the syntactic structure should be directly interpretable by semantics. Therefore, Partee argues that restrictive relative clauses are of the form shown in (30), in which the relative clause is attached to the noun phrase before the modified noun is combined with the definite article. In this structure the semantic interpretation can be derived from syntax because the definite article selects a unique element out of the intersection of both the denotation of the noun phrase and the relative clause (Partee, 1973, p. 54).

(30)



According to Partee, appositive relative clauses attach higher in the tree than restrictive ones, as displayed in (31) (Partee, 1973, p. 54). Since appositives modify an already selected referent, a low attachment at the NP-level would not match the computational demands of semantics.

(31)



From a syntactic perspective, different attachment heights for restrictive and appositive relative clauses is the standard analysis. This analysis has been adopted frequently in subsequent studies of relative clauses (e.g., Cinque, 2008b; Del Gobbo, 2003; Demirdache, 1991; Jackendoff, 1977; Potts, 2005). The representations in (32) display the attachment of relative clauses according to the standard assumption adapted to the DP-hypothesis by Abney (1987) (Demirdache, 1991, p. 111).

(32) a. restrictive relative clause b. appositive relative clause

The syntactic standard assumption can capture the observation that appositives have to follow restrictive relative clauses (Del Gobbo, 2003; Demirdache, 1991; Lehmann, 1984). Appositives, which are attached at the DP level, automatically follow restrictive relatives, since restrictives are part of the NP. This requirement on the linear ordering is illustrated in (33). The examples taken from Demirdache (1991, p. 112) show that a restrictive relative clause, introduced by *that*, cannot follow an appositive one.

(33) a) The girl that I saw, who John dislikes

b) *The girl, who I saw, that John dislikes

In addition to the standard approach, other proposals have been suggested. Whereas there is relative consensus on the analysis of restrictive relative clauses, the approaches mainly differ in their analyses for appositive relative clauses. Appositives may be analyzed like restrictive relatives (Sternefeld, 2006), or they may not be integrated in the syntactic representation at all (e.g., Haegeman, 2009; Safir, 1986).

Sternefeld (2006, p. 378) proposes that no syntactic distinction has to be made between restrictive and appositive relative clauses. Sternefeld assumes that the content of appositive relatives is presupposed. If this is the case, the content of the relative clause would not be part of the content of the DP. Consequently, the syntactic position of the relative cannot be determined relatively to the scope domain of the determiner. Sternefeld argues that the base-position for all relative clauses may be in the specifier of the DP, independently of their semantics (see also Blühdorn, 2007; for counterarguments see von Stechow, 2007).

Observations questioning the standard assumption concern the behavior of restrictive and appositive relative clauses under operators. In contrast to restrictives, appositives are barriers for binding relations. As Example (34) demonstrates, a quantifier in the matrix clause cannot bind into an appositive but into a restrictive relative clause (De Vries, 2006; Del Gobbo, 2003; Safir, 1986; Sells, 1985). The Examples (34a) and (34b) are taken from Safir (1986, p. 672).[8]

(34) a) Every Christian$_i$ forgives a man who harms him$_i$.

b) *Every Christian$_i$ forgives John, who harms him$_i$.

Furthermore, appositives differ from restrictives with respect to ellipsis. In contrast to restrictive relatives, appositive relatives are not part of elided material in coordinated structures (McCawley, 1981; De Vries, 2006; Sells, 1985). This is exemplified in (35), taken from McCawley (1981, p. 103).

(35) a) Tom has two cats that once belonged to Fred, and Sam has one. ⇒ Sam's cat once belonged to Fred.

b) Tom has two violins, which once belonged to Heifetz, and Sam has one. ⇏ Sam's violin once belonged to Heifetz.

[8] There are exceptional instances like (I) from Del Gobbo (2003, p. 154), which apparently allow binding into an appositive.

(I) Every Christian$_i$ prays to God, who forgives him$_i$.

The exceptions in which a pronoun in an appositive relative clause can be bound by an element of the matrix clause involve modal or temporal subordination (Del Gobbo, 2003; Sells, 1985). The context of modal and temporal subordination licenses binding relations in general more freely than contexts without this kind of subordination. Therefore the possibility to bind into an appositive under these circumstances may be due to independent reasons (C. Roberts, 1989; Poesio & Zucchi, 1992).

As the examples demonstrate, restrictive relatives are reconstructed and interpreted as part of the elided NP. Appositives, in contrast, are not reconstructed. A similar pattern holds for question-answer patterns, as in (36) and (37) by McCawley (1981, p. 117). When a question includes a restrictive relative clause, the relative has to be repeated in the answer. For questions containing an appositive relative clause like in (37), a repetition of the relative clause is infelicitous.

(36) Did you read the exam that I left on your desk?
  a) Yes, I read the exam that you left on my desk.
  b) ?Yes I read the exam.

(37) Did you read Schwartz's exam, which I left on your desk?
  a) ??Yes, I read Schwartz's exam, which you left on my desk.
  b) Yes, I read Schwartz's exam.

The binding facts and the scope differences under ellipsis led to disagreement regarding the question whether and how appositives are integrated in the syntactic structure. A number of different proposals have been advocated to account for the data: integration approaches (Bianchi, 1999; Cinque, 2008b; Del Gobbo, 2003; Demirdache, 1991; De Vries, 2000, 2006; Jackendoff, 1977; Griffiths & De Vries, 2013; Kayne, 1994; Platzack, 2000; Smith, 1964), radical orphanage accounts (Haegeman, 2009; Safir, 1986), and less radical orphanage accounts (Emonds, 1979; McCawley, 1981; von Stechow, 1979).

Proponents of an *integration approach* stress the fact that appositive relative clauses have to form a syntactic constituent together with the head noun (Bianchi, 1999; Cinque, 2008b; Del Gobbo, 2003; Demirdache, 1991; De Vries, 2000, 2006; Jackendoff, 1977; Griffiths & De Vries, 2013; Kayne, 1994; Platzack, 2000; Smith, 1964). It is this approach that underlies the syntactic standard assumption. Griffiths and De Vries (2013) give additional evidence in favor of the subordinate clause hypothesis and the integration approach (see Section 2.2.2). The grammatical example (38) and the ungrammatical counterpart in (39) show that appositive relative clauses can only be used in an elliptic answer to a question if the head noun is present in the response.

(38) A: What did John steal?
  B: Mary's computer, which crashes all the time.

(39) A: Who stole Mary's computer?
  B: *John (did), which crashes all the time.

In the fragmentary answer to the object question in (38) everything following the fronted constituent is elided and the answer is grammatical. This is displayed in (40). In the elliptic answer to the subject question in (39), the elided part would be identical to that in (40) except for the appositive relative clause that is following the elided material.

(40) A: What did John steal?
B: [CP [DP/ParP[9] [DP Mary's computer] [ARC[10] which crashes all the time]]$_1$ [C' ~~C^0~~ [TP ~~John stole t_1~~]]].

(41) A: Who stole Mary's computer?
B: *[CP John$_1$ [C' ~~C^0~~ [TP ~~t_1~~ [VP ~~stole~~ [DP/ParP [DP ~~Mary's computer~~] [ARC which crashes all the time]]]]]].

The ungrammaticality of (39) and (41) would be unexpected if the appositive relative clause was independent, and attached at the root as a separate constituent. In this case, the appositive in (41) should not be targeted by the ellipsis. The example of Griffiths and De Vries (2013) demonstrates that the appositive is attached to its head noun and that ungrammaticality arises because the elided material in (39) and (41) does not form a syntactic constituent. In case the head noun is deleted, the appositive relative cannot be disregarded by the ellipsis.

Rejecting syntactic integration, the proponents of the so-called *radical orphanage account* assume the appositive to be independent of the matrix clause at any representational level up to LF (Haegeman, 2009; Safir, 1986). The syntactic independence is assumed to be the reason for the independence of the appositive with regard to matrix clause scope and question formation. Safir (1986), for example, proposes that appositive relative clauses are only attached and co-indexed at a level LF' that follows the syntactic and semantic representations. Haegeman (2009) argues for a stricter view of the orphanage approach than Safir (1986). She denies any necessity of a structural attachment within any representation. She argues that co-indexation based on the discourse context suffices to achieve the target interpretation. Following Haegeman (2009), LF' may be understood as a discourse level, where interpretation can be guided also by non-linguistic factors in the context of the utterance, as for unintegrated adverbials and other parentheticals.

Less radical proponents of the orphanage account, for example Emonds (1979), McCawley (1981), and von Stechow (1979) argue that appositives are coordinated sentences that are combined with the matrix clause via the root. The root coordination and the assumption that the appositive is generated as an independent clause can explain why it is not possible to bind into the relative from the matrix clause and why the appositive can have independent illocutionary force.

One major problem for all orphanage approaches is the implementation of the correct linearization of the appositive relative within the matrix clause. The linearization is achieved by different means in the literature. McCawley (1981) assumes crossing branches of the syntactic tree, whereas Emonds (1979) postulates that arbitrary chunks of the matrix clause are right-dislocated. These mechanisms contradict base assumptions of standard syntactic theory (Chomsky, 1995; Ross, 1967). Haegeman (2009) proposes

[9] Following De Vries (2002), Griffiths and De Vries (2013) assume that the appositive relative clause is modifying the head noun via a specifying or parenthetical coordination phrase ParP. Since the argument made in the examples discussed here is independent of this specific aspect, I added the label *DP* and left out the postulated head *Par*^{0} in the structures (40) and (41).

[10] ARC stands for appositive relative clause.

that these kinds of peripheral parts of utterances could be generated within a representation which is constructed in parallel to the one of the host clause. Alternatively, orphans may start out from a separate enumeration. In Haegeman's terms, linearization is guided by pragmatic principles, which cannot yet be formalized. In addition to the problem of linearization, opponents of the coordination hypothesis argue that coordination does not lead to the correct meaning. Instead, the meaning and the truth conditions of non-restrictive relative clauses are identical to sequences of sentences (Demirdache, 1991; Sells, 1985). This interpretative observation will be discussed in more detail in Section 2.3.

For the remainder of this thesis, I adopt an integration account for appositive relative clauses. In contrast to the orphanage account, syntactic integration of the appositive can explain the facts with regard to coordination and ellipsis. In addition, the constituency of appositive relative clauses and their head nouns can be captured. Moreover, the barrier effects of appositives for binding into them from the matrix clause can be captured semantically, as will be shown in Section 2.3.2. Therefore, I will follow the proponents of the integration account and will assume that appositives, like restrictives, are integrated in the matrix clause at some syntactic level.

In addition to the question of the position of relative clauses within the syntactic tree, another line of research has centered around the question of the internal structure of (restrictive) relative clauses and especially of how the relativized element is linked to the head noun. As Alexiadou et al. (2000) argue, the standard approach to restrictive and appositive relative clauses typically advocates that the head noun is base-generated outside of the relative clause. It is represented within the relative clause by an operator. The structure assumed by the earliest proponents of the standard assumption (e.g., Safir, 1986) is displayed in (42) (Alexiadou et al., 2000, p. 3).

(42) a) The claim (that) John made

b) $[_{DP}$ the $[_{NP}$ $[_{NP}$ claim$_j$] $[_{CP}$ OP$_j$ (that) John made t_j]]]

In the representation in (42) an operator without lexical content is located in the specifier of the relative clause CP. This operator binds its trace, a variable in the position in which the head noun is interpreted. This *wh*-dependency within the relative is linked to the head noun by an interpretative relation, e.g., binding, co-indexation or construal depending on the adopted approach. The operator-variable chain may be headed by a null operator or a ($\pm wh$)-pronoun. The relative clause itself is adjoined to the external head.

This version of the standard assumption has been questioned frequently. As noted by Alexiadou et al. (2000), an argumentation in favor of a structure with an internal or external head noun does not depend on the choice between an adjunction vs. complementation analysis of the relative clause. Both structural assumptions are independent of each other. Consequently, both aspects of the standard assumption, adjunction as well as the relative-external head noun have been questioned. Three major proposals, a complement analysis with external head, a complement analysis with an internal head, and an adjunction analysis with an internal head have been put forward. Smith (1964)

and Platzack (2000) argue for a complement analysis combined with an external head noun. Kayne (1994), Alexiadou et al. (2000), Bianchi (1999), De Vries (2002), Schmitt (2000), and Zwart (2000), among others argue for a complement analysis in combination with an internal head noun. The third option is advocated by Carlson (1977), Salzmann (2006), and Sauerland (2003), for instance. They propose analyses in which an internally headed relative clause is adjoined to a nominal projection.

Smith (1964) offers an alternative view to the standard assumption, focussing on the role of the determiner of the head noun. She bases her analysis on the selectional properties of the determiner restricting the kind of relative clause the head noun can be combined with. Smith (1964) proposes that relative clauses are not adjuncts but complements of the determiner. In addition, she assumes that the head noun is base-generated external to the relative clause. Pursuing a different line of argumentation, Platzack (2000) also argues for a complement analysis of the relative clause, and an external head noun. Unlike Smith, Platzack proposes that the relative clause is a complement of N.

One major argument for the presence of an internal head in relative clauses are reconstruction effects. Examples like (43) show that the head noun has to be reconstructed in restrictive relative clauses. In the example, the reflexive pronoun has to be bound locally but the only possible referent is *Peter*, a noun phrase within the relative clause. This observation cannot be explained assuming an operator-variable chain as assumed in the standard approach in (42). The necessity to bind the reflexive pronoun out of or within the relative clause led to the postulation of a representation of the head within the relative clause (e.g., Salzmann, 2006).

(43) Das [Gerücht über sich$_i$], das Peter$_i$ nicht ___ ertragen kann
the rumor about himself which Peter not bear can

'the rumor about himself$_i$ that Peter$_i$ cannot bear' (Salzmann, 2006, p. 187)

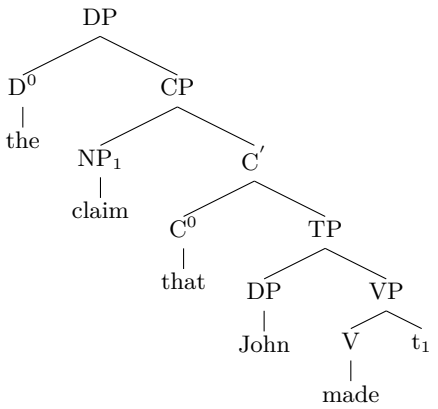
In addition, the existence of head-internal relative clauses as discussed in Section 2.2.1 speaks in favor of a representation of the head noun within the relative clause (Alexiadou et al., 2000, Introduction). The advocates of head-internal relative clauses have developed two different proposals – the *Raising approach* and the *Matching approach*. A *Raising analysis* assumes that the head of the relative clause is base-generated within the relative clause and is then moved to a position higher up in the CP-layer of the relative clause or even higher in the external DP. The proposal is spelled out in detail below. For references on proponents of a raising analysis see Kayne (1994), Bianchi (1999), De Vries (2002), and Alexiadou et al. (2000) and references therein.

Kayne (1994) argues for a transparent syntactic structure such that the linear order of constituents is fully determined by their hierarchical structure. This central assumption is formulated in the *Linear Correspondence Axiom (LCA)*. When a node X is asymmetrically c-commanding another node Y, all terminals that are dominated by X have to precede the terminals that are dominated by Y. One crucial consequence of the LCA is that right-adjunction as adopted in the standard approach for relative clauses is prohibited. According to Kayne, relative clauses are selected by the determiner within the matrix clause and are thus complements. This idea goes back to Smith (1964). In contrast

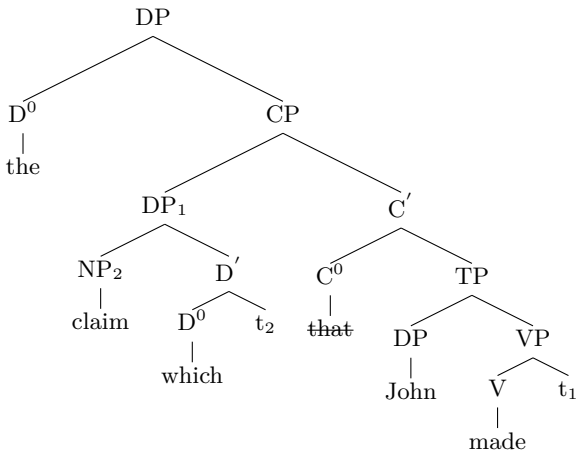
to Smith, Kayne (1994) assumes that the head noun is base-generated relative clause-internally. This allows the determiner to select a full CP and not a modified NP. (44a) displays the derivation for a restrictive relative clause with a complementizer according to Kayne's assumptions. (44b) shows the derivation for a restrictive relative clause with a relative pronoun.

(44) Restrictive relative clauses according to Kayne (1994)

a.



b.



While a relative clause complementizer is merged in C^0, a relative pronoun is base-generated as a determiner of the head noun in Kayne's analysis. In a first step the DP containing the head noun is moved in the specifier of CP. In a second step the head noun is moved within this DP to the specifier to achieve the target word order. This derivation can capture the local binding of the reflexive pronoun in (43), '*Das [Gerücht über sich] das Peter nicht _ ertragen kann*', because the head noun that contains the reflexive starts out within the relative clause as the object, i.e., in a position where it is bound by the relative clause subject *Peter*. In addition, a raising analysis can account for examples where idioms seem to be split between the matrix clause and the relative clause as in (45). The example is taken from Hulsey and Sauerland (2006, p. 113).

(45) John was satisfied by the amount of headway that Mary made.

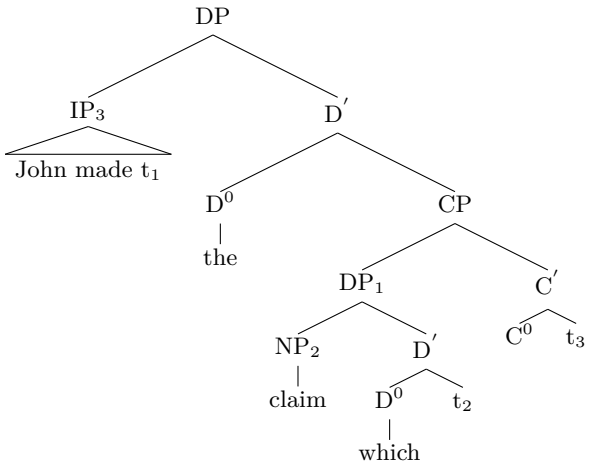
To license an idiomatic reading of *make headway*, *headway* has to be the complement of *make* at the beginning of the derivation. If the head noun *headway* was base-generated external to the relative clause, this configuration could not be present. Therefore, the idiomatic reading could not be available – contrary to the facts.

The raising approach faces one general problem. In the analysis, the head noun receives two potentially different thematic roles and cases, one within the relative clause and one as a constituent of the matrix clause. Kayne assumes that the relative pronoun receives the case and thematic role from the verb inside the relative clause. The head noun instead receives its role and case from the matrix clause D (Kayne, 1994, chapter 8, footnote 15). In contrast to Kayne, Bianchi (1999) assumes that the head noun cannot stay within the

CP of the relative clause but has to move out into the matrix clause, in order to explain the matrix clause case on the head noun.

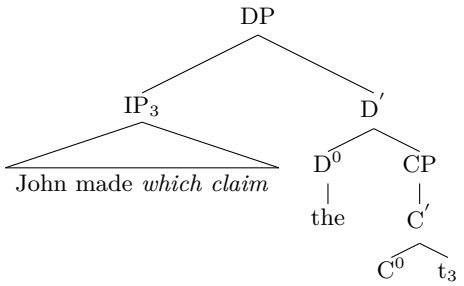
Within the raising approach appositive relative clauses are derived like restrictive relative clauses. To arrive at the target interpretation, Kayne and other proponents assume that at LF the appositive has to move out of the scope of the determiner as it is displayed in (46).

(46)



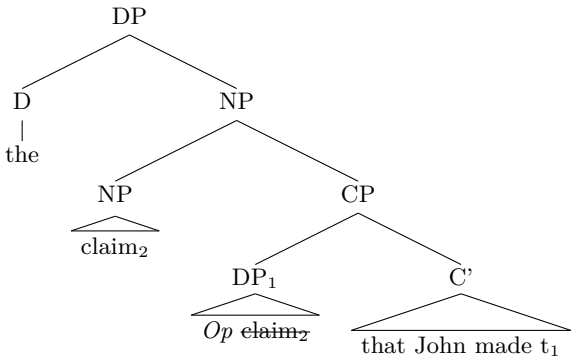
The additional movement at LF in case of appositives may capture another fact discriminating restrictive and appositive relative clauses: Appositives do not show reconstruction effects in contrast to restrictives and also lack definiteness effects. As Bianchi (1999) discusses in detail in her chapter 4, there is evidence that the head of appositive relative clauses cannot be reconstructed in its base position. Consequently, splitting up idioms across the relative and the matrix clause, as well as variable binding into the appositive is not possible. The lack of reconstruction could be seen as a strong counterargument to a raising structure of appositives in general, especially, since reconstruction effects were the main motivation to argue for a raising structure in the first place. Following Bianchi (1999), the lack of reconstruction can be explained by the additional movement of LF. If the head noun was reconstructed in its base position within the IP, the LF representation would be similar to (47). In this configuration the head noun is not within the scope of the external determiner in D^0 since the IP at LF has been moved into the specifier of the DP. Bianchi (1999) argues that a structure as in (47) will be interpreted as if no reconstruction of the head had taken place.

(47)



Another implementation of head-internal relative clauses is proposed in the *Matching approach* (e.g., Carlson, 1977; Salzmann, 2006; Sauerland, 2003). Proponents of the matching approach argue that the head noun is represented twice, once as originating in the matrix clause as the NP that is interpreted, and once base-generated within the relative clause. The relative internal head noun has to be non-distinct from the external head NP to license ellipsis (Sauerland, 2004). The derivation proposed by Sauerland (2004) is shown in (48).

(48)



Under the matching approach the DP containing the relative operator and the copy of the head noun is moved to the left edge of the relative clause. According to Sauerland (2004), a deletion feature is inserted automatically, which leads to the phonetic deletion of the NP *claim* by the process of movement deletion. Sauerland as well as Salzmann (2006) argue that the matching derivation is necessary to explain sentences as in (49) taken from Sauerland (2004, p. 75) and (50) taken from Hulsey and Sauerland (2006, p. 113).

(49) Bill made the amount of headway that Mary demanded.

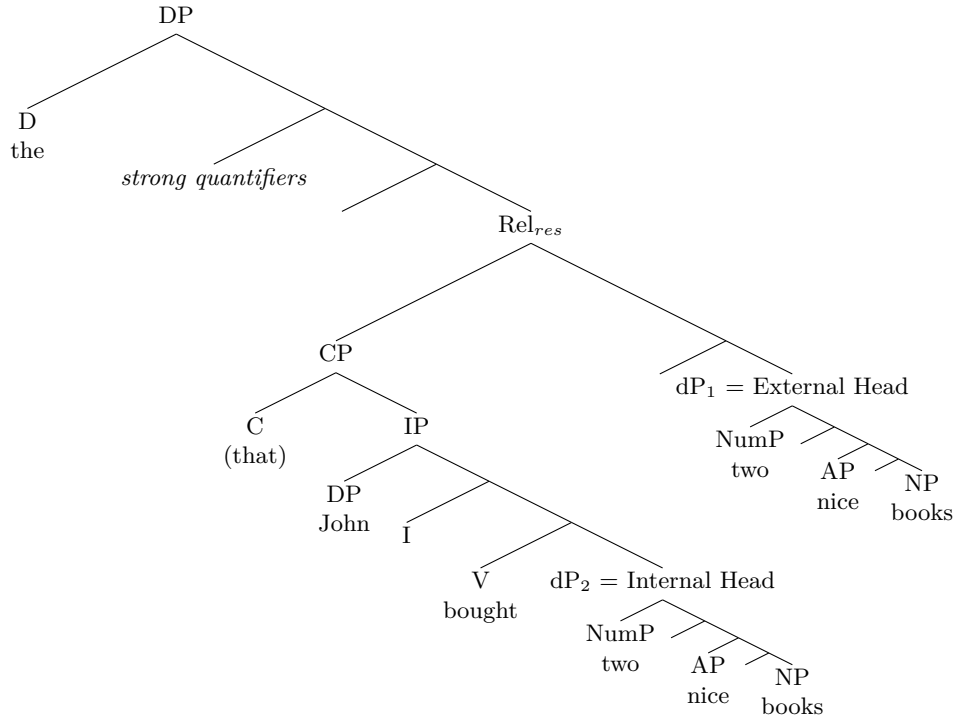
(50) Which is the picture of John$_1$ that he$_1$ likes?

In (49), *make headway* is interpreted as an idiom, which indicates that *headway* is a complement of *make*. Since both parts in this example are in the main clause, a raising analysis cannot explain the availability of the idiomatic reading. Instead it is necessary to postulate that *headway* is also present in the matrix clause.

The lack of Condition C effects in Example (50) is additional evidence for this claim. If the nominal expression *picture of John* would be merged in the relative clause as in the raising analysis, the subject pronoun *he* would c-command the noun phrase, which should result in ungrammaticality. Indeed, ungrammaticality arises in the corresponding *wh*-question '*Which picture of John*$_1$ *does he*$_1$ *like?*'. The absence of a Condition C effect in (50) and thus a lack of reconstruction could therefore only be explained if no possible binder is present in the relative clause. This is the case in the matching analysis after the ellipsis of the internal copy of the head noun. For further arguments in favor of a matching analysis coming from extraposed relative clauses see Sauerland (2004).

The arguments presented so far provide evidence for both head-internal analyses, i.e., raising and matching accounts. This observation forms the basis for the account of Hulsey

(51) Base structure for *the two nice books that John bought*



and Sauerland (2006) and Sauerland (2003, 2004). They argue that raising and matching both are available in principle. Cinque (2008a) also pursues this idea. He combines the main idea of different attachment sites for restrictive and appositive relative clauses as spelled out in the syntactic standard assumption with the possibility to derive both types of head-internal relative clauses. Cinque suggests that both structural variants, raising and matching can be derived from one single structure, in which the relative clause is attached as a prenominal modifier of the external head noun according to the LCA. Cinque's base structure, slightly modified by Poletto and Sanfelici (2014, to appear), is given in (51).

As marked in the syntactic tree, Cinque proposes the existence of an external as well as of an internal head, as in a matching structure. Only one of the heads is spelled out at PF. The restrictive relative clause itself is integrated into the matrix clause DP as it is the case for adjectives and other nominal modifiers. To derive either the raising or the matching structure from (51), it is necessary that one of the heads moves into a position in front of the relative clause. If the internal head is moved into a higher projection within the external DP, the restrictive relative clause shows the properties of a raising structure; if the external head is moved, the characteristics of a matching structure will be derived. In either case Cinque assumes that the higher copy causes a phonetical deletion of the lower instance of the head. According to Cinque (2008a), a major advantage of the structure given in (51) is that head-internal as well as free

relative clauses can be derived. In these cases, the lower copy of the head noun licenses the deletion of the higher copy in a backward fashion as it is also possible in instances of VP-deletion[11]. Both pre- and postnominal relative clauses can be derived by this structure. Whereas prenominal relative clauses result from a direct spell-out of the base-generated DP, postnominal relative clauses require an overt fronting of the head, as described above.

Another aspect of Cinque's analysis is that a restrictive relative clause is attached above adjectival modifiers and cardinal numbers and other weak determiners. This attachment site is also proposed by Sternefeld (2006) to account for data of adjectival modifications in German. In (52), the adjective *angeblich* 'alleged' is taken to only modify the noun *Diebe* 'thieves', not the intersection of the noun and the relative clause *thieves that specialized on free-standing cottages* (Sternefeld, 2006, p. 380).

(52) die meisten angeblichen Diebe, die sich auf freistehende Landhäuser
the most alleged thieves who self to free-standing cottages
spezialisiert haben
specialized have

'most of the alleged thieves that specialized on free-standing cottages'

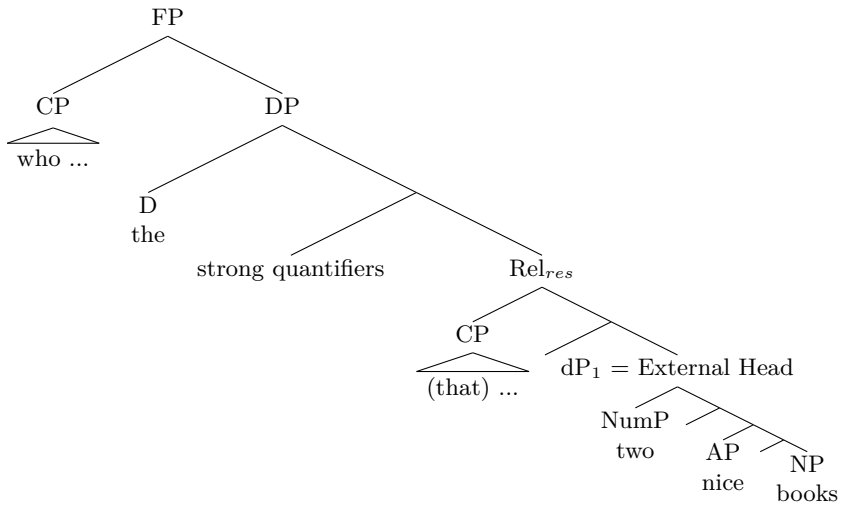
To achieve the target word order, these weak determiners and adjectives have to be moved together with the head noun independently of whether the internal or external head is raised.

In accordance with the standard assumption, Cinque (2008a, 2008b) proposes that appositive relative clauses are attached to a higher layer in the syntactic structure. Based on his distinction of integrated and unintegrated appositives (Cinque, 2008b) (see page 19), Cinque claims that integrated appositives appear above the definite determiner within the left periphery of the DP, yielding the structure illustrated in (53).

[11] An example of backward VP-deletion is given in (I) taken from Hartmann (2000, p. 146).

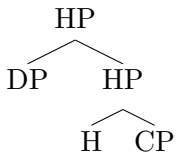
(I) Anyone who can ~~come~~ should come to the party tonight.

(53)



Regarding the internal derivation of integrated appositive relatives, Cinque adopts a matching derivation in his examples. Whether a raising derivation is also possible for integrated appositives, is not explicitly mentioned. According to Cinque (2008a, 2008b), unintegrated appositive relative clauses are attached to a discourse head H as in (54). An integration at the discourse level and not within the syntactic structure of the matrix clause is reminiscent of the analysis of Safir (1986).

(54)

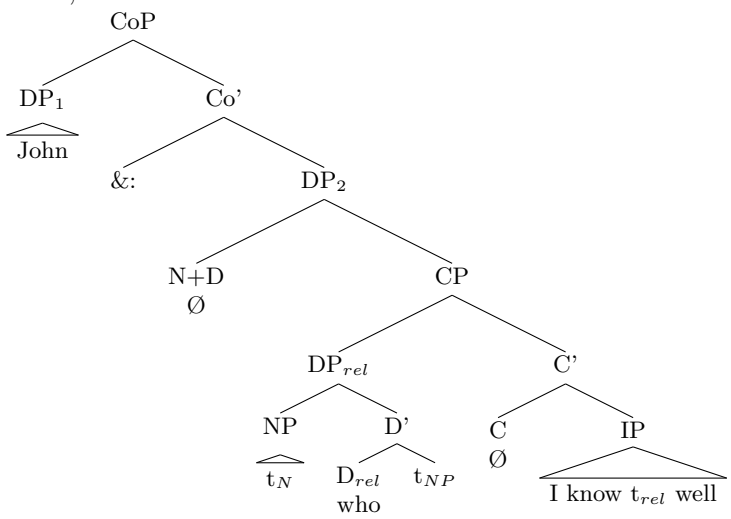


Cinque assumes that the discourse head H blocks relations like internal Merge, Agree, and Binding between the antecedent and the unintegrated appositive relative clause. Consequently, a raising derivation is not possible for unintegrated appositives. One major problem arises for Cinque's analysis of integrated and unintegrated appositive relative clauses. It is unclear how the target word order for postnominal relative clauses is derived. In Cinque's syntactic structures, integrated appositive relative clauses are attached above the positions for quantifiers and demonstratives. In languages with postnominal relative clauses, the head noun is assumed to move even higher in overt syntax. It is an open question to which position the head noun is moved. The same holds for the structure in (54). It is unclear how the continuation of the matrix clause is linked to the piece of discourse structure that is assumed to connect the head DP and the relative clause.

A second minor problem is linked to reconstruction effects in appositive relatives. Cinque assumes a transparent mapping of syntax and semantics. In contrast to other approaches involving a raising analysis, he does not assume additional movements at LF to derive the target meaning of appositive relative clauses. Thus, in contrast to Bianchi (1999) and Kayne (1994), Cinque (2008a, 2008b) cannot explain the lack of reconstruction effects in integrated appositive relative clauses if they were derived via raising.

De Vries (2002, 2006) argues for an analysis of appositive relative clauses similar to Cinque (2008a, 2008b). He also assumes that a functional projection is mediating between the head noun and the appositive relative clause. In his proposal, this functional projection is spelled out as specifying coordination phrase, CoP as in (55).

(55) John, who I know well



As (55) shows, the relative clause CP is not directly coordinated to the head noun. Instead De Vries (2002, 2006) assumes that appositive relative clauses are false free relatives, i.e., free relative clauses with a pronominal head. In the case of appositives, De Vries postulates that this pronominal head is empty. By adopting this view, De Vries can establish that the specifying coordination coordinates two DPs. Unbalanced coordination between a DP and a CP can thereby be avoided.

De Vries (2002, 2006) argues that the internal structure of restrictive and appositive relative clauses is derived via raising. The two types of relatives differ only with regard to what is raised. In the case of appositives the empty D of the relativized DP is raised, whereas the head of appositive relative clauses originates externally. This analysis can explain many properties of appositive relative clauses, for example the fact that reconstruction of the head noun within the appositive is not possible (because it is not the head noun being raised). In addition, binding into the relative clause can be excluded as was mentioned in (34) because binding into the second part of a conjunct is prohibited due to independent reasons. According to De Vries, the specific semantics of the appositive can be derived from the semantic properties of the specifying coordination. As described in detail in Den Dikken (2005), the specifying coordination may be interpreted as a topic-comment structure.

The assumption that all appositive relative clauses are in fact false free relatives is problematic for various reasons (see the discussion in Bianchi, 1999, chapter 5). Nevertheless, the assumption of an mediating functional projection between the head noun and the appositive relative clause may account for some of the different properties between restrictive and appositive relatives. Furthermore, assuming an intermediate projection

is, in principle, independent from the specific syntactic proposals, as e.g., Kayne's LCA, or the decision between the standard syntactic structure and a raising analysis.

Taken together, a variety of proposals for the syntactic representation of relative clauses has been advocated. In general, there is more agreement on the analysis of restrictive relative clauses than on the representation of appositive relatives. With respect to the semantic functions, the core idea of the syntactic standard assumption, attachment at NP for restrictives but attachment at DP for appositives, is still predominant. In general, it is assumed that restrictive relatives are attached at a lower position in the syntactic tree than appositives. In contrast to the early formulations of the standard assumption, more recent proposals assume that the relative clause head has to be represented within the relative clause. In addition, there is evidence that restrictive relative clauses can be derived via a matching and a raising structure.

2.2.4. Summary

This section focused on syntactic analyses of relative clauses. The cross-linguistic overview demonstrated that relative clauses are available in all languages investigated so far. With regard to the syntactic format of relative clauses, languages differ considerably. Four different types have been identified: Pre- and postnominal relative clauses, in addition to circumnominal relatives and correlatives. The cross-linguistic comparison showed that appositive interpretations of relative clauses are limited to one structural type. They are attested exclusively in languages with postnominal relative clauses. Furthermore, an implication holds that languages with appositive relative clauses always have restrictive counterparts.

With regard to the cross-linguistic variation, Cinque (2008a) offers a syntactic account to derive both pre- and postnominal types of relatives in addition to head-internal, circumnominal relative clauses. Nevertheless, all proposals presented above use languages with postnominal relative clauses, mainly English or Italian, as the only source of evidence. As a consequence, the syntactic proposals presented here do not offer an explanation why appositive interpretations are only possible in postnominal relative clauses.

Taken together, three topics in the syntactic analysis of relative clauses are controversial. First, the status of appositive relative clauses regarding subordination, second, the attachment of the relative clauses within the syntactic representation, and third, the internal structure of relative clauses. With regard to the first aspect, I will follow the proponents of the subordinate clause hypothesis, assuming that both, restrictive and appositive relatives, are integrated at the syntactic level. The second factor is linked to the first one. The widely accepted syntactic standard assumption in this respect assumes an attachment at the NP level for restrictive relative clauses and an attachment at the DP shell for appositives. In addition, the majority of syntactic proposals consider different attachment heights to be responsible for the different properties of restrictive and appositive relative clauses. This leads to the third aspect under debate, the internal structure of relative clauses. The data support two options by which the head noun can be linked to the relativized element within the relative clause, raising and matching constructions. Both analyses seem necessary to explain the properties of relative clauses.

What is more, most approaches assume that restrictive and appositive relative clauses do not differ with regard to their internal structure.

Thus, with regard to syntactic complexity the two types of relative clauses cannot be clearly distinguished. However, two proposals assume different degrees of complexity for restrictive and appositive relatives, the analysis of appositives by De Vries (2002, 2006) as false free relatives and the raising approaches as formulated by Bianchi (1999) and Kayne (1994). In both views, appositive relative clauses could be seen as the more complex structural type.

This assumption will be relevant for the analyses of the experimental data of this thesis. In the following, the syntactic standard analysis of relative clauses as implemented by Demirdache (1991) (see (32)) is used to represent syntactic differences between restrictive and appositive relative clauses. I remain agnostic about which of the specific approaches is underlying the attachment at the different layers of the DP because they do not change the hypotheses that can be derived with regard to acquisition.

2.3. Assigning meaning to relative clauses

Research on relative clauses in the generative framework very early centered on the semantic difference between restrictive and appositive relative clauses. As said before, proponents of Montague's idea of compositional semantics (Montague, 1973) as for example Partee (1973), Rodman (1976) and von Stechow (1979) aimed to achieve a transparent mapping of syntax and semantics. In principle, the computation of the semantic content should be based on the syntactic structure. This assumption is still valid in the more recent syntactic proposals as for example by Cinque (2008a) or De Vries (2002). As the following sections show, however, the syntactic representations presented above cannot capture all semantic properties that are associated with restrictive and appositive interpretations of relative clauses. The following sections will present approaches to derive restrictive and appositive relative clauses in at type-driven compositional semantic framework (Heim & Kratzer, 1998; T. E. Zimmermann & Sternefeld, 2013). Section 2.3.1 deals with the semantics of the internal structure of the relative clause. Section 2.3.2 discusses semantic implementations of how the relative clause is attached to its antecedent. Subsequently, restrictivity and appositivity of adjectives as a related class of nominal modifiers is addressed in Section 2.3.3.

2.3.1. Relative clauses and semantic types

A core difference concerning restrictive and appositive relative clauses is that they modify elements of different semantic types. As discussed in the previous section, many syntactic analyses do not postulate internal differences between restrictive and appositive relative clauses. An important consequence of this assumption is that a differentiation between the two readings is postponed to semantics. One has to resort to differences in the semantic computation of relative clauses to explain how attachment to different syntactic positions and different semantic types is possible. In this respect, at least two aspects have to be captured semantically since they cannot be directly derived from the syntactic

representation of relative clauses; first, the function of relative clauses as predicative modifiers or as propositional statements, and second, the different types of head nouns relative clauses can attach to.

The first difference, which cannot be derived directly from syntactic properties, is the following. Restrictive relatives express properties and help to identify the referent of the head noun. In contrast, appositives function like propositions and add information about a selected referent. In semantic terms, restrictive relative clauses act like intersective modifiers such as adjectives or predicates (von Stechow, 1979; Heim & Kratzer, 1998, among others). With respect to their semantic type, restrictives appear to be simple predicates of type <e,t>, like intransitive verbs or common nouns (Heim & Kratzer, 1998). In contrast, the interpretation of appositives is similar to a subsequent independent sentence of type t (Demirdache, 1991; Ross, 1967), as exemplified in (56) taken from Sells (1985, p. 2/3) and in (57) from Del Gobbo (2003, p. 125).

(56) a) Every rice-grower in Korea owns a wooden cart, which he uses when he harvests the crop.

b) Every rice-grower in Korea owns a wooden cart. He uses it when he harvests the crop.

(57) a) John, who was late, came to the party with Mary.

b) John came to the party with Mary. He was late.

The second difference concerns the type of head nouns to which restrictive and appositive relative clauses can attach. The examples in (58) demonstrate that the range of possible antecedents differs depending on the semantic function of the relative clause (Del Gobbo, 2003; Rodman, 1976; Sells, 1985, among others). The examples in (58) illustrate that only nominals of type <e,t>, which are semantically analyzed as predicates, can be modified by a restrictive relative clause. Thus, *no fish* in (58a) can be the antecedent for a restrictive but not for an appositive relative clause. In (58b) the proper name *Omen II* forms the antecedent of the relative clause. Here, only an appositive interpretation is possible. The semantic generalization can be captured as follows: In contrast to appositive relative clauses, the head of a restrictive relative clause cannot be a referring expression of type e, e.g., a proper name. Appositives, on the contrary, can have referring antecedents of type e. The examples are taken from Sells (1985, p. 1/2).

(58) a) Louise has eaten no fish, that/*which has come from the Atlantic.

[restrictive / *appositive]

b) I have not seen Omen II, who is playing at the Bijou.

[*restrictive / appositive]

In addition, restrictive relative clauses can modify quantificational expressions, as shown in (59). In contrast to restrictive relatives, quantificational expressions can be

modified by appositive relatives only in a very limited set of contexts.[12] The contrast between (59a) and (59b) demonstrates that appositives can have quantified (non-referential) antecedents if they are in sentence-final position. In addition the presupposition for a unique potential antecedent has to be met in discourse. Restrictive relatives can modify quantified expressions independently of the position of the clause (Del Gobbo, 2003). The examples are from Del Gobbo (2003, p. 126).

(59) a) Many/Most students, who were late, came to the party with their parents.

[restrictive / *appositive]

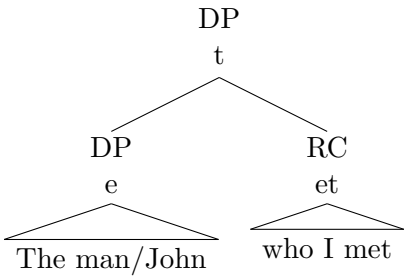
b) They invited many/most students, who arrived very late.

[restrictive / appositive]

The different semantic properties of restrictive and appositive relative clauses have led researchers to different conclusions. On the one hand, it has been argued for different semantic types of appositive and restrictive relatives (Heim & Kratzer, 1998; Demirdache, 1991; Del Gobbo, 2003); on the other hand type difference are rejected in favor of different semantic composition modes (von Stechow, 1979, 2007).

Heim and Kratzer (1998), for example, argue that non-restrictive relative clauses cannot be of type <e,t> as assumed for restrictive relative clauses. Since the definite article would select an individual denoted by the NP, the appositive relative clause – if it was of type <e,t> – would incorrectly return a truth-value by applying functional application as depicted in (60).

(60)



Since the modified DP including the appositive does not differ from the unmodified one in its referential status, type t is not an appropriate type for the modified DP; it should still be of type e. Therefore, as Heim and Kratzer (1998) argue, the semantic computation would break down. What is important here, is that this argument is not valid if a mode of composition different from functional application is assumed for appositive relative

[12] A frequently cited example for the possibility to attach a non-restrictive relative clause to a quantified, non-referring head noun from Sells (1985) is given below.

(I) A tutor will register each student, who is then responsible for getting his papers to the Dean's office on time.

This example is not relevant for the purpose of this thesis since a continuative discourse relation holds between the matrix clause and the relative. Thus, this example belongs to the class of continuative relative clauses as defined by Holler (2005).

clauses in this context. This aspect will be addressed in detail in Section 2.3.2. Based on the observations above, Quine (1960), Sells (1985), and Del Gobbo (2003) propose that appositive relative clauses do not denote properties of type <e,t>, but denote propositions of type t. The assumption of a type difference has some crucial consequences for the semantic analysis. One has to assume that the internal semantic structure of restrictive and appositive relative clauses differs (e.g., Del Gobbo, 2007; Demirdache, 1991; Heim & Kratzer, 1998). Otherwise it would be implausible to derive different semantic types from a similar syntactic structure. Generally, the crucial difference in computing the semantics between restrictive and appositive relatives in these approaches is ascribed to the function of the relative pronoun.

In contrast, von Stechow (1979, 2007) argues that restrictive and appositive relative clauses do not differ with regard to their internal semantic computation. He claims that all relatives are of type <e,t>. In his analysis, the problem described by Heim and Kratzer (1998) is circumvented differently. He assumes a different mode of attachment for appositives that is not based on functional application. According to von Stechow, the confusion about potential differences between restrictive and appositive relative clauses results from the more complex syntactic configuration. He assumes that in contrast to the syntax of relative clauses, their semantics is simple.

Von Stechow (1979, 2007) assumes that the relevant aspect of relative clause formation from a semantic perspective is the fronting of the relative pronoun. Independently of the type of antecedent and semantic function of the relative clause, the semantic effect of fronting the relative pronoun out of its base position is simply property abstraction. If a sentence S has the logical form $\phi(x_i)$, then the respective relative clause has the logical form $\lambda x_i \phi(x_i)$. For von Stechow, movement of the relative pronoun is an instance of Quantifier Raising[13] and therefore a syntactic device for expressing variable binding. The formalization how the relative clause is attached to an individual of type e is addressed in the following Section 2.3.2.

For restrictive relative clauses, von Stechow's assumption is accepted by Heim and Kratzer (1998). Also Heim and Kratzer (1998) assume that the relative pronoun in restrictive relatives is a syncategorematic expression, i.e., an expression that does not have a semantic value itself but that affects the semantic computation of the next higher constituent (Heim & Kratzer, 1998, p. 98). Whereas a complementizer like *that* is analyzed as a vacuous element without any semantic contribution to the clause, the semantic contribution of the relative pronoun is to abstract over one element of the relative clause and to introduce a variable assignment. This variable assignment is relevant for the interpretation of the trace within the relative clause. The *predicate abstraction* rule as formulated by Heim and Kratzer (1998) is given in (61).

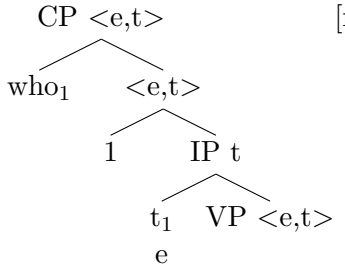
(61) Predicate Abstraction by Heim and Kratzer (1998, p. 96)
If α is a branching node whose daughters are a relative pronoun and β, then

[13] The rule of Quantifier Raising is the following (von Stechow, 2011, p. 2186):
Move an NP or DP out of an XP and adjoin it to XP. Leave a co-indexed trace. If i is the index created by the rule, the trace t_i is interpreted as a variable of type e. In addition, the movement index i, i.e., the index of the moved NP/DP, is spelled out as λi at LF.

$[\![\alpha]\!] = \lambda\ x \in D\ .\ [\![\beta]\!]^x$.

For restrictive relatives, the same structure is assumed independently of the approaches regarding a type difference for restrictive and appositive relative clauses (von Stechow, 1979, 2007; Heim & Kratzer, 1998). By applying the predicate abstraction rule on the IP-level, the restrictive relative clause is turned into a predicate or property. The resulting internal semantic structure of a restrictive relative clause according to Del Gobbo (2007, p. 175) is given in (62). At LF, the movement index 1 is spelled out as $\lambda 1$.

(62) [restrictive]



As discussed in the previous section, the internal structure of restrictive relative clauses may be syntactically derived via raising or matching. From a semantic perspective both derivations are possible and semantically interpretable (Sauerland, 1998, 2003, 2004; Hulsey & Sauerland, 2006). Except for the examples discussed in Section 2.2.3, which can be explained only by one or the other structure, Sauerland (1998) assumes that restrictive relative clauses in general are ambiguous between the two options. Both possible LF structures are exemplified in (63). They are taken from Hulsey and Sauerland (2006, p. 112).

(63) The book that John read

a) the λx. that John read the$_x$ book (raising)

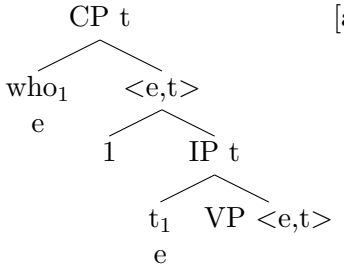
b) the book λx. John read the$_x$ book (matching)

Hulsey and Sauerland (2006) assume that the head noun is interpreted in its base position at LF. This is indicated using the notation *the$_x$ book*. The abbreviation *the$_x$ book* for 'the λy. (x=y and book(y))' can be interpreted as a variable g(x) with the presupposition that g(x) is a book. In the raising structure, the head noun is interpreted only in the relative clause. In the matching structure, it is interpreted outside the relative. Additionally, it is interpreted relative clause internally where it is represented as an elided NP at the base position. In line with the accounts of Heim and Kratzer (1998) and von Stechow (1979, 2007), both semantic representations are derived via predicate abstraction as described above. For the remainder of this thesis, no semantic distinction is made between the two syntactic options to derive the internal structure of restrictive relatives. The crucial assumption regarding the hypotheses for the empirical part is that all semantic approaches derive restrictive relative clauses via predicate abstraction and agree on an analyses as a predicate of type <e,t>. For more details on the semantic

implementation of the raising and matching structure see Sauerland (2003, 2004) and Hulsey and Sauerland (2006).

For appositive relative clauses, the proposals of von Stechow (1979, 2007) on the one hand and of Heim and Kratzer (1998), Demirdache (1991), and Del Gobbo (2003) as proponents of a type difference on the other hand diverge. As mentioned before, for von Stechow (1979) the same abstraction operation as in restrictive relative clauses is at work. Del Gobbo (2007), on the contrary, argues that the appositive itself is of type t. This can be easily derived under the assumption that the relative pronoun is analyzed as an anaphoric pronoun of type e in appositives (Demirdache, 1991; Del Gobbo, 2003; Sells, 1985). Fronting the anaphoric pronoun constructs a movement chain that allows its reconstruction at LF. By functional application, the combination of the pronoun and the abstracted predicate resolves to type t, as displayed in (64) (Del Gobbo, 2007, p. 175).

(64) [appositive]



The assumption that the relative pronoun is an anaphor of type e requires further explanation about how the pronoun receives its interpretation. In Section 2.3.2, assumptions with regard to the semantic integration of restrictive and appositive relative clauses into the matrix clause are explicated.

Based on the assumption that appositive relative clauses denote propositions, properties like illocutionary force and the licensing of proposition-modifying adverbs (see Section 2.2.2) can be derived directly from the appositive semantics. In contrast to appositive relative clauses, proposition-modifying elements would not be semantically licensed in restrictive relative clauses being of type <e,t>. Restrictive relatives containing such particles would be filtered out at the interface to interpretation. The examples (26) repeated in (65) demonstrate that appositive in contrast to restrictive relative clauses can express non-declarative speech acts.

(65) a) Have you seen the strange-looking man, who was here a minute ago?
[restrictive / appositive]

b) He said he'd show a few slides towards the end of the talk, at which point please remember to dim the lights. [*restrictive / appositive]

c) Finde endlich Müller, den du doch auch noch von damals kennst?
Find finally Müller, who you PRT also still from back then know
'Find Müller, who you still know from back then?' [*restrictive / appositive]

In general, indicators of illocutionary force operate on propositions (Searle, 1969)[14]. The analysis of appositives as being a proposition of type t thus licenses the availability of independent speech acts for these structures. Likewise, the possibility to contain sentential adverbs like *frankly* and discourse particles can be captured semantically (see (27) in Section 2.2.2). Independent of the details of the semantic analysis of discourse particles, the analyses agree that these particles take scope over a proposition. Therefore, sentential adverbs and discourse particles may be semantically licensed due to the propositional status of the appositive. Likewise, the fact that non-declarative illocutionary force and proposition-modifying particles are banned from restrictive relative clauses can be accounted for by the type difference. Since restrictive relatives are assumed to be simple predicates of type <e,t>, these properties, which are associated with propositionality, are not expected for these expressions.

2.3.2. On the semantics of relative clause attachment

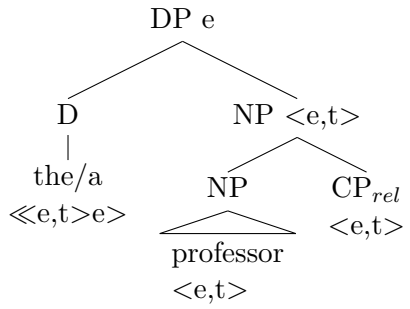
In this section, the semantic assumptions about how the relative clause is attached to the head noun are reviewed. With regard to the attachment of restrictive relative clauses, the two major groups of approaches assuming either type differences between restrictive and appositive relatives (e.g., Del Gobbo, 2007; Demirdache, 1991; Heim & Kratzer, 1998) or a uniform relative internal semantics (von Stechow, 1979, 2007) do not differ. According to the syntactic standard assumption, restrictive relative clauses are attached either as a complement or as an adjunct below the definite determiner. From a semantic perspective, a restrictive relative clause is attached to a nominal of type <e,t>. Following the general assumption for restrictive relative clauses spelled out in von Stechow (1979, 2007) and Heim and Kratzer (1998), both the head noun and the modifier are of type <e,t>. This disallows modification via functional application. To solve the problem of combining two elements of the same type, which is also encountered with other intersective modifiers such as adjectives for instance, Heim and Kratzer (1998, p. 65) propose the rule of *predicate modification*. The rule is defined as follows:

(66) Predicate Modification by Heim and Kratzer (1998, p. 65)
If α is a branching node, $\{\beta, \gamma\}$ is the set of α's daughters, and $[\![\beta]\!]$ and $[\![\gamma]\!]$ are both in $D_{<e,t>}$, then $[\![\alpha]\!] = \lambda x \in D_e.\ [\![\beta]\!](x) = [\![\gamma]\!](x) = 1$.

This type of modification can be understood as an intersection of two sets of type <e,t>. The intersection will result in a set of type <e,t> again. The elements of the resulting set can be described by the characteristic function that combines the properties of the nominal and those of the relative clause. As displayed in (67) by Del Gobbo (2003, p. 123), the definite determiner then selects the unique element out of this (restricted) set.

[14] According to Searle (1969, p. 30) also referring expressions may be the input to express a speech act. In case of questions, the speech act is expressed on the basis of an open proposition.

(67)



Restrictive relative clauses being part of the nominal below the determiner, lead to existence presuppositions. The sentence in (68) presupposes that a professor exists and that this professor teaches very well.

(68) The professor that teaches very well has to supervise many theses.

This type-driven approach can explain the observation that a restrictive relative cannot modify individuals of type e. If the modifier of type <e,t> is attached to an individual of type e, the result of the functional application would be of type t (see the argumentation of Heim and Kratzer (1998) in Section 2.3.1). However, type t is not an appropriate type to denote a definite DP, i.e., a unique referent. The derivation of type t at the position of the DP in the semantic composition would rule out further computations.

The approaches of Del Gobbo (2003, 2007)[15] and von Stechow (1979) differ regarding the attachment of appositive relative clauses. According to the standard assumption for the syntactic integration of appositive relative clauses, appositives are attached at the DP-level. In semantic terms, appositive relative clauses modify individuals of type e. As explicated above, Del Gobbo (2003, 2007) assumes appositive relative clauses to be of type t. Von Stechow (1979), on the contrary, proposed them to be predicates of type <e,t>. How to attach elements of these types to the referential head noun of type e is a central problem for the analyses of appositive relative clauses. For both approaches, a simple type-driven attachment does not work. Therefore, both approaches define new modification rules to allow appositive relative clauses to combine with the head noun without changing the type of the referential head.

Von Stechow (1979, 2007) proposes that appositives are predicates ranging over individuals, thus of type <e,t>. Furthermore, von Stechow assumes that appositives, in contrast to restrictive relatives, express a presupposition[16] on the reference of the head noun (von Stechow, 2007). This idea goes back to Keenan (1971). According to von Stechow (2007), the sentence in (69) can only be true if the presupposition that the speaker has known Ede for thirty years is satisfied for the person Ede that is referred to in the situation of the utterance.

[15] Heim and Kratzer (1998) do not propose a specific analysis for appositive relative clauses.

[16] Keenan (1971, p. 45f.) defines a presupposition as follows: A sentence S logically presupposes a sentence S' just in case S logically implies S' and the negation of S, $\tilde{S}$, also logically implies S'. In other words, the truth of S' is a necessary condition on the truth or falsity of S. Thus if S' is not true then S can be neither true nor false (and must in the formal logic be assigned a third or "nonsense" value).

(69) Ede, den ich seit 30 Jahren kenne, trägt vor.
Ede, who I since 30 years know, is presenting
'Ede, who I have known for 30 years, is presenting.'

Attaching a predicate of type <e,t> to an individual of type e would result in a proposition of type t. This type, however, would lead to a clash in the further semantic composition. To overcome this problem, von Stechow (2007) defines a new modification rule for the interpretation of an appositive relative clause. The rule models the attachment of a predicate of type <e,t> to an individual of type e for an arbitrary assignment g and derives a presupposition based on the predicate of the appositive relative clause. The modification rule is given in (70). In the formula, c stands for the utterance context, s for the utterance situation.

(70) Apposition (von Stechow, 2007, p. 100)
Be ρ a tree of type e with daughters α of type e and β of type et.
$[\![\rho]\!]^g = \lambda c.\lambda s : [\![\beta]\!](c)(s)([\![\alpha]\!](c)(s)).[\![\alpha]\!](c)(s)$

The property $[\![\beta]\!]$ denoted by the appositive relative clause in a context c and a situation s has to be evaluated by applying it to the referent $[\![\alpha]\!]$ in c and s. The result is a presupposition, i.e., a proposition that functions as a domain restriction for the interpretation of the head noun. The modified DP is still of type e. Applied to the example in (69) the appositive restricts the set of situations in which the sentence can be true. The reference of *Ede* is only defined for those situations in which the speaker has known Ede for 30 years. In contrast to other presupposition triggers like definite articles or factive verbs, the presupposition derived from appositive relative clauses is not lexically triggered (Beaver & Geurts, 2012). On the contrary, the presupposition results from the mode of attachment. According to von Stechow's analysis, the appositive relative clause does not formulate an existence presupposition but rather implies the existence of the referent indirectly because the content of the relative clause has to be true and thus, the person that is mentioned has to exist.

Note that the apposition rule is only defined for head nouns of type e. Von Stechow (2007) does not account for instances in which an appositive relative clause modifies a quantified head noun. Accordingly, von Stechow (2007) does not explain the ordering restrictions for appositives attached to quantified head nouns. In addition, von Stechow does not discuss how the possibility of independent illocutionary force, the inability of operators in the matrix clause to bind into an appositive, and the presence of proposition-modifying particles in appositive relative clauses. These properties of appositive relative clauses, however, may be compatible with the analysis of von Stechow (2007). When the predicate, i.e., the appositive relative clause of type <e,t>, is applied to the referent of type e denoted by the head noun, the derived presupposition is a proposition. The analysis may account in principle for the differences between restrictive and appositive relative clauses because a propositional status is a prerequisite for the expression of a speech act and the licensing of proposition-modifying elements as said above. In addition, the independence of appositives from operators in the matrix clause could be captured

by this approach. One of the general properties of presuppositions is the that they project out of embedded contexts (Beaver & Geurts, 2012). Whereas modality, negation or question contexts may change the propositional content of a clause, the associated presuppositions do not change.

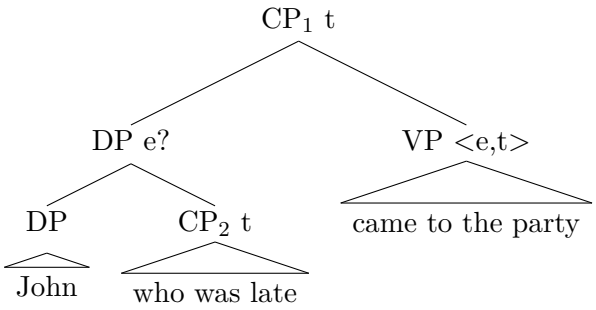
Taken together, von Stechow (2007) analyzes appositive relative clauses as predicates of type <e,t>. Like in restrictive relative clauses, the relative pronoun is a semantically vacuous element. Due to the semantic composition, the content of the appositive relative clause applied to the referent of the antecedent is turned into a proposition. This composition may capture the differences found between restrictive and appositive relative clauses. In addition, it predicts that a sentence can only judged true or false when the presupposition derived from the appositive relative clause is satisfied for the denoted referent. Whether this assumption holds, is still under debate (see e.g., Syrett and Koev (2015)).

A different composition mode is postulated by Del Gobbo (2003, 2007). As described above, Del Gobbo assumes that appositive relative clauses are themselves of type t. In a strictly type-driven account, it is not possible to combine an object of type e with a modifier of type t due to a resulting a type-clash. To circumvent this problem, following Demirdache (1991), Del Gobbo (2003, p. 119) claims that appositives are not directly interpreted at the position in which the relative is syntactically attached. The attachment of appositive relative clauses follows the *Principle of Independent Computation*, as given in (71). The notion "Text node" in this definition refers to a node at discourse level.

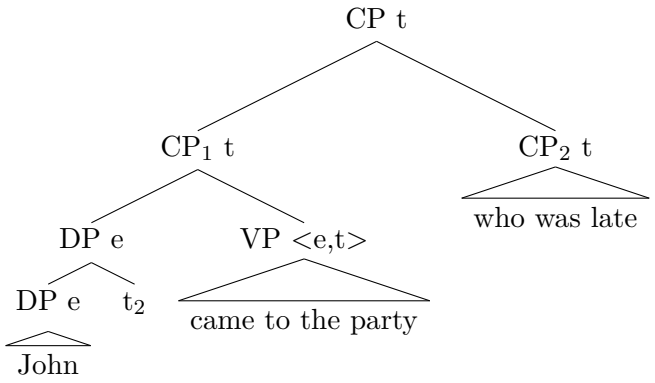
(71) Principle of Independent Computation (Del Gobbo, 2003, p. 119)
If two nodes α and β are of a basic type (type e or t), the node which gets the t value is computed separately by raising to a Text node.

Del Gobbo (2007) slightly modifies the Principle of Independent Computation. She assumes that the appositive relative clause is moved out of the DP into the CP-layer, similar to assumptions about quantifier raising and proposals by Demirdache (1991). For the syntactic representation in (72a) the derivation at LF is displayed in (72b).

(72) a) Surface



b) LF



By applying the principle of independent computation, Del Gobbo can maintain a subordination approach at the syntactic level and is able to implement the main clause hypothesis at the semantic level. Accordingly, the semantic independence of appositives can be captured. After movement at LF, no type clash would occur. At the CP-layer, or alternatively at some discourse level, only objects of type t are combined, i.e., the matrix clause proposition and the proposition denoted by the appositive relative clause.

To achieve type t for appositive relative clauses, Del Gobbo (2003, 2007) analyzes the relative pronoun not as a semantically vacuous expression as in restrictive relatives but as an anaphoric E-type pronoun. This idea goes back to Sells (1985) and Demirdache (1991). Del Gobbo (2003, 2007) follows Heim (1990) in her analysis of discourse anaphora and E-type pronouns[17], and assumes that in case of relative pronouns in appositives with definite antecedents the relative pronoun can be replaced by a copy of the antecedent. For the example in (72a)/(72b) the structure with the denotation of the pronoun is represented in (73a) for the syntactic level and in (73b) for LF.

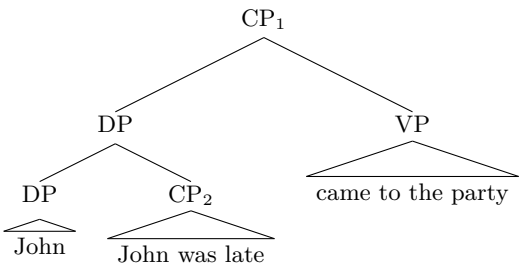
[17] According to Heim (1990), discourse anaphora can be analyzed as definite descriptions (Elbourne, 2001; Evans, 1977). For all instances of unbound pronouns that have a definite antecedent, i.e., if the antecedent is a proper name, a pronoun, a demonstrative, or a definite description, the pronoun is replaced at LF by the corresponding definite description. E-type anaphora, in contrast, refer to antecedents that are not definite and do not have scope over the pronoun, like in (I). In these instances, the whole antecedent-containing sentence has to be interpreted in place of the pronoun as illustrated in (II).

(I) Every man that owns *a donkey* beats *it*.

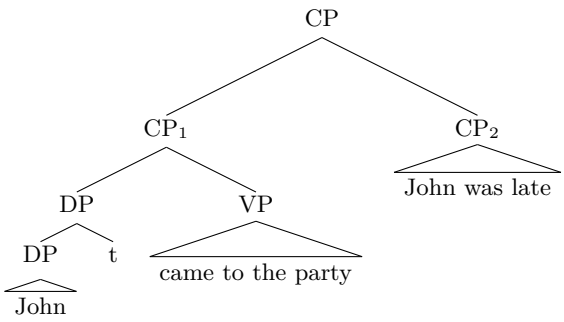
(II) Every man that owns *a donkey* beats *the donkey he owns*.

(73) John, who was late, came to the party.

a. Surface



b. LF



To capture the problem of the formal link, i.e., the problem of how a formal connection between the antecedent and the pronoun can be established, Del Gobbo (2007) follows Elbourne (2001)[18]. Elbourne assumes that a pronoun is in fact a definite determiner that is followed by an elided NP. Since deletion in general is only licensed in the presence of an overt linguistic antecedent, a spell-out of the pronominal form is only possible if such an antecedent exists in the previous context.

According to Del Gobbo (2003), the assumption that relative pronouns in appositives are E-type pronouns can account for the typological generalization that only postnominal relative clauses are compatible with an appositive interpretation. E-type pronouns similar to discourse anaphora need an antecedent in the previous context (Reinhart, 1983). First, a referent has to be introduced. Then, a pronoun can be used to refer back to the established referent. As argued for by Reinhart (1983), the reference cannot be established backwards. This is shown in the examples in (74) by Del Gobbo (2003, p. 136).

(74) a) Rosa$_i$ entered the room. She$_i$ was wearing a hat.

b) *She$_i$ was wearing a hat. Rosa$_i$ entered the room.

In prenominal relative clauses, the relative clause precedes the head noun. As a consequence, the referent for the E-type pronoun will only be introduced to the discourse after the pronoun is processed. Therefore, Del Gobbo assumes that appositive interpretations of relative clauses cannot be derived in prenominal relative clauses.

As observed by Del Gobbo (2003), appositives can also be attached to quantified antecedents, as displayed in (59) at the beginning of this chapter, repeated as (75).

(75) a) Many/Most students, who were late, came to the party with their parents.

[restrictive / *appositive]

b) They invited many/most students, who arrived very late.

[restrictive / appositive]

[18]For a general discussion on the problem of the formal link see the discussion in Heim (1990).

Del Gobbo observes that appositives have to be sentence-final in case they are attached to quantified expressions[19] and argues that this is also a consequence of the E-type character of the relative pronoun. Del Gobbo assumes that unbound pronouns that anaphorically refer to quantified expressions (and other non-definite descriptions) need a more complex way of interpretation. This assumption is in accordance with Evans (1977), Heim (1990), and Heim and Kratzer (1998). To interpret these cases of E-type anaphora, a copy of the antecedent is not sufficient. Instead, also the predicate of the host clause needs to be taken into account to achieve the correct interpretation for the pronoun (see footnote 17).

According to Del Gobbo (2003, 2007), an attachment of an appositive relative clause to a quantified head noun as in (75a) is not possible because the predicate has not yet been processed when the relative pronoun has to be interpreted. For sentences like (75b), in contrast, no problems arise because the pronoun can be replaced by the enriched expression *the students that came to the party with their parents*. A reformulation by a sequence of sentences like in (76) would be interpreted similarly (Del Gobbo, 2003, p. 126).

(76) Many/Most students came to the party with their parents. They were late.

For appositive relative clauses attached to quantified head nouns, Del Gobbo (2007) follows Heim and Kratzer (1998) and assumes that E-type pronouns anaphoric to non-definite antecedents form a third category of pronouns (besides the bound variable interpretation and those that can be replaced by a definite description of its antecedent) with a more complex internal structure. Since these real E-type cases will not be relevant for the empirical work of this thesis, the details will not be explicated further. For a motivation and further discussion of E-type pronouns with quantified antecedents, see Evans (1977), Heim (1990), Heim and Kratzer (1998) as well as Poschmann (2013), and references cited therein.

Taken together, the account of Del Gobbo (2003, 2007) is able to explain a variety of differences between restrictive and appositive relative clauses on purely semantic grounds. One aspect, however, cannot be fully captured. It is the observation that appositive relative clauses are not equal to the matrix clause in its information status. According to von Stechow (1979, p. 227), the content of the matrix clause *John came to the party* in (77) is the *main information* of the utterance, whereas the relative clause adds *background information*. Von Stechow (2007) assumes that the appositive is a presupposition. This may explain the backgrounding notion of the information conveyed by the appositive compared to the information of the matrix clause.

(77) John, who was late, came to the party.

Del Gobbo argues that this backgrounding property is a result of the coindexation of the head noun and the E-type pronoun. It is questionable though whether coindexation

[19] But see Poschmann (2013) for experimental evidence that sentence-medial positions for appositive relative clauses that are attached to quantified antecedents are possible in German.

can explain the difference. According to Heim (1990), an E-type anaphor always has to be coindexed with the head noun. Contrary to the expectations raised by Del Gobbo, a notion of backgrounding cannot generally be observed in the standard examples including E-type anaphora as in (75b) or (I) in footnote 17. However, the backgrounded status may result from the adjunction of the appositive to the root node of the matrix clause, which leads to an interpretation of the appositive as an 'assertion to follow'. This has been proposed by Demirdache (1991).

To capture the different information status of restrictive and appositive relative clauses, further accounts, as for instance a two-dimensional semantics by Potts (2005) or a dynamic model by AnderBois, Brasoveanu, and Henderson (2015), have been argued for. Potts (2005), for instance, assumes a two-dimensional model for the semantics of appositive relative clauses and of parentheticals in general. He proposes that appositives are interpreted as conventional implicatures. In addition, they are interpreted at a second semantic layer. A *comma operator* shifts the appositive out of the semantic representation of the matrix clause into the second dimension. In this analysis, the semantic independence of appositive relatives is implemented even more radically than by Del Gobbo (2003, 2007). In addition, AnderBois et al. (2015) argued for a dynamic model to account for the discourse-related properties of appositives. AnderBois et al. assume that at-issue content compared to the content of appositives leads to different updates of the Context Set, i.e., the set of shared knowledge of speaker and hearer.

The differences of restrictive and appositive relative clauses with regard to their informational status are not explored in the experiments reported in the empirical part of this thesis. Therefore, these aspects are not discussed in depth here. The interested reader is referred to AnderBois et al. (2015), Potts (2005) and Amaral, Roberts, and Smith (2007) for further elaboration of discourse-related properties of appositive relative clauses.

For the remainder of this thesis, I will assume the following semantic representations for restrictive and appositive relative clauses. In line with Heim and Kratzer (1998), von Stechow (1979, 2007), and Del Gobbo (2003, 2007), I assume that restrictive relative clauses are predicates of type <e,t> that are attached via predicate modification to the nominal head. In addition, I assume that appositive relative clauses are semantically more complex than restrictive relatives due to the specific mode of composition. To avoid a type clash at LF, the appositive relative needs to escape from the representation of the matrix clause. This is achieved either by a conversion of the appositive in a presupposition that has to be satisfied for the referent of the head noun (von Stechow, 2007), or by a detachment of the appositive at LF (Del Gobbo, 2003, 2007)[20]. Both approaches are able to account for the observed differences between restrictive and appositive relative clauses. For the remainder of the thesis, I adopt the approach of Del Gobbo (2003, 2007) because it corresponds more closely to the assumptions of syntactic approaches for relative clauses. The assumption that appositive relative clauses but not restrictive relatives are propositions is in line with the different attachment positions in the analysis of Cinque (2008a, 2008b). Moreover, an analysis of the relative pronoun as an anaphoric

[20] In the broadest sense, such a detachment at LF is also proposed by Potts (2005) introducing a more elaborate semantic framework in this respect.

pronoun in appositive relative clauses corresponds to the syntactic analyses, for instance by Cinque (2008a, 2008b) and De Vries (2002, 2006). A different approach, however, will not alter the general line of argumentation in the empirical part of this thesis.

The semantic functions restrictivity and appositivity are not only relevant for the interpretation of relative clauses but also for an additional class of nominal modifiers, adjectives. In the following, the semantic functions of relative clauses are compared to those of adjectives to analyze whether findings can be generalized across both classes of nominal modifiers. Depending on the analysis, relative clauses are closely linked to adjectives. The short detour serves the function to show that despite numerous commonalities, adjectives and relative clauses need to be differentiated and have to be acquired differently from each other.

2.3.3. A related phenomenon: The semantics of adjectival nominal modification

Back in 1960, Quine reports that there is a close link between relative clauses and adjectives. Quine states: 'At any rate the peculiar genius of the relative clause is that it creates from a sentence '...x...' a complex adjective summing up what that sentence says about x." (Quine, 1960, p. 110f). This idea was taken up among others by Cinque (2008a). Within the syntactic structure of the DP, Cinque integrates relative clauses similarly to adjective phrases (see Section 2.2.3).

Adjectives and relative clauses have in common that they may receive restrictive or appositive interpretations (e.g., Bolinger, 1967; Fabricius-Hansen, 2009; Larson & Marušič, 2004; Morzycki, 2008). This is displayed in (78) from Larson and Marušič (2004, p. 275).

(78) Every unsuitable word was deleted.
'Every word was deleted; they were unsuitable.' (appositive)
'Every word that was unsuitable was deleted.' (restrictive)

Like in relative clauses, the semantic effect of a restrictive adjective is to restrict the denotation of the following noun. Appositive adjectives do not change the referent denoted by the nominal[21]. A formalization of restrictive and appositive adjectival modification is given in (79) and (80) following Fabricius-Hansen (2009, pp. 93-95).

(79) Restrictive adjectival modification: $[\![ADJ \cap N]\!] \subset [\![N]\!]$

(80) Appositive adjectival modification: $[\![ADJ \cap N]\!] = [\![N]\!]$

[21] Fabricius-Hansen (2009) distinguishes between conceptual and referential non-restrictivity. For referential non-restrictive adjectives the following relation holds: $[\![ADJ \cap NOM]\!] \subseteq [\![NOM]\!]$. These adjectives may restrict the denotation of the NP but do not change the reference of the NP. An example similar to Fabricius-Hansen (2009, p. 89) is given in (I).

(I) The Norwegian painter Edvard Munch lived from 1862 to 1944. The manic-depressive Norwegian feared a therapy.

Similar to relative clauses, appositive interpretations of adjectives cannot be directly derived from the surface word order (Fabricius-Hansen, 2009; Kayne, 1994; Morzycki, 2008; Potts, 2005). Within the DP, appositive adjectives appear between the definite article and the noun phrase. To prevent a restriction of the NP denotation, the adjective would need to be interpreted at the DP level. Such an interpretation, however, is not directly licensed by the position of the appositive adjective within the DP. Similar to appositive relative clauses, there is no consensus for the analysis of appositive adjectives. Frequently, they are analyzed in analogy to appositive relative clauses (Jackendoff, 1977; Kayne, 1994; Morzycki, 2008; Potts, 2005). Jackendoff (1977) analyzes them in parallel to appositive relative clauses as attached to the DP level. Kayne (1994) argues for a covert movement of the adjective at LF to the specifier of DP. Potts (2005) and Morzycki (2008) analyze appositive adjectives in parallel with appositive relative clauses and expressives. In their analyses, these expressions are interpreted as conventional implicatures in a second semantic dimension. Fabricius-Hansen (2009) makes a different proposal. She assumes that restrictive and appositive interpretations of adjectives are determined at the discourse level. With regard to their syntax and computational semantics, they contribute similarly to the meaning of the NP. Both readings are represented as λx[x: Adj(x), Nom(x)], where the comma can be paraphrased by 'and' (Fabricius-Hansen, 2009, p. 95). Fabricious-Hansen assumes that definite descriptions are anaphorically linked to a discourse referent. She argues that an adjectival modification is interpreted non-restrictively when both the modified and unmodified DP are linked to the same discourse referent. When different referents are chosen, the interpretation is restrictive.

The semantic similarities between adjectives and relative clauses led some linguistics to assume a closer link between the two types of modifiers. It has been proposed that adjectives are analyzed as (reduced) relative clauses (Bach, 1968; Emonds, 1976). The derivation of an adjectival modifier from a relative clause as described by Bolinger (1967, p. 2) is given in (81).

(81) I bought the table
The table was big } → I bought the table that was big

→ I bought the table big → I bought the big table

Bolinger (1967), among others, argues that an Adj-N structure is derived from two independent sentences. First, they are combined in a structure involving a relative clause. Then the copular construction is deleted and the order of adjective and noun is inverted.

However, a comparison of the properties of adjectives and relative clauses shows that a reduction of adjectives to relative clauses makes wrong predictions (Baker, 1975; Bolinger, 1967; von Stechow, 1979). Von Stechow (1979) argues that relative clauses have to be a syntactic category of their own because they can be extraposed. Extraposition is not possible for adjectives. The contrast is illustrated in Example (82) adapted from von Stechow (1979, p. 231).

(82) a) Tief in den Fels ist eine Grotte ___ gesprengt, [die vom Sonnenlicht
Deep in the rock is a grot shot that by-the sunlight

nicht mehr erreicht wird]$_{RC}$.
not more reached is.

'A grot that is not reached anymore by the sunlight is shot deeply into the rock.'

b) *Tief in den Fels ist eine ___ Grotte gesprengt, [große]$_{Adj}$.
Deep in the rock is a grot shot big

'A big grot is shot deeply into the rock.'

In addition to the possibility to be extraposed, adjectives and relative clauses may differ with regard to the properties of the nominal modification. All restrictive relatives are intersective modifiers. They are combined with their head nouns via predicate modification as described in Section 2.3.2. This type of modification is based on the intersection of sets and therefore always intersective, independent of the content of the clause. In addition, relative clauses are subsective modifiers. (83) states the definition of intersective (or predicative) modification according to Kamp (1975, p. 124). Subsectivity is defined in (84). W stands for a non-empty set of possible worlds, situations, or contexts. F represents the meaning of an adjective. The meaning of a noun phrase is analyzed as a property P by Kamp (1975).

(83) Intersectivity
There is a property Q such that for each property P and each $w \in W$,
$F(P)(w) = P(w) \cap Q(w)$

(84) Subsectivity
For each P and each $w : F(P)(w) \subseteq P(w)$

Intersectivity may be paraphrased as: If *x is [Adj N]*, then *x is Adj and x is N*. The definition of subsectivity may be paraphrased as such: From *x is [Adj N]* follows *x is N*. From the definition of intersectivity follows that the property of the noun has to hold for the modified noun. As a consequence, subsectivity is always implied by an intersective modifier. Based on the definitions of restrictivity and appositivity in adjectival modification in (79) and (80), only intersective adjectives can receive a restrictive or appositive interpretation (Morzycki, 2008)[22]. The definitions request that the modified nominal either is a subset of the denotation of the nominal, or is identical to it. Consequently, both kinds of modification require intersective and thus subsective modifiers.

If all adjectives were reduced relative clauses, all adjectives should share the properties of intersectivity and subsectivity as e.g., *grey* in (85). This is not the case. The range of interpretations found for adjectives is broader than for restrictive relative clauses. In contrast to relative clauses, adjectives can also be interpreted non-intersectively and/or non-subsectively. This is demonstrated in the Examples (86) and (87), respectively.

[22] Morzycki (2008) argues that the availability of restrictive and appositive interpretations for adjectives is an indicator for intersective modification. Accordingly, dimensional and other context-dependent adjectives are intersective modifiers since they can be interpreted as restrictive or appositive.

(85) x is a grey dog ⇒ *x is grey and x is a dog*
⇒ *x is a dog* (+intersective, +subsective)

(86) x is a good father ⇏ *x is good and x is a father*
⇒ *x is a father* (–intersective, +subsective)

(87) x is a former mayor ⇏ *x is former and x is a mayor*
⇏ *x is a mayor* (–intersective, –subsective)

There is an ongoing debate about the analysis of the different types of adjectives. Intersective adjectives, like restrictive relative clauses, are frequently analyzed as type <e,t>. For non-intersective and non-subsective adjectives, more complex types like ≪e,t>,<e,t≫ or ≪s<e,t≫,<e,t≫ are proposed (Hamann, 1991; Heim & Kratzer, 1998; Kamp, 1975; McKinney-Bock, 2010).

A further difference between adjectives and relative clauses is the ability to bear tense features. In contrast to finite relative clauses, adjectives cannot bear tense features. Contrary to what Bach (1968) and Emonds (1976) propose, these observations suggest that adjectives should not be analyzed as relative clauses in general[23]. For more arguments against a relative clause analysis for adjectives see Bolinger (1967).

Taken together, adjectives and relative clauses have a number of commonalities regarding the syntactic and semantic analysis. Similar problems arise because the semantic functions of restrictivity and appositivity cannot directly be derived from the syntactic structure. In addition, similar solutions have been proposed to account for appositive readings of relative clauses and adjectives. Despite the similarities, however, I assume that adjectives cannot be fully reduced to relative clause structures. Compared to relative clauses, adjectival modifiers have a broader range of interpretations when they are combined with the noun they modify.

2.3.4. Summary

This section focused on proposals on the semantic representation and computation of restrictive and appositive relative clauses. In addition, semantic properties of adjectives as another instance of nominal modification were discussed. Independent of the different proposals, the derivation of an appositive interpretation is argued to be more complex than that of a restrictive interpretation, e.g. due to the different mode of computation (Del Gobbo, 2003, 2007; von Stechow, 1979, 2007, among others).

The semantic analysis of restrictive relative clauses is uncontroversial. In general, restrictive relative clauses are analyzed as intersective modifiers and predicates of type <e,t> (Del Gobbo, 2003, 2007; Heim & Kratzer, 1998; von Stechow, 1979, 2007). Hence,

[23] The assumption that some adjectives can be analyzed as relative clauses is not fully discarded. Cinque (2010, 2014) claims that some but not all adjectives should be analyzed as reduced relative clauses. He distinguishes between direct modification in terms of an Adjective Phrase for non-restrictive, non-intersective and modal adjectives and a reduced relative analysis for restrictive and intersective adjectives.

restrictive relative clauses pattern with intersective adjectives. There is agreement that restrictive relatives are derived via an abstraction operation. In accordance with syntactic approaches postulating an attachment of restrictive relatives at the NP level, the restrictive relative clause is attached to a nominal head noun of type <e,t>. The computational procedure is predicate modification.

For appositive relative clauses, the analyses differ. Von Stechow (1979, 2007) argues that appositives, like restrictives, are of type <e,t> but that they impose a presupposition on the referent of the head noun. The presupposition is derived as part of the procedure to combine the relative to the head noun. Del Gobbo (2003, 2007) assumes that appositives are propositions of type t and that they are interpreted subsequently to the main clause. In contrast to von Stechow, Del Gobbo analyzes the relative pronoun as an E-type pronoun. In the case of a definite head noun the relative pronoun is interpreted as a copy of the definite description.

In sum, both semantic approaches, von Stechow (1979, 2007) and Del Gobbo (2007), can capture many of the differences between restrictive and appositive relative clauses. Moreover, the proposed composition rules allow to combine the advantages of both the syntactic subordination and the main clause hypotheses. In addition, the transformation of the appositive into a presupposition (von Stechow, 2007) as well as the detachment of the appositive at LF (Del Gobbo, 2007) can explain the impossibility to bind into the appositive. Moreover, the semantic composition captures the fact that appositives are not part of elided material in coordinated structures.

Furthermore, both semantic accounts are compatible with a variety of syntactic proposals. They can be used to derive an interpretation of the syntactic structure of relative clauses postulated by the syntactic standard assumption, as well as of more recent approaches by Cinque (2008b, 2008a) and De Vries (2002, 2006). In contrast to the proposal of von Stechow (1979, 2007), the approach of Del Gobbo (2007) may also explain on semantic grounds why appositive interpretations are restricted to postnominal relative clauses.

For the remainder of this thesis, I will adopt the analysis of Del Gobbo (2003, 2007) to represent the semantics of relative clauses. In contrast to von Stechow (2007), Del Gobbo's account is more consistent with the syntactic assumptions about the nature of the relative pronoun in appositive relatives. However, the argumentation in the empirical part does not depend on the details of the semantic analysis.

The following section focuses on relative clauses in German. Since German is the language under investigation in the empirical part, properties of relative clauses specific to German are introduced.

2.4. Relative clauses in German

This section focuses on relative clauses in German as the language under investigation in the empirical part of this thesis. First, the results of corpus studies are presented. The studies quantified the occurrence of relative clauses in different types of utterances. Furthermore, syntactic and semantic properties of German relative clauses are addressed

in more detail. This section forms the basis for the development of the experimental material used in the empirical part of this thesis.

Compared to other subordinated clauses, relative clauses are used frequently in German (Birkner, 2008). Birkner (2008) analyzed a corpus on spoken German comprising 206,900 words from a TV soap and from seven application talks for a trainee program at a German bank. In her corpus, relative clauses made up about one fifth of the subordinate sentences identified. Besides *dass*-complement clauses and *wenn*-conditional clauses, relative clauses were the third frequent class of subordination attested in her data. In addition to their general frequency, analyses of corpora have shown that the frequency of occurrence of relative clauses varies depending on the kind of utterances and the purpose of the verbal exchanges. In formal situations such as job interviews or academic consultations, relative clauses are more frequently attested (3-5 relative clauses per 1000 words) than in daily-life conversations or scene description tasks (Birkner, 2008; Hirschberg, Reinert, Roth, & Féry, 2014; Weinert, 2004). In addition, relative clauses are more frequent in written language (about 9 relative clauses per 1000 words) than in spoken conversations (only 2 relative clauses per 1000 words) (Weinert, 2004). Weinert's analysis is conducted on a corpus of 101,000 words based on spoken German comprising informal conversations, a map description task and academic consultations. With regard to language acquisition these data suggest that children may encounter relative clauses only to a limited extent. However, the data show that relative clauses are found among the most frequently used subordinate clauses in German.

With respect to syntactic aspects of German, the general introduction in Section 2.1 illustrated a number of properties specific to German relative clauses. As mentioned in Section 2.1, headed German relative clauses are postnominal modifiers with the finite verb in sentence-final position. These properties are illustrated once more in (88).

(88) Der Junge, [der ein großes Geschenk bekommen hat]$_{RC}$, war sehr glücklich.
The boy who a big present got has was very happy
'The boy$_{(,)}$ who got a big present$_{(,)}$ was very happy.'

In German, relative clauses are introduced by a relative pronoun. Unlike in English, reduced relative clauses as shown in (89b) are not possible (Pittner & Bermann, 2007, p. 103).

(89) a) The book I am reading is interesting.
b) *Das Buch, ich lese, ist interessant.
The book I read is interesting
'The book I am reading is interesting.'

The presence of a relative pronoun is obligatory[24] and typically *d*-pronouns (*der, die, das*) are used. These are homophonous with definite articles and with demonstratives.

[24]Note that according to Fleischer (2004, p. 226) very few German dialects allow to omit relative pronouns. One example from a North Saxonian variety is given in (I).

In more formal contexts, also interrogative-like pronouns of the form *welch-* 'which' can be used. The relative pronouns have to agree with the antecedent in the matrix clause in number and gender. Additionally, relative adverbs like *was* 'what', *wo* 'where', *wann* 'when' can introduce a relative clause (Bußmann, 2002). In some German dialects also *wo* 'where' is used as a relative complementizer like in (90). In some varieties, *wo* 'where' can be also combined with a relative pronoun (Pittner & Bermann, 2007), as displayed in the Bavarian example in (91).

(90) ... dea Mo wo seine Schu verlora hot
... the man that his shoes lost has

'The man$_{(,)}$ who lost his shoes' (Brandner & Bräuning, 2013, p. 132)

(91) Der Mo, den wo i gestern gseng hob ...
The man who that I yesterday seen have ...

'The man$_{(,)}$ that/who I saw yesterday$_{(,)}$ ... ' (Pittner & Bermann, 2007, p. 84)

Resumptive pronouns, as demonstrated in (92), are not licensed in German relative clauses.[25]

(92) *Der Junge, den der Mann *ihn* gesehen hat, war sehr glücklich.
The boy who-MASC-SG-ACC the man him seen has was very happy

'The boy$_{(,)}$ that/who the man him saw$_{(,)}$ was very happy.'

With regard to their semantics, German relative clauses can be interpreted as restrictive, appositive, and continuating modifiers. Whether amount interpretations are possible is an open question (p.c. Cécile Meier). Contrary to languages like Italian, Spanish, Dutch and Japanese, restrictive relative clauses in German cannot receive a *pseudo-relative* interpretation (Belletti, 2012, 2015; Cinque, 1992; Grillo, 2012; Grillo & Costa, 2014). A related structure expressing such an event reading, however, is available in German. A subordinated clause introduced by the relative adverb *wie* 'how', as exemplified in (93) is comparable with the interpretation of pseudo-relative clauses as described e.g., by Grillo and Costa (2014). Similar to pseudo-relatives, the event interpretation with

(I) de ... Rägen, Ø wi harren vörgestern
the ... rain REL we had before_yesterday

'the ... rain we had the day before yesterday'.

[25] Resumptive pronouns can be used in structures with extraction out of islands that include multiple embedding as in (I) by Müller (2014, p. 6). Müller (2014) describes that resumption can license extraction out of islands in which standard movement is always blocked. But see Keller and Alexopoulou (2005) for empirical evidence on different sentence types where resumptives do not ameliorate grammaticality judgements.

(I) Das ist ein Buch [$_{CP}$ Op$_1$ [$_C$ wo] ich eingeschlafen bin [$_{CP}$ nachdem ich es$_1$ gelesen habe]]

(II) #Das ist ein Buch [$_{CP}$ Op$_1$ [$_C$ wo] ich eingeschlafen bin [$_{CP}$ nachdem ich t$_1$ gelesen habe]]

wie 'how' is limited to verbs of direct perception. In contrast to prototypical pseudo-relatives, these clauses are not string-identical to restrictive relative clauses in German due to the different introducing element.

(93) John hat ein Mädchen gesehen, wie es rannte.
John has a girl seen how it ran

'John saw a girl running.'

Several means can be used to mark a relative clause as restrictive or appositive and to exclude the other interpretation in German. Unlike in English or French, the comma is not a formal cue for the semantics of the sentence. In addition, extraposition is possible for both semantic functions of relative clauses in German as illustrated in (94) (Hirschberg et al., 2014, p. 412).

(94) a) Ich habe unlängst das Heft gefunden, in das ich eintrug, was ich
I have recently the notebook found in which I entered what I
für Hanna im Lauf der Jahre aufgenommen habe.
for Hanna in the course of the years recorded have.

'Recently I found the notebook in which I entered what I recorded for Hanna over the years.'

b) Ich habe unlängst mein Tagebuch gefunden, in das ich eintrug, was ich
I have recently my diary found in which I entered what I
für Hanna im Lauf der Jahre aufgenommen habe.
for Hanna in the course of the years recorded have.

'Recently I found my diary, in which I entered what I recorded for Hanna over the years.'

In German, a clear indication of a restrictive reading can be given by the choice of the determiner of the head noun. If *derjenige/diejenige/dasjenige* 'the one' is used, only a restrictive interpretation is possible (Pittner & Bermann, 2007). This is exemplified in (95).

(95) *Dasjenige* Mädchen, das ein großes Geschenk bekommen hat, war sehr
The-one girl who a big present got has was very
glücklich.
happy

'The girl that got a big present was very happy.'

Contrary to other languages including English, in German a relative clause can be marked as appositive by the use of *discourse particles* (Thurmair, 1989). This is exemplified in (96). Discourse particles are not universally available. They exist, for instance, in languages like Dutch, Finnish, Greek, Chinese, or Japanese (M. Zimmermann, 2011).

In English, sentence-modifying adverbs like *by the way* or *frankly* may serve similar functions, but they cannot cover the full range of semantic contributions of the German discourse particles.

(96) Das Mädchen, das *übrigens/ja* ein großes Geschenk bekommen hat, war sehr
The girl who PRT a big present got has was very
glücklich.
happy

'The girl, who by the way/as you know got a big present, was very happy.'

Discourse particles are used as lexical markers for appositive interpretations of relative clauses in the experiments reported in the empirical part of this thesis. Therefore, they are addressed in more detail here. Discourse particles belong to the expressive content of a clause. They do not change its propositional content. As demonstrated in (97), the particles indicate whether the proposition is mutually accepted by the speaker and the addressee (*ja*), or whether it is controversial (*doch*), or uncertain (*wohl*) (M. Zimmermann, 2011, p. 2013).

(97) a) Max ist *ja* auf See.
Max is PRT at sea.

'Max is at sea, as you know'

b) Max ist *doch* auf See.
Max is PRT at sea.

'Wait a minute, I thought Max is at sea.'

c) Max ist *wohl* auf See.
Max is PRT at sea.

'It seems as if Max is at sea.'

Competing analyses have been proposed for the semantic contribution of discourse particles (e.g., Jacobs, 1991; Lindner, 1991; Kratzer, 1999). Jacobs (1991) and Lindner (1991) propose that discourse particles specify the illocutionary type of the utterance. In contrast, Kratzer (1999) assumes that discourse particles add felicity conditions that have to hold for the context of the utterance. *Ja*, for instance, is only appropriate in a context in which the proposition expressed by the utterance in the context is a fact, and this fact, for all the speaker knows, might be known to the addressee (Kratzer, 1999, p. 1). Lindner (1991) argues for third type of analysis. She states that by using *ja* "the speaker indicates that in his/her eyes the proposition p is not controversial" (p. 174). For an overview of proposals see M. Zimmermann (2011), Abraham (1991), Cardinaletti (2011), and K. Fischer (2006).

Despite the different semantic analyses for discourse particles, these approaches coincide in the assumption that the host clause expresses a proposition. This general assumption is crucial for the analysis of appositive relative clauses as having a propositional

status. The fact that these particles are licensed in appositive but not in restrictive relative clauses in German supports the assumption of different underlying syntactic and semantic representations for restrictive and appositive relative clauses.

The following section focuses on the interaction of relative clause semantics with prosody. This interaction is relevant for the experiments reported in Chapters 5 to 7 because acoustic stimuli are used the experimental designs.

2.5. Interfaces of syntax and semantics to prosody

Many syntacticians assume that prosody is the crucial cue for a restrictive or appositive structure (e.g., Emonds, 1979; Kayne, 1994; Pittner & Bermann, 2007; Potts, 2005; Seiler, 1960). However, the empirical results available demonstrate that the prosodic patterns of relative clauses are more heterogenous and complex than assumed by work from theoretical syntax and phonology (e.g., Auran & Loock, 2006, 2011; Birkner, 2008; Dehé, 2007, 2009, 2014; Döring, 2007; B. A. Fox & Thompson, 1990; Hirschberg et al., 2014; Kaland & van Heuven, 2010; Schaffranietz, 1997, 1999; Schubö, Roth, Haase, & Féry, 2015; Truckenbrodt, 2005; Weinert, 2004).

In theoretical syntax it is generally assumed that restrictive relative clauses are prosodically integrated into an intonational unit with the head noun. There is no pause between the head noun and the relative clause. In addition, the main stress of the modified nominal is placed on an element in the relative clause (Seiler, 1960). Appositives, on the other hand, are prosodically unintegrated. They are separated from the head noun by a *comma intonation* (Jackendoff, 1977; Emonds, 1976). Unlike restrictive relatives, appositives are supposed to be set off by pauses from the head noun. They form a distinct intonation phrase (Lehmann, 1984; Seiler, 1960; Nespor & Vogel, 2007). For an overview of the proposed prosodic formats for restrictive and appositive relative clauses in the theoretical syntactic literature see Birkner (2008).

According to the syntactic approaches, the distinct prosodic patterns of restrictive and appositive relative clauses are a reflex of the syntactic derivation. In addition, syntactic analyses are based on the assumption that prosodic differences are a crucial cue for the identification of a relative clause as restrictive or appositive. Research in phonology, on the other hand, showed that this view is too simplistic. In general, prosodic phrasing is not determined by syntax alone (Nespor & Vogel, 2007; Dehé, 2009). Other factors influence the size of prosodic units such as the tendency of balanced intonation phrases (intonation phrases tend to be of equal size) or the focus structure of the sentence (Augurzky, 2008; Dehé, 2007; Fodor, 1998a, 1998b; Hemforth et al., 2015).

The differences between the intonational patterns of restrictive and of appositive relative clauses are closely linked to the notion of *intonation phrases*. This phonological unit is not homogeneously defined in the literature. Féry (1993, p. 60) lists four criteria that define intonation phrases almost certainly. These criteria are similar to those that set apart appositives from restrictive relative clauses. First, the boundaries of intonation phrases frequently correspond to those of some syntactic constituent. Second, a pause can precede and follow an intonation phrase. Third, an intonation phrase contains an

element with the most prominent accent. Fourth, boundary tones and the adjustment of the pitch range sometimes mark the boundaries of intonation phrases.

Aligning these phonological criteria with the assumptions of theoretical syntax, appositive but not restrictive relative clauses form a separate intonation phrase. This is in line with the assumptions of Nespor and Vogel (2007) and Selkirk (2005). Nespor and Vogel (2007) assume that root clauses but not embedded clauses obligatorily form an intonation phrase. To unify the prosodic patterns of root clauses and parentheticals, which do not necessarily form root clauses, Selkirk (2005) assumes that intonation phrases are linked to the comma feature proposed by Potts (2005). Selkirk assumes that both, parentheticals and root clauses bear the comma feature. At PF this feature is interpreted as a marker of intonation phrase boundaries.

Studies from experimental phonology investigated whether the theoretical assumptions about the prosodic patterns of relative clauses hold empirically (for German: Birkner, 2008; Döring, 2007; Hirschberg et al., 2014; Kaland & van Heuven, 2010; Schaffranietz, 1997, 1999; Schubö et al., 2015; Truckenbrodt, 2005; Weinert, 2004; for English: Auran & Loock, 2006, 2011; Dehé, 2007, 2009, 2014; B. A. Fox & Thompson, 1990; for Dutch: Kaland & van Heuven, 2010). The empirical results available demonstrate that the prosodic patterns of relative clauses are more heterogenous and complex than assumed by work from theoretical syntax and phonology.

In the following, first, corpus studies are presented that investigated prosodic formats of relative clauses in German and other languages (Truckenbrodt, 2005; Birkner, 2008; Schaffranietz, 1997; Hirschberg et al., 2014; B. A. Fox & Thompson, 1990; Dehé, 2007, 2009, 2014; Auran & Loock, 2006, 2011). Then, results from experimental studies are addressed (Kaland & van Heuven, 2010; Schaffranietz, 1999; Schubö et al., 2015).

Truckenbrodt (2005) investigated restrictive relative clauses only. He observed that restrictive relative clauses do not form an intonation phrase on their own. In his data, only the right boundary of the relative coincides with an intonation phrase boundary. It is marked by an upstep of the F0 contour and a lengthening of the segments before the boundary. Birkner (2008) analyzed the prosodic formats of restrictive and appositive relative clauses in spoken German. She studied a corpus of 1013 German relative clauses. The corpus includes data of colloquial German based on conversations about video tapes of the German Big Brother season 1, and formal conversations during job interviews. Birkner identified 853 headed relative clauses that could be classified as restrictive or appositive on the basis of the utterance context and/or the presence of lexical markers. 708 out of 853 relative clauses (83%) were restrictive; 145 out of 853 (17%) were appositive. 801 out of the 853 relative clauses were considered for the prosodic analysis. 52 relatives were excluded because the relative clause was not directly adjacent to its head noun. The prosodic analysis of the 801 relative clauses took into account the accent structure of the head noun and the relative clause, pauses, and prosodic boundaries, i.e., intonation phrases. Birkner defined seven prosodic formats ranging from prototypical appositive prosody (Format 1: two intonation phrases and two accents, on the head noun and within the relative clause) to prosodic integration as proposed for restrictive relatives (Format 6: one intonation phrase and main accent within the relative clause). Formats 2 and 3 are less pronounced realizations of the unintegrated, appositive format with two

intonation phrases. Formats 4 and 5 differ from the prototypical restrictive format in their accent placement but not in their phonological phrasing. Format 7 comprises all instances that were not classifiable according to the criteria relevant for restrictivity and appositivity (e.g., relative clauses with an accent on the verb of the relative clause). The results of Birkner's prosodic analysis are displayed in Table 2.2.

Table 2.2.: Prosodic formats of restrictive and appositive relative clauses (from Birkner 2008, p. 182)

		Semantic classification	
		Appositive relatives	**Restrictive relatives**
Prosodic classification	Format 1 (appositive)	84 (64%)	127 (19%)
	Format 2	23 (18%)	81 (12%)
	Format 3	4 (3%)	23 (3%)
	Format 4	16 (12%)	167 (25%)
	Format 5	1 (1%)	44 (7%)
	Format 6 (restrictive)	3 (2%)	211 (31%)
	Format 7 (other)	0 (0%)	17 (3%)
	Total	131 (100%)	670 (100%)

Table 2.2 shows that 64% of appositive relative clauses are realized with the prototypical appositive prosodic Format 1. Summing up the Formats 1 to 3, 85% of appositive relative clauses are produced with an unintegrated prosody. Only 2% of appositive relative clauses were realized with the prototypical restrictive contour of Format 6. On the contrary, the prosodic realization of restrictive relative clauses is less homogenous. 31% of restrictive relatives are produced with the prototypical contour, Format 6. 62% of restrictive relative clauses are integrated in one intonation phrase with the head noun (Format 4-6). In addition, 19% of restrictive relative clauses were realized with the prosodic contour associated with an appositive relative (Format 1). These corpus data indicate that appositive relative clauses are produced in a more homogenous prosodic format than restrictive relative clauses. Nevertheless, an unintegrated prosodic contour is not a clear indicator for an appositive interpretation. Out of 211 relative clauses in Format 1, only 84 (40%) are semantically appositive.

Similar to Birkner, Schaffranietz (1997) reports that the prosodic realization does not consistently match the semantic function of relative clauses in German. Schaffranietz (1997) investigated a corpus of 147 spoken German relative clauses. In contrast to Birkner (2008), the prosodic patterns detected by Schaffranietz (1997) are more heterogenous for appositives than for restrictive relative clauses. Twenty-one appositive relative clauses had an unintegrated appositive intonation. In addition, 90 restrictive relative clauses were prosodically integrated. However, six restrictive relative clauses were produced with an appositive prosody, and 30 appositive relative clauses were produced with an integrated, restrictive prosodic contour. In total, Schaffranietz found a mismatch between semantics

and prosody in 25% of the data.

Similar results to those of Schaffranietz (1997) are reported in Hirschberg et al. (2014). Hirschberg et al. (2014) analyzed 44 non-restrictive[26] and 53 restrictive relative clauses of spoken German with respect to their prosodic realization. These relative clauses were part of a bigger corpus comprising 328 restrictive and 192 non-restrictive relative clauses from spontaneous speech and from a German audiobook. Without giving detailed figures, Hirschberg et al. (2014) summarize that non-restrictive relative clauses were separated from the head noun more often than restrictive relative clauses. As in the other corpus studies, there was no clear-cut correspondence between the semantic classification and the prosodic implementation. One appositive relative clause was produced with an integrated prosody and some restrictive relative clauses showed prosodic separation.

The heterogeneity of prosodic patterns in the production of relative clauses is also found for English (B. A. Fox & Thompson, 1990; Dehé, 2007, 2009, 2014; Auran & Loock, 2006, 2011). B. A. Fox and Thompson (1990) analyzed relative clauses of spontaneous speech in English. For their analyses, the authors could not discriminate between restrictive and appositive relative clauses. B. A. Fox and Thompson claim that in their corpus no appositive relative clauses could be identified on intonational grounds.

Dehé (2009, 2014) analyzed prosodic parameters of 59 non-restrictive relative clauses[27] in contrast to other parenthetical constructions including comment clauses and sentential parentheses. The data comes from a variety of spoken text types out of the British Component of the International Corpus of English. 55 out of 59 (92%) non-restrictive relative clauses were clearly separated from the surrounding matrix clause. Separate intonation phrases preceded and followed the relative clause. The four remaining non-restrictive relative clauses were integrated in the preceding intonation phrase. No boundary phenomena were observed between the head noun and the non-restrictive relative clause. In all instances the right boundary of the relative clause coincided with a boundary of an intonation phrase.

Auran and Loock (2006, 2011) analyzed 157 appositive relative clauses coming from corpus data of scripted and unscripted spoken English. Auran and Loock show that the prosodic implementations of appositive relative clauses vary with respect to a number of acoustic and phonetic properties (e.g., pitch level and onset value of the relative compared to the matrix clause). The differing prosodic patterns may be linked to different discourse functions of appositives. Since no comparison to restrictive relative clauses was conducted, it remains unclear whether the observed differences can be used to distinguish restrictive and appositive relative clauses.

Experimental work on the perception and production of prosodic aspects corroborate the results from corpus studies (Kaland & van Heuven, 2010; Schaffranietz, 1999; Schubö et al., 2015). The association between relative clause semantics and prosody is not as strict as assumed in the theoretical accounts. The same holds for the prosodic realization of other ambiguous structures involving lexical ambiguities, ambiguous attachments of

[26] Hirschberg et al. (2014) did not differentiate between appositive and continuative relative clauses in their analysis.

[27] Dehé (2009, 2014) did not differentiate between appositive and continuative relative clauses.

adverbs and focus particles, or the interaction of conjunctions like *and* and *or* (Allbritton, McKoon, & Ratcliff, 1996; Schafer, 1997).

Kaland and van Heuven (2010) investigated experimentally which prosodic contour is preferred for restrictive and appositive relative clauses in German and Dutch. Twenty relative clauses, which were lexically marked either for an appositive or a restrictive reading, were manipulated to meet 5 different accent patterns. The test sentences were disambiguated using negative quantified heads for restrictive readings and sentence-adverbs like *by the way* for appositive relative clauses. The accents of the head noun and at the relative clause boundaries were systematically varied. The restrictive contour no. 1 had only one accent on the relative clause and no marking of the relative clause boundaries. The head noun and the relative formed one intonation phrase. The appositive pattern no. 5 had a pitch accent on the head noun and additionally both relative clause boundaries were marked. This should lead to a perception of different intonation phrases for the main clause and the relative. The intermediate patterns (2-4) varied in the kind of accent on the head noun. In addition, either the initial or final boundary of the relative clause was marked by an accent. Marking the initial boundary, may lead to the perception of different intonation phrases for the matrix clause and the relative. Twenty participants had to judge on a 0-10 scale how well the intonation matched the content of the sentence. The results are displayed in Figure 2.2.

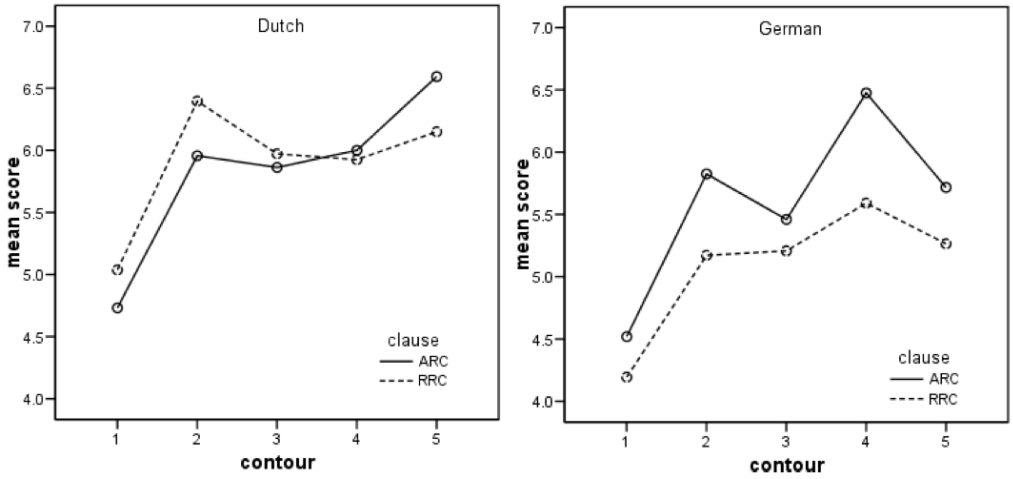


Figure 2.2.: Mean acceptability scores per prosodic contour for restrictive and appositive relative clauses. Adapted from "The structure-prosody interface of restrictive and appositive relative clauses in Dutch and German" by C. Kaland and V. J. van Heuven, 2010, *Speech Prosody 2010 Chicago*, p. 3. Copyright 2010 by the ISCA Archive. Reprinted with permission.

The results of Kaland and van Heuven (2010) show no clear association of prosodic contour and semantic interpretation of relative clauses for German. Independent of the accent pattern, appositive relative clauses were judged better than restrictive relatives. Moreover, the ratings for the prototypical appositive pattern no. 5 were not significantly

higher than for the other patterns when the prosodic contours were paired with lexically disambiguated appositive relative clauses. Furthermore, a typical restrictive accent pattern with only one accent in the relative clause was rated lowest for restrictive relatives. For Dutch, the unintegrated appositive accent structure was judged best for appositive relative clauses. The results for restrictive relatives were as inconclusive as in German. An additional analysis on the impact of the presence or absence of pauses and syllable lengthening at the relative clause boundaries did not change the overall results. These results, especially for German, may indicate that listeners cannot use the prosodic cues to distinguish the semantic functions of relative clauses reliably.

Schaffranietz (1999) investigated the perception of relative clauses in German. In three reaction time experiments participants judged whether descriptions of objects in an array were true or false. The descriptions contained either a restrictive or an appositive relative clause and were combined with either an integrated or unintegrated prosodic contour of the relative. Similar to the results of Kaland and van Heuven (2010), Schaffranietz (1999) found a processing advantage for relative clauses with an unintegrated prosodic contour independent of the semantics. When the boundaries of the relative clause were marked by pauses or by accents alone, both, appositives and restrictives, were judged correctly more quickly than in the absence of marked boundaries. These results show that consistent prosodic and semantic information do not facilitate the perception and interpretation of relative clauses. Nevertheless, an error analysis showed that inconsistent semantic and prosodic information led to more errors in the judgement tasks.

Schubö et al. (2015) investigated the perception and production of restrictive and appositive relative clauses in German. To investigate perception, Schubö et al. (2015) used a picture selection task. Since the general procedure of Schubö et al. is similar to the one used in the experimental tasks of the empirical part of this thesis, this study is presented in more detail. Twenty participants had to select one out of two pictures, as exemplified in Figure 2.3, on the basis of a prerecorded stimulus sentence, as given in (98).

(98) Das Dreieck, das gestreift ist, ist rot.
the triangle that/which striped is is red

'The triangle that is striped is red.' / 'The triangle, which is striped, is red.'

The stimulus sentences were presented with four different prosodic contours. Two prosodic patterns matched the properties associated with appositive relative clauses: Pattern 1 with pauses preceding and following the relative clause and Pattern 4 with a boundary tone preceding the relative clause. The other two patterns corresponded to a restrictive interpretation. Pattern 2 involved an accent on the determiner of the head noun, and pattern 3 had an accentuation on the relative clause without boundary phenomena on the head noun. Seven participants were excluded from the analysis because they chose a restrictive interpretation consistently throughout the task.

The results of an analysis of 623 relative clauses show that both pauses and boundary tones (Pattern 1 and 4) were perceived as indicators for an appositive interpretation in more than 70% of items. In contrast, an accent shift onto the determiner of the head

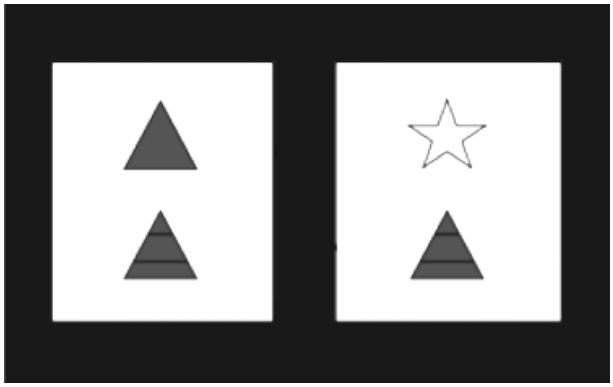


Figure 2.3.: Visual context adapted from "Experimental investigations on the prosodic realization of restrictive and appositive relative clauses in German" by F. Schubö, A. Roth, V. Haase, and C. Féry, 2015, *Lingua, 154,* p. 80. Copyright 2015 by Elsevier. Reprinted with permission.

noun favored a restrictive interpretation of the relative in 87% of items. Relative clauses with an accent on the relative clause were also interpreted restrictively more often than appositively (63% of restrictive interpretations). The preference for restrictivity in this condition, however, was not as clear as in the other conditions. Moreover, the experiment demonstrates that not all participants in the picture selection task made use of the prosodic information conveyed. One third of the participants always selected the picture that matched the restrictive interpretation.

In addition to the perception task, Schubö et al. (2015) conducted two elicited production tasks. In the first experiment, Schubö et al. compared the production of relative clauses between naive speakers and speakers who were informed about the semantic functions of restrictive and appositive relatives. In a second experiment, informed participants had to read restrictive or appositive relative clauses to describe one out of two pictures. In this task, speakers were aware of the semantic ambiguity of the relative clause.

The results of Experiment 1 of five participants show that the produced relative clauses of uninformed participants did not differ in the restrictive and appositive relative clause condition with regard to the realization of pauses, accent placement, segment lengthening, or the F0-contour. Contrary to expectations, prosodic boundaries sometimes were produced before restrictive relative clauses but not before appositive relatives. The patterns changed only slightly for informed participants in a second testing round. Informed participants shifted the accent on the determiner of the head noun in 50% of productions for restrictive relative clauses. Besides the accent shift, no clear prosodic distinction could be observed to mark the semantic functions of relative clauses. In Experiment 2, five in-

formed participants had to describe one out of two pictures that were placed in front of them. Schubö et al. (2015) report that in this task, appositive relative and restrictive relative clauses were produced differently as supposed by the theoretical accounts. Appositive relative clauses showed boundary phenomena (higher F0 values, lengthening, and pauses) significantly more often than in restrictive relative clauses. These results demonstrate that speakers use prosodic markings if they know that they are necessary.

In addition to relative clauses, studies investigated the influence of prosody on the interpretation of adjectives (Schafer, 1997). Schafer reports a preference for restrictive interpretations in Adj-Adj-N structures[28]. Testing sentences as in (99) with and without an intonation phrase boundary between the two adjectives showed a general preference for restrictive interpretations. After hearing the sentences, participants had to choose between two interpretations displayed on a screen by pressing a button. The two interpretations paraphrased the restrictive or appositive interpretation of the adjective *unmarried*. When no medial intonation phrase boundary was present, participants chose a restrictive interpretation in 67.7% of items. In the presence of a prosodic boundary, the adjective was interpreted restrictively in 56.7% of items. Besides the general preference for restrictive interpretations, the results show that appositive interpretations were enforced when a prosodic boundary was present.

(99) a) Occasionally, John's favorite unmarried uncle takes him to the park.

b) Occasionally, (John's favorite)$_{IPh}$ (unmarried)$_{IPh}$ uncle takes him to the park.

Taken together, the experimental results confirm the mixed results of the corpus studies. Although there are clear intuitions about the prototypical prosodic contour of restrictive and appositive relative clauses, empirical studies demonstrate that these patterns are not realized consistently in production. In addition, perception studies show that prosodic markings are not systematically used to disambiguate restrictive and appositive relative clauses. The prosodic implementation of restrictive and appositive relative clauses thus is not as reliable and stable as proposed by theoretical works. The same seems to hold for restrictive and appositive adjectives.

In the following, basic assumptions on the processing of relative clauses are presented to investigate whether human language processing may help to derive hypotheses on the acquisition of the two semantic functions of relative clauses.

2.6. Processing of relative clauses

In the empirical part of this thesis interpretation preferences and acceptability judgements were explored for semantically ambiguous relative clauses in children and adults. It is generally assumed that ambiguity resolution is guided by processes underlying human language processing. Therefore, Section 2.6.1 introduces assumptions about how the

[28] Eight items with two prenominal adjectives served as control condition in Schafer's experiment on the interpretation of context-sensitive intersective adjectives like *tall*, or *expensive*. Schafer (1997) aimed to investigate whether the prosodic boundary between the adjective and the noun enforces intersective interpretations over subsective interpretations of the adjective.

human parser deals with relative clauses, and how interpretations are derived from an acoustic input in general. First, general processing principles and their universal range of application are presented. Second, the assumptions to motivate incremental syntax-first models proposing encapsulated syntactic processing are summarized. Third, experimental results on the incremental nature of natural language processing are discussed with regard to semantic processing. This topic is addressed in more detail since the interaction of syntactic processing and referential processes are relevant for the experimental tasks developed in this thesis. To date, the processing of restrictive and appositive modifiers has not been investigated. Therefore, this section closes with some remarks on how processing may influence the derivation of these semantic functions (Section 2.6.2).

2.6.1. Basic assumptions on incremental processing

A variety of models have been proposed to explain the fundamentals of natural language processing (Syntax-first approaches: e.g., Frazier, 1987, Friederici & Mecklinger, 1996; Head-driven Parsing: e.g., Pritchett, 1991; and Interactive models: e.g., Altmann & Steedman, 1988). In general, it is assumed that the human parser is optimized to process language in an efficient way on the basis of grammatical knowledge. More radical approaches advocate a slightly different claim, i.e., that languages are shaped by properties of the human parser (Fodor, 1998a, 1998b; Hawkins, 2004, 2014; McDaniel, McKee, Cowart, & Garrett, 2015, among others). Whereas grammar in principle allows for multiple embedding and recursive structures of infinite depths, human language processing is limited in certain respects. For instance, the parser is limited in its operations by the capacity of the short term memory (Baddeley & Wilson, 2002). Unlike computers, the human parser is not able to store and retrieve an unlimited amount of linguistic input while a syntactic structure is built up. To achieve good performance despite limited memory resources, language is processed incrementally. Experimental evidence suggests that structure-building is initiated instantly in a top-down fashion, as soon as the category of an incoming linguistic element can be determined (Kimball, 1973; Frazier, 1987; Frazier & Rayner, 1987; Sedivy, Tanenhaus, Chambers, & Carlson, 1999; Bader, 2011)[29].

On the basis of interpretation preferences and data on ambiguity resolution, basic processing routines of the parser have been formulated in terms of general processing

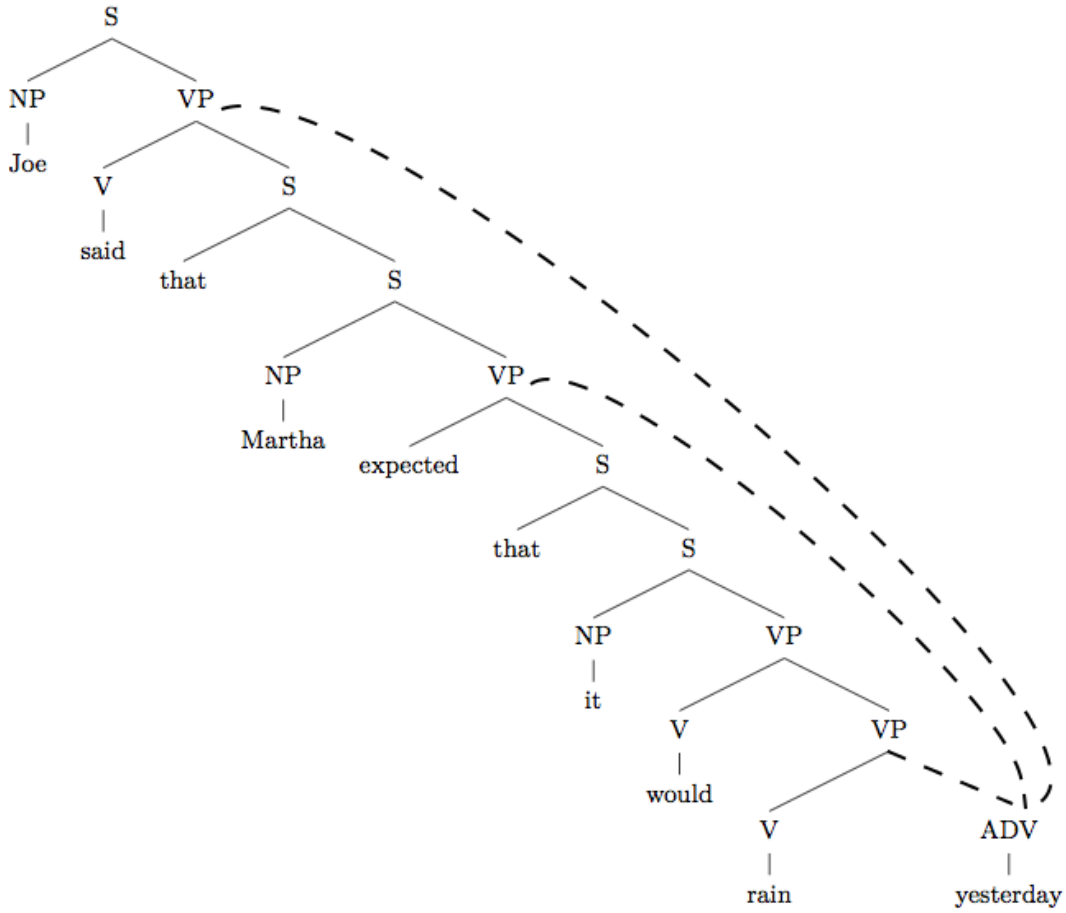
[29] Frazier and Rayner (1987) demonstrate that the structural integration of lexical material is delayed in case of categorial ambiguity. Reading times are longer for sentences as in (I), in which *desert trains* may either be analyzed as a Noun-Verb sequence or as an Adjective-Noun sequence. In cases of categorial ambiguity, the word category can be determined locally on the basis of the subsequent word categories. The authors show that reading times of the region following the ambiguous words are longer than in sentences with early word category disambiguation as in (II). This reading time pattern indicates that the syntactic integration of ambiguous words is delayed until the word class can be unambiguously determined.

(I) a) I know that the desert trains young people to be especially tough.
b) I know that the desert trains are especially tough on young people.

(II) a) I know that this desert trains young people to be especially tough.
b) I know that these desert trains are especially tough on young people.

principles e.g., by Kimball (1973), Frazier (1987), and more recently by Hawkins (2004, 2014). Based on data as in (100) to (102), Kimball (1973) postulated that incoming words are associated to the lowest nonterminal node (*Principle of Right Association*). A similar assumption was formulated by Frazier (1987) in the *Principle of Late Closure*.

(100) Joe said that Martha expected that it would rain yesterday.



(101) a) The girl took the job that was attractive.

b) The girl that was attractive took the job.

(102) Joe figured that Susan wanted to take the cat out.

Example (100) is ambiguous with regard to the attachment of the adverb *yesterday* (Kimball, 1973, p. 27). Although the adverb may in principle modify each of the predicates (*John said something yesterday, Martha expected something yesterday, it rained yesterday*), it is intuitively interpreted as a modifier of the most embedded proposition in (100). Similarly, although extraposition of the relative clause is possible in English, the sentences in (101a) and (101b) are not interpreted alike. In (101a), the relative clause

is interpreted to modify the adjacent noun *job*. Only with some effort is a modification of the subject *the girl* possible. A preference for low attachment is also found for the interpretation of particles, as in (102). The preferred interpretation, here, is to interpret the particle as part of the lower verb phrase *to take the cat out*.

The impact of the Right Association/Late Closure principle has been studied extensively with regard to attachment preferences of relative clauses on complex nominal heads (e.g., Brysbaert and Mitchell (1996); Cuetos and Mitchell (1988); Deevy (2000); Felser, Marinis, and Clahsen (2003); Frazier and Clifton (1996, 1997); Gilboy, Sopena, Clifton, and Frazier (1995); Grillo (2012); Grillo, Fernandes, and Costa (2012); Grillo, Santi, Fernandes, and Costa (2013); Grillo and Costa (2014); Hemforth, Konieczny, Seelig, and Walter (2000); Hemforth, Konieczny, and Scheepers (2000); Delle Luche, van Gompel, Gayraud, and Martinie (2006); Rohde, Levy, and Kehler (2011); Traxler and Frazier (2008), and references cited in these works). Based on interpretation preferences for structures as in (103), it has been investigated whether processing principles like Late Closure are universal, or whether they operate only in some specific languages. The example in (103) is due to Cuetos and Mitchell (1988, p. 89).

(103) Someone shot the servant of the actress who was on the balcony with her husband.

The principle of Right Association or Late Closure predicts that the relative clause is attached to the phrase currently processed. Therefore, attachment to *the actress* should be preferred over a higher attachment to *the servant* in (103). This pattern has been found in a variety of languages (for an overview see e.g., Grillo & Costa, 2014). Nevertheless, the prediction has also been questioned (e.g., Cuetos & Mitchell, 1988; Brysbaert & Mitchell, 1996). Some languages, like Spanish and Dutch, seem to prefer attachment of the relative clause to the higher referent. This pattern would contradict the universal appliance and validity of the basic parsing principles.

More recent studies suggest that attachment preferences of relative clauses to complex nominal heads have been confounded by language-specific factors (Grillo, 2012; Grillo et al., 2012, 2013; Grillo & Costa, 2014; Hemforth et al., 2015). As observed by Grillo and colleagues, the presence of pseudo-relative clauses, as discussed in Section 2.1, may be responsible for high attachment preferences in the respective languages (Grillo, 2012; Grillo et al., 2012, 2013; Grillo & Costa, 2014). When the possibility to derive a pseudo-relative interpretation is excluded by the experimental design as in (104), a preference for low attachments is observed for instance in Italian (see discussion in Grillo & Costa, 2014). In the example below, the perfective tense excludes a pseudo-relative reading about an ongoing event. The preference for low attachments of relative clauses when no pseudo-relative clause is available is in line with the assumptions of Fodor (1998a), who strongly argues in favor of Late Closure as a universal parsing operation. The example in (104) is taken from Grillo and Costa (2014, p. 173).

(104) Ho visto il ragazzo che ha corso la maratona domenica scorsa.
I saw the boy that has run$_{PERF}$ the marathon sunday previous
'I saw the boy that ran the marathon last Sunday'.

In addition, the length of the relative clause and the interpretation of the complex DP as a topic or focus seems to influence the attachment preferences (Hemforth et al., 2015). These aspects may lead to different attachment preferences for specific constructions across languages and may be responsible for different rates of high/low attachments, as reported for instance for German (Augurzky, 2006; Hemforth, Konieczny, Seelig, & Walter, 2000; Hemforth, Konieczny, & Scheepers, 2000; Hemforth et al., 2015). Despite these language-specific differences, the studies agree that the principle of Right Association/Late closure is operative in general independent of the language. Therefore, I assume that the principle of Right Association/Late closure guides the attachment of relative clauses in German as well.

Note that with regard to the question of how restrictive and appositive relative clauses are processed, these studies are inconclusive. The above mentioned studies do not discuss the semantic contribution of the clause as a restrictive or appositive modifier. Written stimuli are presented without any context determining the number of discourse referents. In addition, comprehension questions targeted only the attachment site and not the implications of a restrictive or appositive modification of the head noun. However, the attachment differences may also be due to the plausibility of restrictive and appositive interpretations. This aspect has not been investigated up to now.

In addition to Right Association, Kimball (1973) assumes that a phrase is closed as soon as possible, unless the incoming material can be integrated as an immediate constituent of the presently processed phrase (*Principle of Closure*). Furthermore, he assumes that function words indicate the beginning of a new phrase. More generally, he postulates that the parser sends a phrase to the processing unit as soon as it is closed, and then clears it from short-term memory. In the subsequent processing unit, the structure is syntactically and semantically processed. This processing of chunks is reminiscent of the idea of phases formulated in the framework of syntactic Minimalism thirty years later by Chomsky (2008).

Frazier (1987) proposes an additional principle focussing on the parsimony of the parser, the *Principle of Minimal Attachment*. It states that no potentially unnecessary nodes are postulated. By this principle it is ensured that the parser builds up the simplest structure initially. The application of the principle is illustrated in (105a) and (105b).

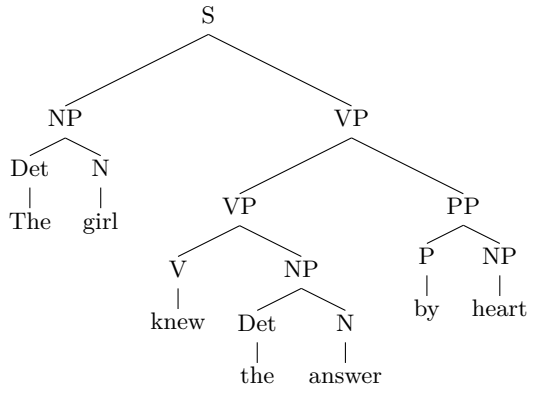
(105) The girl knew the answer...

a) by heart.

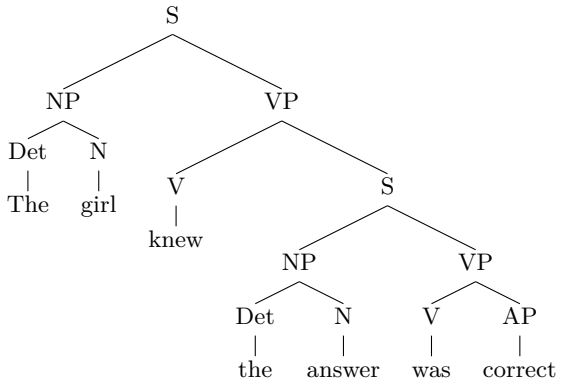
b) was correct.

Minimal Attachment predicts that in both instances, *the answer* is analyzed first as argument of verb *to know* by the structure-driven parser. This is illustrated in (106a) (Frazier, 1987, p. 562), the syntactic structure with the least number of nodes at this point of the derivation.

(106) a.



b.



In (105a)/(106a), this assumption is borne out, and *by heart* can be integrated directly in the parse tree. In (105b)/(106b) on the contrary, the following verb *was* indicates that a second sentence has to be represented. Thus, a revision has to take place to adjust the already established tree structure. As demonstrated experimentally by Frazier and Rayner (1982), so-called garden-path sentences as in (105b) are more difficult to parse. Frazier and Rayner (1982) show that a reanalysis is associated with higher processing complexity and leads to longer reading times of the sentence. Likewise, the observation that higher complexity is linked to the unfavored interpretation became already evident in Examples (100) and (101a). It is possible to interpret a relative clause or an adverb at a position higher up in the syntactic tree, but more effort is required for the derivation of these interpretations. Higher processing load associated with the repair of syntactic structure has been postulated already by Kimball (1973). Kimball assumed that a structural change of an already closed phrase bears higher effort.

In addition to the principles of Late Closure and Minimal Attachment, data show that the parser tries to assign fillers (moved elements) to their base positions (gaps) as soon as possible within sentences (e.g., Clifton & Frazier, 1989; Frazier & Flores D'Arcais, 1989; for an overview, see McDaniel et al., 2015). As a consequence, subject extraction is preferred over object extraction for instance in *wh*-movement as well as in relative clauses. This observation has been addressed in terms of the *Active Filler Hypothesis* given in (107) (Clifton & Frazier, 1989).

(107) *Active Filler Hypothesis* (Clifton & Frazier, 1989, p. 292)
When a filler of category XP has been identified in a non-argument position, such as COMP, rank the option of assigning its corresponding gap to the sentence over the option of identifying a lexical phrase of category XP.

The preference for subject extraction has been frequently studied with a variety of methods. With regard to relative clauses, subject relative clauses (SRC) as in (108a) are more easily processed than object relative clauses (ORC) as in (108b) (King & Just, 1991, p. 581). According to the Active Filler Hypothesis, the relative pronoun or

complementizer[30] is identified as a filler because it is placed in the domain of the CP. As a consequence, the relative pronoun has to be linked to a suitable base position further down in the syntactic tree.

(108) a) The reporter that _ attacked the senator admitted the error. (SRC)
b) The reporter that (_) the senator attacked _ admitted the error. (ORC)

Thus, subject relative clauses are easy to process since the parser can directly posit a gap in subject position. In (108a), the filler can be assigned rapidly and does not have to be kept in working memory while processing other material. In object relatives in contrast, the parser also postulates a gap in subject position first. Due to the following subject *the senator*, the gap has to be overwritten by the lexical material. In the following, the parser has to find an alternative position for the filler. According to the Active Filler Hypothesis, the parser will postulate the gap again at the next possible position, i.e., at the position of the direct object. In the meantime, the filler has to be stored in memory. Therefore, a subject-object asymmetry arises. Besides the longer search for the trace position for the object, object relatives are more difficult to parse than subject relatives due to an additional filler-gap-dependency. While the filler matching the object *the reporter* is kept in memory, the subject *the senator* is encountered. Assuming VP-internal subjects (Koopman & Sportiche, 1991), subjects in the specifier of TP/IP can also be identified as fillers. Frazier, Clifton, and Randall (1983) assume that the filler encountered most recently is assigned first in such cases. First, a gap position for the subject *the senator* is looked for while the search for a gap position for the relative pronoun/*the reporter* is delayed. As a consequence, the identified dependencies are nested within each other. This is displayed in (109).

(109) The reporter$_i$ that$_i$ the senator$_m$ $\_\__m$ attacked $\_\__i$ admitted the error.

A variety of studies demonstrated that the Active Filler Hypothesis may not be the only source for the observed asymmetry between the processing of subject and object relative clauses (Gordon, Hendrick, & Johnson, 2001; Gordon, Hendrick, & Levine, 2002; Gordon, Hendrick, & Johnson, 2004; Gordon, Hendrick, Johnson, & Lee, 2006; Mak, Vonk, & Schriefers, 2002, 2006, 2008). In addition, the type of noun phrase seems to be relevant. The interpretation difficulties arise most strongly when two lexical DPs are used in object relative clauses as head noun and relative clause-internal DP like *reporter* and *senator* in (109). The asymmetry, however, can be modulated by a variety of factors. Inanimate head nouns, as well as the use of different kinds of noun phrases (lexical DP vs. pronoun/pro/quantifier) improve the performance in object relative clauses. As a consequence, the difference between subject and object relative clauses is reduced or completely absent in self-paced reading studies when different types of DPs are used (Gordon et al., 2001, 2002, 2004, 2006). In contrast, differences between definite and

[30] In instances of an underlying raising structure, the head noun is identified as moved element when the relative pronoun or complementizer is encountered and the type of subordinate clause is identified. Then, the head noun has to be reconstructed within the syntactic tree.

indefinite DPs, as well as between different levels of lexical differentiation (*person* vs. *barber*) (Gordon et al., 2004) do not lead to facilitation effects in object relative clauses in adult processing. Furthermore, the frequency of occurrence of different DP types (definite/indefinite/generic) does not predict the difficulties associated with their processing in relative clause structures (Gordon et al., 2004). For an account to explain these patterns see Gordon et al. (2001, 2002, 2004, 2006) for an explanation based on properties of the working memory, and Friedmann, Belletti, and Rizzi (2009) for a formalization in a linguistic framework based on the syntactic locality principle called *Relativized Minimality* (Rizzi, 1990, 2004). Both accounts assume that structures involving movement are more complicated to parse when an element with similar properties intervenes between the moved constituent and its base position.

Hawkins (2004, 2014) paraphrases the observed patterns in a broader, more general way. He proposes three principles of efficient parsing that are not limited to syntactic parsing but comprise also morphological and phonological patterns. His principle *Minimize Domains* covers the previously mentioned data that led to the formulation of the principles of Late Closure, Minimal Attachment, and the Active Filler Hypothesis. The principle Minimize Domains states that the parser shows a preference for structures in which all dependency relations as well as syntactic and semantic properties of the structure can be resolved in a minimal domain. Therefore, this principle also covers the observation that the parser tries to assign fillers to their base positions as soon as possible within sentences.

Further evidence for the instant postulation of gaps comes from studies investigating interpretation preferences for locally ambiguous structures like in (110). In addition, data as in (110) argue for an encapsulated syntactic processing, which is not influenced by the content of the integrated words. The examples are taken from Schriefers, Friederici, and Kühn (1995, p. 502).

(110) a) Das ist die Managerin, die die Arbeiterinnen gesehen hat.
This is the manager who the workers seen has
'This is the manager who saw the workers.' (SRC, neutral semantics)

b) Das sind die Arbeiterinnen, die die Managerin gesehen hat.
These are the workers, who the manager seen has
'These are the workers, who the manager saw.' (ORC, neutral semantics)

c) Das sind die Arbeiterinnen, die die Managerin entlassen hat.
These are the workers who the manager fired has
'These are the workers who the manager fired.' (ORC, bias to ORC)

d) Das sind die Managerinnen, die die Arbeiterin entlassen hat.
These are the managers who the worker fired has
'These are the managers who the worker fired.' (ORC, bias to SRC)

In the German examples above, the agreement pattern of the auxiliary disambiguates between a subject and object relative clause. Up to this point, the relative clauses are

ambiguous. The results of the reading-time study by Schriefers et al. (1995) showed a general advantage of reading times for subject relative clauses over object relative clauses at the auxiliary in the semantic neutral condition ((110a) vs. (110b)). Moreover, the semantic bias of the preceding matrix clause did not effect the results. In sentences as in (110c), which were biased towards the target object relative clause structure, auxiliaries in the subject relative condition were read faster than in object relatives.[31] Similar observations from English led to the assumption that the parser builds up syntactic structures initially independently of other information (e.g., Frazier, 1987). These so-called *syntax-first models* assume that information based on the semantic content of the utterance, as well as based on animacy of the discourse referents, or the general discourse context, influence parsing only at a second step (Clifton et al., 2003; Clifton & Frazier, 1989; Rayner, Carlson, & Frazier, 1983; Traxler, Morris, & Seely, 2002). Information about the thematic roles or the content of the verbs are available soon after the syntactic integration. They are used as control mechanism, and may lead to a revision of the initially proposed syntactic structure when necessary. The ease of restructuring seems to depend on the amount of information available to determine the target structure (Frazier & Rayner, 1982; Frazier, 1999). In addition, a structural reanalysis seems to be more complicated when the initial structure has already been interpreted by the semantic component (Frazier & Rayner, 1982).

The view that the syntactic structure is built up initially independently of other information is challenged, for instance, by results from Altmann and Steedman (1988), Eberhard, Spivey-Knowlton, Sedivy, and Tanenhaus (1995), and Sedivy et al. (1999). In addition, these studies are informative on how nominal modifiers are interpreted on-line. Therefore they are addressed in detail here. Previous studies investigating the interplay of syntactic, semantic and contextual information used written linguistic stimuli and reading time measures. A series of eye-tracking studies shows that contextual information supplied by written instructions is used differently in processing than the visual context of a scene in front of the participants. A visual context is used more rapidly to influence syntactic and semantic processing. The following results show that referential processing is not dependent on a completed syntactic analysis of the test sentences. In the studies of Eberhard et al. (1995) and Sedivy et al. (1999), participants had to select (and move) an object in an array of other objects. In this study, a visual context was supplied that was relevant for the task. Confronted with one of the visual contexts displayed in Figure 2.4 participants had to select an object according to the instruction in (111) (Eberhard et al., 1995).

(111) Touch the starred yellow square.

As shown in Figure 2.4, three conditions were tested. Depending on the visual display, participants had to select an object that could be identified at three different points of the verbal prompt. Either disambiguation occurred early at the first modifier *starred*, or at the second modifier *yellow* (condition 'mid'), or late, at the following noun *square*. While

[31] For related results on German based on event-related potentials see Friederici and Mecklinger (1996) and Friederici, Steinhauer, Mecklinger, and Meyer (1998).

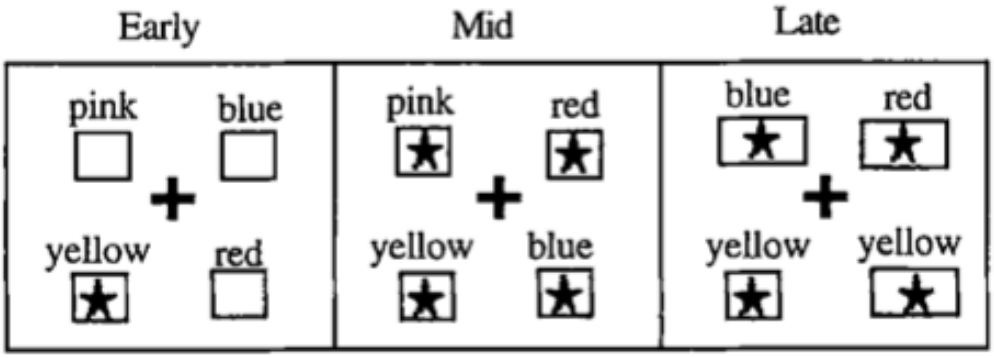


Figure 2.4.: Example stimulus pictures for early, mid, and late condition. Adapted from "Eye movements as a window into real-time spoken language comprehension in natural contexts" by K. M. Eberhard, M. J. Spivey-Knowlton, J. C. Sedivy, and M. K. Tanenhaus, 1995, *Journal of Psycholinguistic Research, 24*, p. 415. Copyright 1995 by Springer. Reprinted with permission.

hearing the verbal prompt of the experimenter, the eye-movements of the participants were recorded. Measuring started at the determiner *the* for all conditions.

Note that the semantic contribution of the adjectives in the experimental stimuli used by Eberhard et al. (1995) and Sedivy et al. (1999) is not explicitly discussed. In case of early disambiguation, the color adjectives could be analyzed as an appositive modifier, since the reference is established already on the first adjective. In the mid and late disambiguation condition, both adjectives serve to restrict the set of potential referents and thus need to be analyzed restrictively. Information of prosodic realizations are not provided.

The results show an incremental processing of the prompt in (111). It is not the case that the participants waited with their search for a suitable referent until the full DP was encountered. When the referent of the DP could be identified early, participants fixated the target referent on average 630 ms after the onset of the DP. In the medial disambiguation condition, the target was identified about 900 ms following the definite determiner. For the late disambiguation condition, the identification of the referent took about 1200 ms on average. Thus, deciding on the reference for the mentioned object is not delayed until the end of the complex noun phrase. On the contrary, it is established directly following the point of disambiguation.

The data show that semantic or referential processing proceeds incrementally on a word-by-word basis. Incremental processing thus is not restricted to syntax. This observation demonstrates that the idea of Kimball (1973), that structures are only sent to the semantic processing when syntactic phrases are completed, cannot hold. Instead, information is used as soon as a word is identified and implemented in the syntactic structure. Nevertheless, instant referential processing does not challenge the assumption of a syntax-first parsing strategy (e.g., Frazier, 2000). Frazier (2000) assumes that the

parser has a modular structure and that different semantic processes work independently. According to Frazier, the parser builds up a syntactic parse tree as soon as the category of the lexical items is identified. In the following, coreference relations are established and subsequently the structure is processed to identify the relevant discourse referents. In addition, another module links the thematic roles to the identified referents. In the model, reference is established as soon as possible in the syntactic parse and, if possible, is assigned on the basis of the surface structure.[32] The strategy of direct interpretation is advantageous because it reduces processing load. For working memory, memorizing referents is less demanding than memorizing surface forms that are semantically uninterpreted. In addition, direct interpretation facilitates the work of the theta role module. According to Frazier, the determination of the most plausible assignment of a theta role relies on the interpretation of a DP and not on its surface form. Thus, a prior selection of the referent reduces the work load of the assignment procedure.

The assumption that adjectives are interpreted as soon as possible to select a potential referent for the DP is supported by the results of Sedivy et al. (1999). The previous studies by Eberhard et al. (1995) reported above tested the incremental interpretation of intersective color words. Sedivy et al. (1999) aimed at investigating whether context-sensitive (non-intersective) adjectives like *tall* are also interpreted as soon as possible. The results of Sedivy et al. indicate that reference is established early without waiting for the following noun to be processed. In addition, the results demonstrate that color adjectives as well as context-sensitive adjectives are interpreted restrictively. In their experiments the adjectives were interpreted contrastively whenever possible to resolve referential ambiguity. To investigate the incremental processing of intersective and non-intersective adjectives, four objects were presented in an array with a fixation cross in the middle. Examples are displayed in Figure 2.5 on the following page.

In Experiment 1B, color adjectives were tested in a sequence of instructions as shown in (112). In the second experiment, non-intersective adjectives like *tall*[33] were addressed using prompts as in (113).

(112) Touch the pink comb. Now touch the YELLOW/yellow comb/bowl.

(113) Pick up the tall glass and put it below the pitcher.

In Experiment 2, the visual displays varied with regard to whether a second glass was displayed as a contrasting element along the dimension of the adjective.

In short, the results show incremental processing of both, color words and size terms. In addition, contrastive interpretations were favored. In Experiment 1, two identical objects were present in the visual scene that contrasted with regard to their color. The

[32] Following the Mapping Hypothesis by Diesing (1992), Frazier assumes that all VP-external DPs receive a presupposed, d-linked interpretation. DPs that are VP-internal are interpreted existentially. Frazier assumes that, on the surface, all English DPs are moved out of the VP. To receive an existential interpretation, they have to be lowered at LF back into their VP-internal position. With regard to interpretation, Frazier (2000, p. 305) proposes the Principle of *Minimal Lowering*: "'Lower' only when necessary, e.g., interpret a DP in its surface position if possible".

[33] The other items are not reported in Sedivy et al. (1999).

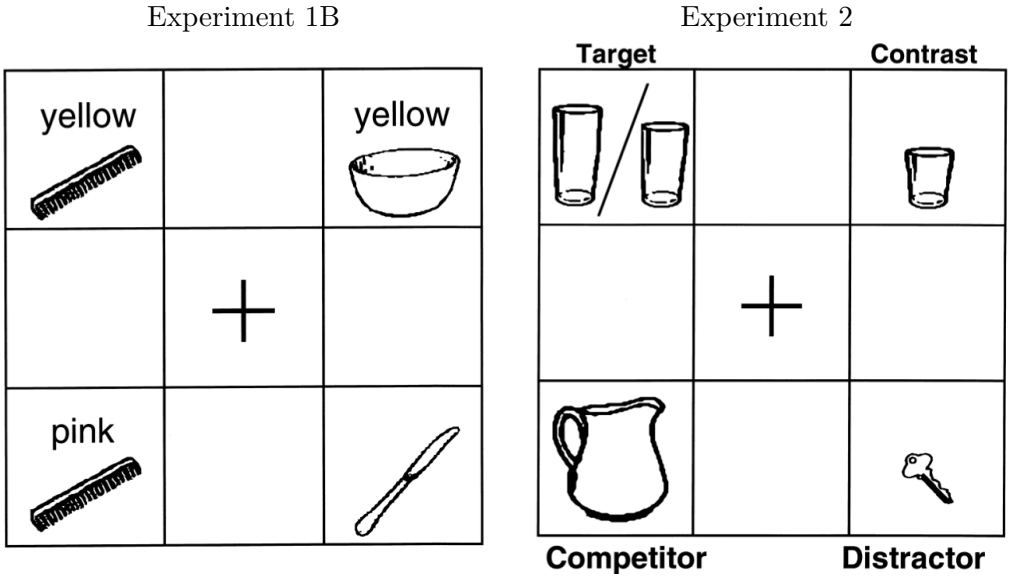


Figure 2.5.: Example test items for Experiment 1B and Experiment 2. Adapted from "Achieving incremental semantic interpretation through contextual representation" by J. C. Sedivy, M. K. Tanenhaus, C. G. Chambers, and G. N. Carlson, 1999, *Cognition, 71*, pp. 124 and 130. Copyright 1999 by Elsevier. Reprinted with permission.

first sentence of the instruction targeted one element of this contrast set. Eye-movements were not reported for this sentence. The fixation patterns recorded during the second sentence indicate that participants expected the second part of the instruction to target the other element of the contrasting set. Independent of whether the color word carried contrastive stress, participants were faster to fixate the contrasting object (e.g., in the display of Experiment 1B, the yellow comb) than the non-contrasting element (the yellow bowl). Similar results were obtained in Experiment 2. Participants were faster in fixating the target object in the upper left corner when a contrasting element (additional glass in upper right corner) was present. This indicates that they evaluated the scalar adjective to establish a contrast between two elements. When no additional glass was present, participants frequently focussed on the other tall object in the array, the pitcher, and took longer to fixate the target object. Thus, even in the absence of a direct contrast, objects were evaluated along the lines of the dimension of the adjective and a contrast set was established. A manipulation of the size of the displayed glass in the upper left corner showed that participants decided for a potential referent while hearing the adjective on the basis of whether the adjective corresponded to a prototypical description of the object. The pitcher was focused more often when the glass was judged as a bad representative for a tall glass in a previous rating task.

In these experiments, all potential referents were displayed. The results demonstrate that a corresponding referent may be selected prior to the processing of the noun even

for relational, non-intersective adjectives like *tall*. At first sight, this may be taken as evidence for an initial analysis of *tall* as an intersective adjective, which can be evaluated independently of the noun. This conclusion may be too strong, however. Since the potential referents were displayed in the experimental setting, they can offer comparison classes for the evaluation of the adjective. As the second experiment of Sedivy et al. (1999) demonstrates, only those elements that were expected to be described by *tall* were considered as potential referents for the noun phrase. This can be taken as evidence that relational adjectives are immediately interpreted as non-intersective, and as involving a comparison class.

The observation that comparisons classes are immediately used when a non-intersective adjective is processed is in line with assumptions by Frazier (1999). She assumes that (in the absence of an informative visual context) modified nouns are frequently interpreted as non-intersective modifiers. In principle, the adjectives in phrases as *heavy smoker*, *old friends*, and *strong applicants* are ambiguous between an intersective and a relational, non-intersective interpretation. According to Frazier (1999), they are interpreted intuitively as relational modifiers and not as context-independent intersective ones. This can be derived from the *Head Primacy Principle* by Kamp and Partee (1995) given in (114).

(114) *Head Primacy Principle* (Kamp & Partee, 1995, p. 161)
In a modifier-head structure, the head is interpreted relative to the context of the whole constituent, and the modifier is interpreted relative to the local context created from the former context by the interpretation of the head.

The Head Primacy Principle postulates delayed semantic processing for non-intersective adjectives as long as the head noun has not been processed. According to this assumption, the head needs to be encountered to restrict the context for evaluating the modifying adjective. Thereby, the adjective is contextually restricted to the extension of the head noun. In the presence of a visual context, information about the potential reference of the head noun may be available prior to the corresponding word. Nevertheless, the Head Primacy Principle may be operative to select an appropriate comparison class.

Further experimental results that suggest an influence of contrasting elements on the selection of a comparison class come from a study by Tanenhaus, Spivey-Knowlton, Eberhard, and Sedivy (1995)[34]. Tanenhaus et al. (1995) show that visual context is used to guide syntactic integration. In a manipulation task, participants had to move objects according to prompts as in (115) and (116). Two different visual contexts were supplied, a 1-referent context and a 2-referent context as displayed in Figure 2.6 on the following page.

(115) Put the apple on the towel in the box.

(116) Put the apple that's on the towel in the box.

[34]The data of Tanenhaus et al. (1995) is discussed in more detail in Eberhard et al. (1995). In the following, information from both references are integrated.

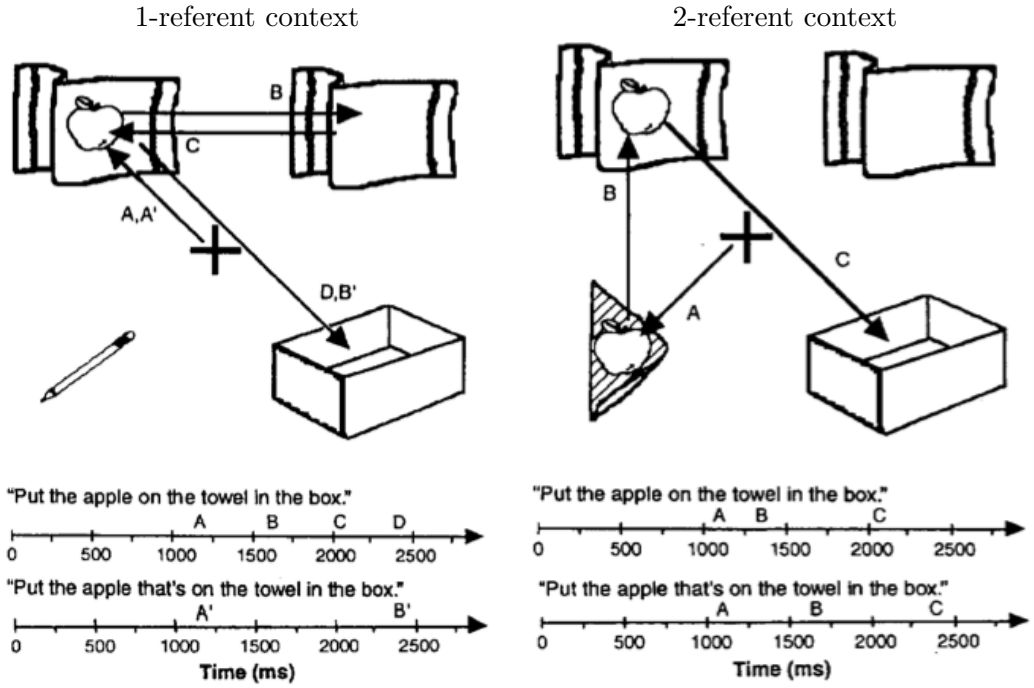


Figure 2.6.: Visual contexts including eye-movement patterns. Adapted from "Integration of Visual and Linguistic Information in Spoken Language Comprehension" by M. K. Tanenhaus, M. J. Spivey-Knowlton, K. M. Eberhard, and J. C. Sedivy, 1995, *Science, 268*, p. 1633. Copyright 1995 by The American Association for the Advancement of Science. Reprinted with permission.

The visual stimulus contained either one referent, an apple on a towel, or two potential referents, two apples placed on different objects. According to the authors, a syntax-first account would predict that in both verbal prompts the phrase *on the towel* is interpreted initially as the goal of the action. The initial analysis should be independent from the kind of visual display. As indicated by the eye-movement patterns displayed in Figure 2.6, the empty towel is, indeed, considered as a referent for the phrase *the towel* in the 1-referent context combined with the ambiguous PP stimulus. When the stimulus was unambiguous due to the relative clause, participants interpreted the phrase *the towel* exclusively as a modifier of the apple. In the 2-referent context, no differences were observed between the two verbal instructions. *The towel* was interpreted as a modifier both with the ambiguous PP stimulus as well as with the unambiguous relative clause.

An analysis of the fixations to the incorrect destination (the empty towel) in the different conditions shows that the presence of a visual contrast has immediate consequences on the syntactic parse. Participants fixated the incorrect destination in more than 50% of trials when they listened to the ambiguous instruction in a 1-referent context. When the participants listened to an unambiguous instruction in this condition, they never focused on the incorrect target. In the 2-referent context, the incorrect target was fixated

at similar rates for both types of stimuli. Participants considered the incorrect referent in 17% for trials with an ambiguous instruction and in 11% for unambiguous instructions. In addition, the data show that relative clauses introduced by *that* are interpreted as restrictive modifiers by adults. These results will be important with respect to the acquisition of processing phenomena as discussed in Section 3.3.

According to Tanenhaus et al. (1995), their results are taken as evidence against an encapsulated syntactic processing. They assume that the immediate use of referential information is indicative of a constraint-based parsing model, as proposed by Altmann (2000). The authors propose that all available information is integrated simultaneously to guide syntactic processing. Frazier (1999), on the contrary, analyzed the rapid integration of contextual information as the ability to repair a postulated syntactic structure as soon as relevant information is encountered. Since the visual information is present from the beginning of the sentence, the repair can take place immediately.

Up to date, it is not possible to clearly distinguish the two proposals on the basis of experimental evidence. However, the studies motivating the processing principles Late Closure, Minimal Attachment, and the Active Filler Hypothesis speak in favor of a syntax-first account. They show that in the absence of visual context, contextual effects influence interpretation only at a secondary level. In a constraint-based integrative model, this lack of contextual influence is unexpected. Rapid integration of visual information is not necessarily speaking against a syntax-first approach because information gathered by subsequent modules can be used very quickly to initiate changes of the postulated syntactic structure.

Taken together, the experimental evidence summarized in this section demonstrates that human language processing proceeds in a highly incremental way. In its processing routines, the syntactic parser adheres to economy principles, including Minimal Attachment and Late Closure. On the basis of these processing principles, it is possible to predict which syntactic structures are easy or difficult to process. In case of structural ambiguity, interpretations are preferred when they are in accordance with the initial syntactic structure. In addition, semantic interpretation and especially referential processing is performed incrementally. According to syntax-first models, the initial syntactic parse does not interact with non-syntactic information. Information from the utterance discourse, visual context or semantics are integrated at a second level of processing. Whenever the initial syntactic structure does not align with the output of subsequent processing modules or information from the situational context, the syntactic structure is reanalyzed and repaired.

2.6.2. Processing restrictive and appositive relative clauses

To date, there are no studies explicitly investigating the influence of relative clause semantics on the syntactic parse. However, the observed principles should also be active when restrictive and appositive relative clauses are processed. The preference for low attachment may be relevant to predict processing preferences for restrictive over appositive relative clauses. As postnominal restrictive relative clauses involve a low attachment to the last processed phrase, they may be derived without altering the initial syntac-

tic parse. Appositive relative clauses, in contrast, would require a reanalysis in which the relative clause is attached higher in the tree at the DP level. So far, studies have not investigated phenomena in which different positions within a single DP result in different interpretations. Therefore, it is still an open question whether a preference for restrictive interpretations may be derived from the processing principles discussed so far. Potential evidence for a restrictive preference comes from the interpretation of adjectives. As Sedivy et al. (1999) showed, adjectives are interpreted as signaling contrasts between potential referents. This preference is not exclusive to intersective adjectives, it also holds for relational adjectives that involve a comparison class like *tall*. The preference for contrasting interpretations in the experiments of Sedivy et al. (1999) may be indicative for a preference of restrictive interpretations. Restrictive, but not appositive adjectives are used to restrict the identity of a noun referent and to establish a contrast to other members of the presupposed set of elements denoted by the head noun. On the other hand, rapid identification of discourse referents may speak in favor of appositive interpretations for postnominal modifiers such as relative clauses. In case the head noun is sufficient to determine a possible referent, the relative clause may be encountered as additional information on this referent. As a consequence, the initial syntactic analysis may be reanalyzed to allow an appositive interpretation. So far, these two lines of thought, preference for restrictivity due to low attachment and preference for appositivity due to rapid identification of a referent, are speculative. They will be taken up in Chapter 8, where the results of the experimental part of this thesis are discussed.

2.7. Summary

In this chapter, I established the theoretical background for the empirical investigation of restrictive and appositive relative clauses. In addition to syntactic and semantic proposals, previous findings on the interplay of syntax, semantics, and prosody were summarized. Syntactic proposals frequently claim that different prosodic structures of restrictive and appositive relative clauses are a consequence of the proposed structural differences. Empirical data on the production and comprehension of relative clauses and their prosodic contours suggest a less uniform relation between semantic function and prosodic realization.

With regard to natural language processing, the semantics of relative clauses has not been addressed so far. Previous studies showed that linguistic input is processed incrementally at a word-by-word level. Ambiguity resolution and attachment preferences for a variety of languages indicate that processing principles as Late Closure or Minimal Attachment guide the initial syntactic parse independently of the language. In addition, these studies showed that integration of information coming from visual contexts happens very quickly and is able to override or repair syntactic preferences very early.

For the remainder of this thesis, I adopt an analysis along the lines of the syntactic standard assumption for relative clauses formulated in Demirdache (1991). I assume that restrictive relative clauses are attached at the NP-level and appositive ones at the DP-level. Semantically, I assume that restrictive relatives are analyzed as predicates

of type <e,t>. Following von Stechow (1979, 2007) and Heim and Kratzer (1998), the relative pronoun in restrictive relatives is analyzed as a vacuous expression with regard to its semantic contribution. In accordance with Sauerland (2003, 2004) and Hulsey and Sauerland (2006), I assume that both raising and matching structures are available as possible derivations for restrictive relatives.

For appositive relative clauses, I assume that they are attached at the DP shell. In line with Del Gobbo (2007), I assume that appositive relative clauses differ in their internal semantic computation from restrictives and are propositions of type t. Unlike relative pronouns in restrictive relative clauses, the relative pronoun in appositives is an anaphoric pronoun that has to be co-indexed with the head noun. In line with Del Gobbo (2007), the differences between restrictive and appositive relative clauses may be semantically achieved by an additional movement of the appositive at LF out of the scope of the matrix clause. The analysis of the appositive as proposition licenses the presence of sentence and proposition-modifying elements, such as adverbs like *frankly* in English or discourse particles in German. In addition, the different semantic computation is responsible for the contrasting behavior of restrictive and appositive relative clauses with regard to the scope of operators in the matrix clause.

On the basis of these theoretical assumptions, I assume that appositive relative clauses are more complex than restrictive relative clauses. Depending on the syntactic analysis, appositive relative clauses may involve a more complex derivation. In addition, the derivation of appositive interpretations requires a complex semantic composition rule independently of the adopted analysis.

Implications for acquisition

These assumptions have crucial consequences for the acquisition of restrictive and appositive relative clauses. They suggest that appositive interpretations are more difficult to acquire than restrictive readings of relative clauses. The principles underlying human language processing may also point in this direction. The processing principle Late Closure leads to a preference for an attachment at the immediately processed phrase. This may favor restrictive interpretations for relative clauses adjacent to their head nouns. However, the incremental nature of syntactic and semantic processes may also favor appositive readings of nominal modifiers. When the modifier does not serve to restrict the denotation of the head noun, reference of the DP may be established earlier than when postnominal modifiers need to be considered.

The following chapter addresses the syntax, semantics, and processing of relative clauses in acquisition.

3. Acquisition of relative clauses

This chapter summarizes previous research on the acquisition of relative clauses and related phenomena. Regarding the acquisition of restrictivity and appositivity, this chapter shows that the acquisition of the semantic functions is an understudied area of research. To date, it is an open question when and in which order children acquire restrictive and appositive readings for relative clauses and adjectives.

The chapter is structured as follows. Section 3.1 summarizes corpus studies on the production of relative clauses in German-speaking children. Experimental studies on the acquisition of the syntactic structure of relative clauses are presented in Section 3.2. Section 3.3 focuses on the existing studies investigating the acquisition of relative clause semantics. Section 3.4 deals with the acquisition of related phenomena, especially the acquisition of the semantic functions in adjectival modification. The experiments presented in Section 3.4 are important with regard to the experimental part of this thesis because they served as a starting point for the experimental design developed here to investigate the acquisition of restrictive and appositive relative clauses. The acquisition of discourse anaphora is addressed in Section 3.4.2, and previous research on the role of processing in the acquisition process is presented in 3.5.

3.1. Relative clauses in child German

In spontaneous speech, relative clauses start to occur in the third year of life in German (Brandt, 2004; Brandt, Diessel, & Tomasello, 2008; Rothweiler, 1993; Tracy, 2007) and in other languages like Englisch (Diessel & Tomasello, 2000) and Italian (Belletti & Chesi, 2011). A typical early relative clause is illustrated in (1) (Tracy, 2007, p. 79).

(1) das sind ALle legos die ich AUSgeschüttet hab
These are all legos which I out-poured have

'These are all the Lego pieces that I poured out.' Age 2;2

In general, analyses of child language corpora show that relative clauses occur with lower frequency than in corpora on adult speech. The first study investigating the acquisition of subordinate clauses in German has been based on a corpus consisting of 841 subordinate clauses produced by seven German-speaking children aged 2;0 to 5;0 (Rothweiler, 1993). Rothweiler (1993) found relative clauses to be produced later and less frequently than complement clauses or adverbial clauses. The children produced a total of 97 relative clauses defined as sentential modifiers on a nominal head or as free relative clauses without an antecedent in the matrix clause. The 97 relative clauses com-

prised 80 restrictive relative clauses (2a), 1 appositive relative (2b)[1] and 16 free relative clauses like in (2c). According to Rothweiler's classification, an appositive relative clause modifies a proper name[2]. A restrictive clause, in contrast, serves to identify the referent of the modified object.

(2) a) Gib mir den Stift wo rot oben is.
Give me the pencil where red on top is
'Give me the pencil that is red on top.' Martin, age 2;11

b) Wer mir immer spielen dat is der säck.
Who we always play that is the Jack
'Who we always play with that is Jack.' Martin, age 2;9

c) Soll ch dir zeing was der so hat?
Shall I you show what he so has?
'Shall I show you what he has?' Daniel, age 3;6

All relative clauses showed verb-final word order. In Rothweiler's corpus, the amount of relative clauses produced did not increase with age. In general, children relativized subjects, direct objects, local adverbials, and instrumental adverbials. (3) shows the production of a locative relative clause (Rothweiler, 1993, p. 218).

(3) ich geh in de schule wo der vogel drin is
I go in the school where the bird within is
'I go to the school where the bird is in.' Martin, age 3;1

Overall, subject, direct object, and locative relatives were produced at similar rates (32 subject relatives, 26 object relatives, 33 locative relatives). Relativization of indirect objects and genitive objects is not attested in the data. With regard to the choice of relative pronouns, the majority of subject relative clauses were produced with case marked d-pronouns (see Example (1)). Direct object relative clauses, in contrast, were produced with the relative pronoun *was*, which is not overtly marked for case. In general, relative clauses followed the matrix clause, i.e., they were not center-embedded. Notably, the majority of relative clauses were produced target-like. Only few errors occurred: two erroneous gender markings and three errors marking case on the relative pronoun.

[1]Note that the relative clause classified as appositive in Rothweiler (1993) is better analyzed as a pseudo-cleft. In addition to (2b), there is one other example in which a relative clause is attached to a proper name (I). However, Rothweiler classified this example as restrictive because it served to identify the referent in the respective context.

(I) ich spiel nie mehr mit die (...) radia (=Claudia) (...) der in mein kinergarten (is).
I play never more with the (...) radia (=Claudia) (...) who in my kindergarten (is)
'I'll do not play anymore with the Claudia who is in my kindergarten.' Marianne, age 3;10

[2]See footnote 1.

Brandt et al. (2008) analyzed a corpus of utterances produced by one German-speaking child, Leo, over a time span of 3 years. Daily to weekly recordings of play sessions and daily-life routines were audio-taped between age 2;0 and 5;0. The rate of relative clauses relative to the total number of utterances ranged between 0.12% at age 2;0-2;6 and 0.86% at age 4;0-5;0. In total, Brandt et al. (2008) identified 786 relative clauses in the data set. Compared to the amount of relative clauses in child-directed speech, Leo produced relative clauses at a lower rate than his caregivers, which used relative clauses in 1.4% of child-directed utterances. Brandt et al. observed that Leo's first relative clause utterances consisted of syntactically and information structurally simple constructions. In the earliest occurrences, relative clauses frequently modified isolated DPs as in (4) or were used in monopropositional structures with intransitive verbs, as in (5) (Brandt et al., 2008, p. 335). With increasing age, the matrix clauses became more complex and the variety of relative clause structures increased.

(4) Und da ist der Fisch, ... Zahnschmerzen/ein Wal, der hat
And there is the fish ... toothache/a whale, that-NOM has
Zahnschmerzen.
toothache-PL

'And there is the fish, ... toothache/a whale, that has toothache.' Leo, age 2;9

(5) Wo ist ein Wal, der Zahnschmerzen hat?
Where is a whale that-NOM toothache-PL has

'Where is a whale that has toothache?' Leo, age 2;9

In (4), the finite verb is in second position. Brandt et al. (2008) propose that V2-relatives (see Section 2.1) are precursors of subordinated relative clauses with verb-final word order. In their corpus, the authors identified 465 verb-final relative clauses, 247 verb-second relatives, and 71 relatives that were ambiguous with regard to verb placement. The V2-variant was especially frequent up to age 3. Up to age 2;6, 70% of relative clause structure were produced with the finite verb in second position. In contrast, 8% were clearly marked as verb-final. The proportion of Leo's verb placement in relative clauses changed between 2;6 and 3;0. Between 3;0 and 3;6, almost 90% of relative clauses showed a verb-final pattern and less than 10% were produced with verb-second word order. It has been questioned whether utterances like (4) identified by Brandt et al. (2008) should be classified as verb-second relative clauses. Sanfelici et al. (2017) argue that the majority of V2-relatives observed by Brandt et al. should be analyzed as structures involving left dislocation. Many instances in Leo's utterances including (4) do not fulfill the properties of integrated V2 relative clauses summarized in Gärtner (2001a, 2001b). For a more detailed discussion see Section 2.1 and Sanfelici et al. (2017).

Similar to Rothweiler (1993), Brandt et al. (2008) did not find relative clauses in which the indirect object or genitive object was relativized. Subject relatives, direct object relatives, and locative/oblique relatives were attested. Longitudinally, the proportion of Leo's of subject relative clauses decreased from 85% between 2;0 and 2;6 compared to 45% at age 3;0-3;6. From this age onwards, production rates were stable. Subject relatives

were still the most frequently produced type of relatives, but direct object relatives and obliques were also produced in 20-30% of the utterances each starting from age 3;0.

These results on German are similar to data of spontaneous speech in English (Diessel & Tomasello, 2000) and Italian (Belletti & Chesi, 2011). Diessel and Tomasello (2000) analyzed data of four English-speaking children from the CHILDES database[3] between age 1;9 and 5;2. In 146,014 utterances, the authors identified 329 relative clauses. Thus, 0.2% of all utterances included a relative clause. Like in German, only subject relatives, direct object relatives, and locative/oblique relative clause were attested. In addition, the majority of relative clauses were found in presentational constructions (47%) or attached to isolated NPs (22.5%). These instances expressed only one proposition. Very similar to the development of the German-speaking child Leo, subject relatives were produced more often than direct object relatives and obliques. In addition, the amount of subject relatives decreased from 63% between 2;0 and 2;11 compared to a rate of 26% between age 4;0 and 5;2. During this period, the production of direct object relatives and oblique relatives increased to 42% and about 20% respectively.

Regarding the acquisition of relative clauses in Italian, Belletti and Chesi (2011) analyzed data of eight children of the CHILDES database and the respective child-directed speech. Spontaneous speech data were recorded for all children up to age 3;4. In total 94 relative clauses were produced by the children with first occurrences at the age of 2;0. In the child-directed speech of the care-givers, relative clauses were used more often (677 instances). The percentage of subject relative clauses produced by children up to age 3;4 is similar to the proportion reported in Brandt et al. (2008) and Diessel and Tomasello (2000) for the respective age range. In the data of Belletti and Chesi (2011), 83 subject relatives (88%) were produced in comparison to 11 object relative clauses (11%). As in the other languages investigated, indirect object relatives were not attested in the children's data.

In sum, the analyses summarized here show that relative clauses are attested in spontaneous speech data from age 2;0 onwards. Cross-linguistically, the development of relative clause production is similar. Across languages, subject relative clauses are more frequently produced than direct object relatives and locative/oblique relative clauses. Other grammatical functions are not relativized. Compared to the frequencies of relative clauses in child-directed speech, the rate of relative clauses produced by children is lower. In general, relative clauses are produced less frequently than other subordinated clauses. Regarding German, children use d-pronouns in subject relatives and do not have major difficulties marking number and gender agreement. In object relatives, children frequently avoid overt accusative case markings by using the wh-pronoun *was* as relative pronoun.

Except for the data of Rothweiler (1993), relative clauses in child language have not been classified according to their semantic function. In Rothweiler's data, the majority of relative clauses produced were restrictive. Only one appositive relative clause was identified (but see footnote 1). Brandt et al. (2008) and Diessel and Tomasello (2000) argue that children frequently use presentational constructions that should not be classified

[3]The CHILDES corpus is accessible via http://childes.psy.cmu.edu.

as restrictive. The authors assume that subject relative clauses involving presentational constructions serve to characterize a human or non-human antecedent by adding new information. So far, it is an open question at which age appositive relative clauses emerge and when they are used productively. The next section presents studies investigating the syntactic properties of relative clauses in more detail.

3.2. Studies on the acquisition of syntactic properties of relative clauses

Many experimental studies investigated the acquisition of (morpho-)syntactic properties of relative clauses in a variety of languages in comprehension and production. A non-exhaustive overview of studies focusing on production is given in Table 3.1. Table 3.2 lists studies focusing on the comprehension of relative clauses across languages.

Table 3.1.: Studies investigating the acquisition of relative clause production

Language	**Studies**
Chinese	Hsu et al., 2009
Danish	Jensen de López et al., 2014
English	Hamburger & Crain, 1982, McKee et al., 1998, Pérez-Leroux, 1995
French	Guasti & Cardinaletti, 2003
German	Adani, 2011, Adani et al., 2013, Sanfelici et al., n.d.
Greek	Stathopoulou, 2007
Hebrew	Arnon, 2010, Friedmann et al., 2011, Friedmann et al., 2015, Novogrodsky & Friedmann, 2006
Italian	Belletti & Contemori, 2012, Contemori & Belletti, 2014, Crain et al., 1990, Utzeri, 2007
Palestinian Arabic	Botwinik et al., 2015
Portuguese	Corrêa, 1995, Costa et al., 2011, Costa et al., 2014
Quechua	Courtney, 2006
Serbo-Croatian	Goodluck & Stojanovic, 1996
Spanish	Pérez-Leroux, 1998
Swedish	Hakansson & Hansson, 2000

Studies in comprehension and production mainly investigated the so-called *subject object asymmetry*. As mentioned in Section 2.6, adults show a preference for subject

Table 3.2.: Studies investigating the acquisition of relative clause comprehension

Language	**Studies**
Basque	Gutierrez-Mangado, 2011
English	Brandt et al., 2009, Brown, 1971, Eisenberg, 2002, Goodluck & Tavakolian, 1982, Hamburger & Crain, 1982, Kidd & Bavin, 2002, Sheldon, 1974, de Villiers et al., 1979
German	Adani et al., 2013, Arosio et al., 2012, Brandt et al., 2009
Greek	Guasti et al., 2008
Hebrew	Arnon, 2010, Friedmann et al., 2009
Italian	Adani et al., 2010, Arosio et al., 2011, Guasti et al., 2008
Japanese	Suzuki, 2011
Portuguese	Corrêa, 1995, Friedmann & Costa, 2010
Quechua	Courtney, 2006
Romanian	Sevcenco & Avram, 2012
Spanish	Pérez-Leroux, 1995
Swedish	Hakansson & Hansson, 2000

relative over object relative clauses in sentences with (local) ambiguities. In addition, subject relative clauses are processed faster than object relatives. A similar asymmetry has also been observed in the acquisition of relative clauses. As observed in the corpus studies on spontaneous speech data in the previous section, subject relatives are produced better and earlier than the corresponding object relative clauses. Similarly, the results of the elicited production tasks reported in this section mirror the findings from spontaneous speech data summarized in Section 3.1. Subject relatives are produced by children as young as 2;8; object relatives are produced later, less frequently and more erroneous than subject relatives in the experimental tasks.

Crain et al. (1990) were the first to demonstrate that relative clauses can be elicited in children as young as 2;8. This was shown in a study eliciting subject and object relative clauses from 26 Italian-speaking children between age 2;8 and 3;11. Twelve stories were acted out in front of the child to elicit 6 subject relatives and 6 object relatives. The animacy of the head noun and of the relative clause internal DP was varied in the intended target responses (*Pick up the boy that sat down* vs. *Pick up the car that fell down*). Six children had to be excluded because they did not respond verbally. Instead, these children consistently pointed at the respective object. The other 20 children produced relative clauses target-like in above 80% of items. Each of the 20 children produced an appropriate relative clause in at least 6 out of 12 test items. Crain et al. did not split up

the results according to subject and object relatives. In addition, subject relative clauses in the passive voice (e.g., *Pick up the pear that was hidden by the smurf.*) were counted as appropriate responses in the object relative clause condition. Therefore, it is not clear whether children as young as 2;8 produced object relatives target-like.

Sanfelici et al. (n.d.) investigated the elicited production of subject and object relatives in 114 typically developing, monolingual German-speaking children between age 3 and age 6 and in 21 adults. Sanfelici et al. used a picture supported elicitation task in which one experimenter and a blindfolded puppet were involved. The blindfolded puppet had to describe a picture by heart. Then, the child put a hat on one of two identical animals present. In the following, the puppet asked which animal was wearing the hat, and the child's task was to respond. An example test item from Sanfelici et al. to elicit an object relative clause is displayed in (6). It is presented together with the picture displayed in Figure 3.1. The expected response is given in (7).

(6) Here, there are two apes and one hare. The hare is stroking one ape and he is biting one ape. Which ape is wearing the hat?

Figure 3.1.: Example picture of Sanfelici et al. (n.d.).

(7) Der Affe, den der Hase beißt.
the-NOM ape-NOM that-ACC the-NOM hare bites

'The ape that the hare is biting.'

The results show a clear contrast between the amount of target-like productions in the conditions eliciting subject and direct object relative clauses (24 items each). Children at age 3 produced subject relatives already in 26% of items. With age, the number of target-like responses increased: 67% at age 4, 73% at age 5 and 80% at age 6. Adults produced subject relative clauses target-like in 89% of items. In the object relative condition, target-like responses ranged between 5% at age 3 and 11% at age 6. Adults performed below the children's groups with 3% of correct object relative clauses. Comparable to the results of Crain et al. (1990), 35% of the responses in the 3-year-olds consisted of pointing to the respective animal. Unlike in Crain et al. (1990), these children were not excluded

from the analysis. At age 4, children pointed in only 3% of items instead of producing a subject or object relative clause. Instead of object relatives, children and adults frequently resorted to the production of subject relatives. Either they produced subject relatives in the passive voice, a pragmatically appropriate strategy, or they produced erroneous subject relative clauses with reversed thematic roles.

The production of subject and object relative clauses of older children was investigated by Adani et al. (2013). Adani et al. elicited relative clauses from 43 German-speaking children aged 5 to 9 and from 12 adults. In the design based on Zukowski (2009), intransitive subject relatives in addition to transitive subject and object relative clauses were elicited. Compared to the results of Sanfelici et al. (n.d.), the number of target-like subject relative clauses was slightly lower at age 5 and 6, both in intransitive subject relatives (62% correct at age 5, 80% at age 6-7, and 79% at age 8-9) and transitive subject relative clauses (54% at age 5, 70% at age 6-7, and 77% at age 8-9). Adults were at ceiling with 96% and 98% of target responses in both subject relative conditions. Nevertheless, the subject-object asymmetry was clearly present. Object relative clauses were produced target-like in 17% of items at age 5, in 24% of items at age 6-7, and in 19% of items at age 8-9. German-speaking adults produced object relative clauses in this study in 58% of items. The most frequent avoidance strategy, as in Sanfelici et al. (n.d.), were subject relative clauses in the passive voice. For children Adani et al. report lower rates of passive sentences, 3% in the 5-year-old children, 12% in children aged 6-7, and 31% at age 8-9, since more target-like object relatives were produced. Adults produced passive subject relatives in 40% of object relative clause items.

The German data show that object relative clauses are frequently avoided by the use of subject relative clauses in passive voice. Similar findings are reported for Italian (Belletti & Contemori, 2012). In languages like Hebrew, which do not use passive subject relative clauses as avoidance strategy, object relative clauses are produced target-like at the age of 7 (Novogrodsky & Friedmann, 2006). To date, it is an open question why object relative clauses are avoided at different rates in elicited production tasks within and across languages.[4]

The subject object asymmetry has also been frequently investigated in the comprehension of restrictive relative clauses. Children's interpretation of relative clauses has been assessed using picture-selection and act-out tasks. The children's task is to select the picture that matches the subject or object relative clause stimuli (see Costa, Friedmann, Silva, and Yachini (2015) and Costa et al. (2014) for the comprehension of oblique relatives). A minimal pair to investigate subject and object relatives in Hebrew is given in (8a) and (8b) taken from Friedmann et al. (2009).

(8) a) Tare li et ha-para she-menasheket et ha-tarnegolet.
Show to-me ACC the-cow that-kisses ACC the-chicken

'Show me the cow that is kissing the chicken.' (subject relative)

[4]Belletti and Rizzi (2013) argue that the preference for passive subject relative clauses in place of object relatives can be explained by their syntactic derivation. The authors propose that the derivation of passive subject relatives avoids structural intervention in terms of Relativized Minimality (Rizzi, 1990, 2004).

b) Tare li et ha-pil she-ha-arie martiv.
Show to-me ACC the-elephant that-the-lion wets

'Show me the elephant that the lion is wetting.' (object relative)

The results of a variety of studies show that subject relative clauses are comprehended target-like between 4 and 5 years of age in different languages (see Table 3.2). In contrast to the good performance in the subject relative conditions, the comprehension rates for object relatives stay at chance level up to age 6 or 7 (e.g., Friedmann & Novogrodsky, 2004, Friedmann et al., 2009, Arosio et al., 2012). In the following, two studies are summarized exemplarily (Adani, 2012; Friedmann et al., 2009).

Friedmann et al. (2009) tested 22 Hebrew-speaking children aged 3;7 to 5;0 with both a picture-selection task and an act-out task on sentences as in (8). Independently of the method, all children were above chance-level in the comprehension of subject relative clauses. At a group-level, children interpreted 92% of subject relatives target-like in the picture-selection task. In the act-out task, 89% of items were interpreted correctly. In contrast, object relative clauses with two full lexical DPs were interpreted in 70% of items correctly in the picture-selection task. In the act-out task, only 38% of items were interpreted target-like at age 3;7 to 5;0. As a group, the results in the object relative clause condition were not different from chance-level.

Adani (2012) used a picture-selection task to test 19 4-year-old and 19 5-year-old German-speaking children. The interpretation of relative clauses was tested varying the animacy of the head noun and of the relative clause internal DP as illustrated in (9a) to (9c). At age 4, children interpreted transitive subject relative clauses as in (9a) in 82% of items correctly. At age five, performance increased to 89%.

(9) a) Welche Farbe hat der Mann, der den Jungen kratzt?
Which color has the man who-NOM the-ACC boy scratches?

'Which color is the man that is scratching the boy?'

b) Welche Farbe hat der Mann, den der Junge kratzt?
Which color has the man who-ACC the-NOM boy scratches?

'Which color is the man that the boy is scratching?'

c) Welche Farbe hat der Pulli, den der Mann kratzt?
Which color has the pullover who-ACC the-NOM man scratches?

'Which color is the pullover that the man is scratching?'

Compared to the subject relative clause condition, Adani reports correct interpretations in 41% of object relative clauses with two animate DPs as in (9b) for 4-year-old German-speaking children. When the head noun was inanimate, as in (9c), comprehension rates increased to 62%. At age 5, object relative clauses with two animate DPs were still at 41%. In addition, the performance in the condition with inanimate heads remained at a chance level with 43% of correct interpretations.

In sum, these studies show that the interpretation of restrictive relative clauses develops almost in parallel to the production data. Subject relative clauses are interpreted target-like between age 4 and 5. In addition, the asymmetry between subject and object relative clauses has been corroborated with respect to comprehension.

Regarding the acquisition of restrictive and appositive relative clauses it is important to note that the majority of studies listed above investigated restrictive relative clauses in production and comprehension. Elicited production tasks as used in Crain et al. (1990), Sanfelici et al. (n.d.), and Adani et al. (2013) usually contrast two potential referents as heads for the relative clause. This methodology dates back to Hamburger and Crain (1982). They argued that relative clauses can be elicited when the testing procedure is natural and the felicity conditions for the production of restrictive relative clauses are met. Therefore, it is necessary to contrast two potential referents as heads for the relative clause to establish a restrictive setting. In addition, the production of the child should be informative in the context of the experiment. These considerations have led to different experimental implementations. Hamburger and Crain (1982) and Crain et al. (1990), for example, developed an experimental set-up in which a story was acted out in front of the child. The story involved one out of two identical objects or characters present, e.g., one of two motorcycles pushing a horse (Hamburger & Crain, 1982; Crain et al., 1990). Pérez-Leroux (1995) used picture cards instead of the act-out procedure. Two different situations involving the same characters were depicted and presented to the child. In both designs, one experimenter got blind-folded after the characters or pictures were presented. Pointing to a picture or character in front of the child, e.g., the motorcycle that was pushed, a second experimenter prompted the child to describe the character to the blind-folded experimenter. The second experimenter then had to select the picture or character according to the child's description.

Novogrodsky and Friedmann (2006) modified the task to elicit relative clauses without the support of pictures or scenes. As before, two potential referents were contrasted. An example to elicit a subject relative is given in (10), an example to elicit an object relative is displayed in (11).

(10) There are two children. One child gives a present, the other child receives a present. Which child would you rather be?
Target response: I would rather be the child that receives a present.

(11) There are two children. The father combs one child, the barber combs another child. Which child would you rather be?
Target response: I would rather be the child that the father combs.

The most natural way to describe the selected character appropriately in all these tasks is to use a restrictive relative clause. Based on the results of the studies, however, it is an open question whether children at this age differentiate between restrictive and appositive relative clauses. Moreover, it has not been clearly shown that children apply a restrictive interpretation to the relative clauses produced or processed in the restrictive settings. Hamburger and Crain (1982) hypothesize that a change of the experimental setting to elicit appositive relative clauses may reduce the overall rate of relative clause

productions. In a scenario with only one suitable referent, the relative clause would not be necessary and may therefore be omitted. This aspect will be addressed in the following, where studies that focus explicitly on restrictive and appositive interpretations of relative clauses are presented.

3.3. Studies on the meaning of relative clauses in acquisition

While the acquisition of subject and object relatives is well understood, only few studies investigated the semantic properties of relative clauses. Up to now, there are no studies that contrast the interpretation or production of restrictive and appositive relative clauses. This section focuses first on studies that may have tested the interpretation of non-restrictive relative clauses without explicitly addressing this aspect (de Villiers et al., 1979; Sheldon, 1974). Subsequently, two studies are presented that focus explicitly on the acquisition of restrictivity in English relative clauses (Fragman, Goodluck, & Heggie, 2007; Trueswell, Sekerina, Hill, & Logrip, 1999). Furthermore, a pilot study by Verbuk (2006) is summarized, which investigated properties of appositive relative clauses in English. Up to now, no studies on the semantic functions of restrictivity and appositivity have been conducted in German.

As discussed in Section 3.2, studies exploring syntactic properties of relative clauses mainly focused on restrictive relative clauses. Hamburger and Crain (1982) discussed the possibility that some of the earliest studies investigating the acquisition of relative clause comprehension may have tested non-restrictive relative clauses. The studies of de Villiers et al. (1979) and Sheldon (1974) investigated the comprehension of relative clauses using an act-out procedure. These studies focused on potential differences resulting from center-embedded and right-branching relative clauses in addition to the influence of different syntactic functions relativized in the subordinate clause. In contrast to the studies described in Section 3.2, de Villiers et al. (1979) and Sheldon (1974) gave the children only one toy animal of each type to act out sentences as in (12) (de Villiers et al., 1979, p. 507).

(12) a) The gorilla that bumped the elephant kissed the sheep.
b) The turkey that the gorilla patted pushed the pig.

Thus, the experimental set-up in these studies did not offer a restrictive setting for the interpretation. This was already noted by de Villiers and colleagues. The authors state that as a consequence of their procedure the relative clauses have to be non-restrictive. In these two studies, thus, different cues compete: Despite the non-restrictive context, the complementizer *that* was used in the stimuli, which is claimed to allow a restrictive interpretation only (see Section 2.2.2). According to Hamburger and Crain (1982), this clash may have led children to not act out the relative clause because it was not necessary for the main clause proposition to be true.

In the two studies, the rates of target-like comprehension for stimuli as in (12) were lower than in subsequent experiments that used a restrictive setting (Hamburger & Crain,

1982). In the study of Sheldon (1974) children between 3 and 5 years were tested. Subject relative clauses were acted out correctly in less than 60% of items at age 5 (compared to rates around 90% in tasks with restrictive settings). The rates for object relatives were below 40% in 5-year-old children, which is only slightly below the performance of children in restrictive settings. De Villiers et al. (1979) tested 114 children between age 3 and 6. The results were coded differently than in the studies reported in Section 3.2. The authors did not report scores for correct or nontarget actions as the other studies. Instead, the performed actions were coded as correct or incorrect for the matrix clause and the relative clause independently of each other. In addition, de Villiers et al. did not split up the results for the different age groups. Their results show that subject relatives were interpreted correctly at a maximum in 46% (independent of the correctness of the matrix clause action). Similarly, object relative clauses were acted out target-like in 44% of items independent of the correctness of the matrix clause. Although the results are not directly comparable to the other studies, de Villiers et al. (1979) observed lower comprehension rates for subject relative clauses as studies with restrictive settings.

What is more, de Villiers et al. (1979) report that no child acted out the relative clauses sequence before the matrix clause action. The authors assume that a restrictive relative clause in stimuli as (12) is presupposed and should be acted out before the matrix clause assertion. In their sample, children did not follow this conceptual order but followed the order in which the actions were mentioned. According to de Villiers et al., this could be seen as an indicator that the relative clause was interpreted as a separate proposition. This would be in line with an appositive reading of the relative clause. Hamburger and Crain (1982), implementing a restrictive setting, argue that children in his study frequently followed the conceptual order and acted out the relative clause before the assertion of the matrix clause[5]. These observations may be taken as evidence that the relative clause stimuli from de Villiers et al. (1979) were perceived as appositive relatives. As a consequence, these results may show that appositive relative clauses are comprehended target-like to a lower extent than restrictive relative clauses in children.

This conclusion, however, is questioned by the study from Eisenberg (2002). Eisenberg addressed the question whether a felicitous context with two potential referents improves the interpretation of restrictive relative clauses marked morphologically by the complementizer *that* in 3- to 4-year-old English-speaking children. Eisenberg compared contexts with one or two animals of the same type in an act-out task. She investigated center-embedded and right-branching subject relative clauses as in (13a) and (13b) with two characters being involved.

(13) a) The cow that touched the pig jumped over the fence.
b) The cow touched the pig that jumped over the fence.

As de Villiers et al. (1979), Eisenberg (2002) coded the actions performed in accordance with the matrix clause and the relative clause independently of each other. Both types of complex sentences displayed in (13a) and (13b) were acted out correctly at a maximum

[5]Hamburger and Crain (1982) assume that since restrictive relative clauses are presupposed, they do not need to be acted out in general.

of 54% of items. The results do not show any effect triggered by the number of referents available in the context. These results can be interpreted in two ways. Either restrictive and appositive relative clauses are interpreted correctly at the same rate by 3- to 4-year-old children. Or, children interpret relative clauses introduced by *that* restrictively independently of the felicity of the experimental set-up. I.e., children may interpret the relative clause introduced by *that* as an restriction on the set of referents denoted by the head noun, independently of whether the set contains one or more potential referents.

Trueswell et al. (1999) explored the acquisition of restrictive modifiers explicitly. Trueswell et al. followed up the assumptions of Hamburger and Crain (1982) to establish natural and felicitous contexts in experimental designs. In contrast to the studies reported so far, Trueswell et al. investigated attachment preferences for temporary ambiguous prepositional phrases in 5-year-old English-speaking children. The task was comparable to the one used with adults reported in Tanenhaus et al. (1995) and Eberhard et al. (1995), summarized in Section 2.6. Therefore, Trueswell et al. (1999) directly compared the results of this study with the ones reported previously for adults. An example stimulus of Trueswell et al. (1999) is displayed in (14a).

(14) a) Put the frog [on the napkin] in the box. (temporary ambiguous)
b) Put the frog [that's on the napkin] in the box. (unambiguous)

Recall that the prepositional phrase *on the napkin* in (14a) may be interpreted as a modifier of the subject *the frog*, or it may (temporarily) be part of the destination of the action. Like in the eye-tracking study by Tanenhaus et al. (1995), restrictive relative clauses in (14b) served as an unambiguous control condition. In both studies, the relative clause always modified the preceding subject DP. Eight sentences per condition were presented in two different visual contexts. In parallel to the study with adults, Trueswell et al. (1999) used a restrictive, 2-referent context and a non-restrictive, 1-referent context. The restrictive setting involved two frogs, one of them on a napkin, an empty napkin, and an empty box. In the 1-referent context only one frog, which sat on a napkin, was present. The second frog was replaced by another toy animal. Varying the visual context, Trueswell et al. (1999) investigated whether a restrictive setting guides children's interpretations towards a subject modification reading, as found for adults. According to Hamburger and Crain (1982), the visual context should influence the results.

Sixteen 5-year-old children had to perform the action according to the instruction. In addition to their actions, eye-movements were recorded. For Trueswell et al. (1999), fixations of the empty napkin were relevant as they indicate a nontarget-like interpretation of the prepositional phrase *on the napkin* as the destination of the action. When the PP was interpreted as the destination of the action, it was not correctly interpreted as a (restrictive) modifier of the subject.

The results of Trueswell et al. (1999) show that the temporary ambiguous prepositional phrases (PPs) were interpreted differently from restrictive relative clauses in 5-year-old children. In the temporary ambiguous PP condition, the eye-tracking data showed that children fixated the empty napkin in 70% of trials. On the contrary, children looked to

the empty napkin in only 35% of trials with the unambiguous relative clause in the 1-referent context. Similar results were obtained for the 2-referent context. Thus, for both types of stimuli, the number of referents in the context (1 vs. 2) did not influence the results significantly. The contrasting interpretation patterns for PPs and relative clauses were even more prominent in the results of the action analysis. Children performed an incorrect action in approximately 60% of trials involving the ambiguous PP, i.e., they did not move the frog that was sitting on a napkin to the target position, but for instance moved the other frog first onto the empty napkin and then in the box. In contrast, only 3% of actions in the relative clause condition were incorrect. Again, the context (1-referent vs. 2-referent) did not influence the performance of the children.

The results of the adult control group showed a different pattern. Like children, adults fixated the empty napkin as an incorrect destination in more than 60% of the PP trials with one referent. In the corresponding relative clause condition, incorrect fixations were only found in 10% of trials. Thus, in contrast to the children, adults interpreted the unambiguous relative clauses more often as modifiers of the preceding noun. Unlike the children, adults showed sensitivity to the number of potential referents in the context. The proportion of incorrect fixations in the PP condition dropped to less than 20% in the 2-referent context. In contrast, fixations to the empty napkin in the relative clause condition remained at 10%. A second difference between children and adults regarded the results of the action analysis. Despite 60% of fixations to the empty napkin in the temporarily ambiguous PP condition, adults moved the object incorrectly in less than 20% of trials.

These results show that children interpreted relative clauses as modifiers in 97% of items. Thus, they can use relative clauses to determine the reference of a noun phrase at age 5. Furthermore, the interpretation as a modifier is found independently of the felicity of the context, comparable to the results of Eisenberg (2002). This is further evidence that 5-year-old children know the syntactic function of the complementizer *that*. Based on these results, it is still an open question whether the complementizer *that* is systematically interpreted as introducing a restrictive relative clause. An appositive interpretation of the relative clause, as shown in (15), would also be compatible with the results.

(15) Put the frog, [which is by the way on the napkin], in the box. (appositive)

In this context, appositive as well as restrictive relative clauses require that the respective frog is positioned on a napkin. This requirement is fulfilled in the experimental setting of the study. As long as restrictive relative clauses are investigated in isolation, the results cannot be taken as clear evidence that children apply a target-like semantic interpretation to the sentences.

Another important aspect of the results is the observation that the fixation pattern of the children differs from the action pattern with regard to relative clauses. Although children initially look to the incorrect destination, i.e., the empty napkin, their actions demonstrate that they arrive at a modifier interpretation for the relative clause. In contrast, prepositional phrases are misinterpreted as the destination of the action in more

than half of the items, and the subsequent actions mirror the fixations to the incorrect destinations. These differences have consequences for the underlying processing patterns assumed for children. The incorrect fixations may be taken as evidence that relative clauses are initially considered as destinations and not as modifiers of the preceding referent. The action patterns show that this wrong initial parse is reanalyzed and the relative clause is attached target-like as a modifier. This assumption finds further support in the eye-movement results. As soon as the disambiguating word *napkin* was perceived in the relative clause, children fixated the target animal significantly more often than the wrong destination.

In the condition with PPs, no overt morphological cue was present to initiate a reanalysis. In these cases, children's fixations alternated between the two frogs. Moreover, children frequently selected the frog that they fixated first. This indicates that in the ambiguous PP condition, children walked down a garden-path and were not able to revise the syntactic structure. Consequently, children performed an incorrect action. The results demonstrate that children selected the correct frog in only 10% of trials in which they misinterpreted the PP as the destination of the action and fixated the empty napkin. The majority of children, however, maintained their incorrect interpretation and moved the incorrect referent: the frog that was not on the napkin. This happened in 60% of trials.

The second difference between the fixation patterns of children and adults regards the influence of visual context. Trueswell et al. (1999), in line with the results of Eisenberg (2002), did not find an effect for the restrictive or non-restrictive context. Thus, the presence of an alternative referent did not facilitate the integration of the PP as a restrictive modifier. In contrast, both, relative clauses as well as PPs were interpreted similarly in both visual conditions as a destination of the action. This finding is contrary to the assumptions raised in Hamburger and Crain (1982) that a felicitous restrictive context is necessary for target-like performances. In addition, the results differ form findings for adults reported in Eberhard et al. (1995) and Tanenhaus et al. (1995) in this respect.

According to Meroni and Crain (2011), the lack of context effects found in Trueswell et al. (1999) for the attachment of temporary ambiguous PPs may be attributed to methodological issues and processing decisions. Meroni and Crain replicated the experiment of Trueswell et al. (1999) for the PP conditions, but changed the procedure such that the children had to turn away from the visual display while listening to the stimulus sentence. Twenty-two English-speaking children between 3 and 5 years were tested in a 2-referent context. In addition, 12 children in the same age-range were tested in a 1-referent context. The modification of the procedure led to an increase of children's performance in the 2-referent context compared to the results of Trueswell et al. (1999). Children performed correct actions in 92% of trials in the 2-referent context for prepositional phrases. In contrast, incorrect actions were observed in 52% of trials in the 1-referent context. This is comparable to the results of Trueswell et al. (1999), who reported 60% of incorrect actions in this condition.

Meroni and Crain (2011) conclude from the improved performance in the replication of Trueswell et al. (1999) that children are able to use the visual context to decide how

a linguistic stimulus is interpreted. When two potential referents are available, children use the linguistic information about a potential modifier to choose between them. To uncover this ability in children, it is necessary to prevent them from executing the action immediately. The comparison of the data of Meroni and Crain and Trueswell et al. show that the majority of children cannot recover from an incorrect decision in the parsing process when they have to react before they have listened to the complete stimulus.

Differently from previous studies (de Villiers et al., 1979; Sheldon, 1974; Eisenberg, 2002; Trueswell et al., 1999), Fragman et al. (2007) investigated the semantic contribution of the relative complementizer *that*. In this study it was investigated whether children between age 3 and 6 know that relative clauses introduced by *that*, in contrast to relatives introduced by a *wh*-pronoun, cannot modify proper names. In addition, Fragman et al. investigated whether children and adults allow the extraposition of restrictive and appositive relative clauses. In English, only restrictive relative clauses can be extraposed. This is used in the experimental design (see (16) below). To test children's knowledge on the restrictivity of *that*-relatives, Fragman et al. used an act-out task in four different experiments. The experimental setting was similar in all four experiments. Three pairs of animals were arranged in a circle. One animal of each pair was a well-known character of a comic-strip and had a name, i.e., Pluto (a dog), Donald (a duck) and Champion (a horse). The children had to manipulate the arrangement according to a stimulus such as (16).

In experiment 1, the test sentences used the prompt *Put ...!*. In the second experiment the existential *There is* construction was used. In each experiment, Fragman et al. tested relative clauses under three conditions. As one variable, the type of the second DP was varied: DP Y was either an indefinite DP (labeled NP), as in (16a), or a proper name (PN), as in (16b). For sentences with proper names, additionally, the element introducing the relative clause was varied. Half of the sentence involved *that* and half *who* (see (16b) vs. (16c)).

(16) Put/There is [$_{DP}$ X] [$_{PP}$ near [$_{DP}$ Y]] [relative clause]

a) Put/There is a duck near a horse that's fallen over. (NP-*that*)

b) Put/There is a duck near Champion that's lying down. (PN-*that*)

c) Put/There is a horse near Pluto who's jumping around. (PN-*who*)

Fragman et al. (2007) analyzed children's actions assessing which NP, X or Y, the relative clause had been attached to. In the NP-*that* condition, the relative clause had to be attached the adjacent DP Y. In condition PN-*that*, the *that*-relative could only modify the first DP X. It could not be attached to the adjacent DP because this DP contained a proper name. The only possibility to interpret a relative clause like (16b) target-like would be an interpretation as an extraposed relative clause. The third condition, PN-*who*, was compatible with both attachment possibilities in principle. The relative clause could be interpreted restrictively as an extraposed clause or appositively when it modified the adjacent proper name.

With respect to the third condition, Fragman et al. assume that a processing constraint restricts the options for relative clause attachment. According to Fragman et al.,

the *who*-relative clause can only modify a non-adjacent DP if no other potential referent intervenes. Thus, a restrictive interpretation should not be possible in the test sentences like (16c) of the experiments because the proper name would be an intervening referent. According to the authors, this processing constraint, though, is not encoded in the grammar. Therefore, it may be violated by children in the acquisition process.

For experiment 1, 16 English-speaking children aged 3 to 5 (mean 4;9) and 16 adults were tested. Experiment 2 was carried out with another group of 15 children between age 3 and 6 (mean age 5;2) and 15 adults. The results show that children as well as adults modify an adjacent indefinite NP significantly more often than a proper name with a relative clause introduced by *that*. In condition NP-*that* in (16a), children manipulated the horse in up to 75% such that it fell down. In condition PN-*that*, the adjacent DP was a proper name. Here, children manipulated the corresponding referent of the proper name in 30% to 47% of items depending on the experiment. In addition, children distinguished the complementizer *that* from the relative pronoun *who*. Relative clauses introduced by *who* were attached to the adjacent proper name in 38% to 61% of items. A comparison between the matrix predicates *put* and *there is* indicated that the existential predicate reduced the tendency to attach the relative clause locally in all conditions. The existential predicate, thus, led to more target-like interpretations in the PN-*that* condition.

Fragman et al. argue that the difference between the three conditions indicates that 3- to 5-year-old children already know that relative clauses introduced by *that* can only be interpreted restrictively, and that a modification of a proper name is not possible. In contrast, children seem to know that relative clauses introduced by *who* can receive both restrictive and appositive interpretations. However, the data are not as clear as this conclusion may suggest. Children used *that*-relative clauses in up to 47% of items to refer back to a proper name. Moreover, adults attached *that*-relative clauses in sentences with the matrix clause predicate *put* to proper names to an even higher extend. Unexpectedly, a local attachment to the adjacent proper name was observed in 73% of items in the PN-*that* condition for adults. This incorrect attachment of a restrictive relative clause to a proper name dropped to less than 20% in the group of adults when the existential matrix clause predicate was used.

In the third experiment, Fragman et al. (2007) replicated Experiment 1 and 2 with prerecorded stimuli. This modification investigated whether the different results of Experiment 1 and 2 resulted from prosodic differences that depended on the matrix clause predicate. The stimuli were cross-spliced after the second syllable to eliminate possible prosodic differences. Therefore, the initial chunk *Put the* from the stimuli of Experiment 1 was continued with the part following *There is* from the stimuli in Experiment 2 and vice versa. The results were similar to those obtained in Experiment 1 and 2. Thus, the different interpretation patterns were not due to phonetic properties of the stimuli.

Additionally, Fragman et al. (2007) investigated whether the length of the pause between the matrix clause and the relative clause influences the attachment preference in children and adults. The authors claim that a long pause of 900 ms may favor appositive interpretations in terms of attachment to the adjacent proper name. A short pause of 200 ms could more likely lead to a restrictive interpretation. Only relative clauses introduced by *that* were used in the existential *There is* context in Experiment 4.

The results show that neither children's nor adults' preferences were influenced by the length of the pause between the matrix clause and the relative clause. Children as well as adults attached a relative clause introduced by *that* in about half of the items to an adjacent common noun phrase. When the adjacent DP was a proper name, children and adults avoided an attachment to the adjacent DP. Incorrect attachment to the proper name was found at a maximum of 23% across groups.

Summing up, the studies of Trueswell et al. (1999) and Fragman et al. (2007) indicate that children around age 5 interpret relative clauses as nominal modifiers. In addition, English-speaking children are sensitive to morphological cues, such as relative pronoun vs. complementizer, as markers of the semantic function of the clause. However, it remains open whether a developmental sequence can be observed in the acquisition of restrictivity and appositivity in 3- to 5-year-old children. In both studies, only group results were reported for the child participants. Therefore, it is an open question whether individual differences can be found in the participants' groups with regard to interpretation preferences. Moreover, it is unclear whether these results can be transferred to German. In contrast to English, the relative pronoun in German does not differ depending on the semantic function of the clause. Thus, no comparable morphological cue is available for German-speaking children.

The studies of Trueswell et al. (1999) and Fragman et al. (2007) focused mainly on restrictive relative clauses. A study that explored properties of appositive relatives is reported in Verbuk (2006). Verbuk investigated the acquisition of supplementary expressions in the multidimensional framework of Potts (2003, 2005) in an exploratory pilot study. She tested whether children can recover the at-issue proposition of the main clause if the content of the appositive relative clause turned out to be false in an unfolding story. Verbuk assumes that the truth or falsity of appositive relative clauses as conventional implicatures is computed independently of the truth value of the main clause proposition. When the content of the implicature is false, as indicated by a correction of the speaker or hearer, the proposition of the complex sentence may nevertheless be computed, and thus be true in a given context. If, in contrast, the relative is interpreted restrictively, the truth-value of the matrix clause proposition should be undefined when the relative clause content is false.

In the study, Verbuk tested 16 5- to 10-year-old English-speaking children on 9 to 11 scenarios including different supplementary expressions. The task involved two relative clause test items. In the item in (17), the relative clause was attached to a proper name. Another item investigated the attachment of an appositive relative clause to a definite description like *the boy with red hair*. In addition, Verbuk tested different types of adverbials, another class of supplementary expressions involving a multidimensional semantics according to Potts (2003, 2005). The adverbial test conditions are not addressed here.

(17) The Drawing Scenario
One day, Mark's little sister Julie, who was four, decided to draw a picture of her favorite doll. She wanted Mark to help her but he didn't feel like drawing dolls. He wanted to draw an airplane. Mark and Julie's room was really messy and, at first, they couldn't find any pencils. Mark and Julie started to look for pencils under the

table. When they finally found some pencils, they started to draw. Mark drew an airplane in blue pencil. Little Julie, who found a pink pencil, drew a pink Barbie doll. When she was finished, she gave her pencil back to Mark. Oh, wait, she gave her pencil back to Mark because Mark was the one who found both pencils under the table. Julie didn't find the pencil herself.

a) Who drew the Barbie doll?
The Adult Response: Julie.

b) Who found a pink pencil?
The Adult Response: Mark.

The results show that children answered the questions more often correctly when the relative clause was attached to a proper name instead of a common noun (81% vs. 50%). An individual analysis showed that an appositive interpretation was already available for the youngest children at age 5 in the unambiguous context of the proper name. In the item with the common noun, target-like responses can only be found in 8 children at age 6 and older. Here, children seemed to have more difficulties to apply a (multidimensional) appositive semantics. To explain the error patterns, Verbuk (2006) argues that children mainly apply a single dimensional semantics before they acquire the multidimensional semantics of appositives. Either the relative clause content is interpreted as an independent assertion or as a restrictive relative clause. In case of the assertion, children assume the relative clause content to be true, although it was falsified in the story. This pattern was observed for 4 children in the item with a common noun head. In addition, Verbuk states that two children misinterpreted the appositive relative clause as a restrictive relative clause in this condition.

There are several weak points associated with this study. As Verbuk states herself, the results should be interpreted with care due to the low number of items and participants. In addition to these limitations, another factor may have influenced the results. Some variation in the results of Verbuk (2006) may also be due to the differences in the two experimental items. In the item with a common noun antecedent, children had to evaluate a statement of the experimenter by answering a *yes-no*-question. In item (17), in contrast, they had to answer a *wh*-question. Furthermore, some questions remain with regard to the result's interpretation. Verbuk took a negation of the relative clause content as evidence for a restrictive interpretation. It seems questionable whether this analysis correctly captures the interpretations of the children. In general, it remains unclear which properties of appositive relative clauses these items really test. As Verbuk states in her introduction, a general property of supplementary expressions is that they cannot be cancelled as easily as presuppositions and conversational implicatures. Instead, as with assertions made by main clauses, the content of the appositive relative needs to be corrected by the speaker or the hearer. Even if children analyzed the appositive relative as an independent assertion, this assumption should nevertheless be corrected by the unfolding story. Thus, these items may have rather tested the sensitivity of children to corrections than knowledge about the recoverability of the main clause assertion in cases of falsified appositives.

Taken together, conclusive results regarding the acquisition of relative clause semantics have been obtained mainly for restrictive relative clauses. Trueswell et al. (1999) and Fragman et al. (2007) showed that 3- to 5-year-old children in principle know that relative clauses introduced by *that* are interpreted restrictively and cannot be attached to proper names. However, 3- to 5-year-olds still differed from adults in these respects regarding the percentage of correct interpretations. Whether appositive relative clauses are acquired later than restrictives is still an open question. Some studies that elicited relative clauses in an appositive experimental setting yielded lower rates of target-like relative clauses than studies using a restrictive setting. This may indicate difficulties with appositives on the one hand or pragmatic knowledge on the other hand because appositive relative clauses may be interpreted as comments that are irrelevant for the identification of a referent. Importantly, based on the results obtained up to now it remains open which interpretation children apply to relative clauses in a 1- or 2-referent setting. Direct comparisons of restrictive and appositive settings to elicit relative clauses have not shown effects of the context (Eisenberg, 2002). That is, the number of potential referents in the experimental context did not influence the rate of correct productions in the children's groups. In addition, the data of Fragman et al. (2007) showed that prosodic markers like pauses separating the relative clause from the matrix clause do not increase the number of appositive interpretations in children. Regarding the acquisition of appositive relative clauses, the results from Verbuk (2006) suggest that children can compute the semantics of unambiguous appositive relative clauses at age 5.

Up to now, no study explicitly contrasted restrictive and appositive relative clauses. Therefore, it remains an open question when and in which order the semantic functions of restrictivity and appositivity are acquired. Section 2.3.3 pointed to the tight relation of relative clauses and adjectives as nominal modifiers. Both types of modifiers can receive restrictive and appositive interpretations. Therefore, the following section focuses on the acquisition of adjectives and their semantic properties to enlarge the background for the experimental part of this thesis. In addition, the experimental design of studies reported in the following section formed the basis for the experiments reported in Chapter 5 to 7.

3.4. Studies on the acquisition of related phenomena

This section reports studies investigating the acquisition of restrictivity and appositivity in adjectives. As summarized in Section 2.3.3 similar proposals have been argued for to capture the semantic functions of relative clauses and adjectives as nominal modifiers. Therefore, the acquisition of restrictive and appositive readings for adjectives may allow insights transferrable to the acquisition of the semantic functions of relative clauses. Moreover, the studies reported in the following Section (3.4.1) form the basis for the development of the experiments reported later in this thesis. The studies exploring the semantic functions of adjectives used a design to contrast restrictive and appositive readings that was adapted to investigate relative clauses. In Section 3.4.2, previous research on the acquisition of discourse anaphora is summarized. According to Del Gobbo (2003, 2007) and De Vries (2006), appositive relative clauses are analyzed as independent propo-

sitions and are introduced by an anaphoric d-pronoun. For the acquisition of appositive interpretations, therefore, the interpretation of discourse anaphora may be a relevant prerequisite.

3.4.1. Acquiring the semantics of adjectival modification

The interpretation of adjectives has not been investigated in detail regarding acquisition. Four studies addressed the acquisition of restrictive adjectives (Hamburger & Crain, 1984; Marcilese, Corrêa, & Augusto, 2013; Matthei, 1982; Roeper, 1972). The starting point for this series of studies was the question when children acquire recursive structures. To address the acquisition of structural embedding, sequences of adjectives like *the second green ball* were investigated. To derive a restrictive interpretation of the phrase, the ordinal number words needs to restrict the set of green balls. The ordinal number *second* has to scope over the complex nominal *green ball*, in which *green* restricts the denotation of *ball*. Thus, a restrictive interpretation requires recursive embedding of the two modifiers as illustrated in (18).

(18) [second [green [ball]]] (Recursive structure)

Roeper was the first to investigate the acquisition of these recursive structures in his dissertation. An array of balls, as in Figure 3.2, was paired with two different prompts. These are shown in (19) and (20).

Figure 3.2.: Visual context for *second green ball* (Roeper, 1972, p. 85).

(19) Show me the second green ball.

(20) Show me the second brown ball.

Using two items per child, Roeper (1972) piloted whether German-speaking children between the age of 3 and 5 interpret the sequence of adjectives as restrictive modifiers.[6] To select the second green ball, i.e., ball no. 6, the ordinal number *second* has to modify the set of green balls. In principle, an appositive, or as Roeper calls it, a conjoined interpretation is possible as in *second, (and) green ball* illustrated in (21).

(21) [[second green] [ball]] (Conjoined structure)

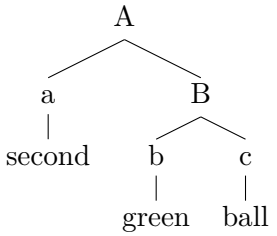
[6] Roeper (1972) tested the acquisition of adjective sequences in German-speaking children but reports only English translations of the experimental stimuli.

To license this reading, the two adjectives need to be separated by a comma or an *and*. In the appositive case, both adjectives modify the noun *ball* without being ordered hierarchically.

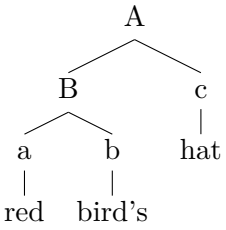
For the item in (19) above, Roeper (1972) reports a variety of different response patterns. Unfortunately, no comprehensive overview of the results is given. Roeper summarizes that 7 out of 24 children (29%) wrongly pointed at the second ball of the array with both verbal instructions in both items. According to Roeper, these children applied a conjoined, unembedded structure for the adjectives although a comma intonation was absent. Four other children erred on the prompts in (19) by choosing ball no. 2 in both items, but pointed correctly to the second brown ball with the instruction in (20). In case of *the second brown ball* the array of objects did not match a conjoined interpretation. Here, only the restrictive reading was supported by the visual context. A third group of 4 children seemed to learn from the prompt in (20). These children chose ball no. 2 in the first item. Then they selected the target ball according to the prompt in (20). In the second item, then, these four children pointed at the correct balls for both kind of instructions.

Matthei (1979) investigated the interpretation of adjective sequences on the basis of Roeper's findings in more detail. The results of his thesis have been published in Matthei (1982). Matthei explored the source of difficulties that lead to conjoined interpretations in children. The question was whether the preference for flat, unembedded structures results from working memory load associated with the structural parsing, from recursive structures in which a node dominates itself, or from some general bias to prefer flat structures. Therefore Matthei contrasted structures of type a) and b), displayed in (22).

(22) a)



b)



In addition, Matthei addressed the question whether children assume all adjectives to be intersective at an early stage of the acquisition of adjective semantics. This could be another explanation for the conjoined interpretations reported in Roeper (1972). If ordinal numbers were classified as intersective instead of being interpreted relative to the following noun phrase, a conjoined meaning is predicted to arise independently of the syntactic structure. This is the reason, why Matthei does not use the label *conjoined meaning* but classifies these interpretations as *intersective*.

Matthei tested 35 English-speaking children evenly distributed across an age range from 3;9 to 6;3 with a mean age of 5;1. All children performed target-like in a pretest on the prerequisites for the adjective tasks. Children were tested on counting objects in a left-to-right direction, as well on counting objects of subgroups. Furthermore, the knowledge of the ordinal numbers *second* and *third* was ensured. In addition to the child

participants, 10 adults were tested as control group. The experiment consisted of 6 sub-experiments, of which only Experiment 1, 2, and 3 will be discussed in detail here. The items of all sub-experiments were completely randomized.

Experiment 1 was a replication of Roeper (1972). Two different types of phrase-array pairs were tested. The *biased condition* corresponds to the *second green ball* condition by Roeper in (19) and Figure 3.2. The objects in the array matched both the restrictive target interpretation as well as the intersective interpretation. In the *unbiased condition*, corresponding to the Roeper's prompt *second brown ball* only the restrictive interpretation matched the array of objects. An example for this condition is given in (23) in combination with Figure 3.3. Four items were constructed in each condition. In both conditions, half of the items used color words as the second adjective, and half of the items used contrasts between big and little objects in combination with the ordinal number word.

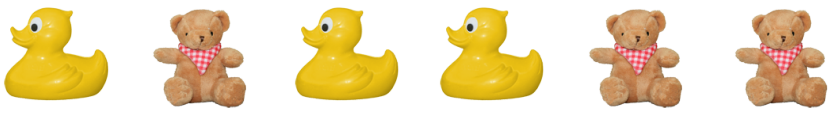
(23) Show me the second green car.

1 2 3 4 5 6

Figure 3.3.: Unbiased visual context of Experiment 1 by Matthei (1979, p. 38).

In Experiment 2, the linguistic stimulus was simplified but the cognitive demands were kept comparable to Experiment 1. As shown in (24), the prompt included only one nominal modifier, the ordinal number word. The cognitive task, to count within a subgroup of elements displayed in the visual array, was kept constant because two different types of objects were intermixed. Parallel to Experiment 1, a biased (Figure 3.4) and unbiased visual context (see Figure 3.5) was supplied.

(24) Show me the second teddy.



1 2 3 4 5 6

Figure 3.4.: Biased visual context of Experiment 2 by Matthei (1982, p. 306).

The results show that 3- to 6-year-old children pointed at the *second green ball* correctly, i.e., restrictively, in 46% of items in the biased condition of Experiment 1. The

Figure 3.5.: Unbiased visual context of Experiment 2 by Matthei (1982, p. 306).

rate of correct pointing increased in the unbiased condition to 63%, as was reported by Roeper (1972) in the pilot study with German-speaking children. Also comparable to Roeper's results, Matthei reports 52% of intersective interpretations in the biased condition. In the unbiased condition, no corresponding picture for the intersective interpretation was present. Nevertheless 22% of the responses were coded as intersective because of comments supplied by the children. Due to the restrictive prosodic contour, Matthei argues that these interpretations should not be classified as appositive. In the absence of a comma intonation, the intersective interpretations should be analyzed as corresponding to an unembedded, conjoined syntactic structure.

In comparison to Experiment 1, the results of Experiment 2 show an increase in the rate of correct interpretations in the biased condition from 46% to 64% while intersective interpretations decreased from 52% to 36%. In the unbiased condition, the results were comparable to Experiment 1 (57% of correct picture selections and 22% of intersective interpretations based on the comments). Statistical comparisons of the two experiments yielded significant interactions of the factors 'Two versus One prenominal modifier' and 'Type of condition (biased vs. unbiased)' both, for correct interpretations and for intersective interpretations. This indicates that children had more difficulties to assign the restrictive interpretation in the biased condition of Experiment 1 than in any other condition. In addition, children applied the incorrect intersective interpretation in general more often when it was suitable for the visual array, i.e., in the biased condition. Nevertheless, the number of intersective interpretations in the biased condition were significantly lower in Experiment 2 than in Experiment 1. Furthermore, the rate of uninterpretable responses was significantly higher in the unbiased condition than in the biased condition for both experiments. This increase of uninterpretable responses in the unbiased condition may indicate that children were confused when the array was not suitable for an intersective interpretation.

Matthei argues that the drop of intersective interpretations in the biased condition of Experiment 2 points to linguistic problems associated with the two prenominal modifiers. Since the cognitive demands of identifying the relevant set of objects and then counting within this subgroup were comparable across the two experiments, the source for the problems in Experiment 1 can be linked to the linguistic stimulus. In both tasks only one subset of the displayed objects was relevant to interpret the ordinal number (Experiment 1: green balls, Experiment 2: teddies). The experiments differed only in the complexity of the linguistic term used to determine this subgroup. The higher rate of intersective interpretations, therefore, were linked to the more complex expression *green*

ball in contrast to the single noun *teddy*. Matthei (1982) interpreted the results in terms of a general preference for fewer hierarchical levels in the syntactic structure. Recursive structures as in the two modifier condition are avoided and 'flattened'. This conclusion is supported by the results of a third experiment on possessive structures as in (25).

(25) Show me the red bird's hat.

Children saw two pictures, one red bird wearing a blue hat and a differently colored bird with a red hat. Matthei predicted that children would point at the red hat of the differently colored bird when they preferred a flat syntactic structure. This is exactly what happened in the children's group. Matthei reported that the rate of correct responses, as well as the rate of intersective responses did not differ significantly from those of the biased condition in Experiment 1. Thus, children seemed to interpret left-branching possessive structures similarly to double adjective structures in an unembedded, conjoined way.

The high rates of intersective interpretations in all three experimental tasks point to general difficulties associated with the acquisition of nominal modifiers in 3- to 6-year-old children. Besides the complexity due to the presence of two prenominal modifiers, 36% and 22% of intersective interpretations in Experiment 2 cannot be assumed target-like. Unfortunately, the children's group were not split up according to different age groups. In addition, no individual analysis of participants' response patterns was performed. Therefore, it remains unclear whether there was an age-related development with regard to target-like interpretations, or intersective responses respectively. Thus, it remains an open question whether intersective responses were for instance limited to the younger participants. In addition, it is unclear whether these deviant interpretations were derived consistently by only some participants, or whether they were present in all children. Matthei suggests that there may be a stage in the acquisition process in which non-intersective modifiers are not yet interpreted relative to the following noun. Due to the lack of individual analyses, this assumption cannot be addressed based on the findings reported so far.

Hamburger and Crain (1984) modified the design of Matthei (1982). In the studies of Roeper (1972) and Matthei (1982), only one type of objects was displayed in the visual array. Hamburger and Crain argue that it is necessary to include an additional type of elements to fulfill the felicity conditions for restrictive interpretations of the phrase *the second green ball*. Their experimental set-up is displayed in Figure 3.6. According to Hamburger and Crain (1984), the instruction in (26), *Take the third green ball*, can receive three different interpretations. First, it can receive the target reading as in (26a). In this restrictive interpretation the ordinal scopes over the complex noun phrase *green ball*. Second, the prompt can be interpreted appositively as in (26b). The authors label this interpretation as head-set reading. In this case, balls are counted independently of their color, and the color adjective gives additional information about the third ball. For adults, this reading is available with a strongly pronounced comma intonation only. The third possible interpretation is the intersective reading, which is ungrammatical for adults. It is exemplified in (26c).

Figure 3.6.: Certigenic visual context from Hamburger and Crain (1984, p. 117).

(26) Take the third green ball.

a) Target reading (restrictive, no. 5): Take the third of the green balls.

b) Head-set reading (appositive, no. 4): Take the third (and), by the way, green ball.

c) #Intersective reading (no. 3): Take the third thing if it is a ball and green.

Based on this visual display, called *certigenic* condition, it is possible to disentangle all three readings. Therefore, it is possible to investigate the nature of nontarget-like interpretations in more detail. In the previous studies, intersective interpretations could not be distinguished from appositive readings. To investigate the nature of intersective interpretations it is especially interesting to differentiate these two readings. Both, Roeper (1972) and Matthei (1982), proposed that intersective interpretations indicate a non-hierarchical syntactic structure paired with a simple intersective semantics. In case of the visual array in Figure 3.6, it is possible to see from children's pointings whether they interpreted the ordinal number as a relational, non-intersective modifier (necessary for an appositive interpretation) or whether it is misanalyzed in a purely intersective way.

Hamburger and Crain (1984) tested eight items divided into three conditions. Two items were of the form displayed in Figure 3.6. In these items of the certigenic condition, all three interpretations were clearly distinguishable. In addition, three items were comparable to the biased condition used in the previous experiments. An example context for the instruction in (27) is given in Figure 3.7. In this so-called *ambiguous condition*, all three interpretations were depicted but the head-set reading was not distinguishable from the intersective one. The third, so-called *biased condition*, comprised items in which only the target interpretation was licensed by the visual context. Neither the appositive head-set reading nor the intersective reading matched the visual display, as exemplified in Figure 3.8. Note that Hamburger and Crain use the label *biased* for the condition that corresponds to the *unbiased* condition of Matthei (1982).

Hamburger and Crain (1984) introduced another additional factor into the experimental design. They investigated whether a so called handling procedure would reduce non-syntactic difficulties associated with the task. At the beginning of each item the experimenter asked the child to give him a certain number of objects from different piles. This procedure was meant to facilitate the selection of the target object because the child was expected to be aware of the presence of different subgroups. To investigate the effect of the handling procedure, children were assigned to one of three groups. For

(27) Take the third green ball.

Figure 3.7.: Ambiguous visual context from Hamburger and Crain (1984, p. 117).

Figure 3.8.: Biased visual context from Hamburger and Crain (1984, p. 117).

the Experimental Group 1 and for the Control Group the experiment was administered twice with an interval of one week. The Control Group carried out the experiment twice without a change in the procedure. In the Experimental Group 1, the handling procedure was introduced in the second session of the experiment. To ensure that potential effects of the handling procedure were not due to a repetition of the task, children in Experimental Group 2 were directly tested using the handling procedure. They participated in only one experimental session, which was identical to the second session of Experimental Group 1. Note, that the Session 1 in this experiment is closely comparable to the design of the studies conducted by Roeper and Matthei because a similar task was used.

In addition, Hamburger and Crain (1984) implemented a change in the general procedure compared to the previously conducted studies. Hamburger and Crain presented the sentence first, and only subsequently they showed the array of objects to the child. By this change, children were prevented from starting to look for an object before they have processed the complete linguistic stimulus. Fifty-nine children between age 4;5 and 6;2 were tested. Fourty-five children passed a pretest on color words, counting up to five, and on the meaning of the ordinal numbers *second* and *third*. Fifteen children were assigned to each group. The results are displayed in Table 3.3.

No statistical analysis was performed on the data. As one can see from the table, the results of the Control group and the Experimental Group 1 were very similar. In both groups, the rate of correct, i.e., restrictive interpretations was highest in the biased condition. In this condition, the visual context did only match the restrictive interpretation and no intersective distractor was present. Furthermore, the rate of correct interpretations was lower in the ambiguous condition, in which the appositive head-set reading and the intersective interpretation resulted in the same picture-choice. In addition, the number of restrictive interpretations was lowest in the certigenic condition. In this condition all three possible interpretations could be differentiated in the visual array. Thus, although Hamburger and Crain (1984) used a slightly different procedure (prompt before

Table 3.3.: Percentage of restrictive interpretations for two prenominal modifier constructions of Hamburger and Crain (1984)

Group[a]	**Condition**	**Session 1**	**Session 2**
Control Group	Ambiguous	62%	62%
	Biased	82%	84%
	Certigenic	57%	57%
Experimental Group 1	Ambiguous	62%	89%
	Biased	73%	89%
	Certigenic	47%	77%
Experimental Group 2	Ambiguous		96%
	Biased		87%
	Certigenic		70%

[a] n = 15.

picture), the results are comparable to previous studies. The number of errors increased when the deviant intersective interpretation was depicted in the visual context. For Session 2, two main results were obtained. First, as the results of the Control Group show, a repetition of the experimental task did not influence children's responses. These children took part in the experiment twice without any change of the procedure. As expected, the results did not differ between the two sessions. For the Experimental Group 1, the handling procedure in Session 2 led to an increase of correct, restrictive interpretations for all conditions. The effect of handling was also present in Experimental Group 2, which was only tested with this procedure. Nevertheless, the tendency of lower accuracy rates for the certigenic condition was also present in Session 2 across all groups.

To investigate the nature of the intersective interpretations, Hamburger and Crain (1984) performed an error analysis for the certigenic condition of children in Session 1. The data of the Experimental Group 1 and the Control group were merged. The overall error rate of these 30 children in the certigenic condition was 48%. Hamburger and Crain report that one-fourth of these errors, i.e., about 12% of the overall errors, correspond to an appositive, head-set interpretation. The other three-fourth, i.e., 36%, of errors were due to intersective interpretations.

The error analysis of the certigenic condition indicates first that the category of intersective interpretations in the previous experiments may consist of two different interpretations. In addition to 'real' intersective interpretations also appositive interpretations may have led to pointings to the respective nontarget picture. Second, the results show that children between the age of 4 and 6 can interpret prenominal adjectives as appositive modifiers. This interpretation is chosen despite a restrictive prosodic contour in this task. Unfortunately, as in Matthei (1982), no correlation or individual analysis was performed to investigate possible effects of age on the number of correct interpretations or on the error types.

Hamburger and Crain (1984) aimed to address the nature of children's syntactic rep-

resentations in more detail. Therefore they set up a follow-up experiment consisting of two parts. First, they replicated the original task by Matthei (1982). Four items of the biased condition using instructions as in (27) on page 113 in combination with a visual context in Figure 3.7 were tested with the procedure used by Matthei. In these items, the visual array did not distinguish appositive and intersective responses. In the following, two items of the form in Figure 3.9 were added using prompts shown in (28). The prompts contained a second clause with the proform *one*. A pronominal form like *one* can refer back to constituents of different sizes. Hamburger and Crain wanted to investigated whether the sequence *green ball* is represented as an intermediate node in children's representation. If a child is able to use *one* to refer back to the constituent *green ball* in contrast to *balls* only, then the syntactic representation of the DP cannot be completely flat.

(28) Point to the first green ball; point to the second one.

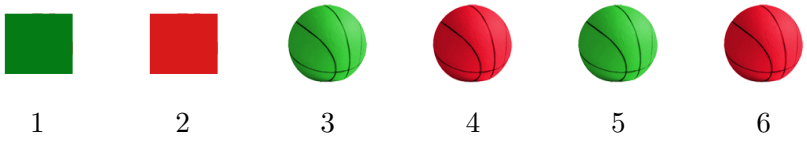


Figure 3.9.: Visual context for the *one*-substitution task of Hamburger and Crain (1984, p. 131).

Twenty-five children with a mean age of 4;10 took part in the study. Ten children made intersective errors in at least three out of the four items of the biased condition. Hamburger and Crain report that 9 out of these 10 children used *one* to refer back to the constituent *green ball* at least once in the two items. Five out of the 10 children did so in both items. Thus, in contrast to their intersective responses in the items used in the first part, the majority of children was interpreting the stimulus restrictively in the second part.

The results of the follow-up experiment suggest that the children's syntactic structure is hierarchically layered. At least a restrictive syntactic structure is available for children in the circumstances of items as in (28) paired with Figure 3.9. This result is expected. The pairing of context and prompt in this experiment corresponds to the condition in which only the restrictive target interpretation matches the visual display. Across all experiments reported so far, children performed more often target-like in this condition than in conditions where intersective distractor items were present. Taken together, this study gives additional evidence that deviant intersective (or appositive) interpretations co-occur with restrictive interpretations in the same individuals at the age of 4 to 6. Moreover, the type of response may be influenced by the task the children have to perform.

Task effects on the interpretation of adjective sequences were also explored by Marcilese, Corrêa, and Augusto (2011) and Marcilese et al. (2013). The authors took the co-occurance of restrictive and intersective interpretations as starting point to investigate

whether task demands may be responsible for the misinterpretations in children. In a first experiment, Marcilese et al. (2011) investigated the fixation patterns of adult speakers of Brazilian Portuguese using an eye-tracking procedure. This study served as a control condition for the results of children reported in the second paper by Marcilese et al. (2013). In the study focussing on adults, 24 participants were exposed to stimuli as in (29).

(29) Olha para a terceira estrela laranja!
Look at a third star orange

'Look at the third orange star!'

Figure 3.10.: Biased visual display from Marcilese et al. (2011, p. 149).

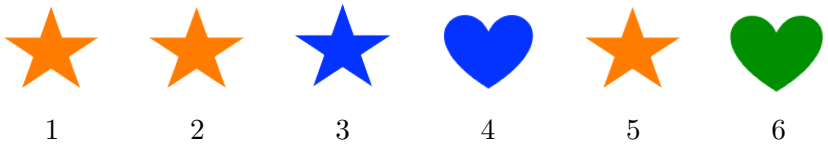


Figure 3.11.: Unbiased visual display analogous to Marcilese et al. (2011, p. 149).

Sixteen pre-recorded stimuli were paired either with a biased and an unbiased visual display in the sense of Matthei (1982). Examples are displayed in Figure 3.10 and Figure 3.11. In addition, 32 distractor items were included (*Look at the yellow cube behind the blue circle!*). Besides the visual context, Marcilese et al. varied the task to investigate the influence of the visual context on the interpretations of adults. Either the objects were displayed simultaneously with the auditive prompt, or sequentially, after the auditive stimulus presentation. For the results, first fixations to a nontarget object of at least 200-250 ms were analyzed.

The authors found a significant main effects for the factor TASK. When the visual array was displayed in parallel to the auditive prompt, adults showed more nontarget fixations than with the sequential presentation. An analysis of the nontarget fixations revealed that participants tended to look at the object matching an intersective interpretation in their first search. This happened more often in the simultaneous presentation condition than in the subsequent one.

Marcilese et al. argue that the erroneous, intersective search pattern shows the influence of cognitive task demands on the processing of linguistic structures. Fixations at the deviant intersective object may indicate a direct, linear parse on the basis of the

incoming auditive prompt. In addition, the misinterpretations in the simultaneous condition may be favored by the specific word order pattern *Ordinal-N-Adj* of the prompt (i.e., *Look at the third star orange*). Since the color adjective follows the noun in Brazilian Portuguese, the corresponding picture of the phrase *Ordinal-N*, the third star, can be selected as referent in an intermediate processing step. Both, in the biased and the unbiased condition, a suitable picture for this potential referent was present. In both arrays depicted in Figure 3.10 and 3.11, there was a star at third position. Therefore, no interaction of the factors TASK and VISUAL CONTEXT were observed. In case the objects were displayed after the linguistic stimulus, participants already knew that they had to take the color word into consideration. Therefore, the number of intersective fixations may be generally lower in the condition in which the display was presented subsequently.

In a second study, Marcilese et al. (2013) investigated children's interpretation of stimuli as in (29). Based on the results of the eye-tracking study, a sequential presentation of the linguistic stimulus and the visual array was chosen. Hence, to reduce task demands, the visual arrays were presented after the auditive prompt was given to the children. Twelve verbal prompts were paired with 6 biased and 6 unbiased visual displays as shown in Figure 3.10 and Figure 3.11 above. Fourty-seven 4- to 6-year old Brazilian-Portuguese-speaking children took part in the study. They were divided into three age-groups of 14 to 18 participants.

Marcilese et al. (2013) report a significant effect for the factor AGE. Four-year-old children were still at chance level in the biased condition while they performed better in the unbiased condition (56% vs. 83%). The performance increased especially from age 5 to age 6. The 6-year-old children performed at ceiling in the unbiased condition and at 88% in the biased condition. In addition to the age-related increase, there was a significant effect of the TYPE OF VISUAL ARRAY. For all age groups, the number of restrictive interpretations was higher in the unbiased than in the biased condition, in which an intersective distractor was present. This is in line with previous findings. Compared to the results of the corresponding conditions of Hamburger and Crain (1984) in Figure 3.3 on page 114, the figures of the 4- and 5-year olds are almost identical. Thus, the differing word order of adjectival modification in English and Brazilian Portuguese does not seem to influence the interpretation patterns in general.

This study is the first to show a developmental trend in the acquisition of restrictive adjectival modification. The results demonstrate that restrictive interpretations are available already at age four in 83% of items when task demands are reduced. Otherwise, in the presence of intersective distractors, the 4-year-olds are at chance level with 56% of restrictive interpretations. Marcilese et al. (2013) argue that processing limitations hinder children from overcoming intermediate interpretations as observed for adults in their first fixations. The authors suggest that limitations related to the maturation of executive control mechanisms are responsible for the lower performance of younger children. In addition, Marcilese et al. point to a potential relation of intersective interpretations in young children and the acquisition of ordinal number words as relational, non-intersective modifiers.

In sum, these studies on the acquisition of restrictivity in adjective sequences demonstrate that children at age 4 can derive the recursive syntactic structure that is necessary

to interpret these items restrictively. In addition, Hamburger and Crain (1984) demonstrated with their error analysis, that also appositive interpretations are available at the age of 4 to 6. So far, no individual analyses of children's response patterns have been reported. Therefore, it is an open question whether specific response patterns, like appositive or intersective misinterpretations, are found in all children, or whether they are limited to individual children or to children within a specific age range. These unexpected readings may indicate intermediate steps in the acquisition process.

The next section deals with the acquisition of discourse anaphora as a potential prerequisite for appositive interpretations of relative clauses.

3.4.2. Acquiring the meaning of discourse anaphora

According to Del Gobbo (2003, 2007), appositive relative clauses are analyzed as independent propositions. In her semantic analysis, the introducing relative pronoun is an anaphoric (demonstrative) pronoun of type e in contrast to the semantically vacuous relative pronoun in restrictive relative clauses (see Section 2.3.1). On the basis of this assumption, the acquisition of discourse anaphora is a relevant prerequisite for the availability of appositive interpretations. In this section, the main findings of previous research on this topic will be summarized. The survey is limited to studies on cross-sentential anaphors since relative pronouns have to find their antecedent in a different clause. The findings show that discourse pronouns are acquired at the age of 3. Thus, an anaphoric use of relative pronouns can be expected at a similar age as long as the relative pronoun is identified as anaphoric expression.

The acquisition of anaphoric reference across sentence boundaries has been studied extensively in production (for an overview see Allen, Skarabela, & Hughes, 2008; Graf & Davies, 2014) and comprehension (e.g., Graf & Davies, 2014; Hughes & Allen, 2015). While regular referential pronouns have been studied in acquisition, E-type pronouns (see Section 2.3.2) have not been addressed so far. Previous studies show that the basic mechanisms to select and interpret anaphoric expressions are available to children very early, already at the age of 2 to 3 (e.g., Girouard, Ricard, & Decarie, 1997; Hughes & Allen, 2015; Song & Fisher, 2005, 2007). The full range of anaphoric expressions as well as differences in their internal specification, however, need more time to be acquired. Differences to adults-like usage and interpretations can still be observed at age 5 (Bittner & Kuehnast, 2012; Lust, Solan, Flynn, Cross, & Schuetz, 1986, among others).

In the following, first, a short introduction to the use of pronouns is given. Then, first results from spontaneous speech data are reported (Hughes & Allen, 2015). Subsequently, experimental studies are presented (Girouard et al., 1997; Song & Fisher, 2005, 2007) including a study with German-speaking children (Bittner & Kuehnast, 2012). The last study summarized here focuses on the acquisition of bound and free pronouns (Lust et al., 1986) because relative clauses in contrast to general discourse anaphora cannot select their antecedent freely in the discourse.

The use and interpretation of referential expressions requires an integration of different types of information. For instance, the utterance situation itself as well as knowledge about the interlocutor's representation of the utterance situation is necessary to select an

appropriate linguistic form to encode subjects and objects. According to the accessibility of a referent in the discourse (Gundel, Hedberg, & Zacharski, 1993), a more or less informative element can be chosen to establish coreference. To determine the accessibility of a referent, a variety of factors have to be considered. Among the factors to make a referent more or less accessible are i) the physical presence or absence of a referent, ii) joint attention, iii) linguistic or contextual disambiguation, as well as iv) whether a referent has been mentioned prior in the discourse or whether it has been installed as a topic of the conversation so far. These factors interact and determine whether a speaker uses an informative lexical DP, a demonstrative or personal pronoun, or a null pronoun to encode a referent. Furthermore, these factors give information to the interlocutor how to interpret a certain form of a referential expression.

Hughes and Allen (2015) analyzed the production of referential expressions in a corpus of spontaneous speech data of four English-speaking children. The spontaneous speech data were analyzed at two time points, when children were 2;1 and 3;1. Hughes and Allen found that at age 3, English-speaking children show the same tendencies as adults to adapt referential expressions to the degree of accessibility. At the previous point of analysis at age 2;1, children's use of referential expressions still differed from those of adults. To refer back to already established referents, children used null pronouns frequently, although these are not a grammatical option in English. Nevertheless, already 2-year-old children showed sensitivity to the accessibility of referents. For completely inaccessible referents (newly introduced ones that were not mentioned previously), children at age 2, as adults, used lexical noun phrases predominantly. One year later, the pattern of all four children changed to a more adult-like use of referential expressions in the recordings. At age 3, the children used personal pronouns in spontaneous speech to refer to highly accessible referents, which were physically present and were mentioned before in the discourse. The less accessible a referent the higher was the tendency to use a demonstrative pronoun or a lexical noun phrase. As for adults, demonstratives were used with high probability when the referent was physically present. These results show that at age 3 children have the capacity to integrate linguistic knowledge about referring expressions and knowledge about the previous discourse to select the appropriate linguistic form to refer to a referent.

Girouard et al. (1997) investigated the acquisition of first, second and third person personal pronouns in English- and French-speaking children experimentally. Starting from age 1;6, 12 children each were investigated in two months intervals with a testing battery on the production and comprehension of personal pronouns. For comprehension, Girouard et al. report that the mean age for acquiring first, second and third person personal pronouns was on average 1;10. For a target-like production of the three pronominal forms, children were on average 2;4. At this age, personal pronouns can be used and interpreted to refer to the speaker, hearer or third person present in the discourse context, who were previously introduced and referred to by their names. Girouard et al. (1997) propose three stages in the acquisition of personal pronouns. First, the interpretation of personal pronouns is target-like without an effect of order for first, second, and third person. Second, first person pronouns are correctly produced. Finally, second and third person pronouns are produced target-like.

Early competence in the interpretation of third person personal pronouns is also reported in Song and Fisher (2005) and Song and Fisher (2007). Using a preferential looking paradigm, these studies investigated whether children use the linguistic context to determine the reference of ambiguous personal pronouns. In picture-supported short stories as in (30), one of two characters was made more prominent in the context sentences.

(30) Context: Look at *the dog* and the horse.
On a sunny day, *the dog* walked with the horse to the park.
Target: And what did *he/the dog* see? Look, he saw a balloon!

The character was mentioned first in the sentence, occurred in subject position, and was – depending on the experiment – also pronominalized. Song and Fisher (2005) tested 3-year-old English-speaking children, and Song and Fisher (2007) tested English-speaking children at age 2;6. Both studies used a preferential looking paradigm on the resolution of the ambiguous pronoun in contrast to a lexical DP. The potential referents, the dog or the horse in the preceding example, were displayed on two monitors in front of the children simultaneous to hearing the target sentence. Each referent was depicted with one object on the screens. In the example above, the dog had a balloon, and the horse had a different object.

During the presentation of the target sentence, the reference of the pronoun is ambiguous. Only the final word of the target sentence in combination with the pictures disambiguated between the two potential referents. Thus, in the period of 4s between the subject DP in the first part of the target sentence and the disambiguation on the last word of the stimulus, the preferred interpretation of the participants could be analyzed on the basis of their fixation patterns. Song and Fisher (2005, 2007) contrasted whether a pronoun or lexical DP was used in the test sentences. In addition, they varied whether the referent of the respective DP was the continued discourse referent or the secondary character of the story.

The results reported in Song and Fisher (2005) and Song and Fisher (2007) for three consecutive preferential looking tasks with children at age 2;6 and at age 3 were robust. The referents for lexical DPs could be identified directly by all participants. Children focused on the correct picture in more than 70% of the time starting 1 second after hearing the common noun. In the pronoun conditions the two age groups differed. Two-year-old children looked at both referents similarly during the first 3 seconds. Only subsequently, in the time window of 3-4 s after the subject pronoun, children fixated the picture of the topical referent more often than the picture of the secondary character. Three-year-old children in contrast, focused on the topical referent earlier. Similar to adults, children at age 3 opted for the more salient character already 1s after hearing the pronominal subject. In addition to adult-like pronoun resolution preferences, these results show that children interpret personal pronouns as soon as they encounter them. Children at the age of 2;6 or 3 years do not wait until the reference of the pronoun is determined unambiguously, but interpret pronouns directly on the basis of information made available by the preceding discourse.

These results show that children, as adults, interpret personal pronouns more often to refer back to a continued subject of a story rather than to another potential referent. Furthermore, the data show that the preference to interpret personal pronouns as referring to the character of maximal salience/accessibility is developing with age. In addition, discourse information is used directly and incrementally to establish potential reference. This has been observed also for adults as discussed in Section 2.6. For the integration, 2-year-old children need more time than their slightly older peers. Children at age 3 already show a pattern similar to adults. This finding will be taken up again in Section 3.5 below, where the processing strategies of children are discussed.

Bittner and Kuehnast (2012) investigated the resolution of ambiguous pronominal forms in German and Bulgarian in children at age 3;0 and 4;9. Bittner and Kuehnast used an elicited imitation task to investigate the production and comprehension of personal pronouns, null pronouns, and demonstratives. The experimental procedure consisted of three steps. First, an experimenter presented a story to the child using toy puppets. Then, the children had to repeat a sentence containing one of the three pronominal forms. Third, a distracted puppet asked a clarification question on the referent of the pronominal form that the child had to answer. An example test item illustrating the experimental procedure is given in (31).

(31)

Experimenter 1:	That's the bear and that's the ball.
	The bear likes to play football.
	Now, the ball is in front of the bear.
Antecedent sentence:	The bear is kicking the ball.
Anaphoric sentence:	*Ø/er/der ist weiß.*
	Ø/he/this is white.

Exp. 2 (distracted puppet):	Pardon? I did not get it.
Child: PRODUCTION	Ø/he/this is white.
Exp. 2:	Who is white?
Child: COMPREHENSION	The bear.

The pronoun may be either interpreted as referring to the topical subject or to the less salient object of the antecedent sentence. Both potential referents were physically present in front of the child and possessed the property mentioned in the anaphoric sentence. In this study, the authors varied the animacy of subject and object to investigate whether children use this cue to resolve the pronoun's reference.

Bittner and Kuehnast (2012) found different production patterns in the two age groups of German-speaking children. Children at age 3;0 predominantly used null pronouns in their repetitions. This pattern, illicit in German, made up almost 60% of repetitions. Demonstrative pronouns were produced in about 25% of items, and personal pronouns in only 15% of items. Children at 4;9 showed the inverse pattern. They produced personal pronouns most frequently, in about 32% of items. Demonstratives were used at a similar rate as in the younger group. In addition, the production of null pronouns decreased to less than 25%. Differently from 3-year-olds and adults, 4-year-olds also used lexical NPs

in about 18% of their productions. Thus, all three types of pronouns were produced in the two age groups, but at different rates.

For comprehension, Bittner and Kuehnast report that children and adults interpreted most of the personal pronouns as being anaphoric to the topical subject. Demonstrative pronouns were treated differently in the groups. Three-year-olds preferred reference to the subject, 5-year-olds did not show a significant preference, and adults preferred a resolution to the object of the sentence. Thus, adults interpreted a demonstrative to indicate a shift in topicality to a less salient entity. For the interpretation of null pronouns, both children's groups did not show a specific preference. In contrast, adults treated them similarly to personal pronouns and showed a subject preference. The interpretation patterns became complex when the (in)animacy of the subject and object was considered. The results indicate that children at age 3 treat personal pronouns not yet target-like. They show a preference for reference to inanimate subjects. Five-year-old children in contrast, prefer animate referents for personal pronouns.

The results of Bittner and Kuehnast (2012) are comparable to those of Hughes and Allen (2015) with regard to the production data in the languages investigated. Both studies find the full range of pronominal forms in children's productions at age 3. In addition, null pronouns are attested in English and German in early recordings, in combination to a decline of their use starting from age 3. In addition to the full repertoire of anaphoric expressions in production, the comprehension data of Bittner and Kuehnast (2012) show that children at the age of 3 do not yet differentiate target-like between the different types of pronouns. For instance, personal pronouns are interpreted as referring to less salient characters (inanimate referents) in this age group. In contrast, children at age 5 show more adult-like interpretations of personal pronouns, but the interpretation of demonstratives still differs from adults. Five-year-olds do not yet use demonstratives to indicate a topic shift in the conversation. Bittner and Kuehnast argue that children start out to interpret pronouns mainly on the basis of situational cues and do not yet differentiate between different types of pronouns. Later, syntactic information as the subject or object status of an expression is taken into account to assign reference. In sum, adult-like competence is not yet achieved in children at age 5.

Further evidence for nontarget-like interpretation patterns of pronouns in children is given by Lust et al. (1986). Here, the production and interpretation of free personal pronouns was compared to the production and interpretation of bound pronouns as the silent PRO in subject control contexts. Example test sentences are given in (32) and (33).

(32) a) *Ernie* tickled *Big Bird*, when *he* dropped the penny.
b) When *he* dropped the penny, *Ernie* tickled *Big Bird*.

(33) a) *Big Bird* patted Oscar, when pushing the car.
b) When pushing the car, *Big Bird* patted Oscar.

As illustrated in the examples, Lust et al. varied the directionality of the anaphoric relation. In contrast to personal pronouns in (32), the interpretation of PRO is limited to the subjects in (33). The subject reference is independent of the direction of the

anaphoric relation. In addition, Lust et al. varied the presence of an additional lead-in sentence. The lead-in established the object of the clause as topical element. As the directionality of the anaphoric relation, topicality should only matter for free personal pronouns. The interpretation of PRO should not be affected.

Lust et al. (1986) tested 101 children between age 3 and 8 on an elicited imitation task for production, as well as on an act-out task for comprehension. The results of Lust et al. are informative in two respects. For personal pronouns on the one hand, children assign reference to both subjects and objects as it is expected in the ambiguous context. Thus, children across all age groups are aware of the fact that personal pronouns are free in finding their referents in the discourse context. On the other hand, the results show that children treat PRO as a free pronoun. Both factors, directionality as well as pragmatic context influenced the overt personal pronoun and the covert pronominal form similarly in interpretation. Children up to age 8 preferred reference to the subject for forward anaphora, but reference to the object in cases of backward anaphora. This preference held for both, the personal pronoun as well as PRO. In addition, in the condition with the lead-in sentence, children established coreference to the object more often for both pronominal types.

The generalization of properties of free personal pronouns to PRO indicates that the children treat bound and free occurrences of cross-sentential anaphora similarly. It seems as if they do not establish obligatory co-indexation to the controlling subject. Nevertheless, children differentiate between both types of pronouns. This becomes evident in the production data. In children's productions PRO forms were frequently substituted by overt pronominal forms. The inverse pattern was not observed. In addition, the substitution data show that the restrictions on tense corresponding to the (c)overt pronominal forms (personal pronoun with tensed clause, PRO without tense) were obeyed.

Taken together, the results on the acquisition of cross-sentential anaphora are mixed. The production data show that the repertoire of referential expressions is acquired early. Children around the age of 3 are able to use different types of referential expressions to express different degrees of salience or accessibility. Furthermore, children at the age of 3 are sensitive to the effect of topicality and discourse continuity in their interpretation of personal pronouns. Nevertheless, full differentiation between the different functions of the pronouns is acquired after age 3. For instance the use of demonstratives as an indicator of reference to a less salient referent is not fully acquired at age 5. In addition, the results on bound anaphora in the case of PRO may indicate that children treat cross-sentential anaphora generally as belonging to the class of free pronouns.

With regard to the acquisition of appositive relative pronouns, the results show that the lexical inventory is acquired at age 3. At this age, demonstrative pronouns are used to refer to a discourse referent that is present in the utterance situation. The results on PRO suggest that children may have difficulties in restricting the reference of the demonstrative to the nominal head of the relative clause as the only possible antecedent. It may be the case that children interpret demonstrative pronouns in appositive relative clauses as referring to non-local antecedents like they interpret a subject-governed PRO as being co-referent to the object of the matrix clause.

3.4.3. Summary

In the previous sections, studies on the acquisition of adjectival modification and the acquisition of discourse anaphora were presented. These phenomena relate to properties that are necessary for restrictive and appositive interpretations of relative clauses. Section 3.4.1 demonstrated that children between 4 and 6 years derive restrictive and appositive interpretations for adjectives in nominal expressions involving two prenominal modifiers (Hamburger & Crain, 1984; Marcilese et al., 2013; Matthei, 1982; Roeper, 1972). In addition to restrictive and appositive interpretations, these studies report deviant, intersective interpretations for ordinal numbers in adjective sequences. The intersective interpretations may indicate a classification of ordinal numbers as intersective modifiers in the acquisition process. Alternatively, they could be taken to indicate a preference for flat syntactic structures over hierarchically structured ones (Marcilese et al., 2013; Matthei, 1982). This aspect will be addressed in more detail in Section 4.3.3. A short overview of the acquisition of cross-sentential anaphora showed that the prerequisites for E-type anaphora are acquired relatively early around the age of 3. Thus, establishing anaphoric reference of relative pronouns to their antecedents in appositive relative clauses may be possible at a similar age. However, it is an open question when obligatory co-reference principles for bound anaphora across sentence boundaries are acquired.

Up to now, detailed studies on individual interpretation patterns and the developmental paths for the semantic functions restrictivity and appositivity are lacking. Thus, it remains an open question within what time frame and order the semantic functions are acquired. However, the availability of restrictive and appositive interpretations for adjectives in 4- to 6-year-old children may be taken as a starting point to investigate restrictive and appositive relative clauses in a similar age range.

The following section deals with the impact of processing on language acquisition. Results are discussed for relative clauses as well as for adjectives and discourse anaphora.

3.5. The role of processing in acquisition

This section discusses the interaction of human language processing and language acquisition. The aim of this section is to give a general overview of abilities and limitations in child processing, not to establish a detailed model of the development of children's processing. After a more general introduction on the interaction of language acquisition and processing, two questions are central with regard to the empirical part of this thesis. First, do children follow the same processing principles as adults? And second, in which respects do children differ from adults in terms of processing?

In the broadest sense, processing may be understood as the ability to identify and categorize linguistic material, i.e., a segmentation of the input stream, and to assign a structural representation to the identified parts (Fodor, 1998a, 1998b). Thus, processing can be seen as a necessary prerequisite for acquisition. A number of psycholinguists assume that the ability to parse linguistic input is an innate resource (e.g., Fodor, 1998a, 1998b; Trueswell & Gleitman, 2009). Children start to parse as soon as they are able to

identify linguistic material. The processing principles, such as Late Closure and Minimal Attachment are assumed to be operative from the beginning, as they are derived from inherent properties of the parser. According to Fodor (1998a, 1998b), the basic parsing routines enable the child to learn the language she or he is exposed to. Depending on the framework, the child is assumed to learn the regularities of a language based on probabilistic routines (e.g., as proposed in the Contraint-based Lexicalist theory by MacDonald, Pearlmutter, & Seidenberg, 1994 and Trueswell & Gleitman, 2009) or is guided by constraints imposed by a Universal Grammar as assumed in the generative framework (see Chomsky, 1981 and subsequent work).

The present thesis follows assumptions from generative grammar. I assume that language acquisition does not depend exclusively on the frequency with which a specific phenomenon is encountered in the input. Instead, I assume that language acquisition is constrained by innate principles that become available in the process of acquisition (for arguments in favor of the UG-Constraint Maturation Theory see, for instance, Wexler, 1990). Assuming that a child acquires grammatical knowledge stepwise based on the interaction of linguistic input and innate principles, the child may encounter linguistic expressions that she cannot parse completely. The child may hear words that she cannot assign to a category, or she may be exposed to structures that are not yet in her grammatical repertoire. Wexler (1990) proposes that a child confronted with such an input nevertheless constructs a representation including only the information that she can make use of.

Regarding the acquisition of grammatical operations, Lebeaux (1990, 2000) proposes that syntactic operations are acquired stepwise. According to Roeper (1992, 2014), children's productions in the two-word phase are applications of the unconstrained operation Merge. With regard to more complex syntactic structures, Lebeaux assumes that coordination is acquired before subordination to combine constituents and sentences. Lebeaux argues that when a child encounters a subordinate clause she cannot completely process, she will fall back into a simpler grammar using coordination to link the sentences. This is a more recent formulation of the conjoined clause hypothesis advocated by Tavakolian (1981). Lebeaux's proposal predicts that children start to attach subordinate clauses at a higher level in the syntactic structure initially.[7] High attachment of phrases and clauses as initial syntactic analysis in language acquisition is also argued for by Roeper (2009). Based on the findings of Matthei (1982) on the *second green ball* task, Roeper assumes that children start out with conjoined interpretations of non-intersective adjectives and only later acquire relative readings. These assumptions will be taken up again in the discussion of the results in the empirical part of this thesis.

The two question raised in the beginning of this section, do children follow the same processing principles of adults? and do children and adults differ with regard to processing? are closely related. These questions have been addressed by investigating a variety

[7]Note that Lebeaux (1990, 2000) is not clear about whether his approach targets sentence production or comprehension or both. The author frequently uses comprehension results to explain patterns observed in production data, although acquisition research also observed phenomena in which both modalities diverge (see for instance A. Grimm, Müller, Hamann, and Ruigendijk (2011) for production-comprehension asymmetries).

of phenomena. Due to limitations of space, the overview in this section is restricted to findings on the processing of phenomena that have been addressed in the sections before, i.e., attachment preferences and movement operations, the subject object asymmetry and the interpretation of adjectives, anaphora, and, of course, relative clauses. In general, the findings suggest that children use the same underlying principles to parse linguistic stimuli as adults (Adani & Fritzsche, 2015; Felser et al., 2003; Fernald, Thorpe, & Marchman, 2010; Huang & Snedeker, 2008; Hughes & Allen, 2015; Love, 2007; McKee, Nicol, & McDaniel, 1993; L. Roberts, Marinis, Felser, & Clahsen, 2007; Traxler, 2002, among others). However, children execute processes related to the identification and integration of information slower than adults (Adani & Fritzsche, 2015; McKee et al., 1993; Trueswell et al., 1999). This may be, at least partially, due to reduced working memory capacities in children (e.g., L. Roberts et al., 2007; Montgomery, Magimairaj, & O'Malley, 2008). As a consequence of the slower performance and reduced working memory capacity, children show reduced abilities to recover from incorrect analyses (e.g., Trueswell et al., 1999; Meroni & Crain, 2011, and subsequent work). The following paragraphs address the availability of processing principles, the slower performance, and the difficulties to recover from incorrect analyses in more detail. First, general processing principles are addressed and similarities with the processing patterns of adults identified.

Traxler (2002) was the first to demonstrate that processing principles like Minimal Attachment and Late Closure are operative in children. With colleagues he tested English-speaking children between 9 and 12 years of age applying similar methods as used for adults (Trueswell & Gleitman, 2009). The authors used a word-by-word self-paced reading paradigm to explore whether children, like adults, misanalyze locally ambiguous sentences as in (34a). Traxler (2002) varied whether a comma, as in (34b), disambiguated the stimuli.

(34) a) When Sue tripped the girl fell over and the vase was broken.
b) When Sue tripped, the girl fell over and the vase was broken.

In short, the results showed longer reading times at the matrix clause verb *fell* in sentences where the comma was absent. Thus, the authors assume that children like adults initially analyze *the girl* as object of the verb *tripped*. The longer reading time at the matrix verb is taken to indicate a disruption of the initial parse and a repair of the syntactic structure. Hence, these results demonstrate that children perceive a garden-path similar to adults.

In a second experiment, Traxler investigated whether plausibility of the initial representation influences children's parsing decisions. The items were similar to those in the first experiment but the initial noun phrase of the matrix clause, *the table* was a poor candidate for being the object of the subordinate clause. Example test items are shown in (35a) and (35b).

(35) a) When Sue tripped the table fell over and the vase was broken.
b) When Sue tripped, the table fell over and the vase was broken.

The results were similar to those obtained in the first experiment. In (35a) children were slower in reading the verb *fell* in the matrix clause, the position at which the initial analysis was proved wrong. Unlike in Experiment 1, reading time slowed down already on the preceding noun phrase *the table*. Traxler assumes that this slowdown is linked to the implausibility of the noun phrase as being the object of the subordinate verb. However, the longer reading times on the matrix clause verb indicate that the implausibility of the preceding noun did not lead to a structural repair. If the reanalysis had been performed already when hearing the unsuitable noun, no further difficulties would have been expected to occur at the main clause verb.

The results of Traxler (2002) show that school-aged children follow the same structural assumptions as adults when processing locally ambiguous sentences. Studies aiming at demonstrating that also younger children follow the same general processing principles like adults had to use different methodologies. In addition to on-line methods like cross-modal priming (Love, 2007; L. Roberts et al., 2007), also behavioral data proofed informative in this respect (e.g., Friedmann et al., 2009). For instance, studies were able to show that children and adults exhibit the same patterns regarding the subject object asymmetry in relative clauses.

As reported in Section 2.6 adults have less difficulty to process object relative clauses when the type of DP differs between the head noun and the relative clause internal one. Friedmann et al. (2009) showed that the same holds for children. They demonstrate that the interpretation difficulties children have with object relative clauses can be modulated by a variety of factors. Object relatives with an arbitrary *pro* subject as in (36) and a lexical head noun were interpreted as well as the corresponding subject relative clauses. 3- to 5-year-old Hebrew-speaking children interpreted object relatives with an impersonal *pro* correctly in 90% of items in a picture-selection task and in 75% of an act-out task. In contrast to object relative clauses with two lexical DPs, the group-level was statistically above chance level. In addition, 19 out of 22 children performed above chance level on an individual basis. These numbers are comparable to the performance on subject relative clauses.

(36) Tare li et ha-sus she-mesarkim oto.
Show to-me ACC the-horse that-brush-pl him

'Show me the horse that *someone* is brushing'

Intrigued by the results of Friedmann et al. (2009), many studies have explored which kind of mismatches facilitate the interpretation of object relatives in language acquisition. The following factors have been identified so far: Mismatches in the *type of DP* (lexical DP vs. pronoun/pro/quantifier) (Friedmann et al., 2009), of *gender features* (Adani et al., 2010), *number features* (Adani et al., 2010; Arosio et al., 2011; Contemori & Marinis, 2013), *case* (Guasti et al., 2008 but see Benţea, 2012), and *animacy* (Adani, 2012). The presence or absence of resumptive pronouns does not lead to an amelioration of the interpretation rates for object relative clauses as reported for Hebrew (Friedmann et al., 2009). For language specific differences of these factors see for instance Adani et al. (2010), Biran and Ruigendijk (2015), Costa et al. (2014), and Guasti, Stavrakaki, and

Arosio (2012). In addition to the linguistic factors, working memory capacity interacts with the ability to take advantage of the mismatching features as shown by Arosio et al. (2011, 2012).[8] Children with higher working memory capacity show higher improvements in the presence of feature mismatches.

Friedmann et al. (2009) assume that in object relative clauses the relative clause internal subject may intervene as potential binder for the trace of the moved relativized phrase. According to Friedmann et al., the feature configuration of the relative clause internal subject forms a subset of the set by the relativized constituent. This subset-configuration is demanding to compute for adults and may lead to a break down in the processing of object relative clauses in children. Without going into detail about alternative approaches that have been put forward to explain the subject object asymmetry, these findings suggest that the comprehension of object relative clauses is affected by the interplay of the involved type of DPs like in adults. Whatever reasons lead to the processing difficulties in adults, they are also found to influence the production and comprehension of subject and object relative clauses in children.

Due to the inapplicability of reading time measures in preschool children, other on-line measure have been used in language acquisition research. The use of cross-modal priming tasks, for instance, made it possible to investigate processing phenomena such as filler-gap dependencies in pre-school children on-line (Love, 2007; L. Roberts et al., 2007; McKee et al., 1993). The task is based on the assumption that semantic representations in the mental lexicon are retrieved faster when they were activated shortly before. For instance, an object can be named faster when it appears a second time in a naming task. Importantly, a representation in the mental lexicon is not only activated by hearing or producing the name of an object but also by seeing a picture of it. This finding is used in the cross-modal picture priming. In this task, children hear a sentence that is interrupted at various positions. During the interruptions, children see a picture and have to perform a task. For instance, they have to judge whether the depicted referent is alive or not, or whether it can be eaten or not. Cross-modal priming, i.e., faster reaction times in the judgement task, can be found when the depicted referent has been activated before due to lexical material presented in the auditive stimulus.

The studies of Love (2007) and L. Roberts et al. (2007) used cross-modal picture priming tasks to investigate whether a moved constituent is reactivated at its gap position in object relative clauses. The stimuli were of the structure in (37). When the pictures appeared, the participants had to judge whether the depicted referent was alive or not, or whether it could be eaten or not.

(37) The zebra$_i$ that [PICTURE$_{Control}$] the hippo had kissed [PICTURE$_{Zebra}$] ___$_i$ on the nose ran far away.

Four- to six-year-old children in the study of Love (2007), as well as children between age 6 and 7 in the study of L. Roberts et al. (2007) showed reliable priming effects for a moved object at its base position, but not at a control position previously in the

[8] See also Weighall and Altmann (2011) for general effects of working memory capacity and comprehension of relative clauses in children.

clause. That is, children were faster to make the judgement only at a position where the antecedent was pre-activated due to syntactic processing. The observed priming effect is explained as follows. When a moved constituent is assigned to its base position, the lexical representation of the antecedent is reactivated. Thus, at the position of the trace in (37), the representation of *the zebra* is active. Therefore, judgements about this referent can be done faster than judgements on other entities. These studies demonstrate that children as young as 4 are able i) to identify moved constituents as such, and ii) to attach or reconstruct the antecedents online in their base positions.

However, children's processing is not identical to that of adults. As reported both in Love (2007) and L. Roberts et al. (2007), children showed slower reaction times than adults. Thus, although children perform similar operations to adults, they need more time to do so.

In addition, L. Roberts et al. (2007) demonstrate that the priming effects are linked to the working memory capacity of the participants. The authors used a listening span task to assess the working memory span of children and adults. With regard to priming effects, children with lower working memory capacity showed inverse effects than their peers with higher working memory performance. They needed more time to judge whether a depicted object could be eaten or not when the picture matched the antecedent than when an unrelated animal was presented. A reliable priming effect at the base position of the moved constituent, thus, was only observed for children with high working memory measures. Comparably, working memory capacity also influenced priming in adults. Adults with lower working memory measures did not show any significant effect of priming in Robert et al.'s study. However, for both children and adults, the presence or absence of priming effects did not influence the comprehension of the sentences. Therefore, L. Roberts et al. conclude that participants with lower working memory capacity finally manage to reactivate the antecedent and to assign it to its base position, but they seem to take longer.

Similar but slower performance of children compared to adults is also reported in tasks investigating referential processes (McKee et al., 1993; Adani & Fritzsche, 2015; Huang & Snedeker, 2008). In tasks in which pronouns, restrictive relative clauses, or adjectives are used to identify a referent, children need more time than adults to establish reference.

McKee et al. (1993) report one of the first studies that investigated referential processes in children using on-line measures. They investigated the interpretation of personal pronouns and reflexives. McKee et al., too, used a cross-modal priming task. Seventeen English-speaking children between the age of 4 and 6, as well as a group of adults listened to sentences as in (38). Again, children had to judge whether the depicted object was alive or not.

(38) The alligator knows that the leopard with green eyes is patting him/himself/the nurse [LEOPARD] on the head with a soft pillow.

For children as well as adults, McKee et al. report shorter response times in the judgement task for items in the reflexive condition than for items in the pronoun and lexical NP condition. Thus, children showed a priming effect in the reflexive condition compared

to the other conditions. This priming effect is due to the fact that the participants interpreted the reflexive pronoun as being coreferential to the leopard. Therefore, the lexical representation of the leopard was reactivated at the position of the pronoun and facilitated the judgement in the *alive or not* task. These results demonstrate that children at the age of 4 process reference relations similar to adults. When reference is established, the referent is reactivated and accessible. Overall, McKee et al. observed longer response times for the child participants compared to the adults.

Similar results are obtained by Adani and Fritzsche (2015). Adani and Fritzsche used an eye-tracking procedure to investigate the subject object relative clause asymmetry in German-speaking children. Four-year-old children and adults saw short movie clips involving three cartoon animals. Two identical animals occurred on either side of the screen and a different animal showed up in the middle of the screen. The animals in the movie clips performed either a chasing action or a splashing action. Eye-movements were recorded while children listened to a question as in (39).

(39) Wo ist die Kuh, die der/den Hund jagt?
Where is the cow who the$_{NOM/ACC}$ dog chases?

Where is the cow who is chasing the dog / who the dog is chasing?

Up to the relative clause internal noun phrase, the relative clause is ambiguous between a subject and object relative reading. For the children at age 4, the results show a significant increase in target-looks, i.e., looks to the target-referent, starting at the disambiguating noun phrase in the relative clause. The target referent was fixated more often in subject relative clauses than in object relative clauses while hearing the relative clause. Adults, in contrast, already started to fixate a referent when hearing the relative pronoun. In addition, prior to the disambiguating noun phrase, the rate of target fixations was higher for subject relative clauses than for object relative clauses in adults. This preference is in line with the assumption that adults postulate a subject gap in their initial parse. In addition, they show that children as well as adults use relative clauses as restrictive modifiers to decide between two potential referents. In sum, the results of Adani and Fritzsche (2015) show on the one hand that children's eye-movements mirror the fixation patterns of adults. On the other hand, they demonstrate that children need more time to process complex sentences such as relative clauses before they can use the linguistic information to establish reference.

Further evidence for delayed referential processing in children is reported by Huang and Snedeker (2008, 2013). Huang and Snedeker investigated dimensional adjectives in an experimental task comparable to those used by Sedivy et al. (1999) presented in Section 2.6. Five-year-old English-speaking children and a group of adults listened to instructions like (40) while they saw a display with four objects as in Figure 3.12. Unlike in Figure 3.12 each of the four boxes contained only one object in the test items. Across conditions, however, Huang and Snedeker varied whether the object was a good or poor token to be described by the adjective *big* (exemplified in the upper left corner) and whether or not a contrasting element of the same category was present (illustrated in the upper right corner).

(40) Point to the mouse that has the big coin

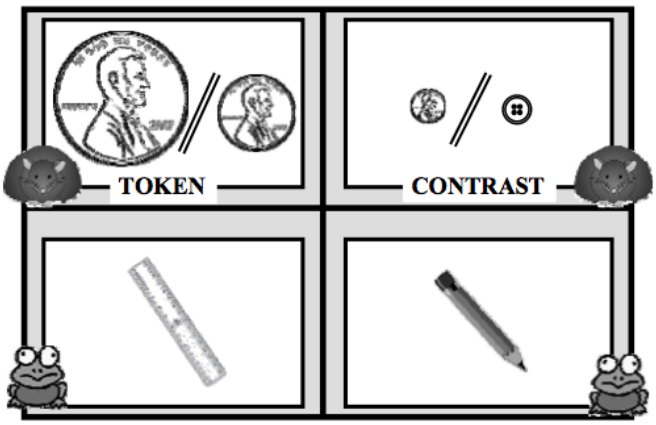


Figure 3.12.: Visual display adapted from "Referential Context in Children's Language Processing" by Y. T. Huang and J. Snedeker, 2008, in B. C. Love, K. McRae, and M. V. Sloutsky, *Proceedings of the 30th Annual Conference of the Cognitive Science Society*, p. 1382. Copyright 2008 by the authors. Reprinted with permission.

Previous results of Sedivy et al. (1999) showed that adults are able to use the information conveyed by the adjective to narrow down the set of potential referents. When a contrasting element of the same type was present (e.g., a big and a small coin), they found that adults use this contrasting set to establish reference to the big object of this set. Huang and Snedeker (2008, 2013) report similar results for children at the age of 5. Like adults, children directly used the content of the adjective to identify the target object. In addition, children and adults were faster in the condition where a contrasting element of the same type was present in the visual display. Thus, a big coin was identified earlier when a small coin was present then when a small button was displayed. A comparison between the groups showed that adults were faster in general to identify the target object. Their fixations converged on the target already during the processing of the adjectives. Five-year-old children, in contrast, reliably differentiated between the target and the contrasting element only 500 ms after the onset of the adjective when the noun was already encountered.

These results show that children, like adults, process adjectives in sentences incrementally. Children do not wait to identify a referent for the DP until the full sentence is processed. Instead, the adjective is used instantly to narrow down the set of potential referents even before (or while) the noun in encountered. Moreover, children use information about contrasts to resolve reference comparably to adults. Despite these

similarities, children at the age of 5 need more time than adults to reliably select the intended referent in the visual display.

Further evidence on the incremental processing of adjectives is given by the study of Fernald et al. (2010). Fernald et al. studied incremental processing of color adjectives in 30 and 36-month-old English-speaking children. The authors show that only 36-month-old children could use color adjectives to identify the referent of an adjective-noun sequences like *red car* when a red and blue car were presented. 30-month-old children, in contrast, showed more variability in their looking patterns. When a red and a blue car were displayed, the younger group could not use the adjective reliably to identify the referent and fixated both cars frequently. The majority of the 30-month-olds seemed to integrate the color word only ofter the end of the noun phrase.

The studies summarized so far show that children share general processing patterns with adults. Although the functioning of processing principles like Minimal Attachment and Late Closure were tested explicitly only in 9- to 12-year-old children, they may be operative in younger ones. More complex principles to detect moved constituents and assign them to a base position are found to be operative in 4- to 6-year-old children (Love, 2007). In addition, pronominal reference is established by reactivating the identified referent at the position of the pronoun, and adjectives are used incrementally to establish reference (Fernald et al., 2010; McKee et al., 1993; Adani & Fritzsche, 2015; Huang & Snedeker, 2008).

Despite these similarities, differences are observed in the processing of children and adults. These differences are addressed in the following. Several studies report that children do not use semantic or contextual information to guide the parsing process or to reanalyze false first parses. Instead, children seem to rely more on syntactic properties. Interestingly, this finding is in accordance with syntax-first approaches and may thus be indicative of a further similarity in the processing mechanisms of children and adults. The remainder of this section focuses on this aspect.

The results of Trueswell et al. (1999) presented in Section 3.3 show clear differences between children and adults with regard to the influence of context. Recall that Trueswell et al. studied the attachment of locally ambiguous PPs in sentences like *Put the frog on the napkin in the box*. The authors found a strong tendency for 5-year-old children to analyze the first PP *on the napkin* as the destination of the putting action without any effect of the referential context. This interpretation is in line with the Minimal Attachment principle formulated by Frazier (1987). Integrating the PP as local argument of the verb requires fewer syntactic nodes than a modifier analysis, in which an additional constituent needs to be present and has to be attached as locative argument. The results of Trueswell et al. were replicated by Hurewitz, Brown-Schmidt, Thorpe, Gleitman, and Trueswell (2000) and by Weighall (2008). The studies show that the preferred analysis of the PP as destination is neither altered by a change of the salience of the objects (Hurewitz et al., 2000) nor by a change of the task which made the objects more relevant (Weighall, 2008). In addition, testing children between the age of 4 and 11, Weighall (2008) showed that an adult-like interpretation pattern is found at the age of 8. That is, only children at the age of 8 and older used the number of discourse referents in the context to decide between a destination and a modifier attachment (1 referent with

destination, 2 referents with modifier analysis).

In contrast to these studies, Meroni and Crain (2011) found adult-like performance in 3- to 5-year-old children with similar stimuli but with a modification of the task. When children had to listen to the complete stimulus before they saw the objects, they performed adult-like and could use the PP as a modifier to restrict the reference of the frog in a 2-referent context. The improved performance in the task of Meroni and Crain (2011) in contrast to findings from Trueswell et al. (1999) demonstrates that children have severe difficulties to recover from an incorrect initial analysis. In the experiment of Trueswell et al. (1999), children fixated a wrong frog in the PP condition in 70% of items. In 60% of items, this incorrect fixation was followed by a selection of the wrong frog. Thus, children revised incorrect decisions in only 10% of trials. In the relative clause condition, in contrast, children fixated the wrong frog in 35% of trials. Furthermore, these incorrect fixations led to an incorrect selection of the referent in only 3% of items. Thus, the presence of the relative complementizer as an overt lexical cue seemed to help children revising their incorrect initial syntactic representation. This is in line with findings from adults processing (Frazier & Rayner, 1982; Frazier, 1999). Interestingly, additional information present in the visual context did not help the child participants. Children seem to disregard the fact that there was no napkin in the box. Thus, *on the napkin in the box* was not appropriate as a complex locative description. However, the visual information given in the context did not effect the interpretation of the PP and the actions performed.

These results indicate that children up to age 8 have severe problems to revise an initial analysis that is not in accordance with subsequent linguistic material. This may be due to different reasons. Either visual information cannot be used to initiate a reanalysis, or the integration of the visual context proceeds too slowly. In the latter case the initial structure may be interpreted by the semantic component before the revision is initiated. These findings point to an encapsulated syntactic processing. The initial syntactic parse is not influenced by contextual information. Furthermore, also the processes of reanalyses are mainly restricted to lexical information in children's processing. This may be taken as further evidence against an interactive processing account as for instance proposed by Altmann and Steedman (1988).

In sum, the studies presented in this section demonstrate that children use parsing routines similar to those of adults. The findings on the processing of adjectives show that linguistic stimuli are processed incrementally. Adjective information can be used on-line to establish reference starting at age 3. Furthermore, the results of Traxler (2002) and Trueswell et al. (1999) show that children walk down the garden-path for structures involving ambiguous attachments as predicted by syntax-first approaches. Moreover filler-gap dependencies as well as referential processes seem to apply as they do in adults. However, the studies demonstrated that children need time to integrate information from different sources. This may be due to reduced working memory capacity compared to adults. When the capacity to store information intermediately is limited, children may need to restrict their focus on one source of information. In addition, the short term memory needs to be cleared rapidly to be able to process new information. Therefore retracing prior decisions may be possible for adults but not to the same extent

for children. Thus, a reduced memory capacity is one potential candidate to explain the observed slowdown in children's processing in general. Furthermore, working memory may also explain some of the problems in cases of misparses. The following section summarizes the findings presented in this chapter.

3.6. Summary

In this chapter, previous research on the acquisition of relative clauses was summarized. In spontaneous speech, relative clauses start to appear in the third year of life. In their speech, German-speaking children mainly use verb-final, postnominal relative clauses introduced by d-pronouns. Data from corpus studies and production studies converge that subject relative clauses are produced earlier and more often target-like than object relative clauses. While object relative clauses with two lexical DPs are frequently avoided or prone to errors, subject relatives are produced target-like at the age of 4 to 5. Similarly, studies on the comprehension of relative clauses show that subject relatives but not object relative clauses are mastered by 4- to 5-year-old children.

The insights from syntactically motivated comprehension studies are informative with regard to the main research question of this thesis, how do German-speaking children acquire restrictive and appositive relative clauses?. When 4- to 5-year-old children interpret subject relative clauses like adults, they are able to built up a converging semantic representation. Whether children arrive at a restrictive, appositive, or deviant interpretation, however, remains open based on these results.

Studies contrasting the number of referents for the head noun in the experimental context of comprehension studies did not find an effect of referentiality on the interpretation of relative clauses in children. Therefore, it remains open whether children at the age of 3- to 5 distinguish between restrictive and appositive modifications at all. Alternatively, they may rely on lexical cues, e.g., the presence of the complementizer *that*, to determine the relative clause's interpretation. The few studies that explicitly focused on the semantics of relative clauses show that English-speaking pre-school children interpret relative clauses introduced by the complementizer *that* restrictively as modifiers of the head noun. Furthermore, restrictive relative clauses tend not to be attached to proper names. However, the results show a high degree of variability and up to now, no study has explicitly addressed appositive relative clauses in detail. Regarding the availability of appositive readings, the small excursus on the acquisition of discourse anaphora in 3.4.2 shows that appositive interpretations cannot be ruled out for 4- to 5-year-old children based on a deficient knowledge of necessary prerequisites. If appositive interpretations require anaphoric reference of the relative pronoun to the head noun, the studies show that the lexical prerequisites for appositive readings are in place in very young children.

Some evidence for the availability of both restrictive and appositive interpretations in pre-school children comes from studies on adjective sequences. Studies presented in Section 3.4.1 demonstrate that instructions like *Take the second green ball* can receive a restrictive and appositive interpretation at age 4. The semantic computation of restrictivity and appositivity in adjectives, however, may be easier than for relative clause

because the sentential modifiers also involve a complex internal syntactic and semantic derivation.

The section on the acquisition of processing showed that children use similar processing principles as adults. Children experience garden-path effects with locally ambiguous constituents according to the principles of Minimal Attachment and Late Closure. In addition, the studies presented showed that children use linguistic information to built up syntactic, semantic and referential representations incrementally. Thus, children and adults do not differ in their underlying processing patterns, but they do differ from each other with regard to processing speed. In contrast to adults, children rely more heavily on lexical than on contextual information. In addition, children up to age 8 have more difficulties to recover from incorrect initial decisions. Based on these findings, it seems possible to transfer expectations about processing complexity regarding restrictive and appositive relative clauses formulated for adults to the processing of these structures in children. Thus, restrictive readings may be derived with less effort by children than appositive interpretations because restrictive but not appositive interpretations may be derived from the initial syntactic parse.

Taken together, the studies presented in this chapter suggest that restrictive and appositive interpretations are available for pre-school children. Both semantic functions were found for adjective sequences and at least restrictive interpretations were found for relative clauses. However, studies focusing on restrictivity in relative clauses and adjectives did not differentiate between different age groups in pre-school children. Furthermore, individual analyses are lacking. Therefore, it is an open question when restrictive and appositive interpretations for adjectives and relative clauses emerge and whether both interpretations are available to each individual child. These gaps will be addressed for the acquisition of relative clauses in the empirical part of this thesis.

4. Implications for the present study

This chapter addresses the research questions and hypotheses of the present thesis and introduces the main idea of the experiments carried out in the empirical part. In Section 4.1, the research questions and hypotheses are motivated and formulated. They relate the results of previous studies on the acquisition of restrictivity and appositivity to the experimental work described in the following chapters. Section 4.2 focuses on the main ideas for the experimental design that is used in the empirical part of this thesis. The section closes with an overview of the hypotheses that are addressed in the individual experiments reported in this theses. Subsequently, Section 4.3 summarizes theoretical background and studies on the acquisition of ordinal numbers. As described in Section 4.2 these prenominal modifiers play a crucial role to obtain truth-functional differences between restrictive and appositive interpretations of relative clauses in the conducted experiments.

4.1. Research questions and hypotheses for the acquisition of the semantics of relative clauses

The acquisition findings presented in the previous chapter show an apparent research gap. So far, the acquisition of the semantic functions restrictivity and appositivity in relative clauses has not been addressed in detail. Studies that systematically contrast both readings as well as studies that investigate the developmental path for the semantic functions are missing. Moreover, there are only few studies that focus on these semantic concepts in related phenomena such as adjectival modification. This thesis aims to start filling this gap by investigating the acquisition of restrictive and appositive relative clauses in German-speaking children. The empirical part of this thesis aims to answer the general research question (Q) repeated here.

(Q) How do typically developing German-speaking children acquire the semantic functions *restrictivity* and *appositivity* of relative clauses?

As was shown in the previous chapters, a relative clause can be ambiguous between a restrictive and an appositive interpretation in German. Therefore, the acquisition of the two semantic functions can be investigated from different perspectives either focussing on preferences in ambiguous contexts or by testing specific readings in unambiguous settings. To address research question (Q) in more detail, more specific research questions are formulated in (Q1) to (Q3).

(Q1) Which interpretation of syntactically and contextually ambiguous relative clauses is preferred at a given age?

(Q2) Which interpretations of syntactically and contextually unambiguous relative clauses are accepted at a given age?

(Q3) Do linguistic and contextual cues influence the choice of interpretation?

Since (Q) asks how children acquire the two semantic functions of relative clauses, also the following research question has to be addressed.

(Q4) Do children and adults differ in their interpretation patterns?

In what follows, hypotheses are formulated that address these questions on the basis of assumptions from linguistic theory presented in Chapter 2, as well as on the basis of findings from acquisition research presented in Chapter 3.

Research question (Q1) focuses on a potential preference in the interpretation of ambiguous relative clauses. Interpretation preferences may suggest that the preferred structure is less complex than the unfavored one. According to findings of human language processing on ambiguity resolution, a syntactic structure and its associated meaning is preferred over alternatives when it is matching the initial syntactic parse (e.g., Frazier, 1987). Thus, assumptions about parsing as well as about the proposed syntactic structure become relevant.

According to the majority of syntactic approaches discussed in Section 2.2.3, restrictive and appositive relative clauses differ with regard to their attachment site: Restrictive relatives are attached to the NP level or below the position of strong determiners, whereas appositive relatives attach higher at the DP shell (see e.g., Demirdache, 1991). With regard to the question of whether restrictive and appositive relative clauses should be analyzed as adjuncts or arguments, there is disagreement between the different proposals (see Section 2.2.3, pages 29ff.).

From a processing perspective, these syntactic differences could be relevant for the initial syntactic structure. The principle of Minimal Attachment favors parse trees with fewer syntactic structure over those involving more syntactic nodes (Frazier, 1987). As a consequence, this principle would favor the integration of arguments over adjuncts. However, the theoretical approaches discussed in Section 2.2.3 disagree with regard to the attachment of relative clauses as adjuncts or arguments. Moreover, frequently the same mode of attachment is assumed for both semantic functions. Therefore, Minimal Attachment cannot be used to derive clear hypotheses on the preference for a restrictive or appositive interpretation.

A second important processing principle is the principle of Late Closure (Frazier, 1987). It states that low attachment to the phrase that is currently processed is generally preferred over attachment higher up in the syntactic tree (see Discussion in Section 2.6 on pages 71ff.). This principle may allow predictions about the preferred interpretation. A parser following this principle would integrate a relative clause at the lowest possible level processed at the moment, i.e., the relative clause would be initially attached to the NP layer. This would lead to a restrictive interpretation of the relative clause. Based on these assumptions, Hypothesis (H1) can be postulated.

(H1) Restrictive interpretations are preferred over appositive interpretations.

(H1) predicts that restrictive interpretations should be preferred over appositive ones in ambiguous situations. This hypothesis is derived independently of whether a raising or matching structure is assumed. In addition, it is independent of the direction of attachment. For instance, in the structure proposed by Cinque (2008a) and subsequent work, relative clauses start out as prenominal modifiers that attach at different positions in the syntactic tree. To derive the target word order of the head noun and the relative clause, Cinque proposes that the head noun moves to the left irregardless of whether the nominal head is moved from a position external or internal to the relative clause. Thus, for the interpretation of a relative clause, the head noun has to be reconstructed in its base position. This necessary reconstruction does not change the assumption that Late Closure favors attachment to the lower position. Taken together, as long as different attachment positions are assumed for restrictive and appositive relative clauses, Hypothesis (H1) should hold. Crucially, the hypothesis is based on the assumption that the parser distinguishes between the level of NP and DP in its processing. To my knowledge, research on attachment preferences differentiating between these levels has not been pursued so far.

A preference for restrictive interpretations may also be grounded in assumptions about the complexity associated with the two semantic functions. Taking semantics into account, appositives are more complex than restrictive relative clauses. Whereas restrictives are simple predicates of type <e,t>, which intersectively modify the noun they are attached to, appositives are full propositions involving an E-type interpretation of the relative pronoun and need an integration at discourse level. Independently of whether this is achieved via movement at LF, as proposed by Demirdache (1991) and Del Gobbo (2003, 2007), by the conversion of the relative clause into a presupposition (von Stechow, 2007), or by adding another semantic dimension via a comma feature, as proposed by Potts (2005), the prediction follows that appositive relatives are more complex than restrictive relative clauses. The higher semantic complexity of appositives may favor interpretations as restrictive relative clauses.

Taken together, several reasons speak in favor of a preference for restrictive interpretations. A preference, however, does not necessarily provide information on the grammatical competence of a child. Despite a restrictive preference, appositive readings may be acquired. Therefore, it is necessary to focus on research question (Q2) in addition.

Research question (Q2) asks whether both restrictive and appositive interpretations are acquired and can be used to interpret unambiguous relative clauses. The arguments put forward to support Hypothesis (H1) on a preference for restrictive readings may also be taken to support the hypothesis that restrictive readings are acquired before appositive ones. However, when it is assumed that restrictive and appositive readings of relative clauses are derived from different underlying structures, the readings may be acquired independently from each other. As described in Section 2.3, the semantic composition of restrictive and appositive relative clauses requires different modification rules. Therefore, no implicational hierarchy can be assumed to hold for the two types of relative clauses; restrictive readings are not necessarily acquired before appositive ones.

However, appositive relatives are the more complex structure compared to the semantic computation of restrictive relatives independently of the semantic analysis (Del Gobbo, 2003, 2007; von Stechow, 1979, 2007). The different degrees of structural complexity may favor the acquisition of restrictive relative clauses over appositive ones.

This assumption could also be supported by typological considerations. Section 2.2.1 showed that restrictive relative clauses are attested in more languages than appositive readings. Furthermore, there seems to be a universal implicature that appositive relative clauses are found only in languages that have restrictive readings. The inverse pattern, however, does not hold. Hawkins (2007) argues that such a universal implicature makes predictions for the acquisition of the respective phenomena. Following Hawkins (2007), the universal implicature predicts that two options are available in the acquisition process. Either only restrictive relative clauses are acquired initially or both structures, restrictive and appositive ones become available to the children simultaneously. The complementary finding, the acquisition of appositive readings before the acquisition of restrictive structures should be ruled out.

So far, it is not possible to decide between the two options. Therefore, Hypothesis (H2) is formulated as the null hypothesis.

(H2) Children can derive restrictive and appositive interpretations for relative clauses.

Based on previous research discussed in Chapter 3, it is not possible to formulate clear expectations about the time course of the acquisition of restrictive and appositive interpretations of relative clauses. The results of studies investigating the interpretation of adjective sequences in English-speaking children suggest that restrictive interpretations are available at the age of 4. Appositive interpretations are also reported for children between the age of 4 and 6 years without giving further details. On the basis of these findings, a similar age range may be relevant for the interpretation of relative clauses. Therefore, the experiments of this thesis focus on children between the age of 3 and 6.

To address research question (Q3), different types of cues could be investigated. In this thesis, three factors are studied. Two factors, the prosodic integration of the relative clause into the matrix clause and the presence or absence of discourse particles marking relative clauses lexically as appositive modifiers, assess the influence of linguistic properties. In addition, the information conveyed by the visual context is investigated as non-linguistic factor. Based on the previous research presented so far, different hypotheses emerge for children and adults with regard to two out of the three factors. Therefore, hypotheses are formulated separately for both groups starting with the expectations concerning the adults labeled (H3a), (H4a), (H5a), before turning to the hypotheses for children labeled (H3c), etc.. This differentiation takes research question (Q4) into account focusing on differences and similarities in the interpretation patterns of children and adults.

For adults, the empirical results on the effect of prosodic marking on the interpretation of relative clauses are heterogenous. The mixed results cast doubts on the assumptions formulated in syntactic proposals that prosody is a strong disambiguating factor for the semantics of relative clauses. However, the studies show that when participants

know about the ambiguity and the role of prosody, this information can be used to identify the reading. In addition, strong prosodic boundaries between adjectives lead to higher rates of appositive interpretations. Hence, I assume that prosody can influence the interpretation of relative clauses as stated in Hypothesis (H3a).

(H3a) Adults use prosody to disambiguate between restrictive and appositive relative clauses.

In addition to prosody, lexical material such as discourse particles can determine the reading of a relative clause. Relative clauses involving a discourse particle like *ja* or *übrigens* can only be interpreted appositively in German. This is formulated in (H4a).

(H4a) Adults interpret relative clauses with discourse particles as appositive modifiers.

The results presented in the previous chapters on processing (see Section 2.6) indicate that adults rely strongly on the visual context to resolve the reference of linguistic expressions. Therefore, a visual context that matches only one of the two interpretations should disambiguate between the two readings as stated in (H5a).

(H5a) Adults use the visual context to disambiguate between restrictive and appositive readings of relative clauses.

For children, the findings of previous studies lead to different expectations regarding the influence of discourse particles and visual context on the interpretation of relative clauses. For prosody, however, detailed studies are missing. Therefore the same hypothesis is adopted as for adults:

(H3c) Children use prosody to disambiguate between restrictive and appositive relative clauses.

Regarding the influence of discourse particles, children differ from adults in their ability to recover from wrong decisions in the process of a parse. Based on the expectations formulated in (H1), appositive interpretations require some further processing in comparison to restrictive relative clauses. A reanalysis of the initial parse may be necessary if disambiguating lexical material is processed or if the structure cannot receive an interpretation in the semantic system. This has to happen, for instance, in case the head noun is a proper name, or when discourse particles mark a relative clause as an appositive modifier. In these cases, interpretation problems would arise at the level of semantic processing when a restrictive structure is derived initially. When the semantic component is not able to interpret the relative clause in its initial position, the syntactic structure has to be reanalyzed and the relative clauses has to be lifted to the DP shell to license the computation of an appositive interpretation. This reanalysis may be easier for unambiguously marked head nouns than for disambiguating material that occurs later within the relative clause. Previous studies reported in Section 3.5 demonstrated that processes involving syntactic reanalyses are more problematic for children than for adults. Thus, the influence of lexical markers may be reduced up to a certain age. This leads to Hypothesis (H4c).

(H4c) Children do not interpret discourse particles as a marker for appositive interpretations of relative clauses.

Moreover, children are found to use information given in the visual context not to the same extent as adults. This leads to the following hypothesis.

(H5c) Children do not use the visual context to disambiguate between restrictive and appositive interpretations.

As a consequence of the hypotheses formulated so far, two further hypotheses can be derived explicitly addressing research question (Q4).

(H6) Children and adults do not differ in their preferred interpretation for ambiguous relative clauses.

(H7) Children and adults differ in their interpretation of unambiguously marked relative clauses.

The following section focuses on implications of these considerations for the concept and the design of experimental tasks.

4.2. Implications for the experimental design

To explore the acquisition of restrictive and appositive relative clauses in detail, the two readings should be contrasted within the same experimental design. This is difficult to achieve since the truth conditions of restrictive and appositive interpretations do not necessarily differ from each other (Frosch, 1996). This can be illustrated in Example (1) repeated here.

(1) Das Mädchen, [das ein großes Geschenk bekommen hat]$_{RC}$, war sehr glücklich.
The girl who a big present got has was very happy

'The girl$_{(,)}$ that/who got a big present$_{(,)}$ was very happy.'

According to Frosch (1996), every situation in which an appositive interpretation of the sentence in (1) is true is also compatible with a restrictive interpretation. In a situation with only one girl being present at a family celebration, who got a big present, an appositive interpretation of (1) is true. In this situation, also a restrictive reading would be true because the specific girl that got the big present was indeed happy. The inverse relation does not hold. In a situation with three girls, and one that got a big present, the restrictive interpretation of (1) is true. However, an appositive interpretation is not true or appropriate, since it would imply that there is only one girl at the celebration. In examples like these, a truth-functional implication holds from appositive interpretations to restrictive interpretations.

An experimental design that aims to investigate the two semantic functions contrastively should avoid this implication. To be able to discriminate between the different

interpretations, it is important to use a design in which both readings result in truth-functional differences. One design that makes a truth-functional distinction between the two readings goes back to Roeper (1972) and Matthei (1982). The combination of two modifiers as in *the second green ball* can be used to identify two different objects in a sequence of balls, as displayed in Figure 4.1. The two readings can be paraphrased using relative clauses as in (2a) and (2b).

(2) Take the second$_{(,)}$ green ball!

a) Take the second ball that is green! (restrictive)

b) Take the second ball, which is green! (appositive)

Figure 4.1.: Example test item of Roeper (1972, p. 85).

Using relative clauses instead of sequences of adjectives to describe and identify different objects was already proposed by Hamburger and Crain (1982). The idea was taken up in this thesis. Arrays of objects as displayed in Figure 4.2 were paired with relative clauses as displayed in (3).

(3) Nimm das dritte Auto, das rot ist, und leg' es in den Koffer!
Take the third car which red is and put it in the suitcase

'Take the third car$_{(,)}$ that/which is red$_{(,)}$ and put it in the suitcase!'

Figure 4.2.: Example for ambiguous visual context.

The task of the child was to select an object according to the instruction in (3). A selection of object no. 6 indicates a restrictive interpretation. The choice of object no. 4 is indicative of an appositive interpretation. In this example, there is also a picture at position no. 3 matching the deviant intersective interpretation as reported by Matthei (1982), Hamburger and Crain (1984), and Marcilese et al. (2013) for double modifier structures. Due to the presence of the ball in Figure 4.2, the car at position 3 is not automatically the third car in the sequence. Thus, the intersective reading can be clearly distinguished from an appositive interpretation. This modification was introduced by

Hamburger and Crain (1984) for double adjectives and was used in all experiments conducted for this thesis.[1]

The crucial aspect of this design is the use of ordinal numbers. Their non-intersective, order-inducing semantics in combination with a second modifier leads to the truth-functional difference of the two interpretations (see Section 4.3 for a semantic analysis and background on the acquisition of ordinal numbers). In case of a restrictive reading of the relative clause in (3), the ordinal number operates on a set defined by the intersection of the relative clause and the noun. In this case, one has to count red cars and take the third one. In case of an appositive interpretation, the reference of the DP is defined only by the ordinal number and the noun. In (3), the third car is identified without taking the relative clause into account. Subsequently, the relative is adding additional information about the color of the selected car.

This design has a number of advantages. First, the visual context can be varied easily. Objects can be arranged in such a way that the array is compatible with both interpretations of the relative clause in (3). This is the case in Figure 4.2 above. Alternatively, the objects can be presented in an array that matches only one of the readings. Examples for unambiguous visual contexts are displayed in Figure 4.3 and Figure 4.4.

Figure 4.3.: Example for restrictive visual context.

In Figure 4.3, only a restrictive interpretation matches the visual context. The third of the red cars can be chosen. The appositive interpretation, in contrast, is not applicable because the third car in the sequence is not a red car. Figure 4.4 shows a scenario that only allows for an appositive interpretation of the relative clause in (3). Since there are only two red cars the 'third red car' matching a restrictive reading cannot be selected. Instead, an appositive interpretation is possible since the car at position 4 is the third car and it is red.

Figure 4.4.: Example for appositive visual context.

The discussion of experiments on the acquisition of *the second green ball* in Section

[1]Note that a pseudo-relative clause interpretation as a forth possible interpretation is ruled out for relative clauses like (3) since no verb of direct perception is used in the matrix clauses (e.g. Grillo et al., 2012).

3.4.1 showed that this design can be used successfully with children at the age of 4 to 6. Children at this age did not have problems to select objects out of an array including 6 to 7 elements. Another advantage of this design is the possibility to pair the visual displays with different verbal stimuli. Relative clauses can be used with different prosodic contours or with and without discourse particles, for instance. By keeping the visual context constant, the influence of the different factors can be investigated in detail.

One potential disadvantage may be the use of ordinal numbers. As suggested in previous works, ordinal numbers receive an intersective interpretation by some children (Matthei, 1982; Hamburger & Crain, 1984; Marcilese et al., 2013). Hamburger and Crain (1984), for instance, report 36% of intersective interpretations in their group of 4- to 6-year-old children. When the ordinal number is interpreted as an intersective modifier, the semantics of the relative clause does not have any effect. Both readings of the relative clause would result in the same object choice when the ordinal is interpreted absolutely, i.e., not relative to the following noun: In (3), the third object would be selected in case it is a car and red. As a consequence, restrictive and appositive interpretations are identifiable only when ordinal numbers are interpreted as relational modifiers. Hence, the missing knowledge of ordinal numbers may limit the amount of children that can be tested on their interpretation of relative clauses. However, children with deviant intersective interpretations of ordinal numbers can be easily identified by using a pretest on the interpretation of ordinal numbers. Whether a child interprets ordinal numbers target-like can be tested with stimuli as in (4).

(4) Nimm das dritte Auto und leg' es in den Koffer!
Take the third car and put it in the suitcase

'Take the third car and put it in the suitcase!'

When children take the object at position 3 instead of the third car in position 4 in the visual displays shown above, it is clear that the ordinal number is interpreted intersectively.

Another potential disadvantage of this task may be due to the pragmatics of the verbal instructions. As noted by Hamburger and Crain (1982, p. 250), "a nonrestrictive relative clause [...] serves as a comment about the noun phrase it modifies [...] This comment is, however, quite unnecessary unless the listener is expected for some reason to need the reassurance of a confirming comment". According to Grice (1989), the use of unnecessary information violates the conversational maxims of quantity and manner in (5) and (6) as stated in Simons (2012).

(5) Maxim of Quantity

a) Make your contribution as informative as is required for the current purposes of the exchange.

b) Do not make your contribution more informative than is required.

(6) Maxim of Manner
Supermaxim: Be perspicuous.

a) Avoid obscurity of expression.

b) Avoid ambiguity.

c) Be brief (avoid unnecessary prolixity).

d) Be orderly.

An utterance should be informative but also brief. Interpreting the relative clause in the instructions as an informative part of the utterance requires a restrictive reading of the relative clause. Only then, the relative has an impact on the interpretation by narrowing down the set of potential referents. Therefore, this experimental setting may have a general pragmatic bias towards restrictive interpretations. This aspect will be taken up again in the discussion of the experiments in Chapter 8.

In sum, the advantages of the design first used by Roeper (1972) outweigh the drawbacks. In the following chapters, the results of three experiments are reported. The first two studies focused on the research questions (Q1), (Q3), and (Q4). In picture selections tasks similar to the one developed in Roeper (1972), the interpretation of relative clauses was investigated. The third experiment addressed research question (Q2). An acceptability task was developed to investigate the acquisition of appositive interpretations in more depth. Table 4.1 gives an overview which hypotheses were investigated in the three experiments reported in the following chapters.

As described above, the core idea of the experimental design relies in the interaction of ordinal numbers and relative clauses. Since ordinal numbers form such a central aspect of the experiment, the following section gives some background on the semantic analysis and the acquisition of these nominal modifiers.

Table 4.1.: Overview of hypotheses addressed in the three experiments of this thesis

			Experiments		
Research Questions & Hypotheses			**Exp. 1**	**Exp. 2**	**Exp. 3**
(Q1)	Interpretation preference for ambiguous relative clauses?				
	(H1)	Preference for restrictive interpretations	x	x	
(Q2)	Acceptance of restrictive and appositive interpretations?				
	(H2)	Restrictive and appositive interpretations available	(x)	(x)	x
(Q3)	Do linguistic and contextual cues influence the choice of interpretation?				
	(H3a/c)	Adults and children use prosody to disambiguate between restrictive and appositive relative clauses	x	x	x
	(H4a/c)	Adults but not children interpret relative clauses with discourse particles appositively		x	x
	(H5a/c)	Adults but not children use the visual context to disambiguate between restrictive and appositive interpretations	x		(x)
(Q4)	Do children and adults differ in their interpretation patterns?				
	(H6)	Children and adults do not differ in their preferred interpretation for ambiguous relative clauses	x	x	x
	(H7)	Children and adults differ in their interpretation of unambiguously marked relative clauses	x	x	x

Note. x = Hypothesis addressed; (x) = Hypothesis partially addressed.

4.3. A note on ordinal numbers

As described above, ordinal numbers are used in interaction with relative clauses in the experiments reported in this thesis. The interaction of an ordinal number like *first*, *second*, or *third* with a relative clause leads to truth-functional differences between a restrictive and an appositive interpretation of the relative clause. This difference arises due to two properties of ordinal numbers. Ordinal numbers belong to the class of subsective, non-intersective adjectives, and operate on a sequence of objects. These two aspects are described in more detail in the following. First, non-intersective modification and the notion of a comparison class is addressed in Section 4.3.1. Then, a semantic analysis for ordinal numbers is given in Section 4.3.2. After this theoretical background, studies on the acquisition of ordinal numbers are summarized in Section 4.3.3. This excursus concludes with a summary in Section 4.3.4.

4.3.1. Ordinal numbers as non-intersective modifiers

Ordinal numbers are subsective but non-intersective modifiers (see Section 2.3.3 on page 56). Thus, *the second ball* will always denote a ball but the interpretation of *the second ball* cannot be paraphrased by *x being second and x being a ball*. In these properties, ordinal numbers are similar to dimensional adjectives such as *big* and *small*. Like ordinal numbers, dimensional adjectives are often classified as non-intersective. Partee (2007) and Kamp (1975), however, argue that these (dimensional) adjectives should be better analyzed as intersective, vague and context-dependent instead of being classified as non-intersective. For dimensional adjectives, context-dependency implies that the adjective has to be interpreted relative to the average size of objects denoted by the noun they modify or relative to the average size of objects that are salient in the context (Heim & Kratzer, 1998, chapter 5). Thus, context-dependent adjectives are evaluated with respect to a *comparison class* and are also labeled as *relational adjectives* (Demonte, 2011). In contrast, relative clauses and intersective adjectives can be interpreted without any context if they do not contain indexical elements. In principle, they do not rely on the extensions of the nouns they are combined with (Kamp, 1975)[2].

Context-dependency does not imply that a certain adjective is non-intersectively combined with a noun. This is shown in (7) and (8) taken from Partee (2007, p. 154). In both examples the snowmen are tall, but what counts as *tall* depends on the context.

(7) My two-year-old son built a really tall snowman yesterday.

(8) The linguistics students built a really tall snowman last weekend.

Hence, the adjective *tall* may be intersectively combined with a noun phrase that involves a comparison class. In (7), for example with *snowmen built by young children* and in (8) *tall* is combined with *snowmen built by students*.

[2]Since intersective adjective are interpreted independently of the context of the utterance, they are also called *absolute* adjectives (Hamann, 1991).

The interpretation of ordinal numbers is context-dependent as well (Bylinina, Ivlieva, Podobryaev, & Yasutada, 2014). This is demonstrated in (9) (Bylinina et al., 2014, p. 13).

(9) a) Context: There are five books (Book 1-5) stacked on each other in the following order. They have different publication dates:

Book 1	published in May 2011
Book 2	published in August 2013
Book 3	published in December 2012
Book 4	published in March 2013
Book 5	published in January 2013

b) John read the first book that was published in 2013.

In (9), John may have read Book 2 or Book 5. The relevant comparison class for the ordinal number in this example is either the order of books in the stack (Book 2) or the order of publication date (Book 5). Which comparison class is chosen, is context-dependent.

Up to date, there is no consensus regarding the question whether dimensional adjectives and ordinal numbers have to be classified as context-dependent, intersective modifiers involving a comparison class (Kamp, 1975; Partee, 2007), or whether they are analyzed as non-intersective (e.g., McKinney-Bock, 2010). For the remainder of this thesis I use the term *non-intersective* to refer to the relational, context-dependent interpretation of nominal modifiers involving a comparison class. This will be important for the analysis of the results of the empirical part.

4.3.2. A semantic account for ordinal numbers

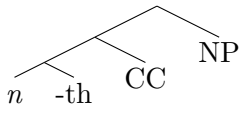
In contrast to other non-intersective modifiers, ordinal numbers have not been frequently studied from a semantic perspective. Only few proposals were put forward (Bhatt, 2006; Bylinina et al., 2014; Sharvit, 2010; Wiese, 2003). Often, ordinal numbers are analyzed as being closely linked to superlatives (Bhatt, 2006; Sharvit, 2010; Wiese, 2003). Bylinina et al. (2014), in contrast, argue that ordinal numbers and superlatives cannot be interpreted by the same mechanisms because they have a similar but not identical range of possible interpretations.

It is generally assumed that both cardinal and ordinal numbers refer to the set of natural numbers, but denote different aspects. Cardinal numbers like *two* or *thirteen* use the property of the stable order of number words to denote the number of elements in a set or sequence. Ordinal numbers, in contrast, describe the position of an object within a sequence. Besides the different functions, cardinal and ordinal numbers belong to different word classes in natural languages. Whereas in many languages, cardinal numbers pattern with quantifiers like *few* and *many*, ordinal numbers are similar to superlative forms of adjectives or adjectives in general (Wiese, 2003). For a more detailed description of the conceptual background on ordinal numbers see Wiese (2003).

Bylinina et al. (2014) implements this close relation of cardinal and ordinal numbers into the semantic representation of ordinals. Despite notational weaknesses regarding

the semantic composition of the ordinal number word and unmotivated, complex assumptions about the comparison class, this approach is described in the following since other detailed approaches are missing[3]. According to Bylinina et al., ordinal numbers are composed of a natural number n and the ordinal suffix *-th* in English or *-(s)te* in German. Suppletion as in *first* or *third* may mask the internal structure. Bylinina et al. (2014) assume that the comparison class CC is structurally represented in addition to the noun phrase, as given in (10) (Bylinina et al., 2014, p. 16).

(10)



The meaning of the ordinal affix *-th* is spelled out in (11) according to Bylinina et al. (2014, p. 17).

(11) $[\![[[n$ -th] CC] NP$]\!]$ (x)

a) is defined only if $A = \{\ y \in D_e \mid \exists! t'[[\![\text{NP}]\!]^{t'}\ (y) = [\![\text{CC}]\!]^{t'}\ (y) = \text{TRUE}]\}$ is such that:

i. $n \leq |A|$; and

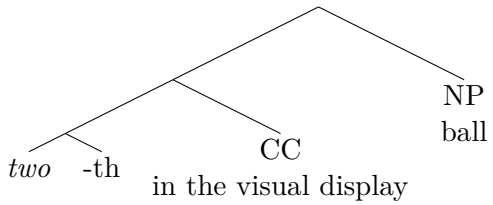
ii. $x \in A$.

b) whenever defined, denotes TRUE iff for the temporal ranking function R induced by NP and CC, $R(x) = n$.

The set A denotes objects of type e that are part of the denotation of the NP, as well as of the comparison class CC at the same temporal interval t'. In addition, the cardinality of A is at least as large as n. Moreover, the object x has to be an element of A. Finally, x is the *nth* element of A, if and only if the result of the ranking function evaluated at x is n. Bylinina et al. (2014) assume that the ranking function establishes an order on A based on the temporal intervals t^x. The ranking function assigns a natural number to an element $y \in A$ according to the number of elements in A that have made the NP and CC true before y.

For the phrase *the second ball* in the context of Figure 4.5, the morpho-syntactic derivation in (12) is evaluated as follows.

(12) the second ball



The phrase *the second ball* can only be true if there is a set of balls in the context. Moreover, the set of balls has to comprise at least two elements. These requirements are

[3]Many thanks to Ede Zimmermann for pointing this out.

Figure 4.5.: Example for the semantic computation of ordinal numbers.

satisfied in Figure 4.5. The referent x of the phrase *the second ball* needs to be an element of this set. In addition, a ranking function establishes an order on the set of balls. The function evaluates whether an object in the context fulfills the property of being a ball and how many balls are present before the present object is evaluated. Thus, the ranking functions gives back the value 1 for the object at position 1. The car at second position is not considered because it is not a ball and thus, is not part of the evaluated set. For the ball at position 3, the ranking function yields value 2. This ball is *the second ball* because all requirements are satisfied.

Bylinina et al. (2014) argue that usually CC is filled by a null pronoun *pro-CC*. Depending on the context, pro-CC receives different interpretations. It may be filled by some contextually salient property or be determined by a linguistic phrase in the sentence. In the latter case, focus plays a crucial role and may determine the interpretation of pro-CC.

In the following section, studies on the acquisition of context-dependent adjectives and ordinal numbers are summarized.

4.3.3. On the acquisition of ordinal numbers

Studies investigating the acquisition of ordinal number words and their conceptual underpinnings mainly come from developmental cognitive psychology. Most of the studies focused on the acquisition of ordinal number words in relation to the acquisition of cardinal numbers (Beilin, 1975, Colomé & Noël, 2012, F. E. Fischer & Beckey, 1990, Fuson & Hall, 1983, Miller, Major, Shu, & Zhang, 2000). To my knowledge, no studies explored linguistic properties of ordinal numbers. Acquisition research has not yet addressed the theoretically close relation to superlatives discussed in Section 4.3.2 nor has the acquisition of ordinals been compared to other non-intersective adjectives. This section focuses first on the acquisition of non-intersectivity, i.e., relational readings of adjectives. Then, studies on the acquisition of ordinal numbers are summarized.

As a background for the acquisition of non-intersective ordinal numbers, three studies are summarized here that investigated the acquisition of non-intersectivity in other types of non-intersective adjectives (Barner & Snedeker, 2008; Syrett, Kennedy, & Lidz, 2010; Tribushinina, 2013). This excursus shows that adjectives like *tall* and *short* are interpreted non-intersectively by children as young as 3. For further references, see the studies cited within these works.

All three studies focused on gradable adjectives like *tall* and *short*. These adjectives are interpreted relative to a comparison class that is determined by the modified noun,

as well as by a general domain restriction (see Section 4.3.1). This relational semantics sets them apart from adjectives like *spotted* or *blue*. Adjectives like *spotted* are also gradable but the cut-off point to classify something as spotted or not is not dependent on the following noun phrase, but on an absolute value specified lexically. For instance, an object may be labeled as *spotted* when there is at least one spot visible.

Testing 150 2- to 7-year-old Dutch-speaking children, Tribushinina (2013) showed that children at age 2 interpret the adjectives *groot* 'tall' and *klein* 'small' in relation to a given visual context. Children had to answer a question like (13) by pointing to objects in arrays as displayed in Figure 4.6.

(13) Welke X vind je groot/klein?
Which X find you tall/small

'Which X do you think is tall/small?'

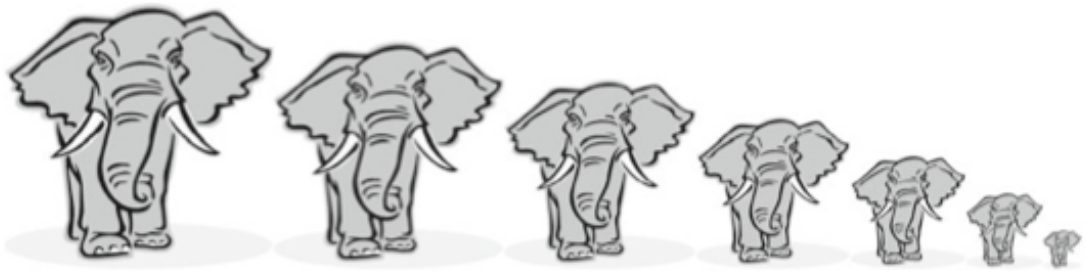


Figure 4.6.: Visual context adapted from "Adjective Semantics, World Knowledge and Visual Context: Comprehension of Size Terms by 2- to 7-Year-Old Dutch-Speaking Children" by E. Tribushinina, 2013, *Journal of Psycholinguistic Research, 42*, p. 211. Copyright 2012 by the author. Reprinted with permission.

Children at age 2 selected the tallest or smallest elephant in about 80% of items. At age 3, the rate of children that selected the tallest or smallest elephant displayed increased to a rate of 95%. The children would not refrain from labeling the biggest elephant tall, even though the depicted objects were small altogether. In case the adjective was interpreted absolutely, all of the displayed elephants should be judged small. Hence, these results demonstrate that already children at a very young age relativize the evaluation of relational adjectives to the respective (visual) context. This is in line with the processing results for adults for adjective interpretations discussed in Section 2.6.

In addition to the relational interpretation of dimensional adjectives, an additional contextual factor is relevant: the prototypical size of the depicted objects. In Tribushinina's study, adults differentiated in their classifications between prototypically small and prototypically tall objects. More objects that are prototypically judged as tall were classified as small in this task and vice versa. This pattern begins to emerge for children only at age 7. However, it does not reach significance at this age. Tribushinina demonstrates

that younger children do not use information about the prototypical size of an object in their evaluations of relational, dimensional adjectives. Thus, this lexical information is not used to contextually restrict the comparison class of relational adjectives in children.

Syrett et al. (2010) demonstrate that English-speaking children at age 3 discriminate between relational and absolute (gradable) adjectives. The procedure in the experiment was as follows. A puppet would ask for an object. Then, the child had to decide whether she could give the puppet the requested object, or whether the request was not appropriate or detailed enough to select one of the two objects on the table. Syrett et al. varied the felicity conditions, such that the pair of objects either satisfied or violated the uniqueness presupposition of the prompt in (14).

(14) Please give me the {big/spotted/red} one.

Three groups of 10 children were tested at age 3, 4, and 5 in a cross-sectional design. In case of the relational adjective *big* all children correctly chose the bigger object, independently of whether both objects were small or big in absolute terms. In contrast, children rejected the request for *the spotted one* in at least 70-80% in situations in which both objects were spotted at different degrees. The same was true for color adjectives. The request for *the red one* was rejected in above 90% in each group when both objects had the respective color. Thus, 3- to 5-year old children discriminate between relational and non-relational, absolute adjectives. Hence, at this age children know that to interpret relational adjectives, the contextually salient objects denoted by the following noun have to be encountered.

Both studies, Syrett et al. (2010) and Tribushinina (2013), tested the interpretation of relational adjectives only in contexts with objects of one category. Thus, it remains open whether children are able to restrict the evaluation of a relational adjective to the category denoted by the following noun. In the two experiments summarized so far, it may also be the case that children considered the complete set of elements available in the context.

To my knowledge, Barner and Snedeker (2008) conducted the only study that tested children's sensitivity to determine the comparison class on the basis of linguistic information. In a series of experiments, Barner and Snedeker investigated the context sensitivity in 4-year-old English-speaking children. In line with the studies reported above, the children in the study of Barner and Snedeker (2008) were able to adjust the comparison class on the basis of the depicted objects for the adjectives *tall* and *small*.

In the first experiment, nine novel objects called pimwits were displayed in a row. The children had to decide which of the nine pimwits were tall or small. Barner and Snedeker showed that the average size determined for a *small* or a *tall pimwit* differed significantly. Experiment 2 demonstrated that children shifted the average size for small or tall pimwits when either four small or tall pimwits were added. In a third experiment, four small objects of a different physical shape were interspersed with the nine pimwits of Experiment 1. The new objects were introduced as tulvers. In contrast to Experiment 2, the addition of the small tulvers did not change the average size of a small or tall pimwit. In Experiment 4, Barner and Snedeker used the same mixture of objects as in

Experiment 3 but labeled all of the objects pimwits. In this case, children changed the average size of small and tall pimwits as in Experiment 2.

This series of experiments shows that children at age 4, as a group, use the linguistic label to determine the comparison class for relational adjectives as *big, tall* and *small*. Additional objects were considered as part of the comparison class only when they were labeled pimwit. As the reported results are group results, it is open whether all participants at this age follow this pattern individually.

Taken together, the studies of Barner and Snedeker (2008), Syrett et al. (2010), and Tribushinina (2013) show that relational dimensional adjectives like *big, tall* and *small* are interpreted non-intersectively by children as young as 3. If an intersective semantics was used for the dimensional adjectives, they would not differ from absolute adjectives in their interpretation and in their context-sensitivity. The studies summarized in this section clearly show that children differentiate between relational and absolute adjectives. Thus, taking the linguistic context into consideration and interpreting adjectives in a non-intersective way does not seem to be a problem in the acquisition of adjectives.

For ordinal numbers, previous research show that their acquisition relies on the knowledge of cardinal numbers (Beilin, 1975, Colomé & Noël, 2012, F. E. Fischer & Beckey, 1990, Fuson & Hall, 1983, Miller et al., 2000). Fuson and Hall (1983), for instance, report that 3- to 6-year-old English-speaking children frequently use their known list of counting words to translate the selected cardinal number word into the appropriate ordinal word (e.g., "One, two, three, four. Fourth. This one is the fourth." Fuson & Hall, 1983, p. 89). In addition, it has been shown that cardinal numbers are acquired step by step starting from age two and developing until age eight for addition and multiplication operations (e.g., Butterworth, 2010, Coubart, Izard, Spelke, Marie, & Streri, 2014, Fuson, Richards, & Briars, 1982, Fuson & Hall, 1983, Gallistel & Gelman, 1978, Piazza & Izard, 2009, Wynn, 1992). Compared to the acquisition of cardinal numbers, the acquisition of ordinal numbers is delayed (e.g., Beilin, 1975; Colomé & Noël, 2012; Miller et al., 2000). Although children's performance increases with age, performance for ordinal numbers is significantly below that of cardinal numbers, both in production and comprehension.

Beilin (1975) reports that the ordinal number *second* is produced correctly more frequently than *third* (about +30%) in children between the age of 3 and 6. In addition, only 63% of the 6-year-olds could label a stick at second position in a row of differently colored sticks. For *third*, only 33% of children at age 6 performed target-like. Colomé and Noël (2012) found slightly better results in a well-controlled study on ordinal number acquisition in French. In a production task, children had to tell the experimenter in which position a yellow car was located in a queue in front of a traffic light. Three-year-old children named the 3^{rd} or 4^{th} position in only 13% correctly. In addition, performance was lower for higher ordinal numbers. The 6^{th} and 7^{th} position was labeled target-like in only 6% of items at age 3. At age 5, performance on ordinal number production was between 86% for small and 82% for large ordinal numbers respectively. With regard to comprehension, Colomé and Noël (2012) found that only 25% of the 3-year-olds picked the correct car at the third or fourth position out of a queue and put it in a garage. None of the 3-year-olds selected the 6^{th} or 7^{th} car in a queue correctly. The performance increased with age. At age 5, children picked the correct car in 67% of items for the

ordinals *third* and *fourth*, and in 59% of items for larger numbers like 6^{th} or 7^{th}. These findings provided first evidence that target-like production of ordinal number words precedes their interpretation. In addition, the results demonstrate that the acquisition of ordinal number words is a long lasting process that is not completed until primary school.

In the studies presented so far, ordinal numbers have been used as nominal modifiers in a context of elements of one type only. Children had to identify the position of differently colored sticks or cars. Thus, the question of whether children use ordinal numbers as intersective or non-intersective modifiers has not been addressed. In a cross-linguistic study on number concepts by Miller et al. (2000), one task involved two different types of objects. Miller et al. (2000) tested 96 English- and Chinese-speaking children each. In both languages, 32 kindergarten children aged 5 to 6 were tested, in addition to groups of 32 children in second and fourth grade each. These children were between age 7-8 and 9-10 respectively. Except for the English-speaking kindergarten children, all groups performed at ceiling when they had to identify the n^{th} car in series of seven cars. In the young group of English children performed target-like in only 66% of trials. In a second task, children had to identify the n^{th} white or black element in a row of interspersed black and white stones. This task required the restriction of the ordinal to a subgroup of elements; the task was thus comparable to the *second green ball*-task used to investigate recursive embedding above. The results show less accurate performances than in the previous task for all groups. Again, English-speaking children at age 5 to 6 performed worst. They selected the correct element in only 56% of items. This is comparable to the results of the tasks presented above studying phrases as *the second green ball*. Chinese children at age 5-6 were up to 84% correct. This may be due to the transparent morphological derivation of number words in Chinese[4], which seems to be a general advantage for acquiring the sequence of cardinal and ordinal number words. Children in second grade performed target-like in 90% of items across languages and they chose the correct object in 94% of items in grade 4. Unfortunately, Miller et al. do not report an error analysis. Thus, it is not possible to infer the semantic representation children used to answer the question whether ordinal numbers were incorrectly interpreted as intersective modifiers, as suggested by Matthei (1982).

In sum, the results of studies on the acquisition of ordinal numbers show that ordinal numbers are a concept that is acquired relatively late in childhood. The acquisition is dependent on knowledge on cardinal numbers (e.g., Beilin, 1975; Colomé & Noël, 2012; Miller et al., 2000), as proposed in the semantic representation of Bylinina et al. (2014) in Section 4.3.2. In the acquisition process, the lexical representation of ordinal numbers is enriched step by step. The language-specific differences found by Miller et al. (2000) indicates that the speed of acquisition of these first steps correlates with the morphological transparency of the number word sequence. First, the sequence of ordinal number words is stored, than the words can be applied to identify the n^{th} object in a series. This step may indicate that the mapping function from the position in a

[4]In Chinese, number words show a transparent morphological derivation. Unlike in English, number words above 10 follow a systematic pattern. For instance, the lexical item for 11 is a literal translation of *ten one*, and 22 corresponds to the term *two ten two*.

sequence to the set of natural numbers is acquired. Only in primary school, English-speaking children can use ordinal numbers consistently in a non-intersective way on series of intermixed objects. Chinese-speaking children can apply ordinal numbers non-intersectively already two years earlier than their English-speaking peers. According to Bylinina et al. (2014) two sources of information have to be integrated to define the relevant set of objects on which the ordinal operates. The content of a comparison class and the following noun phrase has to be considered to define the relevant set. It may be the case that children need time to acquire the complex underlying semantic representation. This may be achieved by English-speaking children only at the age of 7-8. Alternatively, it may be the case that children have a target-like semantic representation but cannot integrate the different sources to define the relevant set for applying an ordinal number before the age of 7-8. Chinese-speaking peers may arrive at a target semantic representation or integration earlier because the acquisition of the ordinal word sequence is morphologically simpler.

This developmental path may suggest, as already proposed by Matthei (1982) and Marcilese et al. (2013), that ordinal numbers are first misclassified as intersective modifiers. This misclassification may be specific to ordinal numbers as shown by studies on the acquisition of other non-intersective adjectives like *tall* and *small* (Barner & Snedeker, 2008; Syrett et al., 2010; Tribushinina, 2013). Due to the complex semantic representation ordinal numbers ordinal numbers may behave differently than e.g., dimensional adjectives in acquisition. This assumption will be addressed in more detail in the empirical part of this thesis.

4.3.4. Summary

Ordinal numbers like relative clauses are modifiers of nominal expressions. In contrast to relative clauses, they have to be interpreted relative to a comparison class and belong to the class of subsective but non-intersective modifiers. A formalization of the semantics of ordinal numbers is put forward by Bylinina et al. (2014). They assume that ordinal numbers are composed of a natural number and an ordinal suffix. The interpretation of the ordinal relies on the intension of the noun phrase and the comparison class as well as on a ranking function that evaluates the position of elements in a sequence. The comparison class may be determined contextually or by some (focused) phrase in the sentence. Studies on the acquisition of ordinal numbers showed that the lexical representation of ordinal numbers is enriched step by step. According to Colomé and Noël (2012), small ordinal numbers were interpreted correctly in more than 60% at the age of 5. However, ordinal numbers may be misclassified as intersective modifiers at an earlier stage in the acquisition process in contrast to other non-intersective adjectives like *tall* and *small* (Barner & Snedeker, 2008; Syrett et al., 2010; Tribushinina, 2013). Consistent non-intersective interpretations are only found for children in primary school (Miller et al., 2000). The overview shows that studies on the acquisition of ordinal numbers in German are lacking. Due to a similar degree of suppletion, German-speaking children are expected to pattern more like English-speaking children than like Chinese-speaking ones. Thus, difficulties with the semantics of ordinal numbers may be expected until

primary school.

Although ordinal numbers may be acquired by some children only in primary school, ordinal numbers are used in the experiments reported in the following three chapters to investigate pre-school children. Based on the results presented here, however, a pretest was implemented to identify children with target-like knowledge of ordinal numbers. In the following, three experiments are reported that investigated the acquisition of restrictive and appositive relative clauses in German-speaking children.

5. Experiment 1: Prosody and visual context in (un)ambiguous relative clauses

Experiment 1 aimed to investigate how German-speaking pre-school children and adults interpret syntactically ambiguous relative clauses as given in (1). The task is a modification of the experiments developed by Roeper (1972) described in Matthei (1982), and Hamburger and Crain (1984), see Section 3.4.1, pages 107ff. The experiment explored whether German-speaking pre-school children and adults choose a restrictive or appositive interpretation for sentences as in (1) when one or multiple factors disambiguated the sentence towards one of the readings respectively. Thus, research question (Q1) was in the focus of interest asking which interpretation of syntactically and contextually ambiguous relative clauses is preferred.

(1) Nimm das dritte Auto, das rot ist, und leg' es in den Koffer!
Take the third car which red is and put it in the suitcase

'Take the third car$_{(,)}$ that/which is red$_{(,)}$ and put it in the suitcase!'

As reported in Section 2.4 on relative clauses in German, sentences like (1) are syntactically and semantically ambiguous between a restrictive and an appositive reading. Two factors were manipulated in the experiment to disambiguate the two semantic functions: Prosody and Visual Context. Hereby, research question (Q3) was addressed asking whether linguistic and contextual information influence interpretation preferences. Structurally ambiguous relative clauses as in (1) were paired either with a restrictive or with an appositive prosody to disambiguate between the possible readings (Lehmann, 1984, among others). Furthermore, the sentences were paired with an ambiguous or unambiguous visual context. The order of the depicted objects either allowed both the restrictive and the appositive interpretation, or only one of them.

In the following sections, the experiment is presented in detail. Section 5.1 gives an overview of the participants. Test items are depicted in Section 5.2. In addition, this section addresses further methodological issues as well as the procedure of the experiment. Results are presented in Section 5.3 and discussed in Section 5.4. Section 5.5 concludes this chapter.

5.1. Participants

Eighty-three monolingual German-speaking children participated in the task that was part of the research project CARU *Child Acquisition of Relative Clauses* headed by Petra Schulz. The project is part of the Research Group 1783 *Relativsätze* 'Relative clauses' funded by the German Science Foundation. The group consisted of 42 girls and

41 boys whose age ranged from 4;0 to 6;10 with a mean age of 5;1 (*SD*: 8.7 months). The children were recruited in 16 day-care centers in Frankfurt am Main, Germany. Written consent for the participation in the study was given by all parents. All children grew up with German as their first language and were not exposed systematically or enduringly to a second language. No participant had a reported history of language or hearing problems, as their parents declared in a questionnaire. In addition to the background obtained in the parental questionnaire, a standardized language test served as inclusion criterion. Only those children were included who performed within the age related norms of the standardized language test (T-value above 40). Four- and 5-year-old children were assessed with the SETK 3-5 (H. Grimm, 2001); with children at the age of 6 the TROG (A. V. Fox, 2006) was conducted. In this sample of participants the standardized language tests did not result in the exclusion of participants. One girl, aged 4, had to be excluded after conducting the experiment due to a large number of missing items. Hence, the data of a total number of 41 girls and 41 boys are taken into account in the following.

In addition, 20 adults (9 men and 11 women) aged 18;9 to 40;9 years with a mean age of 26;9 years (*SD*: 71.5 months) were tested as control group. The adults were mainly students of the Goethe University Frankfurt. Each participant received 7 € for participation. Linguistics students were not admitted to participate. Table 5.1 gives detailed information on the participants that are included for the analysis of the results.

Table 5.1.: Exp. 1 – Overview of participants

	Age 4 $n = 36$	**Age 5** $n = 36$	**Age 6** $n = 10$	**Adults** $n = 20$
Sex	16 boys 20 girls	18 boys 18 girls	7 boys 3 girls	9 men 11 women
Age range	4;0 - 4;11	5;0 - 5;11	6;0 - 6;10	18;9 - 40;9
Mean age	4;5	5;5	6;4	26;9
SD	3.7 months	3.1 months	3.1 months	71.5 months

Note. SD = Standard deviation.

5.2. Method

Experiment 1 used a picture selection task to assess the interpretation preferences of German-speaking children and adults when confronted with syntactically ambiguous relative clauses. The task of Experiment 1 is not a classical preference task. In typical picture selection tasks (see e.g., Schmitt & Miller, 2010), different interpretations of a sentence are depicted in two or more pictures. The child's task is to select the picture that fits best the meaning of the noun phrase or event described in the test sentence. Picture selection tasks are typically used to test the comprehension of unambiguous test

sentences. In the experiment presented here, an ambiguous stimulus was presented. By their picture selections, the participants indicated which reading they derived in the comprehension process. In addition, the design of this experiment used only one visual context instead of different pictures. The visual context offered the possibility to choose between different readings of the relative clauses. Furthermore, there was a possibility implemented in the experimental design to reject all readings supported by the visual context. As a consequence, the participants were not forced to opt for one or the other reading as in typical picture selection tasks. Despite these differences, the design allowed to explore interpretation preferences for syntactically ambiguous relative clauses.

It is noteworthy that the experiment is a modification of the picture-selection task used by Hamburger and Crain (1984). The idea to investigate the interpretation of sentences including multiple modifiers in this experimental setting goes back to Roeper (1972) and Matthei (1979). In contrast to the previous studies, which focused on the interpretation of prenominal adjectives, the experiment presented here investigated interpretation preferences for relative clauses. Experiment 1 focused on contextually ambiguous relative clauses as well as on contextually unambiguous restrictive and appositive relative clauses.

5.2.1. Design and material

Overall the task comprised 42 items: 24 relative clause test items were tested in a 2 × 2 factorial design including the factors Prosody (restrictive vs. appositive) and Visual Context (ambiguous vs. unambiguous). In addition to the four test conditions, the experiment included two warm-up items, four items of a pretest as well as 12 items to control for the interpretation of ordinal numbers. In what follows, first, the test items are presented, then the additional conditions are described, and an example illustrates how the test items were implemented in a computer game.

5.2.1.1. Relative clause test items

All relative clause test item of Experiment 1 were of the structure in (2).

(2) Nimm das *n-te X*, das ___(*Farbe*) ist, und leg' es in den Koffer!
Take the n^{th} *X* which ___(*color*) is and put it in the suitcase

'Take the n^{th} $X_{(,)}$ that/which is ___$(color)_{(,)}$ and put it in the suitcase!'

The verbal stimuli consisted of an imperative to take the n^{th} object with an attached relative clause that specified the color of the object. After the relative clause, a conjoined imperative followed, asking the child to put the selected object in a suitcase. To obtain truth-functional differences between the two readings, the ordinal numbers *zweite/r/s* 'second' and *dritte/r/s* 'third' were included in the prompt. They agreed in number and gender with the following noun. Within each condition, the occurrence of *zweite/r/s* 'second' and *dritte/r/s* 'third' was balanced. Higher ordinals were not included since Colomé and Noël (2012) showed that ordinal numbers are acquired in a stepwise fashion.

Their results showed that comprehension rates for higher numbers such as 6^{th} and 7^{th} are still below 60% at age 5 for English-speaking children. In addition, larger ordinal numbers would require more objects in the visual displays, which would complicate the task unnecessarily.

Eighteen different test sentence were constructed. The sentences were requests for 18 different daily life objects in eight different colors. The lexical material of the experimental items is listed in Table 5.2.

Table 5.2.: Exp. 1 – Lexical material for experimental items

Objects					
apple	ball	cap	car	duck	hat
jacket	lollipop	pencil	pullover	scarf	scissor
sun glasses	toothbrush	towel	trousers	T-shirt	watch
Colors					
black	blue	green	multicolored	pink	red
striped	yellow				

The 18 test sentences were split into three sets of six sentences. Table 5.3 gives an overview of the experimental design. The labels *Set 1*, *Set 2*, and *Set 3* show which set of sentences was presented in which condition.

Table 5.3.: Exp. 1 – Overview of relative clause conditions

Factors	**Conditions**			
Prosody	Restrictive ($n = 12$)		Appositive ($n = 12$)	
Visual Context	Ambiguous ($n = 6$)	Unambiguous ($n = 6$)	Ambiguous ($n = 6$)	Unambiguous ($n = 6$)
	Set 1	Set 2	Set 1	Set 3

As Table 5.3 shows, six sentences were tested in each of the four experimental conditions. The set of sentences used in the two ambiguous conditions, Set 1, were identical. The sentences were presented twice and differed only with regard to their prosodic realization. The following paragraphs focus on the prosodic details of the test sentences. The six sentences of the unambiguous context conditions differed in their lexical material.

To investigate the influence of the factor Prosody on the interpretation of relative clauses like in (1), repeated here as (3), pre-recorded stimuli were used.

(3) Nimm das dritte Auto, das rot ist, und leg' es in den Koffer!
Take the third car which red is and put it in the suitcase

'Take the third car$_{(,)}$ that/which is red$_{(,)}$ and put it in the suitcase!'

All test sentences were pre-recorded in a friendly voice by a native female speaker of German. For relative clauses in the restrictive prosody condition, the head noun and the relative clause formed one intonational phrase. Main stress was realized on the color adjective within the relative clause. Any border phenomena like a pitch accent on the head noun, or pauses between the head noun and the relative clause were avoided. The pause after the relative clause and before the continuation of the matrix clause was manually adjusted to 400 ms. Figure 5.1 shows the wave form and pitch contour of the restrictive realization of (3).

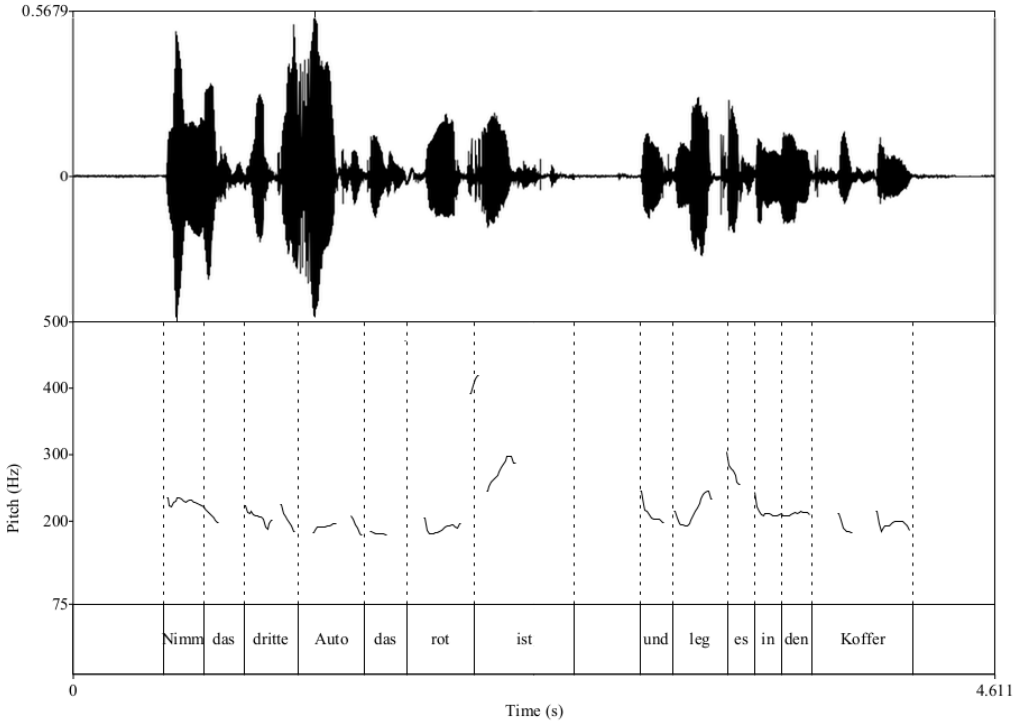


Figure 5.1.: Exp. 1 – Wave form and pitch contour of a restrictive relative clause test item.

For relative clauses with an appositive prosodic contour, the embedded clause was realized as a separate intonational phrase. In this condition, both the head noun and the color adjective in the relative clause were stressed, and the relative clause was slightly backgrounded. In addition, there were pauses before and after the relative clause. Both pauses were manually adjusted to 400 ms. The additional pause between the head noun and the relative clause led to a longer duration of items with appositive prosody than with restrictive prosody. The appositive prosodic pattern for Example (3) is shown in Figure 5.2.

All pre-recorded stimuli were adjusted to an intensity of 75 dB and were controlled by a trained phonologist. Note that it was not possible to include a third prosodic contour, which is neutral with regard to the underlying semantics. As it is reported in Section 2.5,

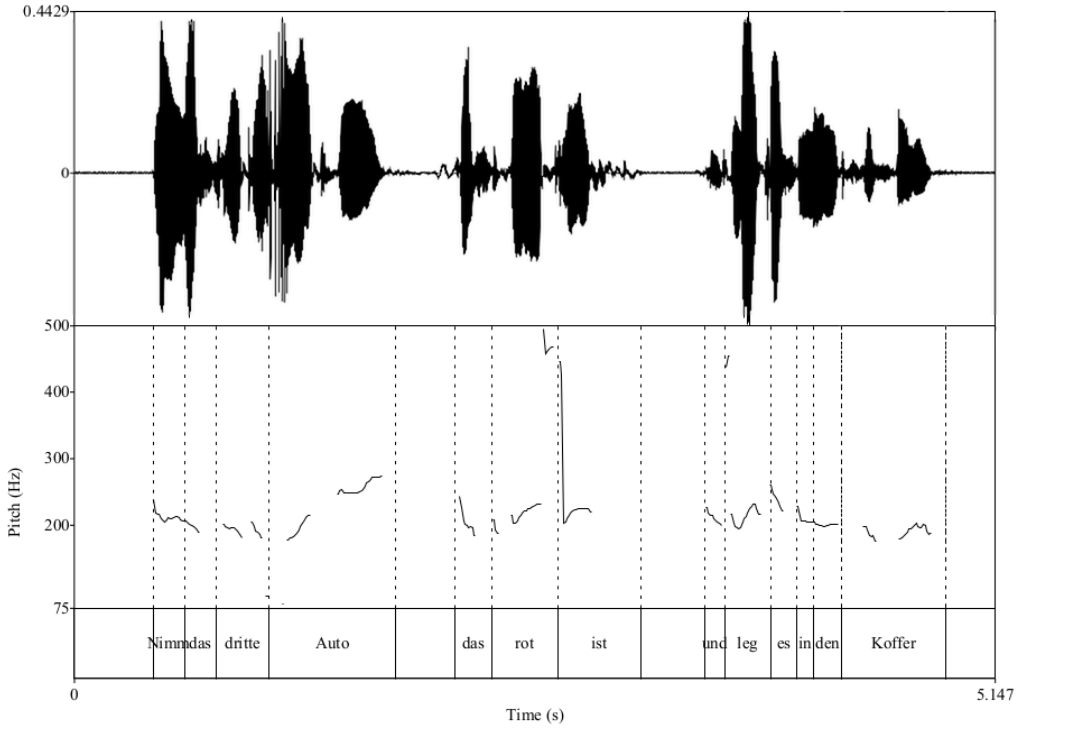


Figure 5.2.: Exp. 1 – Wave form and pitch contour of an appositive relative clause test item.

in studies in which prosody has an effect on comprehension, relative clauses or adjectives marked by an intonation phrase boundary were associated more often with an appositive interpretation (Schubö et al., 2015; Schafer, 1997). The absence of such a boundary was related to restrictive interpretations although this finding was not very robust. Thus, the presence or absence of a boundary, e.g., in terms of pauses between the head noun and the attached relative clause, could be a relevant criterion for the disambiguation between a restrictive and an appositive prosody. Hence, an unambiguous prosody could not be implemented. The use of a robot-like voice with a flat contour of the fundamental frequency F_0 would also be biased towards one or the other reading depending on the presence or absence of an intonation phrase boundary between the head noun and the relative clause.

As a second factor, Experiment 1 investigated the influence of the visual context on the interpretation of semantically ambiguous relative clauses in German-speaking children and adults. Visual contexts were either ambiguous with regard to the relative clause semantics, or they matched only one of the readings. Thus, the visual contexts were comparable to the biased and unbiased conditions investigated by Roeper (1972), Matthei (1982), and subsequent studies.

Figure 5.3 shows an ambiguous visual context for the relative clause test item in (3) asking for the third car that or which is red. The visual display supplied a picture

matching both the restrictive and appositive reading as well as the deviant intersective reading. This is explicated below.

Figure 5.3.: Exp. 1 – Ambiguous visual context for ordinal number *third*.

In principle the visual displays the test sentences were paired with were constructed similarly for all relative clause test items. As in the study of Hamburger and Crain (1984), the visual context for a stimulus sentence consisted of an array of seven objects. Two different types of objects (e.g., cars and balls) were interspersed to keep appositive interpretations apart from the potentially occurring deviant intersective interpretations (see Section 3.4.1, pages 112ff.). In addition, the objects denoted by the head noun were presented in two different colors. The use of two types of objects, target objects and distractors, and the use of different colors assured that both the semantics of the head noun as well as the content of the relative clause had to be encountered to select a referent.

If a child selected object no. 6 in Figure 5.3, this indicated a restrictive interpretation of the verbal stimulus in (3). A choice of object no. 4 corresponds to an appositive interpretation. Previous studies on the interpretation of analogous structures with two prenominal adjectives (like *Take the third red car*) reported that children frequently selected the object depicted at position 3 in a visual context comparable to the one in Figure 5.3. See for instance Matthei (1982), Hamburger and Crain (1984), and Marcilese et al. (2013) and the summary in Section 3.4.1. In Experiment 1, this object matched all three properties mentioned in the stimulus: It was the third object, a car, and red. To investigate this deviant intersective interpretation in more detail, all ambiguous visual contexts of the present experiment included such an object.

Thus, in this experiment, all ambiguous visual displays were constructed to license all three interpretations. However, a full discrimination between a restrictive, appositive, and intersective interpretation was only possible in items using the ordinal number *third*. In case of the ordinal number *second*, two interpretations each led to the same picture choice. Visual contexts could be constructed in two ways: Either one picture corresponded to both the intersective and appositive interpretation, or one picture corresponded to the restrictive and appositive ones. The following visual displays in Figure 5.4 and Figure 5.5 demonstrate the two patterns for the relative clause test sentence in (4).

(4) Nimm die zweite Ente, die grün ist, und leg' sie in den Koffer!
Take the second duck which green is and put it in the suitcase

'Take the second duck$_{(,)}$ that/which is green$_{(,)}$ and put it in the suitcase!'

In Figure 5.4, both an intersective and an appositive interpretation leads to a selection of the object at position 2. Restrictive interpretation can be identified when the object

Figure 5.4.: Exp. 1 – Ambiguous visual display for ordinal number *second*. Intersective and appositive interpretations cannot be distinguished.

Figure 5.5.: Exp. 1 – Ambiguous visual display for ordinal number *second*. Restrictive and appositive interpretations cannot be distinguished.

at position 5 is selected. In Figure 5.5, the deviant intersective interpretation leads to a picture choice of object no. 2. Restrictive and appositive interpretations both fall on object no. 3 and cannot be distinguished on the basis of the picture choice. In this case, the second duck is also the second of the green ducks.

Unambiguous visual displays are shown in what follows. The test sentence in Example (5) together with Figure 5.6 shows a stimulus pair consisting of a semantically ambiguous relative clause paired with an unambiguous, restrictive visual context.

(5) Nimm den zweiten Apfel, der gelb ist, und leg' ihn in den Koffer!
Take the second apple which yellow is and put it in the suitcase

'Take the third apple that is yellow and put it in the suitcase!'

Figure 5.6.: Exp. 1 – Restrictive visual display.

In this stimulus pair, only a restrictive interpretation of the sentence in (5) is possible. In this visual context, the second of the yellow apples can be selected. An appositive interpretation is not possible since the second apple is not yellow. Also the deviant intersective interpretation is ruled out since object no. 2 is not an apple.

A contextually appositive test item is illustrated in Example (6) and Figure 5.7.

(6) Nimm die zweite Mütze, die grün ist, und leg' sie in den Koffer.
Take the second cap which green is and put it in the suitcase

'Take the second cap, which is green, and put it in the suitcase.'

Figure 5.7.: Exp. 1 – Appositive visual display.

The visual array in Figure 5.7 only allows for an appositive picture choice for the sentence in (6). Since there is only one green cap, a restrictive interpretation is ruled out. Also an intersective reading is not licensed by the visual context since at position 2 no green cap is present. Therefore, only the second of the caps, at position 4, can be chosen, which matches an appositive reading.

Throughout the experiment, the target-positions for the restrictive and appositive interpretations were distributed across positions 3 to 7. Intersective interpretations were always linked to the position denoted by the ordinal number, i.e., positions 2 and 3.

5.2.1.2. Pretest and Control conditions

In addition to the 24 test items, 16 items without a relative clause were included in the experiment. They tested the core meaning of ordinal numbers and the semantic properties *non-intersectivity* and *subsectivity* of ordinal numbers (see Section 2.3.3 for definitions of these properties). All auditive prompts for these additional conditions were of the structure in (7).

(7) Nimm das *n-te X* und leg' es in den Koffer!
Take the n^{th} *X* and put it in the suitcase

'Take the n^{th} *X* and put it in the suitcase!'

Four out of 16 items served as a pretest. In these items, the visual displays showed only one type of objects. Similar to the relative clause test items, two different colors were used. An example is depicted in Figure 5.8. The corresponding sentence is given in (8).

(8) Nimm das zweite T-Shirt und leg' es in den Koffer!
Take the second T-shirt and put it in the suitcase

'Take the second shirt and put it in the suitcase!'

The sentences of the pretest items were pre-recorded with a natural intonation pattern. Since no alternative objects were present in the visual contexts, main stress was placed on the ordinal number. The pause between the two coordinated parts was adjusted to 400 ms in all items.

Two control conditions addressed further semantic aspects of ordinal numbers. The first control condition tested the non-intersectivity of ordinal numbers comprising six items. Note that the items correspond to those of the second experiment of Matthei

Figure 5.8.: Exp. 1 – Visual context for the pretest on the core meaning of ordinal numbers.

(1982) reported in Section 3.4.1 on page 109. In this condition, the visual context consisted of two different types of objects that were intermixed. An example is given in (9) and Figure 5.9.

(9) Nimm den zweiten Lutscher und leg' ihn in den Koffer!
Take the second lollipop and put it in the suitcase
'Take the second lollipop and put it in the suitcase!'

Figure 5.9.: Exp. 1 – Visual context for control condition Non-intersectivity of ordinal numbers.

To select the correct object in this condition, children had to restrict the ordinal to the class of objects denoted by the head noun. That is, they had to interpret the ordinal as a non-intersective modifier and should only count within the specified subset of objects. In the visual contexts of this condition, also an intersective distractor was present. At position 2, there was a lollipop but this lollipop was not the *second lollipop* in the sequence of objects. Target-like performance in this control condition was required to obtain truth-functional differences between restrictive and appositive relative clauses in the test items.

The second control condition tested whether children knew that ordinal numbers are subsective modifiers. According to the semantic classification of adjectives, a modifier is subsective when the modified noun is still a member of the set denoted by the noun. That is, a *third hat* is still a hat. This implication was violated in this control condition. Thus, subsectivity was tested indirectly via presupposition failures in this experiment. Six items were used in the condition. An example item is displayed in (10) and Figure 5.10.

(10) Nimm den dritten Hut und leg' ihn in den Koffer!
Take the third hat and put it in the suitcase
'Take the third hat and put it in the suitcase!'

Figure 5.10.: Exp. 1 – Visual context for control condition Subsectivity of ordinal numbers.

As the example demonstrates, the verbal prompt did not match the visual context in this condition. No elements were displayed that belonged to the extension of the noun. In Figure 5.10, for instance, no hat is displayed. Thus, a target-like response under this condition required a statement that there was no matching object in the array.

The visual context of items in the control condition Subsectivity was similar to that of items in the control condition for the non-intersectivity of ordinal numbers; two different types of objects were intermixed. In the pre-recorded sentences of both control conditions, main stress was placed on the noun. Since there was an alternative object present in these conditions, contrastive stress on the noun was the most natural prosodic contour. Like in the other conditions, the pause between the two coordinated clauses was manually adjusted to 400 ms in all items.

In addition to the relative clause test items and control conditions, two warm-up items were used to familiarize the participants with the procedure of the computer game. In these items, the seven objects were of the same type but differently colored, as can be seen in Figure 5.11. The child had to select an object according to a verbal prompt given in (11).

(11) Nimm den zweiten Schlüssel und leg' ihn in den Koffer!
Take the second key and put it in the suitcase

'Take the second key and put it in the suitcase!'

Figure 5.11.: Exp. 1 – Visual context for a warm-up item.

The two warm-up items tested whether the eight color terms used in the experiment were acquired by the children. In addition, the second warm-up item was used to introduce occurrences of presupposition failures. The children were explicitly instructed to use an additional button when the request of the puppet could not be fulfilled. The experimental setting is described in the following.

5.2.1.3. Experimental setting

The experiment was administered in a block design. The two prosodic conditions of relative clauses ('Restrictive' and 'Appositive') were presented in two different sessions. The items of the pretest and of the control conditions were balanced across the two parts. Each part started with the two warm-up trials followed by an ambiguous relative clause and an item of the control condition for the non-intersectivity of ordinal numbers. The subsequent items were pseudo-randomized and mixed across conditions. The number of occurrences of the ordinals *second* and *third* were counterbalanced across the two sessions. A list of items is given in the appendix (see Appendix A.1 on page 349).

To avoid confounds due to the presentation order of restrictive and appositive intonation patterns, the experiment was administered in two versions. In Version 1, participants heard the restrictive prosody for relative clause items first; In Version 2, the appositive prosodic contour was presented first to the participants. Table 5.4 gives an overview of the distribution of test versions across participants.

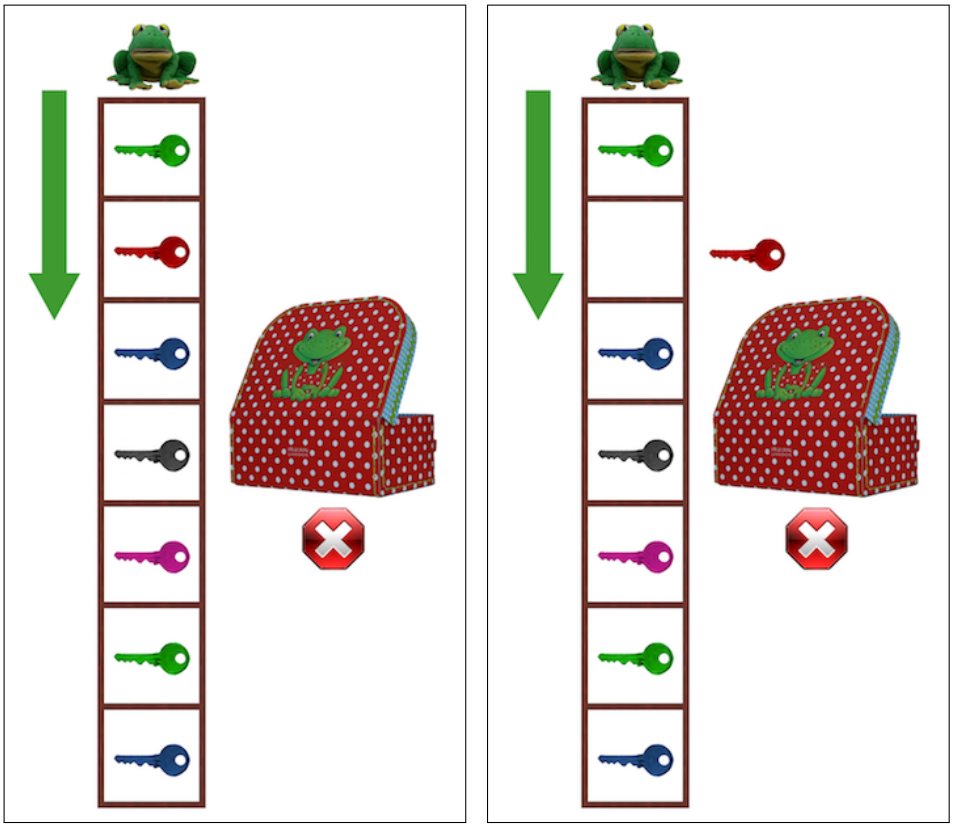
Table 5.4.: Exp. 1 – Distribution of test versions by age group

	Age 4 ($n = 36$)	**Age 5** ($n = 36$)	**Age 6** ($n = 10$)	**Adults** ($n = 20$)
Distribution of test versions	21x Version 1 15x Version 2	20x Version 1 16x Version 2	3x Version 1 7x Version 2	10x Version 1 10x Version 2

Figure 5.12 demonstrates the experimental set up as implemented in the computer game. Figure 5.12a illustrates the situation at the beginning of the items; Figure 5.12b shows the scene after the participant had selected the object of his choice. Subsequently, the object followed an animated path into the suitcase.

So far, the objects in the example test items were aligned left-to-right. In the experimental setting as displayed in Figure 5.12, however, they were aligned top down. This ordering was used to exclude a potential confound due to the counting direction. Children in kindergarten do not yet know that reading proceeds from left to right. Therefore, the handedness of the participants or other factors may lead to different counting directions. The top-down alignment in Figure 5.12 avoided this source of confounds inducing a salient direction. The top-down direction was highlighted further by an arrow to the left of the cupboard with the objects and was practiced in the warm-up items. In addition to the array of objects, a separate button henceforth labeled as 'no matching picture' button was displayed below the suitcase. The child was instructed in the warm-up items to press this button when there was no object present in the visual array that was matching the sentence.

The use of the colors was balanced across target objects and distractors. Each color was used 10 times; Four to five times as target color mentioned in the verbal prompts and four to five times as alternative color displayed in the visual context. The following section focuses on the details of the experimental procedure.



(a) Before picture selection. (b) After picture selection.

Figure 5.12.: Exp. 1 – Screenshot of the experimental setting for warm-up item 1.

5.2.2. Procedure

The children were tested individually in a quiet room of their day-care facilities. Only one child was tested at home. Testing was performed by trained student assistants. At the beginning of the first test session, the experimenter told the participant a background story about the puppet frog Caru. Caru wanted to go on holidays but needed help to pack his suitcase. The experimenter asked whether the participant would help Caru to pack the suitcase. In the following, two warm-up items familiarized the child with the experimental setting. Children had to use the computer mouse to click on the picture of Caru and on the selected objects. If a child could not handle the mouse properly she was instructed to point at the objects. In this case, the experimenter moved the mouse according to the pointing of the participants.

The experimental procedure consisted of the following steps. For every item, i) the children had to name the objects in the cupboard, ii) the children had to name the colors of the objects, iii) they had to click on Caru to listen what the puppet wanted to take with him, and iv) the participants had to click on one object. The selected

object then moved into the suitcase. Thus, children first saw the visual display, then they heard the pre-recorded sentence. When no matching object was present, the child was instructed to click on the button below the suitcase. In this case, the child was told that nothing was packed into the suitcase. No response-contingent feedback was given to the participants. The experimenter was allowed to correct the child only in the warm-up trials to clarify the experimental procedure and to make the children aware of the possibility of presupposition failures. In the following experimental trials, the experimenter neither commented on the picture selections, nor asked for justifications why a certain object was selected.

The two experimental parts were presented in two different test sessions to avoid a transfer of potential response strategies by the children. The two test sessions were administered with at least one day in between. All test sessions were audio- and video-taped for later analyses. In addition, the experimenter marked the picture choices on a protocol. In the following section, the coding of the participants' picture selections is described in detail.

5.2.3. Data analysis and coding

The experiment was implemented as a html script that ran locally on windows laptops within the Mozilla web-browser. All picture choices were stored automatically in a database on the laptops. For every item, the position of the selected element was stored in the database. This raw data were extracted as a csv-file for subsequent analyses.

The raw data were imported into the statistics program SPSS. In SPSS, the positions of the selected objects were transformed into the corresponding interpretations were are linked to the respective picture choices. Picture selections for the relative clause test items were classified according to one of the following five labels: *restrictive*, *appositive*, *intersective*, *no matching picture*, and *other*. This coding process is explicated here for the contextually ambiguous example in (3), repeated as (12) with the corresponding visual context in Figure 5.13.

(12) Nimm das dritte Auto, das rot ist, und leg' es in den Koffer!
Take the third car which red is and put it in the suitcase

'Take the third car$_{(,)}$ that/which is red$_{(,)}$ and put it in the suitcase!'

1 2 3 4 5 6 7

Figure 5.13.: Exp. 1 – Ambiguous visual display for ordinal number *third*.

When a participant chose the object in position 4, i.e., the third car independently of the color, the choice was coded as *appositive*. When the participant opted for the third

of the red cars and took object no. 6, the choice was coded as *restrictive*. In case the 'no matching picture' button was pressed, the response was coded as *no matching picture*. If the object at position 3 was chosen, the response was coded as *intersective*. All other picture choices were coded as *other*.

For relative clause test items including the ordinal *second*, only one of the three readings could be clearly identified by the picture selection (see Figures 5.4 and 5.5). The other two readings collapsed on one object. A selection of the picture that could not receive a clear category, thus, was labeled as *intersective/appositive* or *appositive/restrictive*. Since all three readings could only be distinguished in items testing the ordinal number *third*, statistical analysis on the results could only be performed for this ordinal number. In the unambiguous relative clause items, a target-like response matching the prosodic contour was coded as *restrictive* or *appositive* respectively. Except for the *no matching picture* response all other picture choices were subsumed under the label *other*. For the four items of the pretest, the correct picture choice was coded as *correct*, whereas all other responses were coded as *other*. In the control condition for the non-intersectivity of ordinal numbers, a target-like picture choice was coded as *correct*. In addition, the selection of the *second* or *third* object overall ignoring the type of object was coded as *intersective*. All other picture choices were coded as *other*. Since no matching pictures were present in the control condition Subsectivity, the choice of the *no matching picture*-button was coded as *correct*. All other responses were classified as *other*.

In addition to this automatic coding process, the videos were double-checked for unintended picture selections. In this experiment, children had no possibility to correct an erroneous picture choice. In case of an unintended click on an object, the experimenter made a note in the protocol. In these instances, the automatically recorded values were manually corrected according to the verbal reactions of the participants.

In addition to the picture selections, verbal comments of the participants were transcribed. The spontaneous reactions of the participants to the auditive prompts were taken into account to clarify intended interpretations of participants for additional analyses.

In the following section, the results of Experiment 1 are presented.

5.3. Results of Experiment 1

In this section, the results of Experiment 1 are reported. Section 5.3.1 presents the results for the pretest on the core meaning of ordinal numbers and the results of the control conditions for the semantics of ordinal numbers. On the basis of these results a criterion is defined to include participants for an analysis of the relative clause items as discussed in Section 5.3.2. Results on the interpretation of relative clauses in the two prosodic and contextual conditions are presented in Section 5.3.3.

Since the experimental data were not normally distributed, non-parametric statistic tests were performed throughout this thesis. To compare a dependent variable across multiple independent groups (e.g., across age groups or test versions), Kruskal-Wallis H tests were performed. When two independent groups were compared, Mann-Whitney

U tests were used. Friedman tests are reported for comparisons across multiple related samples (like experimental conditions or interpretation types). Wilcoxon tests were performed to compare two related samples. The p-values were corrected for multiple testings when post-hoc tests were conducted.

5.3.1. Pretest and control conditions for the semantics of ordinal numbers

Table 5.5 shows the group results based on correct picture selections in the four pretest items. In addition, the table displays the proportions correct for the two control conditions. The table is subdivided for the three age groups of for 4- to 6-year-old children and adults.

Table 5.5.: Exp. 1 – Percentages correct (*SD*) for pretest and control conditions on ordinal numbers by age group

	Age 4 (n = 36)	**Age 5** (n = 36)	**Age 6** (n = 10)	**Adults** (n = 20)
Pretest	56.9% (40.8)	88.9% (24.2)	85.0% (31.6)	98.8% (5.6)
Control conditions				
Subsectivity	96.3% (11.3)	97.7% (9.1)	100% (0.0)	100% (0.0)
Non-intersectivity	51.4% (32.0)	59.7% (43.2)	23.3% (41.7)	99.2% (3.7)

As the results show, the performance in the pretest increased from 56.9% at age 4 to 88.9% at age 5. For children at age 6, the performance remained at 85%. Adults performed target-like with 98.8% of correct picture selections. The descriptive increase of correct interpretations in the pretest items was confirmed by a statistical analysis. There was a significant difference between the mean ranks of correct picture selections across age groups ($\chi^2(3) = 24.5$, $p < .001$) with mean ranks of 35.8 at age 4, 58.1 at age 5, 54.4 at age 6, and 66.6 in the adults group. Pairwise post-hoc tests yielded significant differences between age 4 and 5 (U = -22.3, p = .001), as well as between children at age 4 and the adult control group (U = -30.8, $p < .001$).

With regard to the control conditions, Table 5.5 shows that all groups performed above 96% correct in the control condition investigating the subsectivity of ordinal numbers. Interpreting a modified noun as an instance of the noun category, i.e., a second hat as a hat, was not problematic for any of the children tested. The data demonstrate that children in this experiment interpreted ordinal numbers as subsective modifiers independently of their age and of whether they performed target-like in the pretest on the core meaning of ordinal numbers. Furthermore, the results of this condition demonstrate

that children did not hesitate to use the 'no matching picture' button. Remember that in this condition, participants could not select a matching picture from the cupboard because only objects of a different kind were present. All children used the 'no matching picture' option consistently when the visual context did not provide a picture matching their interpretation of the pre-recorded stimulus.

Performance in the control condition for the non-intersectivity of ordinal numbers remained low in children at the age of 4 to 6. Especially the 6-year-old children performed poorly and selected a correct picture for only 23.3% of items. The high standard deviations in this condition indicate heterogeneous interpretation patterns within the age groups. The heterogeneity may be due to the fact that the meaning of ordinal numbers has not yet been fully acquired. The data shown in Table 5.5 do not differentiate between children that interpreted ordinal numbers correctly and those that had problems. To exclude children without proper comprehension of the core meaning of ordinal numbers, performance in the pretest on ordinal numbers was used to define a grouping criterion. Children without target-like interpretations in the pretest could then be excluded from further analyses.

The table in 5.6 gives an overview of how many participants interpreted n items of the pretest correctly. Since it was necessary for the analysis of relative clause interpretations that children had acquired the meaning of ordinal numbers, correct interpretations of all four pretest items was defined as mastery-criterion. Table 5.6 reveals that 69 participants overall and 49 out of 82 children (60%) had selected the correct picture in 4 out of 4 items of the pretest on ordinal numbers. In addition, the proportions of children with four correct picture selections show an increase of mastery from 38.9% at age 4 to 77.8% at age 5. However, even at age 6, three children did not yet reach adult-like interpretation and full mastery of the core meaning of ordinal numbers.

Table 5.6.: Exp. 1 – Cross-table on the number of participants with n correct interpretations and mastery in pretest by age group

	No. of correct interpretations	**Age 4** ($n = 36$)	**Age 5** ($n = 36$)	**Age 6** ($n = 10$)	**Adults** ($n = 20$)
	0	7	1	1	-
	1	8	1	-	-
	2	3	3	-	-
	3	4	3	2	-
Mastery[a]	**4**	14 38.9%	28 77.8%	7 70.0%	20 100%

[a] Mastery defined as 4 out of 4 items correct.

Table 5.7 shows the results for the two control conditions testing the semantics of ordinal numbers by age groups. In this table, the data are partitioned for the group of children that mastered the pretest and for those children who did not pass the pretest. It

was expected that this subdivision reduced the heterogeneity within the control condition testing the non-intersectivity of ordinal numbers.

Table 5.7.: Exp. 1 – Percentages correct (*SD*) for control condition Subsectivity and Non-intersectivity by mastery of pretest and age group

	No mastery in pretest			**Mastery in pretest**			
	Age 4 ($n = 22$)	**Age 5** ($n = 8$)	**Age 6** ($n = 3$)	**Age 4** ($n = 14$)	**Age 5** ($n = 28$)	**Age 6** ($n = 7$)	**Adults** ($n = 20$)
Subsectivity							
Correct	97.7% (7.8)	97.9% (5.9)	100% (0.0)	94.1% (15.5)	97.6% (9.8)	100% (0.0)	100% (0.0)
Non-intersectivity							
Correct	50.0% (25.7)	85.4% (16.5)	66.7% (57.7)	53.6% (40.9)	52.4% (45.7)	4.8% (12.6)	99.2% (3.7)
Intersective	23.5% (19.7)	10.4% (17.7)	33.3% (57.7)	42.9% (41.7)	45.2% (46.7)	90.5% (25.2)	0.8% (3.7)
No match	3.0% (8.4)	2.1% (5.9)	–	–	1.2% (4.4)	–	–
Other	22.7% (26.0)	2.1% (5.9)	–	3.6% (9.6)	1.2% (4.4)	4.8% (12.6)	–

As the results in Table 5.7 show, splitting up the groups according to this criterion did not reduce the variability in the control condition Non-intersectivity in general[1]. Table 5.7 reveals that children without mastery in the pretest interpreted ordinal numbers in the control condition for the non-intersectivity of ordinal numbers target-like to a high extent. Despite non-target performance in the pretest, children at the age of 4 interpreted ordinal numbers in a non-intersective way in 50%[2] of items. In addition, children at age 5 selected the correct picture in 85.4% of cases and 6-year-olds in 66.7% of items although they failed in the pretest. Conversely, the results of the group that interpreted all items of the pretest target-like suggest that some of these children had

[1]The percentages for children at age 4 that did not pass the pretest do not add up to 100% since for one child data of five experimental items are missing. The missing data comprise one ambiguous and one restrictive relative clause item, one item of the pretest and one item of each of the control conditions.

[2]Note that 50% of correct interpretations cannot be considered as chance performance in this experiment. In the picture selection task, seven objects are provided among which four to five are of the noun category. According to the visual context, chance performance could thus be set to 1/7. Alternatively one could assume that the noun phrase is interpreted target-like. Then, chance performance would differ between 1/4 and 1/5 for the respective items. For relative clauses, chance performance varies depending on whether the visual context is (un)ambiguous. In the ambiguous contexts, the picture selections corresponding to restrictive and appositive readings count as correct. This could raise chance performance to 50% when both readings are acquired. Alternatively the number of objects that match all the properties could be considered to define chance level. Taken together, this experiment does not allow a sharp definition of chance performance that could be generally applied.

problems interpreting ordinal numbers non-intersectively. Correct interpretations were found in 53.6% of cases at the age of 4 and in 52.4% of cases in 5-year-old children. The rate of correct interpretations in these groups with mastery in the pretest was similar or below the performance of the group without mastery in the pretest. Especially the performance of the 6-year-old children was unexpected. The 6-year-olds with target-like interpretations in the pretest selected a correct picture in only 4.8% of items in the control condition.

In addition to correct interpretations, also deviant intersective interpretations were found in all groups of child participants. Unexpectedly, the proportion of intersective interpretations was higher in the group that mastered the pretest than for the children that did not perform correctly on the pretest items. Children mastering the pretest chose the deviant intersective interpretation in 42.9% of items at age 4, in 45.2% at age 5, and even at 90.2% at age 6 respectively. These children counted to the n^{th} position without restricting the ordinal number to instances of the head noun. Further analyses of the results were postponed until the unexpected results were analyzed in more detail. The additional analyses are discussed in the following section.

5.3.2. Interim discussion and additional analyses

It was not fully unexpected that the performance of children mastering the pretest was heterogeneous in the control condition Non-intersectivity. Since the items of the pretests consisted only of one type of objects (cf. Example (8) and Figure 5.8), counting to the n^{th} position was enough to reach target-like performance in the pretest. Consequently, the group of children that mastered the pretest could be split into two subgroups: On the one hand, there were children that had acquired the full semantics of ordinal numbers. On the other hand, there were children that showed a deviant intersective interpretation of ordinal numbers. Both readings led to a correct performance in the pretest but to different patterns in the control condition Non-intersectivity.

However, the results of the children without mastery of the pretest items were surprising. In more than half of the items, these children performed correctly in the control condition testing the the non-intersectivity of ordinal numbers. To select the correct picture in this control condition, it was necessary to know that ordinal numbers define the n^{th} position within a scale. This knowledge to select the n^{th} object, however, seemed to be lacking in the pretest items for these children.

To investigate this unexpected pattern more closely, two additional analyses were performed. First, the verbal comments that participants gave during the experiment were analyzed. Second, possible interactions with the experimental test versions were investigated. The analysis of the verbal comments to items of the pretest showed that 24 children adopted an unexpected strategy. At least once, these children asked the experimenter which color they should choose although the auditive prompt (e.g., *Nimm das zweite T-Shirt*, 'Take the second shirt') did not ask for any specific color. The comments in (13) and (14) show examples of children's reactions to items of the pretest on ordinal numbers.

(13) Counting within colors in the pretest on ordinal numbers (1)

Caru: Nimm das zweite T-Shirt und leg' es in den Koffer.
Child: Häh, Falsch. Guck zweites T-Shirt und gar nix mehr gesagt.
Exp: Was soll ich jetzt machen?
Child: Das zweite T-Shirt.
Exp: Zeig mal, welches soll ich einpacken?
Child: Das rote da ... nee das da (points at the 4th object, i.e., the second red one)

Caru *Take the second T-shirt and put it in the suitcase.*
Child: *häh? wrong. Look, second T-shirt and nothing more said.*
Exp: *What shall I do?*
Child: *The second T-shirt*
Exp: *Show me, which one shall I put into the suitcase?*
Child: *The red one there ... no, that one* (points at the 4th object, i.e., the second red one)

04_JLS099, age 4;4

(14) Counting within colors in the pretest on ordinal numbers (2)

Caru: Nimm das zweite T-Shirt und leg' es in den Koffer.
Child: Aber welche Farbe denn, Herr Frosch?
Exp: Was hat er gesagt?
Child: Der hat gesagt: Nimm das zweite T-Shirt und leg' es darein, aber welche Farbe denn?
Exp: Das hat er nicht gesagt, das musst du dir jetzt überlegen, wie du das löst.
Child: (points at the 'no matching picture' button)

Caru *Take the second T-shirt and put it in the suitcase.*
Child: *But which color, mister frog?*
Exp: *What did he say?*
Child: *He said: Take the second T-shirt and put it in there, but which color?*
Exp: *That he didn't tell. So you have to decide how you would solve this.*
Child: (points at the 'no matching picture' button)

04_NSA122, age 5;2

The children's comments and picture selections showed that some of the participants decided for one color and then counted correctly within the selected subset. Alternatively, children refrained from selecting an object since no color was mentioned. Although these 24 children demonstrated correct understanding of *second* and *third* in terms of constructing a scale and counting within a defined subset, these patterns led to a non-target-like performance in the pretest stimuli. They may had selected the *second*

blue or *second red shirt* in the pretest but not the second shirt overall. This pattern showed that they could count non-intersectively within subsets. Thus it is plausible that these children did not have problems to select the correct object in the control condition Non-intersectivity for ordinal numbers.

The wish to count only objects of a specific color could have been a consequence of the pseudo-randomized order of items in the experiment. The items of the pretest were intermixed with the relative clause test items, in which the information about the color of an object was highly relevant. An expectation to form subsets on the basis of the color information could have therefore been transferred to the pretest items.

Statistically, the use of this pattern could not be linked to one of the two test sessions, i.e., to one specific prosodic contour of the relative clause test items in the children's group (Z = -1.64, p = .10). However, a significant influence of the order in which the restrictive and appositive prosodical formats of the relative clauses were presented was found for the color counting strategy across all children (U = 1,020, p = .013). Within the individual age groups, no effect of test version yielded statistical significance (all ps above .19). These results show that children who listened to restrictive relative clauses first were more prone to adopt the color counting strategy when the analysis was performed across all children as one large group.

A significant influence of the order of the prosodical formats was also found for the performance of the participants in the control condition Non-intersectivity (U = 377, $p < .001$). Children at the age of 4 and 5 interpreted items of the control condition Non-intersectivity more often correct when they heard restrictive relative clauses first (age 4: U = 91.5, p = .03; age 5: U = 47.5, $p < .001$). Thus, the restrictive prosodic pattern could have enforced a strategy to detect subsets of elements in this experimental task.

Taken together, mastering the pretest of this experiment was not a reliable cue on whether the lexical meaning of the ordinal numbers *second* and *third* was acquired. Contrary to the expectation, correct non-intersective interpretations of ordinal numbers were also found for children that did not master the pretest. This pattern was due to the fact that a number of children applied an unexpected strategy to count only elements of a specific color in the pretest items. The strategy was enforced but not limited to children who listened to relative clauses first that were presented with a restrictive prosodic contour.

In light of these results, the pretest was abandoned as a relevant grouping criterion for further analyses. Instead, children were grouped exclusively on the basis of their performance in the control condition Non-intersectivity.

Table 5.8 shows a cross-table displaying the number participants by age group that interpreted items of the present control condition correctly n times.

Table 5.8 reveals that the children at the age of 4 performed heterogeneously in the control condition Non-intersectivity. Children at the age of 5 and 6, in contrast, show a bimodal distribution. They either accepted the majority of items, or they performed very poorly in this condition. To investigate the reasons for the poor performance of children in this condition, an error analysis was performed.

The following cross-tables show the distribution of incorrect intersective responses

Table 5.8.: Exp. 1 – Cross-table on the number of participants with n correct interpretations in control condition Non-intersectivity by age group

No. of correct interpretations	**Age 4** ($n = 36$)	**Age 5** ($n = 36$)	**Age 6** ($n = 10$)	**Adults** ($n = 20$)
0	3	10	7	-
1	6	2	-	-
2	6	1	1	-
3	6	1	-	-
4	6	-	-	-
5	3	10	-	1
6	6	12	2	19

(Table 5.9) as well as of incorrect picture selection of the category *other* (Table 5.10).

Table 5.9.: Exp. 1 – Cross-table on the number of participants with n intersective interpretations in control condition Non-intersectivity by age group

No. of intersective interpretations	**Age 4** ($n = 36$)	**Age 5** ($n = 36$)	**Age 6** ($n = 10$)	**Adults** ($n = 20$)
0	11	17	2	19
1	7	5	-	1
2	8	-	1	-
3	3	1	-	-
4	3	1	-	-
5	1	3	-	-
6	3	9	7	-

The data presented in Table 5.9 shows heterogeneous interpretation patterns for children at the age of 4. Intersective interpretations are observed with all possible frequencies in the youngest group of participants. For 5- and 6-year-old children, the individual interpretation patterns reveal a bimodal distribution of consistent intersective or non-intersective interpretations for the majority of participants. Intersective errors constitute the grand majority of errors in these groups. At the age of 5, 22 children interpreted less than two items intersectively, and 12 children showed five or more deviant intersective

Table 5.10.: Exp. 1 – Cross-table on the number of participants with n incorrect interpretations of category *other* in control condition Non-intersectivity by age group

No. of other interpretations	**Age 4** ($n = 36$)	**Age 5** ($n = 36$)	**Age 6** ($n = 10$)	**Adults** ($n = 20$)
0	21	33	9	20
1	6	3	-	-
2	4	-	1	-
3	2	-	-	-
4	2	-	-	-
5	1	-	-	-
6	-	-	-	-

interpretations. At age 6, 3 out of 10 children showed two or no intersective picture selections while seven children went for the deviant interpretation in all 6 test items.

In addition to intersective interpretations of ordinal numbers, the data in Table 5.10 suggest that some children at the age of 4 had not yet acquired the core meaning of ordinal numbers. They had problems to select the nth element from the cupboard independently of whether the n^{th}X was interpreted target-like or intersectively. As the table shows, rates of errors of the category *other* reduce to three at the age of 5 and to two at the age of 6.

Based on the cross-table in 5.9, a new grouping criterion for further analyses was defined. As discussed in Section 5.2.1.2, children had to interpret ordinal numbers consistently as non-intersective modifiers to yield truth-functional differences between the two semantic functions in the relative clause test items. As the performance in the control condition Non-intersectivity shows, a natural cut-off point seemed to be at 4 or 5 out of 6 correct interpretations. As discussed in Footnote 2 on page 176, chance level in this picture-selection task is difficult to define. Above chance performance, thus, could not be implemented as a cut-off point to differentiate between children with and without mastery on the semantic of ordinal numbers. Since stable non-intersective interpretation patterns were required for the relative clause test items, a strict criterion seemed suitable. Therefore, participants were classified as *non-intersective* when they interpreted at least 5 out of 6 items correctly in the control condition Non-intersectivity.

According to this criterion, 33 out of 82 children (40%) and all 20 adults had mastered the semantics of ordinal numbers and had interpreted them correctly as non-intersective modifiers. Table 5.11 gives an overview of participant's distribution of mastery by age group.

The percentages in Table 5.11 show that mastery of the semantic property *non-intersectivity* rose from age 4 to age 5 to a level of 61%. Surprisingly, the performance

Table 5.11.: Exp. 1 – Mastery of non-intersectivity of ordinal numbers by age group

	Age 4 ($n = 36$)	**Age 5** ($n = 36$)	**Age 6** ($n = 10$)	**Adults** ($n = 20$)
Mastery[a]	25.0% (9/36)	61.1% (22/36)	20.0% (2/10)	100% (20/20)

[a]Mastery defined as at least 5 out of 6 items correct.

dropped to 20% in the group of 6-year-olds. At this age, only 2 out of 10 children had mastered non-intersective interpretations of ordinals. Possible reasons for this low achievement at age 6 will be addressed in the Discussion in Section 5.4.

The following table shows the performance of children with and without mastery in the control condition Non-intersectivity for the pretest items and the control condition Subsectivity.

Table 5.12.: Exp. 1 – Percentages correct (*SD*) for pretest and control condition Subsectivity by mastery of control condition Non-intersectivity and age group

	No mastery of non-intersectivity			**Mastery of non-intersectivity**			
	Age 4 ($n = 27$)	**Age 5** ($n = 14$)	**Age 6** ($n = 8$)	**Age 4** ($n = 9$)	**Age 5** ($n = 22$)	**Age 6** ($n = 2$)	**Adults** ($n = 20$)
Pretest							
Correct	53.7% (39.7)	96.4% (13.4)	96.8% (8.8)	66.7% (45.1)	84.1% (28.4)	37.5% (53.0)	100% (0.0)
Subsectivity							
Correct	95.1% (12.9)	95.2% (13.8)	100% (0.0)	100% (0.0)	99.2% (3.6)	100% (0.0)	100% (0.0)

The data displayed in Table 5.12 illustrates again that good performance in the control condition Non-intersectivity was not linked to target-like performance in the pretest. Children that had mastered the non-intersective semantics of ordinal numbers performed worse in the pretest than their peers without mastery. In the control condition for the subsectivity of ordinal numbers, however, children with mastery were performing more often correctly than the children without mastery.

In the next section, the results for the relative clause conditions are presented.

5.3.3. Relative clause test items

This section first reports on the results for relative clauses in the two prosodic conditions with ambiguous visual contexts. Second, interpretations for relative clauses in the unambiguous context conditions are analyzed. These two subsections only report results for children with mastery in the control condition Non-intersectivity. Results from children without mastery in the control condition Non-intersectivity are addressed in the last part of this section. For additional data of the children with and without mastery in the control condition, see Section A in the appendix.

For the presentation of the results of children with mastery in the control condition, the data of the twenty-two 5- and the two 6-year-old children were collapsed. Thus, for the groups that had mastered the semantics of ordinal numbers, results are reported subdivided for nine children at age 4, 24 children at age 5 to 6, and 20 adults.

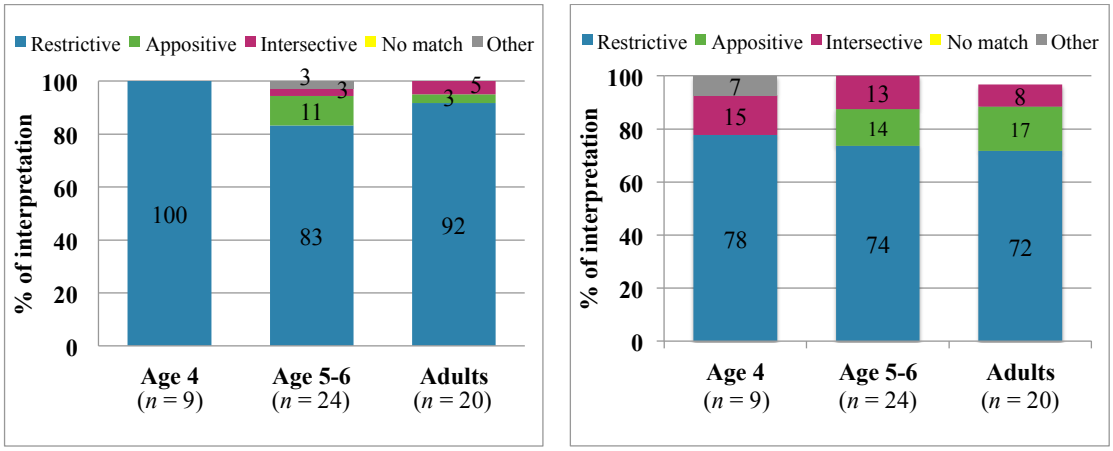
As described in the section on the method employed, relative clause test items were presented in four conditions with six items each: restrictive and appositive prosody was crossed with an ambiguous and unambiguous visual context. In the conditions with ambiguous visual context there was a picture present matching the restrictive and appositive interpretation, as well as a picture that matched the deviant intersective interpretation. Remember that only for the three items involving the ordinal number *dritte/r/s* 'third', all three readings could be clearly discriminated on the basis of the picture selections (see Figure 5.3 vs. Figures 5.4 on page 165). For the three items involving *zweite/r/s* 'second', always two readings converged on the same picture choice. Hence, results in the ambiguous context conditions are reported only for the ordinal number *dritte/r/s* 'third' in the following. Only for sentences including this ordinal number, statistical analyses could be performed. Data for the items involving *zweite/r/s* 'second' is given in the appendix (see Section A.2).

In addition, the experiment was administered in two different test sessions. The order of the prosodic formats in which the relative clause items were presented was balanced across participants. A comparison of the number of restrictive and appositive interpretations revealed no statistical differences across the two test version (all $ps > .056$ in all age groups). Therefore, the data was collapsed for the presentation of the results in this section.

5.3.3.1. The role of Prosody *in visually ambiguous relative clauses*

The bar charts in Figure 5.14 visualize the interpretation patterns for the items with the ordinal number *third* in the ambiguous visual context. A full overview of the results including data on the ordinal number *zweite/r/s* 'second' is given in the Appendix in Table A.2 on page 352.

The charts in Figure 5.14a and 5.14b show that all groups interpreted the relative clauses in the ambiguous visual context predominantly as restrictive modifiers. In the restrictive prosody condition (Figure 5.14a), children at age 4 interpreted the relative clauses restrictively in 100% of items. Children between 5 and 6 years of age selected a picture matching the restrictive interpretation in 83% of cases. Children in this group



(a) Restrictive prosody.

(b) Appositive prosody.

Figure 5.14.: Exp. 1 – Proportions of interpretations for relative clauses with restrictive and appositive prosody and ambiguous visual context for the ordinal number *third*.

selected a picture matching the appositive interpretation in 11% of cases. Adults demonstrated a similar pattern. They adopted restrictive interpretations for 92% of items and appositive ones in only 3% of trials.

To investigate research question (Q4) asking whether children and adults differ in their interpretation patterns, the rates of restrictive and appositive interpretations were compared across groups. Statistically, the rate of restrictive interpretations did not differ across age groups in the condition with restrictive prosody ($\chi^2(2) = 5.98$, $p = .05$). The mean ranks were 33.0 at age 4, 23.1 at age 5-6, and 29.0 in adults. Furthermore, the rate of appositive interpretations did not differ between 5- and 6-year-old children and adults ($U = 184$, $p = .07$).

For relative clauses presented with an appositive prosody as displayed in Figure 5.14b, the rate of restrictive interpretations dropped. However, participants in all age groups chose restrictive interpretations in more than 70% of trials. As with restrictive prosody, a comparison of the rates of restrictive interpretations did not yield significant differences between the age groups ($\chi^2(2) = .11$, $p = .95$). The mean ranks were 25.7 at age 4, 27.3 at age 5-6, and 27.3 for adults. In addition, there were no statistical differences between children and adults with regard to the distribution of appositive interpretations ($U = 242$, $p = .95$).

These results on the performance of the different age groups were informative with regard to the hypotheses formulated in Chapter 4. Children and adults showed the same pattern in interpreting relative clauses paired with an ambiguous visual display across both prosodic conditions: all groups preferred a restrictive interpretation in this experimental setting. Furthermore, children aged 5 to 6 and adults did not differ in their distribution of appositive interpretations. These findings were in accordance with Hypotheses (H1) and (H6).

In a next step, the effect of the factor PROSODY was addressed. Picture selections were compared across the two prosodic conditions to investigate research question (Q3) on the influence of linguistic and non-linguistic factors on the interpretation of relative clauses. Children at age 4 as well as adults selected a picture matching the restrictive reading significantly more often in the restrictive prosody condition than in the appositive prosody condition (age 4: Z = -2.12, p = .03; age 5-6: Z = -1.04, p = .30; adults: Z = -2.22, p = .03). The amount of appositive interpretations varied only for adults with regard to the conditions with restrictive and appositive prosody. For adults, the proportion of appositive interpretations increased significantly in the appositive prosody condition (age 5-6: Z = .63, p = .53; adults: Z = 2.07, p = .04).

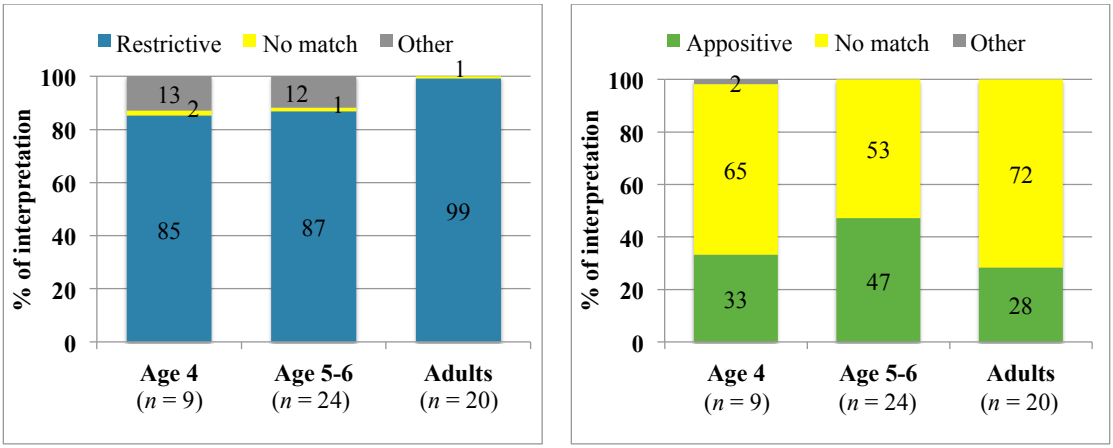
These results indicate that adults used the disambiguating information conveyed by the prosody as expected in Hypothesis (H3a). In the contextual ambiguous setting they chose appositive interpretations more often when prosody was the only cue for this reading. Overall, however, the influence of the factor PROSODY was weak. The amount of appositive interpretations increased for adults from 3% to 17%. For children between the age of 5 and 6, the amount of appositive interpretations was constant between 11% and 14%. In children at the age of 4, appositive interpretations were absent independently of the prosodic condition. However, the amount of restrictive interpretations increased when the items were presented with restrictive prosody. This finding is in accordance with Hypothesis (H3c). In this group, the prosodic difference seemed to lead to more intersective interpretations in the appositive condition.

5.3.3.2. The role of PROSODY *in visually unambiguous relative clauses*

In addition to the factor PROSODY, the factor VISUAL CONTEXT was explored in this experiment. The results for the relative clause conditions in which the visual context allowed only a restrictive or an appositive reading respectively are displayed in the bar charts in Figure 5.15 (see Figures 5.6 and 5.7 for the design of the visual background). In the conditions reported here, test items could be analyzed for both ordinal numbers. In addition to the charts displayed here, Table A.3 on page 353 in the appendix gives a detailed overview of the results in the conditions with unambiguous visual contexts.

The figures in 5.15a and 5.15b show very different patterns. In the condition in which both prosody and visual context were in accordance with a restrictive interpretation, the picture matching the restrictive reading was selected in more than 85% of cases in all age groups. In the condition with appositive prosody, target appositive interpretations did not exceed 47% in all groups. Instead, the 'no matching picture' button was selected in most of the items. Children as well as adults decided that there was no matching picture in the cupboard for 65% of items at age 4, for 53% at age 5-6, and for 72% in the group of adults.

Again, the performances were compared between the groups to explore differences and similarities of the interpretation patterns. A statistical comparison revealed significant differences in the distribution of restrictive interpretations between the different groups ($\chi^2(2)$ = 12.0, p = .003, mean ranks: 18.5 at age 4, 24.1 at age 5-6, 34.4 for adults). Adults differed from both groups of children in their rate of restrictive interpretations



(a) Restrictive prosody and visual context.

(b) Appositive prosody and visual context.

Figure 5.15.: Exp. 1 – Interpretations for relative clauses with restrictive and appositive prosody and unambiguous visual context.

(age 4 vs. adults: U = -15.85, p = .006; age 5-6 vs. adults: U = -10.29, p = .02). The two groups of children, however, did not differ from each other (U = -5.56, p = .79).

With regard to the distribution of appositive interpretations there were no significant differences between the three age groups ($\chi^2(2) = 2.18$, p = .34, mean ranks: 25.2 at age 4, 30.1 at age 5-6, 24.1 for adults). In addition the distribution of 'no matching picture' interpretations did not differ ($\chi^2(2) = 2.14$, p = .34, mean ranks: 28.6 at age 4, 24.0 at age 5-6, and 30.0 for adults).

In addition to the comparisons within the two prosodic conditions with unambiguous visual contexts, the performance across the prosodic conditions was compared to investigate the influence of this linguistic factor. There were significantly more target interpretations in the restrictive prosody condition than in the appositive prosody condition for stimuli with an unambiguous visual context. The medians of restrictive and appositive interpretations significantly differed in all age groups (age 4: Z = -2.21, p = .03; age 5-6: Z = -2.88, p = .004; adults: Z = -3.77, $p < .001$). Furthermore, the medians of 'no match' interpretations differed between the two prosodic conditions for all age groups (age 4: Z = 2.59, p = .01; age 5-6: Z = 3.51, $p < .001$; adults: Z = -3.77, $p <$ .001).

These results show that restrictive interpretations were more frequently observed than appositive interpretations when the conditions with unambiguous visual contexts were compared. In addition, participants selected the 'no matching picture' button more frequently in the condition with appositive prosody than in the one with restrictive prosody. In more than half of the items, participants did not want to interpret the relative clauses as an appositive modifier although both prosody and visual context pointed to an appositive reading. These observations speak in favor of Hypothesis (H1), which assumes that restrictive interpretations are generally preferred over appositive ones. However, the results showed in addition that appositive interpretations were found for all age groups in

the appositive prosody condition. This finding confirms Hypothesis (H2). Furthermore, these findings are informative on the time course of the acquisition of both semantic functions. The results showed that at age 4 restrictive and appositive readings had been acquired (but see the discussion in Chapter 7 and Section 8.2).

5.3.3.3. The influence of Visual Context *across prosodic conditions*

In the following, performance was compared across the two levels of the factor Visual Context to investigate whether this non-linguistic factor influenced the interpretation of relative clauses. For items presented with restrictive prosody, the visual context (ambiguous vs. unambiguous context) did not significantly influence the amount of restrictive interpretations. Restrictive interpretations occurred with the same frequency in the conditions with ambiguous and unambiguous visual context (age 5-6: $Z = 0.96$, $p = .34$; adults: $Z = 1.60$, $p = .11$). For children at age 4, no statistical comparison could be conducted because children at this age chose restrictive interpretations for 100% of the items in the condition with ambiguous visual context.

In contrast, the visual context significantly influenced the results for items presented with appositive prosody. Again, for children at the age of 4 no statistical comparison could be conducted. For children at the age of 5-6 and for adults, however, the amount of appositive interpretations was higher in the condition with an unambiguous visual context than when the visual context was ambiguous (age 5-6: $Z = 2.92$, $p = .004$; adults: $Z = 2.33$, $p = .02$). Thus, the visual context led to higher rates of appositive interpretations in all groups. This finding supports the expectation formulated in Hypothesis (H5a) for adults. The assumption that information from the visual context cannot be used in the children's group was formulated in Hypothesis (H5c). This hypothesis was not confirmed on the basis of the group results.

Taken together, the results showed a robust tendency for children and adults to interpret semantically and syntactically ambiguous relative clauses like in (3) restrictively (Hypotheses (H1) and (H6)). Restrictive interpretations were the predominant pattern when the visual context was ambiguous, i.e., when the context was displaying pictures matching both the restrictive and the appositive interpretations. In these contextually ambiguous items, the factor Prosody influenced only the interpretation patterns of adults. Adults chose pictures matching appositive interpretations to a higher extent when also the prosodic contour was appositive. Children between the age of 4 and 6, in contrast, opted for restrictive interpretations irrespective of the presented prosodic contour.

The results from unambiguous visual contexts supported the findings gained from the analysis of relative clauses in ambiguous contexts. In both conditions, similar proportions of restrictive interpretations were found when the prosodic contour indicated a restrictive interpretation. However, the factors Visual Context and Prosody interacted and influenced the performance in the condition with appositive prosody and an unambiguous visual context. In this condition, all groups of participants showed appositive interpretations in at least 28% of cases. Thus, when two factors indicated an appositive interpretation, appositive readings were chosen significantly more often than when only

prosody cued this reading. In addition to the higher rates of appositive interpretations, 'no match' responses were the most frequently observed reaction in this condition.

For an in-depth analysis of the high amount of 'no match' responses in relative clause items presented with an unambiguous visual context see Appendix A.2.2 on page 354.

5.3.3.4. Individual interpretation strategies

To address the research questions (Q1) on the preferred interpretation of children and adults and (Q2) on the availability of both semantic function in more depth, individual interpretation patterns were analyzed for the four conditions. For a detailed description of the individual results see Appendix A.2.3 on page 356. The individual analysis revealed that the majority of participants was very consistent in their interpretations of the relative clause items. In the condition with ambiguous visual context and restrictive prosody 49 out of 53 participants (92%) each interpreted more than 50% of relative clauses restrictively. For relative clauses with appositive prosody there were only 6 participants that consistently chose an appositive interpretation for the relative clauses (11%). In the condition with unambiguous visual context and restrictive prosody, 51 out of 53 participants (96%) interpreted relative clauses consistently as restrictive modifiers. In contrast, only 16 out of the 53 participants (30%) chose an appositive reading when this interpretation was consistent with the two cues. Across all conditions, 30 out of 53 participants (18 children and 12 adults) interpreted more than half of the items in three out of four conditions restrictively. In the fourth condition, the condition with unambiguous appositive visual context and prosody, these participants either chose the 'no matching picture' button or verbalized that they intended restrictive interpretations. In addition, four children interpreted relative clauses appositively when this was the only interpretation available in the visual context. In all other conditions, these children opted for a restrictive reading. Overall, only four participants (1 child and 3 adults) interpreted the test items in accordance with the prosodic contour of the relative clauses and showed restrictive and appositive interpretations consistently.

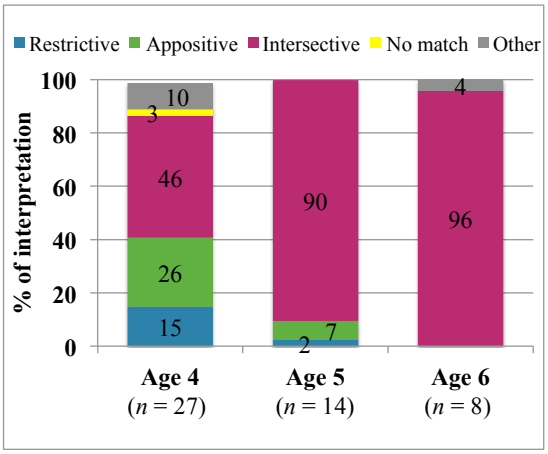
The individual performance of the participants showed that if restrictive or appositive interpretations were used, the interpretations were used reliably in the majority of items per condition. To investigate whether such stable patterns were also observed for children without mastery in the control condition Non-intersectivity, their performance was analyzed. The results are summarized in the following section.

5.3.3.5. Performance of children without mastery in the control condition Non-intersectivity

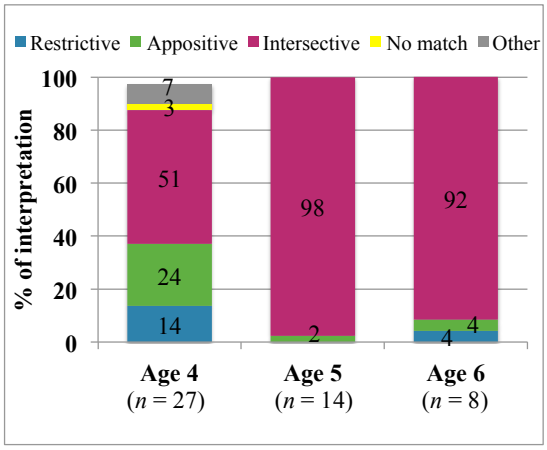
To analyze the results of the interpretation of relative clauses, the groups of children were subdivided by their performance in the control condition Non-intersectivity. As Table 5.8 on page 180 shows, there were 49 children without mastery in the control condition Non-intersectivity of ordinal numbers. These children interpreted less than five items of the control condition correctly. The group without mastery consisted of 27 children at age 4, 14 children at age 5, and eight children at age 6. In the group of 4-year-olds,

six participants missed the mastery criterion only by one item. The data of these 6 children may be more informative than that of the others since they could show stable non-intersective interpretations in the relative clause test items.

In the following, bar charts illustrate the performance of these participants in the relative clause items. No statistic analyses were performed since the data could not add reliable information to the acquisition of the two semantic functions of relative clauses. First, the data is reported for relative clauses in the conditions with unambiguous visual context. Second, the performance in the unambiguous context conditions is displayed. For tables displaying percentages and standard deviations for all response categories, see Section A.3 on page 360 in the appendix.



(a) Restrictive prosody.

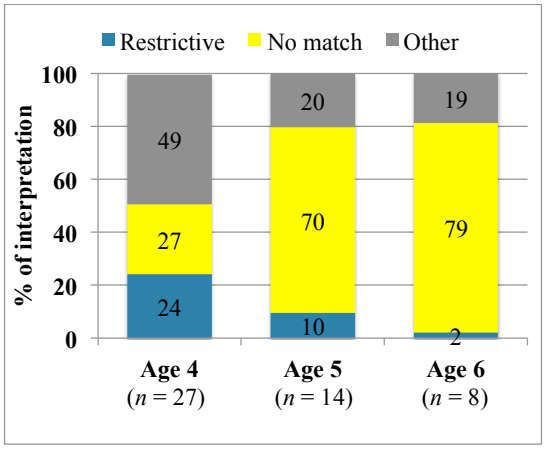


(b) Appositive prosody.

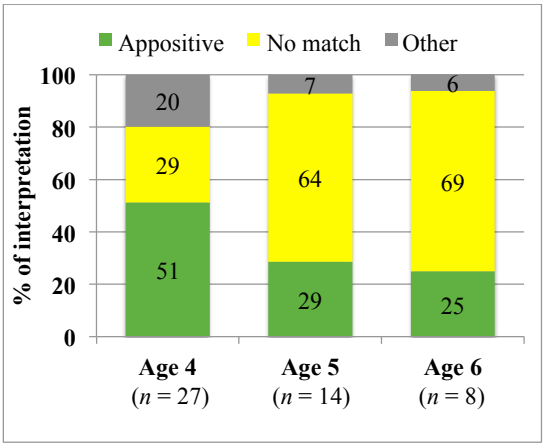
Figure 5.16.: Exp. 1 – Interpretations for relative clauses with restrictive and appositive prosody and ambiguous visual context for ordinal number *third* for children without mastery of the control condition Non-intersectivity.

Figure 5.16a and Figure 5.16b show that the majority of children without mastery of the non-intersectivity of ordinal numbers interpreted relative clauses intersectively. High proportions of intersective interpretations were found for both prosodic conditions. The data show that the performance for 5- and 6-year-old children was very similar. The proportions of interpretations for children at the age of 4 differed from the pattern observed for older children. In the youngest participant group, intersective interpretations made up 46% and 51% of the data in the prosodic conditions. In addition, also restrictive and appositive interpretations were observed. These patterns were surprising since these children did not interpret ordinal numbers consistently as non-intersective modifiers in the respective control condition.

Figure 5.17 illustrates the performance of children without mastery in the control condition for relative clauses in the unambiguous context conditions. Figure 5.17a displays the interpretation of relative clauses in the restrictive prosody condition, Figure 5.17b shows the interpretations for relative clauses with appositive prosody and unambiguous visual context.



(a) Restrictive prosody and visual context.



(b) Appositive prosody and visual context.

Figure 5.17.: Exp. 1 – Interpretations for relative clauses with restrictive and appositive prosody and unambiguous visual context for children without mastery of the control condition Non-intersectivity.

Like in the conditions with ambiguous visual context, children at the age of 5 and 6 showed similar interpretation patterns. For these two age groups, the category 'no matching picture' was the most frequently observed pattern. For 4-year-old children, the majority of picture selections in the restrictive condition was classified as *other*. In the appositive condition, appositive interpretations were the most frequent pattern. Compared across the two prosodic conditions, appositive interpretations were more frequent than restrictive interpretations.

An individual analysis of the children's interpretation patterns revealed consistent patterns for the majority of children. Overall, 30 out of 49 children interpreted more than half of the items in the ambiguous context condition intersectively independent of prosody. In the condition with unambiguous visual contexts, 17 children selected the 'no matching picture' button in more than half of the items of each prosodic condition. In addition, the individual analysis revealed that the restrictive interpretations at the age of 4 are due to those few children with almost target-like performance in the control condition Non-intersectivity. For detailed results see Tables A.9 and A.10 on page 362 and page 363 in the appendix. In sum, the individual results undermine the observation that intersective interpretations were the predominant interpretation pattern for children without mastery of ordinal numbers in the control condition Non-intersectivity.

In the following section, the results are discussed in more detail.

5.4. Discussion

This experiment investigated the interpretation of restrictive and appositive relative clauses in German-speaking children and adults. A combination of two modifiers, an

ordinal number and a relative clause, was used to obtain truth-functional differences between the two readings in a picture selection task. The experiment investigated the influence of prosody and of properties of the visual context on the interpretation of syntactically ambiguous relative clauses. In a within-subject design, the test items were presented either with a prototypical restrictive or appositive intonation pattern. In addition, it was varied whether prosody was the only cue for the interpretation – in this case, ambiguous visual contexts were presented – or whether only the prosodically marked interpretation was available in the arrangement of the pictures in the visual context.

First, the main results are summarized. In a second step, the results are linked to the hypotheses formulated in Chapter 4. Then, this section focuses more closely on three aspects of the reported results: the large amount of intersective interpretations observed in the children's groups, the influence of the order in which the two prosodic formats were presented, and the predominance of restrictive interpretations. The section closes with some methodological considerations on how to change and to improve the design for subsequent experiments conducted for this thesis.

5.4.1. Evaluating the hypotheses

Overall, 82 children between age 4 and 6 and 20 adults participated in the task. Out of these, 33 children and all 20 adults showed correct non-intersective interpretations consistently in one control condition for the semantics of ordinal numbers. Target-like non-intersective interpretations of ordinal numbers were a precondition to yield differences between restrictive and appositive interpretations of relative clauses in this experiment. Therefore, the performance in this control condition was used as criterion to include participants for further analyses. For the 53 participants with mastery in the control condition, the picture selections in the relative clause conditions were analyzed. Overall, the results show clearly that restrictive interpretations were the predominant reading found in this experiment.

In conditions where the prosodic format of the relative clause was the only cue to disambiguate the two semantic functions, restrictive interpretations were observed in more than 70% of items in all age groups. This high amount of restrictive interpretations was not limited to relative clauses with a restrictive prosodic contour but was found also for relative clauses with an unintegrated appositive format. Significant differences due to prosody were only found for children at age 4 and for adults. However, only for adults the rate of appositive interpretations increased with appositive prosody. In the youngest group of participants, intersective interpretations were observed instead of appositive interpretations. As an individual analysis demonstrated, the significant effect of prosody in the control group was driven by the consistent interpretation pattern of three adults. In contrast to the other 50 participants, these three adults interpreted the relative clauses according to the prosodic contour. Thirty-eight of the remaining 50 participants, however, interpreted relative clauses with an ambiguous visual context consistently as restrictive modifiers independently of the prosodic contour. For these participants, the prosodic differences did not lead to a semantic disambiguation of the relative clauses.

A similar pattern was found for relative clauses in which two cues, prosody and visual context, pointed to a restrictive or to an appositive reading respectively. Relative clauses that were marked as restrictive modifiers were interpreted target-like in more than 85% of items across age groups. In contrast, relative clauses for which only an appositive interpretation was available in the context were interpreted target-like in less than 50% of items across groups. An additional analysis of the spontaneous comments of the participants showed that children and adults looked for a picture that was matching the restrictive reading in the appositive condition. Since such a picture was not present in the display of objects, participants selected the 'no matching picture' button in the majority of items in the appositive condition. Furthermore, an individual analysis demonstrated that in the restrictive condition, 51 out of 53 participants (96%) interpreted relative clauses disambiguated by prosody and by the visual context consistently as restrictive modifiers. In contrast, only 16 out of the 53 participants (30%) chose an appositive reading when this interpretation was consistent with the two cues.

In accordance with Hypothesis (H1), these results show that restrictive interpretations were preferred over appositive ones. Furthermore, similar interpretation patterns were observed overall for children and adults. This result confirms Hypothesis (H6), which states that children and adult interpret relative clauses alike. In addition, Hypothesis (H2) claiming that both semantic functions are available for children is supported by the data of nine children: Overall, two of the nine 4-year-old children and seven children aged 5 to 6 used both semantic functions consistently in this experiment.

The hypotheses on the influence of the two experimental factors investigated in this experiment, Prosody and Visual Context, were not fully met. The claim that prosody disambiguates between restrictive and appositive relative clauses, as formulated in Hypotheses (H3a) and (H3c), held only for three adults and one child. For the majority of participants, prosody did not seem to be a cue strong enough to overcome the preference for restrictive interpretations. Based on results from experimental phonology presented in Section 2.5, this finding was not unexpected. Studies that investigated the relation of prosodic contour and semantic function of relative clauses found that prosody does not reliably disambiguate restrictive and appositive relative clauses. Schubö et al. (2015), for instance, reported that one third of the participants chose restrictive interpretations for relative clauses independently of the prosodic contours. In Experiment 1, 15 out of 53 participants (28.3%) interpreted all relative clauses consistently as restrictive modifiers. Thus, the rate of consistent restrictive interpretations was comparable to the proportion reported in Schubö et al. (2015).

In addition, previous research on the attachment of PP suggested that information conveyed by the visual context cannot be used reliably by kindergarten children (Trueswell et al., 1999). This expectation did not find full support in the data of this experiment. For appositive interpretations, the visual context had an effect and led to more appositive interpretations in children and adults. On the one hand, this is evidence in favor of Hypothesis (H5a) for adults assuming that the visual contexts serves to disambiguate the readings. On the other hand, this finding is contradicting the expectations formulated in Hypothesis (H5c) for children claiming that children have problems to integrate visual information to guide their syntactic (re)analysis. Compared to results from previ-

ous research, the finding is comparable to the results of Marcilese et al. (2013), finding more target-like picture selections when the context did not contain a bias for another reading of the stimuli. However, as the data show, not all children in the present study profited from the visual context. Consequently, there is also partial support by this data for Hypothesis (H5c), and the role of the visual context should to be investigated in more detail in future works.

In the following, three different aspects of the reported results are discussed in more detail. First, the large amount of intersective interpretations observed in the children's groups, second, the influence of the order in which the two prosodic formats were presented, and third, the predominance of restrictive interpretations for children with target-like interpretations of ordinal numbers.

5.4.2. Intersective interpretations of ordinal numbers

Like in Matthei (1982) and Hamburger and Crain (1984), intersective responses were attested in the data of Experiment 1. In contrast to previous results, intersective responses occurred in a systematic fashion in the experiment reported here. As shown in Table 5.8 on page 180, the amount of correct interpretations per participant showed a bimodal distribution for children at the age of 5 and 6. Either a child performed well on five or six of the items in the control condition or in less than half of the items. Overall, only 33 out of 82 children, i.e., 40%, interpreted ordinal numbers consistently with a non-intersective reading. Incorrect picture selections in the control condition may be due to different reasons. An error analysis showed that the main source of erroneous picture selections in the control condition Non-intersectivity were intersective interpretations of the ordinal number words. The children showed a bimodal distribution in this condition, too. Either the majority of items were interpreted target-like or children showed high rates of intersective interpretations.

The results on relative clauses showed the same bimodal pattern. When children showed a high rate of intersective interpretations in the control condition Non-intersectivity, they interpreted ordinal numbers intersectively throughout the whole experiment. On the other hand, when children performed target-like in the control condition Non-intersectivity of ordinal numbers, only few deviant intersective interpretations were found for items with relative clauses.

For relative clause items with an unambiguous visual context, 5- and 6-year-old children without mastery in the control condition showed more than 90% of intersective interpretations irrespective of the prosody. For these children, restrictive interpretations were not frequently found. They were only present in the group of 4-year-olds. As the individual analysis illustrated, these restrictive interpretations were observed for those children with 4 out of 6 items correct of the control condition. Appositive interpretations, however, were found also for children with fewer correct non-intersective interpretations.

These results of Experiment 1 show that intersective interpretations do not correlate with the number of modifiers that occur together with the noun phrase. Matthei (1982) reports that the rate of intersective interpretations increased in 4-6-year-old children when two prenominal modifiers were present compared to sentences with only one

modifier. This finding cannot be supported by the results presented here. In contrast, the results of Experiment 1 on the interpretation of ordinal numbers suggest that the observed problems are directly linked to the meaning of ordinal numbers itself. While subsectivity is not violated by the children, non-intersectivity seems to be difficult to acquire. The source of the deviant intersective interpretations, however, remains unclear. Either, more than half of the children in this experimental sample had not yet acquired the semantic properties of ordinal numbers as non-intersective modifiers, or their limited processing capacities were responsible for the high rates of intersective interpretations in this experiment.

Limited processing capacities and associated difficulties to recover from wrong decisions about referents can explain the intersective interpretation pattern. As reported in Section 3.5 on the role of processing in acquisition, children interpret linguistic stimuli incrementally. In addition, they try to identify referents as soon as possible. Compared to adults, these processes proceed similarly but slower in pre-school children. In addition, previous research showed that children rely more on the linguistic stimulus than on other sources of information. Based on these findings, intersective interpretations could be explained as follows. As soon as the child has identified the ordinal number word in the acoustic stimulus, she starts to scan the visual context for appropriate referents. While the ordinal number is processed, it is still open what kind of noun will be encountered. Therefore, the child may focus on or preselect the second or third element in total. Then, the noun appears in the auditive input stream. When the processing capacities are large enough, the child can wait to select the n^{th} element denoted by the noun. To do this, the initial preselection has to be revised. Such referential revisions, however, are very difficult for children, as the studies on the attachment of locally ambiguous PPs showed (cf. Trueswell et al., 1999 and subsequent works as discussed in Section 3.3). Based on the previous research, syntactic and referential revisions are highly taxing tasks. Therefore, it is conceivable that young children use the information about the noun denotation only to confirm their preselections. In case the meaning of the noun matches the type of preselected element, the child can retain the object, which leads to an intersective picture selection of the nth element overall.

For this strategy, it is not important whether the non-intersective semantics of ordinal numbers is in place. Even if children already know that ordinal numbers are non-intersective modifiers, they may not be able to wait in their referential decision until the noun is processed. They may just coerce a semantically empty noun like *the second thing* to fulfill the semantic requirements of the ordinal number word. Marcilese et al. (2011) follow a similar line of argumentation to account for the fixations to intersective distractors in their eye-tracking study with Brazilian-Portuguese-speaking adults.

Additional evidence for this processing explanation comes from 13 children who made only one error in the control condition Non-intersectivity (see Table 5.8 on page 180). The individual response patterns of these 13 children suggest that the non-intersective semantics of ordinal numbers had been acquired but was masked in the beginning of the experiment. Eight of the 13 children showed an intersective interpretation as their only incorrect response. Seven of these errors occurred either in the first or in the second control item that the children encountered. In addition, one intersective error occurred

in item 4, i.e., in the first item of the second test session. All subsequent control items were interpreted target-like. An interesting observation is the fact that for 6 out of these 8 children, the ambiguous relative clause item preceding the intersectively interpreted control item was interpreted intersectively, too. However, all subsequent control items were interpreted correctly in a non-intersective way. Thus, somewhere between the first and the second item of the control condition Non-intersectivity, these six children discovered or remembered that ordinal numbers are non-intersective modifiers. Before, they interpreted ordinal numbers reliably as intersective modifiers. This change in the interpretation pattern may be triggered by the occurrence of the first relative clause item with an unambiguous visual context. In these test items, an intersective reading did not match the array of objects. It seems as if these children knew that ordinal numbers are non-intersective modifiers. However, they showed intersective picture selections until the first unambiguous relative clause was encountered. At this point, the children were confronted with an item where elements of the noun category were present but in which the preselected object did not match the meaning of the noun or color adjective. This mismatch seemed to lead to a revision of their initial referential decision and to a change in the processing routine because, subsequently, no intersective errors were observed anymore.

However, processing difficulties may not be the only source for problems associated with ordinal numbers in this experiment. As displayed in Table 5.10 also other incorrect picture selections were frequent for children at the age of 4. Also for relative clauses, incorrect pictures selections classified as *other* were frequently observed for children without mastery in the control condition Non-intersectivity. The incorrect picture selections that did not result from intersective readings could indicate that ordinal numbers were not yet acquired by some of the 4-year-olds. This finding would be in line with previous studies on the acquisition of ordinal numbers. As e.g., Miller et al. (2000) reported for English, target-like production and comprehension of ordinal numbers was only achieved by children in primary school in their study. Children with high rates of incorrect responses may still have to acquire the core meaning of ordinal numbers, i.e., the function to establish a scale on elements of a set.

Further evidence that intersective interpretations could be linked to processing issues is presented in the following paragraphs.

5.4.3. Influence of test versions and prosody

Statistically, the test version, i.e., the order in which the two prosodic parts were administered, influenced children's performance but not the adults'. For the 4- to 6-year-old children, the order of the prosodic formats of the relative clause items was related to the number of intersective interpretations in the control conditions. As discussed in Section 5.2.1.2 and the following interim discussion, children in the present experiment were more prone to fail in the control condition Non-intersectivity when they heard relative clauses presented with an appositive prosody first. In the test session presented with appositive prosody, these children showed an intersective interpretation pattern for items of the control condition Non-intersectivity more often than their peers who heard relative

clauses with restrictive prosody first.

Although statistically not significant, the low performance of the 6-year-olds in the control condition Non-intersectivity could be related to the unequal distribution of test versions in this age group. Seven out of the 10 children tested in this age group listened to the appositive prosodic pattern first. This could have biased these children to conclude that a restriction to subgroups was not necessary.

One reason for the correlation between the order of the prosodic blocks and the performance in the control condition Non-intersectivity may be found in the pseudo-randomized order of the items in the two prosodic blocks. Remember that the items of the control condition Non-intersectivity were intermixed with the relative clause items. The first unambiguous relative clause item, which was incompatible with an intersective interpretation, occurred in item 6 of the block with restrictive prosody in the experiment. When children were tested with the second version of the experiment, i.e. when they started the experiment with the block with appositive prosody, the first unambiguous item occurred in item 7. Thus, the first cue that intersective interpretations were not felicitous to find a referent that fulfilled all the mentioned properties (e.g., third, car, and red) occurred one item later in the block with appositive than with restrictive prosody. The different randomizations may have influenced the children in their strength of conviction whether an intersective interpretation was appropriate or not. When children followed an intersective interpretation strategy for ordinal numbers, they succeeded in selecting a matching picture in three or four items, respectively, until they encountered the first unambiguous relative clause. In addition, all children heard two items, in which the 'no matching picture' was the appropriate response (one warm-up item and one item of the control condition Subsectivity). The fact that the first occurrence of an unambiguous visual context appeared one item later in the block with appositive prosody might have encouraged more children to stick to the deviant intersective interpretation pattern. This effect could have appeared because the children succeeded previously in 4 out of 6 items with this reading. Instead of revising their search and identification procedure, they used the 'no matching picture' button when their interpretation was not met by the context.

Alternatively, one may conclude that children at the age of 4 to 6 were sensitive to the prosodic contour used in the relative clause items. Children who heard relative clauses with a restrictive prosody first seemed to know that they had to form subsets. They knew that they had to restrict the depicted elements to only those that were denoted by the noun phrase. Children that were confronted with appositive relative clauses first may had inferred from the prosodic format that they did not have to restrict the set of elements mentioned. This may invited children to pursue the deviant intersective reading.

Taken together, the order of the prosodic patterns influenced the children's performance in the control condition Non-intersectivity. This observation suggests that children were sensitive either to the prosodic or visual cues delivered in those parts. These cues seem to favor an increase in the number of intersective interpretations. Such a correlation between properties of the relative clause test items and items of the control condition Non-intersectivity would be unexpected under the assumption that the source of the intersective interpretations was located in the lexical semantics of the number words.

However, it is conceivable that these properties guided the expectations and processing routines for participants that had already acquired the semantics of ordinal numbers. Either the visual context or the prosody may had biased the participants to preselect the n^{th} element overall and to keep this decision in light of additional information.

In the following paragraphs, the focus is on the results in the relative clause conditions.

5.4.4. Predominance of restrictive interpretations

In Chapter 4.1, different arguments were presented to motivate that restrictive interpretations are preferred over appositive ones. This expectation, formulated in Hypothesis (H1), is supported by the results of the present experiment. Restrictive interpretations were the most frequently observed reading for relative clauses in children and adults in this experimental task. The predominance of restrictive interpretations can be accounted for in different ways. Assumptions about the syntactic attachment site of restrictive and appositive relative clauses in combination with the generally assumed processing principles predict that restrictive interpretations are derived as initial analysis. In addition, semantic and syntactic complexity speaks in favor of restrictive interpretations. Moreover, also the pragmatics of the task could have been responsible for the overall results as discussed in Section 4.2.

However, the results show in addition that appositive interpretations were both in the syntactic and semantic repertoire of the participants. When both prosody and visual context established a bias towards an appositive interpretation, this reading was adopted by one quarter of the participants in all age groups. Thus, it was possible for children at the age of 4 to 6, to derive a representation that licensed an appositive interpretation. What is surprising is that the rate of appositive interpretations was strikingly low in the group of adults. For children, previous studies on processing capacities revealed that they have problems to integrate multiple sources of information. If it is true that the syntactic structure that is built up first in the parsing process corresponds to a restrictive interpretation, it is not unexpected that children show fewer appositive interpretations than restrictive ones. As observed for the attachment of locally ambiguous PPs (e.g., Trueswell et al., 1999), children's ability to revise syntactic structures and referential decisions is not yet adult-like. Adults, in contrast, should had used the information that was available in the visual context to initiate syntactic reanalyses and to make decisions about referents described by the linguistic material. Therefore, it is unexpected that the amount of appositive interpretations in the unambiguous visual context condition with appositive prosody stayed at a level comparable to that of 4-6-year-old children. Similar to the children, adults seemed to ignore the prosodic and contextual cues. They did not initiate a change of the initial parse to derive the structure that licenses an appositive reading of the relative clause.

This pattern may be explained either by the rapid identification of discourse referents in the group of adults or by strategic decisions. Proposing a processing account could proceed along the following line of argumentation. The adult participants may proceed as follows: When they hear the ordinal number word, they identify this element as a non-intersective modifier. As a consequence, they scan the objects in the visual display for

good candidates of being the n^{th} element, i.e., they look for elements that are available in the context at least n times. Since the colors are salient in the visual context it seems natural that participants group the objects directly according to their color. Hence, it is possible that adults look for sets containing at least n elements of a certain combination of object type and color. When the noun phrase is encountered, it depends on the context whether it is perceived as informative or redundant information. In some items, only one type of object may be present in at least n instances. Therefore the search is directly restricted to elements of this type of head noun and the encountered noun phrase serves to confirm the expectations. When also n elements of the other object type are present, the processed noun is informative and narrows down the potential set of referents. Then the relative clause begins and the color word is encountered. The color information refines the search for the n^{th} element. At this point the parser can decide which of the n^{th} element is the target one.

Thus, when the initial grouping of objects is guided by the color information, the incremental interpretation is matching a restrictive interpretation. In the condition where the order of objects matched only an appositive interpretation, this incremental procedure failed. The missing referential success in interpreting the initial syntactic and semantic structure should lead to a reanalysis at least in adults. However, in this design, the 'no matching picture' button established an alternative option to solve the incongruence of the derived interpretation and the referential options in the visual context. Remember that in the control condition for the subsectivity of ordinal numbers the puppet frog Caru uttered requests that did not match the visual contexts. This fact may have encouraged participants to stick to their initial interpretation of relative clauses without looking for other options how the sentence could be interpreted. Evidence for this line of explanation comes from the spontaneous comments of the participants. Interestingly, the reactions of the participants did not differ between the age groups. Mainly, children and adults explained that the visual context did not provide enough elements of the respective type. Therefore, they went for the 'no matching picture' button.

Nonetheless, one third of the adults derived appositive interpretations in unambiguous visual contexts. These participants were either more willing to question their initial interpretations, or they did not use the color information to group objects in the first place. When a participant did not expect color information to be mentioned later in the clause, he or she may have grouped the objects in the visual context only according to their category. Then, the preselected n^{th} element is the $n^{th}X$ irrespective of its color. In this case, the relative clause could have served as a confirmation that this element is the correct one. With this procedure, an appositive reading could be observed although it is unclear which structural analysis the participants assigned to the relative clause.

An alternative explanation could rely on strategic decisions of the adults. Some comments of the adults indicated that they were aware of the ambiguity of the relative clauses. This is illustrated in the following comments in (15).

(15) Exp. 1 – Comments of adults noticing the ambiguity of the relative clause test items

a) 04_ZHH208: Das zweite im Regal oder das zweite gestreifte?
Exp: Das, was du denkst.

04_ZHH208: *The second one in the cupboard or the second striped one?*
Exp: *You decide.*

b) 04_ZMH231: Ähm, die zweite die gelb ist, also die zweite der Sonnenbrillen oder die zweite VON den gelben?
Exp: So, wie du das denkst.
04_ZMH231: Is egal, oder?

04_ZMH231: *Well, the second that/which is yellow, i.e. the second of the sun glasses, or the second of the yellow ones?*
Exp: *As you think.*
04_ZMH231: *It doesn't matter, does it?*

In addition to the identified ambiguity, the comments indicated that the majority of participants decided to follow a restrictive strategy and to keep this strategy even when they started to doubt on its validity. This is exemplified in the comment in (16).

(16) Comment of an adult pursuing a restrictive strategy

a) 04_ZCS227: Es gibt wieder nur eine blaue Hose. ... Oder meint es, da bin ich jetzt verwirrt. Oder meint es sozusagen die zweite Hose grundsätzlich? (Repetition of pre-recorded stimulus) Ist genau das gleiche.
Exp: Wo besteht das Dilemma?
04_ZCS227: Ich bin mir immer unsicher, ob ich die zweite grundsätzliche Hose nehmen müsste oder die zweite blaue Hose.
Exp: Nach Bauchentscheidung
04_ZCS227: Ich denke, die zweite blaue Hose.

04_ZCS227: *Again, there is only one blue trouser... Or does it mean, now I am confused. Or does it mean the second trouser in general? (Repetition of pre-recorded stimulus). It's exactly the same.*
Exp: *What's the dilemma?*
04_ZCS227: *I am not sure whether I should take the second trouser overall or the second blue trouser.*
Exp: *Follow your intuition.*
04_ZCS227: *I think, the second blue trouser.*

In a subsequent item:

04_ZCS227: Um jetzt in der Logik zu bleiben kann ich das nicht, weil da sind nur zwei bunte Schals.

To stay with that logic, I can't do this (i.e., select the appositive picture) because there are only two multicolored scarfs.

In this experiment, the participants were not explicitly asked to motivate their decisions and picture selections. Thus, it remains open how many participants noticed the ambiguity and decided for one reading over the other. Nonetheless, the comments indicated that a large number of adults was aware of the availability of appositive readings. However, their preference for restrictive readings seemed to be so strong that it overwrote the prosodic cue for appositive readings.

The following paragraphs propose changes of the experimental design to investigate the nature and derivation of intersective and appositive interpretations in more details.

5.4.5. Recommendations for subsequent experiments of this thesis

Based on the results of this experiment, four changes for subsequent experiments are proposed in this section. They address first the pretest on the core meaning of ordinal numbers, second, the ordering of control items and relative clause test items, third, the construction of the visual displays, and forth, the set of cues for appositive interpretations.

As argued in the intermediate discussion in Section 5.3.2, the four items of the pretest on the core meaning of ordinal numbers did not work as expected. These items did not distinguish between children with and without knowledge on the lexical properties of ordinal numbers and their relation to the sequence of cardinal numbers. Instead, some children pursued a strategy to count objects only within a certain color. This strategy led to nontarget-like performance in the pretest although the children using this strategy knew how to count within a subset of elements. For the analysis of the relative clause test items, however, it was necessary to distinguish between children with and without target-like non-intersective interpretations of the ordinal numbers. Only the results of children with non-intersective interpretations of ordinal numbers were informative with respect to the semantic function of the relative clauses. The items of the pretest did not serve this function. In sum, the items of the pretest in this experimental design were neither informative with regard to knowledge of the ordinal numbers nor did they serve to select children for further analyses of the relative clause semantics. In contrast, the control condition Non-intersectivity for ordinal numbers was sufficient to select children with consistent non-intersective interpretations. Therefore, the pretest could be omitted in follow-up experiments performed for this thesis.

Second, the order of the prosodic relative clause conditions influenced the performance in the control condition Non-intersectivity of ordinal numbers. The analyses performed in this chapter suggest that either the visual context of the unambiguous relative clause items or the prosodic contour of the relative clauses in general confounded the children's performance in the control condition. To prevent these spill-over effects, the items of the relative clause test conditions and those of the control conditions should not be

intermixed. When children have to interpret the items of the control condition Non-intersectivity before they are tested on relative clauses with different prosodic formats, a transfer of interpretation strategies could be avoided. Thus, a reordering of control and test items is suggested for further experiments.

The third change proposed here addresses the construction of the visual contexts. In this experiment, the arrangement of the objects in the cupboard displayed a picture, matching the intersective interpretation in almost all conditions. The only exceptions were items of the control condition Subsectivity and relative clause items with unambiguous visual context. If the processing explanation to account for some of the intersective interpretations is correct, then a change of the visual displays will lead to a reduction of these deviant readings. When the object at the n^{th} position shows an object not denoted by the head noun, this may prevent children from preselecting this object in the first place. When children already know that ordinal numbers are non-intersective modifiers, they should refrain from taking the n^{th} object overall. In this case, they should select the second element of the set denoted by the noun. Taken together, in subsequent studies visual contexts should be used that do not offer intersective distractor pictures.

In addition, when intersective distractors are avoided in the array of objects, the visual contexts can be constructed such that restrictive and appositive interpretation can be differentiated in all relative clause test items. In the experiment presented here, relative clause items with the ordinal *second* were not fully informative. In these items, either the intersective and appositive reading or the appositive and restrictive reading led to the selection of the same picture. Therefore, these items were not considered for a statistical analysis of the results. When no intersective picture is displayed, both ordinal numbers, *second* and *third*, can lead to different picture selections for restrictive and appositive interpretations in the relative clause test items. Due to this change more data could be analyzed to investigate the semantic functions of relative clauses.

The fourth suggestion how to modify the experimental design targets appositive interpretations. The results presented in this chapter showed that restrictive interpretations were the predominant interpretation pattern in both children and adults. To disambiguate between the restrictive and appositive function of relative clauses, the factors Prosody and Visual Context were used as cues. In the future, other factors should be investigated that may identify appositive interpretations. Studies on the role of processing in children report that children rely more on linguistic information. Therefore, lexical indicators of appositive readings may lead to higher rates of appositive interpretations in children and adults. In German for instance, discourse particles are only compatible with appositive readings. Investigating relative clauses including these discourse particles may shed light on what factors initiate structural or referential reanalyses in the processing of relative clauses.

The experiment presented in the following chapter considered these aspects. In a pilot study, the number of intersective interpretations could be reduced due to changes of the visual context. The results are summarized in the beginning of the following chapter.

5.5. Conclusion

The experiment reported in this chapter investigated the interpretation of restrictive and appositive relative clauses in 4- to 6-year-old German-speaking children adults. A picture selection task was used to asses interpretation preferences for relative clauses. Truth-functional differences were obtained due to scope interactions of the relative clause and an additional prenominal modifier, an ordinal number. This idea goes back to Roeper (1972) and Matthei (1979) but to my knowledge, has not been implemented to test the interpretation of relative clauses.

Two conditions investigated the interpretation of relative clauses disambiguated by prosody in visual contexts that supported both semantic functions. In these conditions, children and adults performed alike and showed a clear preference for restrictive interpretations. The restrictive preference was found independently of the prosodic contour of the pre-recorded stimulus sentences. As a second factor, the visual context was varied to explore whether it could serve as a disambiguating factor for relative clauses. The results showed that the change of the visual context led to an increase of appositive interpretations in the corresponding condition. When no restrictive picture selection was possible, participants of all age groups selected pictures compatible with an appositive interpretation in up to one third of the items. However, 30 out of 53 participants either said that no matching picture was displayed in this condition or their comments revealed that they intended a restrictive interpretation of the appositively marked relative clause.

These findings are in line with hypotheses based on linguistic theory that restrictive relative clauses are less complex than appositive relative clauses. Further studies are needed to explore whether appositive readings can be preferred in contexts that establish a stronger bias towards appositivity. The experiment reported in the following chapter pursued this line. Experiment 2 investigated the interpretation of restrictive and appositive relative clauses that were disambiguated either by prosody alone or by the presence of discourse particles marking relative clauses lexically as appositive modifiers.

6. Experiment 2: On the influence of discourse particles

Like Experiment 1, Experiment 2 addresses the research questions (Q1), (Q3), and (Q4). The experiment presented here is a modification of the picture selection task used in Experiment 1. It investigated again how German-speaking children and adults interpret syntactically ambiguous relative clauses as in (1). In contrast to the previous experiment, the visual context was not in the focus of investigation. Instead, this experiment focused on the impact of a lexical marker on the interpretation of relative clauses. The experiment investigated at which age discourse particles like *ja* disambiguate relative clauses towards an appositive reading.

(1) Nimm das dritte Auto, das (ja) blau ist, und leg' es in den Koffer!
Take the third car which (PRT) blue is and put it in the suitcase

'Take the third car$_{(,)}$ that/which (as you know) is blue$_{(,)}$ and put it in the suitcase!'

The chapter is structured as follows. First, the results of a pilot study are summarized in Section 6.1. Subsequently, Experiment 2 is described. Section 6.2 gives an overview of the participants. The experimental design and material is presented in Section 6.3. In Section 6.4, the results are reported. Section 6.5 summarizes the results and discusses them in light of the research questions and hypotheses formulated in Chapter 4. The chapter ends with a conclusion in Section 6.6.

6.1. Summary of a pilot study

Before Experiment 2 was implemented, a pilot study was set up to investigate the influence of the visual context on the interpretation of ordinal numbers. In Experiment 1, the picture at the n^{th} position in the array of objects matched all the properties mentioned in the stimulus sentence. This object, however, was never the target object of the stimulus sentence. The results of Experiment 1 showed that 49 of 82 children between the age of 4 and 6 (60%) interpreted ordinal numbers intersectively and selected the n^{th} picture overall. Consequently, data of only 40% of the participants could be analyzed to investigate the semantic functions of relative clauses. Based on studies on the acquisition of adjective sequences, it seemed plausible that the visual context could have established a bias towards the deviant, intersective reading of ordinal numbers. In the discussion of Experiment 1 I argued that a change of the experimental items may lead to an increase of target-like interpretations of the prenominal modifiers. Higher rates of target-like, non-intersective interpretations of ordinal numbers in the control condition

Non-intersectivity were desirable because more data could be analyzed to investigate the semantics of relative clauses. In the following, the pilot study is summarized.

To investigate the influence of the visual context on the performance in the control condition Non-intersectivity, the visual contexts of Experiment 1 were modified. The design, the task, the order of the items, and the pre-recorded stimuli were identical to those used in Experiment 1. The modification affected exclusively the visual contexts of the stimuli. The order of objects in the visual context of the items was rearranged such that a picture matching the deviant intersective interpretation was not present any more.

The visual contexts in Figure 6.1 exemplify the changes in the visual context for an item of the control condition Non-intersectivity. The corresponding prompt is given in (1).

(1) Nimm den zweiten Lutscher und leg' ihn in den Koffer!
Take the second lollipop and put it in the suitcase

'Take the second lollipop and put it in the suitcase!'

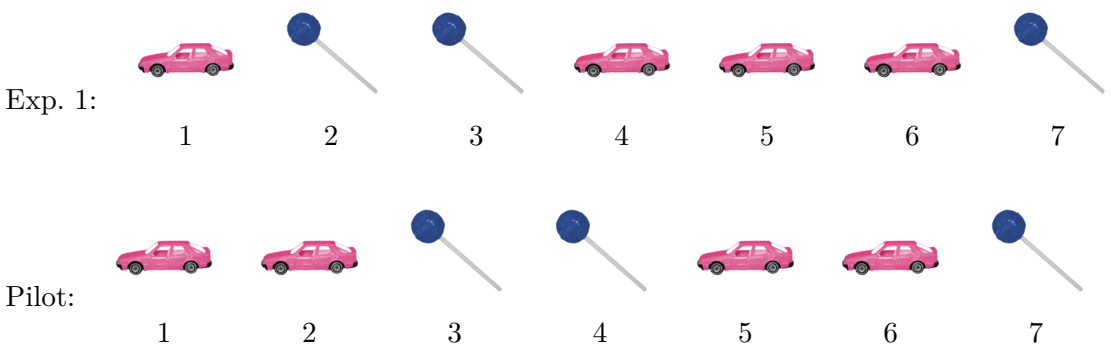


Figure 6.1.: Comparison of the visual contexts of Experiment 1 and the pilot study for the control condition Non-intersectivity of ordinal numbers.

In contrast to the display of objects used in the first experiment, there was no lollipop at position no. 2 in the visual context for the control item in the pilot study.

Similarly, the context was changed for the ambiguous relative clause test items, as exemplified in Figure 6.2. The corresponding verbal prompt is shown in (2). The objects were rearranged such that no red car was displayed at position 3. The picture selections for restrictive and appositive interpretations, however, could still be distinguished. A choice of picture no. 6 corresponded to a restrictive interpretation, and the selection of the car in position 4 indicated an appositive reading of the relative clause.

(2) Nimm das dritte Auto, das rot ist, und leg' es in den Koffer!
Take the third car which red is and put it in the suitcase

'Take the third car$_{(,)}$ that/which is red$_{(,)}$ and put it in the suitcase!'

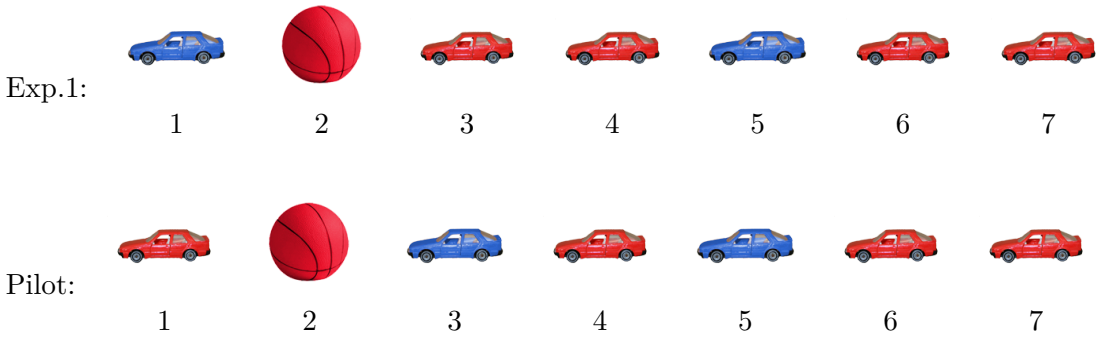


Figure 6.2.: Comparison of the ambiguous visual contexts of Experiment 1 and the pilot study.

Eight typically developing monolingual German-speaking children (4 female, 4 male) between 4;0 and 6;5 years (mean: 4;9, *SD*: 9 months) participated in the task. The results show that the modification of the visual contexts led to an increase of correct interpretations in the control condition Non-intersectivity. In Experiment 1, children chose the correct picture in the control condition in less than 60% of items overall. In the pilot study, items of the control condition were interpreted correctly in more than 77% of cases. An individual analysis showed that 6 out of 8 children (75%) interpreted at least 5 items of the control condition correctly in a non-intersective way. Two children, the youngest child in the sample (age 4;0) and another 4-year-old child (age 4;10) demonstrated either none or only one target-like, non-intersective interpretation in the control condition. Thus, on an individual level, the proportion of children mastering the control condition increased from 40% in Experiment 1 to 75% in the pilot study.

Furthermore, the results of the control condition Non-intersectivity showed that the modification of the items did not lead to an increase of *no matching picture* responses. Such an increase could be expected when the intersective interpretations of ordinal numbers were a result of a deviant semantic representation in the mental lexicon of the children. However, only the amount of target-like picture selection increased due to the change of the visual context. Moreover, the results of the control condition for the subsectivity of ordinal numbers indicated that children were more reluctant to choose the 'no matching picture' button in the pilot study. In the control condition Subsectivity, the performance of children dropped from above 95% in Experiment 1 to 77% in this pilot. An analysis of children's comments, however, indicated that this low percentage of correct interpretations was not due to an incorrect interpretation. In contrast, the children argued in their spontaneous comments that no suitable object was present in the visual context. Interestingly, instead of selecting the 'no matching picture' button, these children selected one of the depicted objects nonetheless. When the verbal comments were considered as correct responses, the amount of correct subsective interpretations rose to 94%. This proportion is comparable to the performance of children in Experiment 1.

The results of the pilot study speak in favor of the processing explanation to account for the high rates of intersective interpretations observed in Experiment 1. If a deficient semantic representation of the ordinal number words were responsible for the intersective interpretations, the rate of occurrence should not differ between Experiment 1 and this pilot study. When only the intersective reading was compatible with their semantic representation, than the children should look at the n^{th} position for the matching object. Since at this position no matching object was displayed, the children should select the 'no matching picture' button or they should select a picture at chance level. Contrary to this line of argumentation, the results of the pilot showed target-like performance for 6 out of 8 children. Hence, the high amount of non-intersective interpretations in this pilot study is incompatible with a semantic deficit.

The difference observed between Experiment 1 and the present study is best accounted for by the assumption that ordinal numbers were identified as non-intersective modifiers by the majority of children tested. The rapid selection of a referent and the difficulties to revise such a selection in the course of processing could have been the reason for the high rates of intersective interpretations in Experiment 1. In the pilot study, the object a the n^{th} position never matched the properties denoted by the linguistic stimulus. In half of the items, the object did not match the denotation of the noun. In the other half of the items, the color word in the relative clause did not confirm a potential pre-selection of the n^{th} element overall. For children with knowledge of the non-intersectivity of ordinal numbers, this consistent mismatch of properties may have been sufficient evidence to postpone the initial selection of a referent until the full noun phrase was processed.

Importantly, the results for the relative clause conditions did not differ from those obtained in Experiment 1. For items in which prosody but not the visual context disambiguated between a restrictive and an appositive reading, the six children chose pictures matching a restrictive interpretation in 67% to 69% of cases. This preference for restrictive interpretations was not influenced by the prosody of the pre-recorded stimuli. A comparison of the two levels of the factor Visual Context showed higher rates of restrictive and appositive interpretations for items with an unambiguous visual context than with ambiguous contexts. While 67% of items were interpreted restrictively in the ambiguous context condition, 92% of items received this interpretation in the condition with an unambiguous restrictive context. For items with appositive prosody, the same tendency was observed. While in items with ambiguous context 14% were interpreted appositively, the proportion increased to 50% in the unambiguous appositive context when the spontaneous comments were considered.

In sum, the results of the pilot study were very similar to those reported for Experiment 1. The modification of the visual context, however, reduced the amount of deviant intersective interpretations reliably. Experiment 2 built on these results and implemented further changes proposed in the discussion of Experiment 1. The design and the results of the new experiment are described in the following sections.

6.2. Participants

Sixty-four monolingual, German-speaking children (38 boys and 26 girls) and 23 adults participated in Experiment 2. The experiment is part of the research project CARU *Child Acquisition of Relative Clauses*, PI: Petra Schulz. The project itself is part of the Research Group 1783 *Relativsätze* 'Relative clauses' at the University of Frankfurt funded by the German Science Foundation DFG. The age of the children ranged from 4;1 to 6;11 with a mean age of 5;5 (*SD*: 8.9 months). The children were recruited in 11 day-care centers in Frankfurt am Main, Germany. All parents gave written consent for the participation of their children in this study. Information about the language background and potential histories of language or hearing problems were obtained via a parental questionnaire. As in the previous experiment, only typically-developing, monolingual German-speaking children were included in the study. In addition to the questionnaire, a standardized language test served as a second inclusion criterion. Four- and 5-year-old children were tested with the SETK 3-5 (H. Grimm, 2001); for children at the age of 6, age appropriate language skills were tested with the TROG (A. V. Fox, 2006). All children reported here showed age-appropriate performance in the standardized tests. One child at the age of 4 had to be excluded after participating in the experiment due to missing data in 14 items.

The adult control group consisted of 23 participants (10 men and 13 women) aged 18;5 to 33;2 years with a mean age of 23;2 years (*SD*: 51.8 months). The adults, mainly students of the Goethe University but none of them students of linguistics, received 7 € for their participation in the study.

Table 6.1 gives an overview about the participants split up for age groups.

Table 6.1.: Exp. 2 – Overview of participants

	Age 4 $n = 20$	**Age 5** $n = 27$	**Age 6** $n = 16$	**Adults** $n = 23$
Sex	10 boys 10 girls	16 boys 11 girls	11 boys 5 girls	10 men 13 women
Age range	4;1 - 4;11	5;0 - 5;11	6;1 - 6;11	18;5 - 33;2
Mean age	4;7	5;5	6;5	23;2
SD	3.3 months	3.3 months	3.5 months	51.8 months

Note. SD = Standard deviation.

6.3. Method

Like in Experiments 1, a picture selection task was implemented as a computer game to investigate the two semantic functions of relative clauses. The idea for this design is due to Roeper (1972), Matthei (1979), and Hamburger and Crain (1984). In contrast

to Experiment 1, Experiment 2 focused on the impact of discourse particles as a cue to derive appositive interpretations.

6.3.1. Design and material

Experiment 2 had a 2 × 2 factorial design investigating the factors PROSODY (restrictive vs. appositive) and LEXICAL MARKER (discourse particle present or absent) on the interpretation of relative clauses. Based on the results from Experiment 1 and the pilot study, the experimental design was changed in several respects. First, the pretest on the core meaning of ordinal numbers and the control condition Subsectivity were omitted. Since the results of the pretest were not helpful to discriminate between children with and without basic knowledge of ordinal number words, the four items were not included in the present experiment. In addition, the experimental design of Experiment 2 did not include the control condition Subsectivity for ordinal numbers anymore. The results of Experiment 1 showed correct subsective interpretations for more than 90% of items in all age groups. On the basis of these results, I assume that this semantic aspect of nominal modifiers is acquired in general for children between the age of 4 and 6. Second, the items of the control condition Non-intersectivity were moved to the beginning of the experiment. This change of order aimed to exclude potential confounds due to properties of the relative clause test items. Third, like in the pilot study, the visual context for all relative clause test items did not contain a picture matching the deviant intersective interpretation. The results of the pilot study demonstrated that this change reduced the number of intersective interpretations throughout the task. Fourth, only ambiguous visual contexts were used to test the interpretation of the pre-recorded stimuli. Instead of the factor VISUAL CONTEXT, the factor LEXICAL MARKER was included in the design. Furthermore, simple main clauses were added as filler items to reduce the task demands in the relative clause conditions. This fifth change was implemented because the items of the control condition were moved to the beginning of the experiment.

Overall, Experiment 2 comprised 36 relative clause test items in four condition and 20 additional items without relative clauses; two warm-up items, 6 items of the control condition Non-intersectivity and 12 fillers.

In the following sections, the changes are described in detail. The first section focuses on the relative clause test items in the four experimental conditions. Subsequently, the filler items and the items of the control condition Non-intersectivity are described.

6.3.1.1. Relative clause test items

The visual context for all relative clause test items corresponded to the ambiguous context condition of the pilot study. In all items, pictures were present for both restrictive and appositive interpretations of the relative clauses. In addition, restrictive and appositive interpretations led to different picture selections in all items independently of the ordinal number. In the arrangement of objects, no picture was present that corresponded to the deviant intersective interpretation.

For this experiment, 18 different test sentences and visual contexts were constructed.

The same 18 daily life objects and eight color terms as in Experiment 1 were used in the test sentences. Table 6.2 lists the lexical material of the experimental items.

Table 6.2.: Exp. 2 – Lexical material for experimental items

		Objects			
apple	ball	cap	car	duck	hat
jacket	lollipop	pencil	pullover	scarf	scissor
sun glasses	toothbrush	towel	trousers	T-shirt	watch
		Colors			
black	blue	green	multicolored	pink	red
striped	yellow				

An example relative clause test item is displayed in (3) and Figure 6.3. The construction of the visual contexts is representative for the relative clause test sentences in all four experimental conditions.

(3) Nimm das dritte Auto, das (ja) blau ist, und leg' es in den Koffer!
Take the third car which (PRT) blue is and put it in the suitcase

'Take the third car$_{(,)}$ that/which (as you know) is blue$_{(,)}$ and put it in the suitcase!'

1 2 3 4 5 6 7

Figure 6.3.: Exp. 2 – Ambiguous visual contexts for relative clause test items.

A picture selection of the car at position 4 indicated an appositive reading. When the fifth object was selected, a restrictive interpretation could be inferred. At position no. 3, there was no blue car.

In 50% of the visual contexts, the picture at the n^{th} position showed an object of a different color than the one mentioned in the stimulus sentence. In the other 50% of items, the type of object did not match the denotation of the head noun.

The rearrangement of the objects in the visual context had an additional advantage. Due to this change, the contexts could be constructed such that both ordinal numbers, *second* and *third*, yielded truth-functional differences between the two semantic functions of the relative clause. This is illustrated in Figure 6.4 and the instruction in (4).

(4) Nimm die zweite Ente, die grün ist, und leg' sie in den Koffer!
Take the second duck which green is and put it in the suitcase

'Take the second duck$_{(,)}$ that/which is green$_{(,)}$ and put it in the suitcase!'

Figure 6.4.: Exp 2 – Ambiguous visual contexts for the ordinal number *second*.

As Figure 6.4 shows, at position no. 2 no green duck was present. This should prevent the children from deriving an intersective reading. A picture choice corresponding to an appositive reading (position no. 3), however, could be distinguished from a restrictive interpretation of the relative clause (picture no. 4). Consequently, all relative clause items could be considered for the statistical analysis.

The two factors investigated in this experiment both apply to the verbal stimulus. Like in Experiment 1, the factor Prosody had two levels. Each of the 18 relative clause sentences was presented twice. The sentences were pre-recorded once with an integrated, restrictive prosody, and once with an unintegrated and backgrounded appositive format. For relative clauses in the condition with restrictive prosody, no intonation boundary was realized between the head noun and the relative clause. In addition, main stress was placed on the color adjective within the relative clause. The pause between the two coordinated parts was manually adjusted to 400 ms. For the appositive format, the relative clause was set off by pauses from the main clause. Both the head noun and the color adjective within the relative clause carried a pitch accent. Examples are shown after the second factor is illustrated.

The factor Lexical Marker investigated the influence of the discourse particle *ja* on the interpretation of relative clauses like (3). The meaning of the discourse particle *ja* can be paraphrased as 'as you know'. When this particle is used within a relative clause, only an appositive reading is compatible with the sentence.

The discourse particle *ja* was used because it is documented in the spontaneous speech of seven German-speaking children in the CHILDES database[1] already before the third birthday.[2] The discourse particle *übrigens* 'by the way', in contrast, is not attested in the spontaneous speech data of these children in the corpora. It was found only once in the German Wagner corpus for a child at the age of 12;2.

The two factors Prosody and Lexical Marker were fully crossed although restric-

[1] http://childes.psy.cmu.edu/browser/index.php?url=Germanic/German/

[2] The corpus search focused only on instances in which *ja* was used as discourse particle, not as a positive answer to a yes-no question. An example utterance of Caroline taken from the file "90-07-08.cha", line 457 from the CHILDES database is given in (I). The child was 2;9 at the time of recording.

(I) MOT: wo ist für mich mein Schlafanzug (1.) ?
CHI: du reicht äh (.) kann doch (.) so in Bett gehen (.) .
CHI: bist ja auch ne Puppe (1.) .
MOT: och aber ich möchte doch so gerne auch einen schicken Schlafanzug (.) oder wenigsten ein Halstuch (
CHI: dis se (.) du (.) dis doch (.) du hast doch keine Hals (.) .

tive prosody and the presence of the discourse particle *ja* may contradict each other. In each prosodic condition, nine relative clauses were presented with the discourse particle and nine were presented without the lexical marker. Figure 6.5 illustrates the prosodic contour for a restrictive relative clause with the discourse particle *ja*. In addition, Figure 6.6 shows a test sentence containing the discourse particle in the appositive prosody condition.

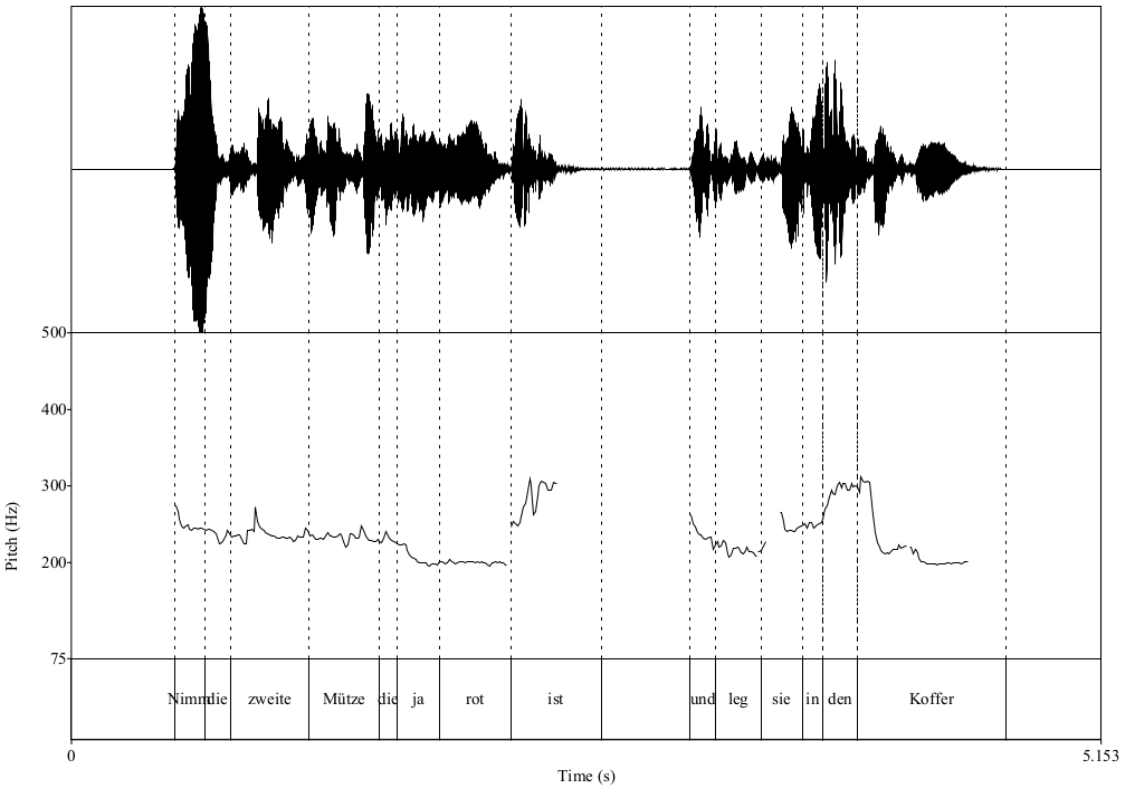


Figure 6.5.: Wave form and pitch contour of a restrictive relative clause test item with discourse particle.

Figure 6.5 illustrates that relative clauses containing the discourse particle were also presented with a restrictive prosodic contour. In this condition, the two cues from prosody and from the lexical content of the clause contradicted each other. The results of this condition could be indicative on the strength of the two different cues on the interpretation of relative clauses.

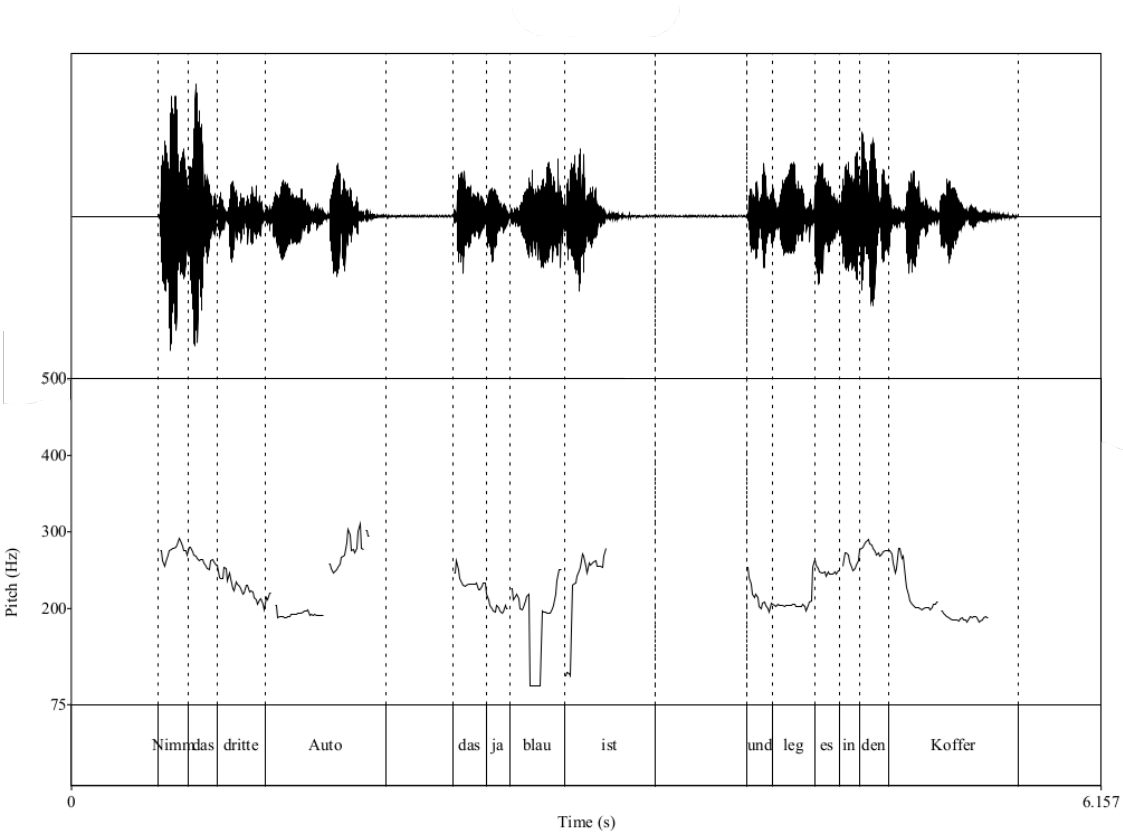


Figure 6.6.: Wave form and pitch contour of an appositive relative clause test item with discourse particle.

Table 6.3 summarizes the experimental conditions.

Table 6.3.: Exp. 2 – Overview of relative clause conditions

Factors	**Conditions**			
Prosody	Restrictive ($n = 18$)		Appositive ($n = 18$)	
Lexical Marker	Without *ja* ($n = 9$)	With *ja* ($n = 9$)	Without *ja* ($n = 9$)	With *ja* ($n = 9$)
	Set 1	Set 2	Set 2	Set 1

In the table, the labels *Set 1* and *Set 2* illustrate that each set of sentences was presented twice.The table shows that when a test sentence was pre-recorded without the discourse particle in the restrictive condition, the appositive counterparts contained

the discourse particle. Vice versa, when the restrictive version contained the discourse particle, the clause did not contain the lexical marker in the appositive prosody condition.

The following section focuses on the items of the control condition Non-intersectivity and the construction of the fillers.

6.3.1.2. Control condition and filler items

Compared to Experiment 1, two aspect of the experimental design concerning the pretest and the control conditions were changed. In Experiment 2, only the control condition Non-intersectivity was included. Similar to the relative clause items, the visual contexts of items in the control condition did not show a picture matching the intersective reading of the ordinal number. Like in the pilot study, this change was supposed to increase the proportion of correct non-intersective picture selections.

An example item of the control condition Non-intersectivity is given in (5) and Figure 6.7. In the six control items, two different types of objects were intermixed. To avoid intersective visual contexts there was always a picture of the non-target object displayed at the n^{th} position.

(5) Nimm den zweiten Hund und leg' ihn in den Koffer!
Take the second dog and put it in the suitcase

'Take the second dog and put it in the suitcase!'

Figure 6.7.: Exp. 2 – Visual context for an item of the control condition Non-intersectivity.

In addition to the control condition, 12 filler items were included in the design to alternate main clause stimuli and relative clause test items. Instead of the ordinal numbers *zweite/r/s* 'second' and *dritte/r/s* 'third', the filler items included *erste/r/s* 'first' and *letzte/r/s* 'last'. The linguistic structure of the filler items was similar to the one of the items in the control condition Non-intersectivity. An example is given in (6). The visual contexts for these items also contained two different type of objects. Figure 6.8 illustrates the arrangement of objects for the sentence in (6).

(6) Nimm den ersten/letzten Apfel und leg' ihn in den Koffer!
Take the first/last apple and put it in the suitcase

'Take the first/last apple and put it in the suitcase!'

Figure 6.8.: Exp. 2 – Visual context for a filler item.

In the filler items, half of objects denoted by the *first X* or *last X* appeared at position no. 1 or 7 respectively. The other half of objects appeared in other positions (mainly at position no. 2 and 6). Thus, 50% of the filler items allowed an intersective reading of the modifier. Due to the inclusion of the filler items, the positions of the target objects were distributed across all seven objects. The target object was displayed in each of the positions at least six times across all items of the experiment.

For both filler items and items of the control condition, the 18 objects used in the relative clause items were used once either as target object or as distractor. In addition, pictures of nine animals were included. They display an ape, a cat, a cow, a dog, an elephant, a giraffe, a horse, a kangaroo or a tiger. The animals appeared once as target category and once as non-target objects in the visual contexts. For all items, a natural intonation contour was realized. In the recordings, main stress was placed on the noun phrase of the first conjunct for both filler and control items. The pause between the two conjuncts was manually adjusted to 400 ms.

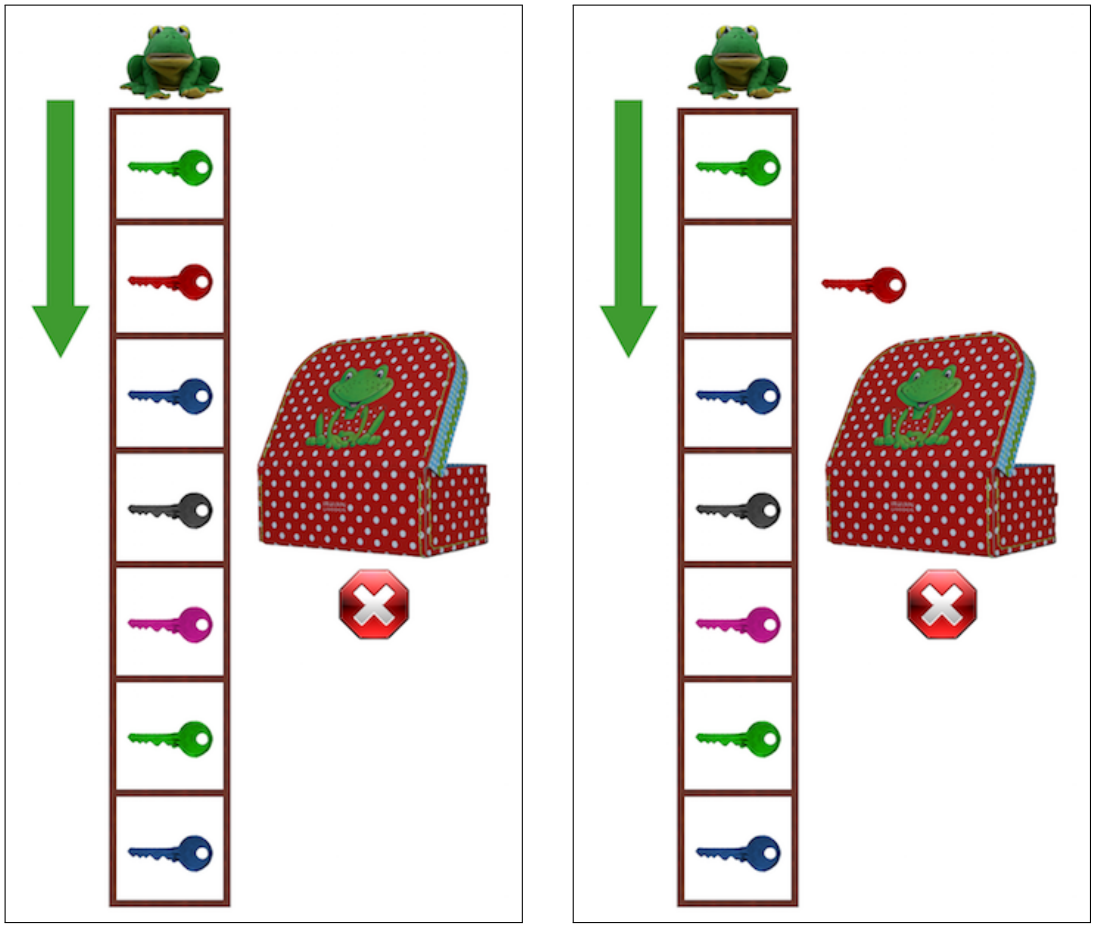
In addition to the control and filler items, two warm-ups familiarized the participants with the experimental design and procedure. For Experiment 2, warm-up item 1 was identical to the one used in Experiment 1. The second warm-up item differed from the one used in the previous experiment. In contrast to Experiment 1, this item did not introduce a presupposition failure. Since the control condition Subsectivity was not included in the design anymore, the 'no matching picture' button was not the target response in any of the items of the experiment. When the participants performed according to the expectations in the experimental conditions, they would not need the button at all as a response option. Therefore, the second warm-up asked to select the third object from the cupboard, which was possible in the visual display.

6.3.1.3. Experimental setting

Like in Experiment 1, the experiment was implemented as a computer game. The experimental setting was identical to the one in the previous experiment. A screenshot of the first warm-up item is repeated in Figure 6.9.

The screenshot shows that the 'no matching picture' button was displayed although it did not serve an explicit function in the experiment. It was displayed to offer a response option to those children without target-like interpretations of ordinal numbers. When these children searched for pictures matching an intersective interpretation, no matching picture was displayed in this experiment contrary to Experiment 1.

Like in the previous experiment, the items were presented in a block design in two



(a) Before picture selection.

(b) After picture selection.

Figure 6.9.: Exp. 2 – Screenshot of the experimental setting for warm-up item 1.

experimental sessions. The relative clause items with the discourse particle followed the relative clause items without the lexical marker for an appositive interpretation. This order was chosen to present the items with only one cue before those that were disambiguated additionally by the lexical marker. A list of items of the experiment is displayed in Section B.1 of the appendix.

To avoid confounds due to the presentation order of the prosodic formats, the experiment was administered in two versions. Half of the children listened to items of the restrictive prosody part first. The other half of the children received the items of the part with appositive prosody in their first test session. The items of the control condition Non-intersectivity were presented after the warm-up items in the first session of each experimental version. Table 6.4 gives an overview of the distribution of test versions across participants.

Table 6.4.: Exp. 2 – Distribution of test versions by age group

	Age 4 ($n = 20$)	**Age 5** ($n = 27$)	**Age 6** ($n = 16$)	**Adults** ($n = 23$)
Distribution of test versions	11x Version 1 9x Version 2	13x Version 1 14x Version 2	8x Version 1 8x Version 2	12x Version 1 11x Version 2

6.3.2. Procedure

The experimental procedure was almost identical to the one in Experiment 1. For a detailed description see Section 5.2.2 on page 171. The only change was the second warm-up item. In this item, the experimenter did not explicitly introduce the 'no matching picture' button. The function of the button was only explained to the participants when the children remarked that no matching picture was available in the visual context.

Like in Experiment 1, testing was performed by trained student assistants of the project CARU *Child Acquisition of Relative Clauses*, PI: Petra Schulz.

6.3.3. Data analysis and coding

The data analysis and coding was similar to the procedure in Experiment 1. The picture selections for the relative clause test items were stored automatically in a database. With the statistics software package SPSS the picture selections were classified as *restrictive*, *appositive*, *no matching picture* or *other*. Due to the change of the visual displays, picture selections in all test items could be classified unambiguously according to one of the above-mentioned categories.

A target-like picture choice in the filler items and in the control condition for the non-intersectivity of ordinal numbers was coded as *correct*. All other picture selections were coded as *other*. When children used the 'no matching picture' button, this was coded as *no matching picture*. In addition to the coding of the picture selections, the spontaneous comments of the participants were transcribed for additional analyses. The following section presents the results of Experiment 2.

6.4. Results of Experiment 2

This section presents the results of Experiment 2. First, the results of the control condition Non-intersectivity and of the filler items are reported in Section 6.4.1. Second, the results on the interpretation of relative clauses are presented in Section 6.4.2. For the analysis of the data, non-parametric statistical test were performed because the data was not normally distributed. To compare a dependent variable across multiple independent groups (e.g., performance across age groups or test versions), Kruskal-Wallis H tests were performed. When two independent groups were compared, Mann-Whitney U tests were used. Friedman tests are reported for comparisons of a dependent variable across

multiple related samples (e.g., proportions of one interpretation type across experimental conditions). Wilcoxon tests were used to compare two related samples. The reported p-values were corrected for multiple testings when post-hoc tests were performed.

6.4.1. Control condition Non-intersectivity and filler items

Table 6.5 displays the proportions of correct interpretations in the control condition Non-intersectivity and in the filler items. The results are subdivided for the different age groups.

Table 6.5.: Exp. 2 – Percentages correct (*SD*) for filler items and control condition Non-intersectivity by age group

	Age 4 ($n = 20$)	**Age 5** ($n = 27$)	**Age 6** ($n = 16$)	**Adults** ($n = 23$)
Non-intersectivity	67.5% (42.3)	79.6% (34.1)	97.9% (5.7)	100% (0.0)
Filler – *first*	98.3% (7.5)	93.2% (16.2)	99.0% (4.2)	100% (0.0)
Filler – *last*	90.0% (17.4)	88.9% (23.1)	100% (0.0)	100% (0.0)

As Table 6.5 shows, the proportion of correct interpretations increased with age in the control condition Non-intersectivity. Children at the age of 4 selected the correct picture for the prompt *Take the second/third X* in 67.5% of cases correctly. The rate of correct interpretations increased to 79.6% at age 5 and to 97.9% at age 6. Adults were at ceiling in this condition.

The age-related differences between the groups were statistically confirmed for the performance in the control condition ($\chi^2(3) = 17.1$, $p = .001$). The mean ranks of the groups were 34.1 at age 4, 37.3 at age 5, 49.9 at age 6, and 54.5 in the adult control group. Pairwise post-hoc tests did not show significant differences between the children's groups (all ps $> .08$). However, children at the age of 4 and 5 differed significantly from the adult control group (age 4 vs. adults: $U =$ -20.5, $p = .003$; age 5 vs. adults: $U =$ -17.2, $p = .009$).

The performance in the control condition was not influenced by the order in which the two prosodic parts of the experiment were administered (ps $> .20$ for all age groups). This was expected because the items of the control condition appeared as a block at the beginning of the experiment before any relative clause test item was presented.

Turning to the filler sentences, higher rates of correct interpretations were observed than in the control condition. Table 6.5 shows that filler items with *first* were interpreted more often correctly than fillers with *last*. No age-related differences could be found for the performance in the filler items with the ordinal *first* ($\chi^2(3) = 6.3$, $p = .10$; mean ranks 44.9 at age 4, 39.0 at age 5, 44.4 at age 6 and 47.0 for adults). For the filler sentences

testing *last*, the performance differed across age groups ($\chi^2(3) = 13.6$, $p = .004$; mean ranks 37.6 at age 4, 37.8 at age 5, 50.5 at age 6, and 50.5 for adults). Post-hoc tests showed that both 4- and 5-year-olds differed in their performance from the adults (age 4 vs. adults: $U = -13.0$, $p = .05$; age 5 vs. adults: $U = -12.7$, $p = .03$).

The results for the filler conditions show that *first* and *last* were interpreted more often correctly than the items of the control condition Non-intersectivity. Thus, they fulfilled the purpose to serve as less complex fillers to be interspersed with the relative clause test sentences. Therefore no further analyses were performed on the filler sentences.

The high rate of correct interpretations in the control condition shown in Table 6.5 indicates that the goal to reduce the number of intersective interpretations was achieved. In addition to the group analysis, an individual analysis was performed to support the claim that the absence of an intersective distractor picture facilitated the performance in the control condition Non-intersectivity.

Table 6.6 shows the individual performance of the participants in the control condition. Like in the previous experiment, the data shows a bimodal distribution for the younger children. Four- and 5-year-old children interpreted either zero to two items correctly, or they showed correct interpretations in at least four items of the condition.

Table 6.6.: Exp. 2 – Cross-table on the number of participants with n correct interpretations in control condition Non-intersectivity by age group

No. of correct interpretations	**Age 4** ($n = 20$)	**Age 5** ($n = 27$)	**Age 6** ($n = 16$)	**Adults** ($n = 23$)
0	3	3	-	-
1	3	-	-	-
2	1	2	-	-
3	-	-	-	-
4	-	1	-	-
5	2	5	2	-
6	11	16	14	23

Like in the previous experiment, mastery was defined at a level of 5 out of 6 correct non-intersective interpretations. The strict mastery criterion was chosen because consistent non-intersective interpretations of the ordinal numbers *zweite/r/s* 'second' and *dritte/r/s* 'third' were necessary to yield interpretable results in the relative clause test items. According to the strict criterion, 50 out of 63 children (79%) and all adults showed mastery on the interpretation of ordinal numbers in the present experiment. Table 6.7 summarizes the data for children with mastery for the individual age groups.

In the following section, the results of the four conditions on the interpretation of relative clauses are reported.

Table 6.7.: Exp. 2 – Percentage of children with mastery of non-intersectivity of ordinal numbers by age group

	Age 4 ($n = 20$)	**Age 5** ($n = 27$)	**Age 6** ($n = 16$)	**Adults** ($n = 23$)
Mastery[a]	65.0% (13/20)	77.8% (21/27)	100% (16/16)	100% (23/23)

[a]Mastery defined as at least 5 out of 6 items correct.

6.4.2. Relative clause test items

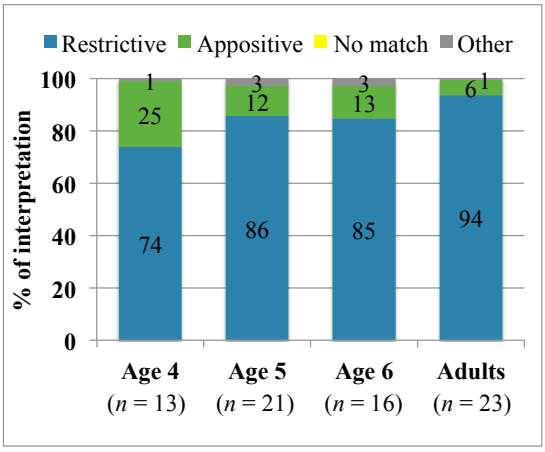
The results on the relative clause test items are first presented for the 63 participants with mastery in the control condition Non-intersectivity. The results are reported with regard to the influence of the two experimental factors Prosody and Lexical Marker. Furthermore, the results of an individual analysis are summarized, before the results for children without mastery in the control condition Non-intersectivity are presented. Additional data and analyses are given in Sections B.2 and B.3 of the appendix.

For children and adults with mastery in the control condition Non-intersectivity, the order in which the prosodic parts were administered did not lead to significant differences. Except for one age group in one condition, no significant differences were found for the two experimental versions. At age 4, the distribution of appositive interpretations in the condition with the discourse particle *ja* and appositive prosody differed between the test versions ($U = 31.5$, $p = .034$). All other ps were above .05 for the comparisons of restrictive and appositive interpretations in the two test versions for the four conditions and age groups. For the presentation of the results the data of the two test versions was collapsed.

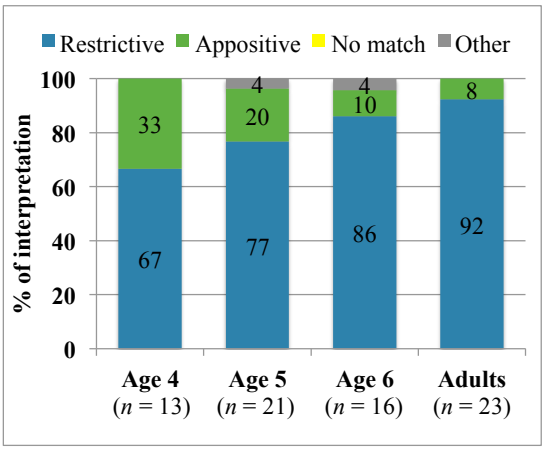
The following figures illustrate the results on the interpretation of relative clauses in the four experimental conditions for the participants with mastery in the control condition Non-intersectivity. Figure 6.10 displays the results on relative clauses without the discourse particle *ja* in the two prosodic conditions. In addition, Figure 6.11 shows the interpretation rates for relative clauses including the discourse particle as a marker for appositivity. See Table B.2 on page 368 of the appendix for detailed information of the standard deviations in these conditions.

Overall, the results show similar patterns across the four conditions. Across all conditions and age groups, participants selected the pictures matching a restrictive interpretation most frequently. Restrictive interpretations occurred in at least 61% of items. Appositive interpretations were found in 8% to 39% of the picture selections. No participant selected the 'no matching picture' button in the relative clause test items.

To address research question (Q4) asking whether children and adults show the same interpretation preferences, the performance of the different age groups was compared statistically. Age-related differences for the rates of restrictive interpretations were only found for one condition. The comparisons yielded significant differences between the age groups in the condition without discourse particle and with appositive prosody in Figure

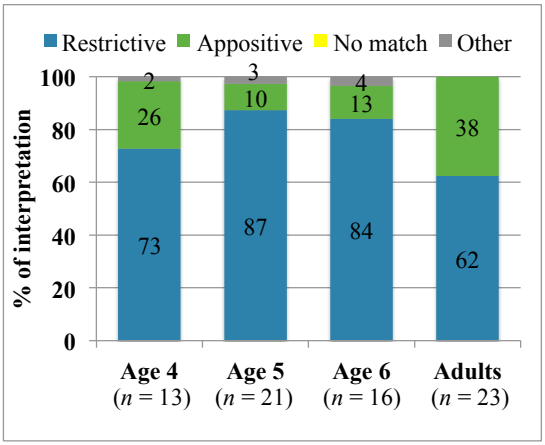


(a) Restrictive prosody.

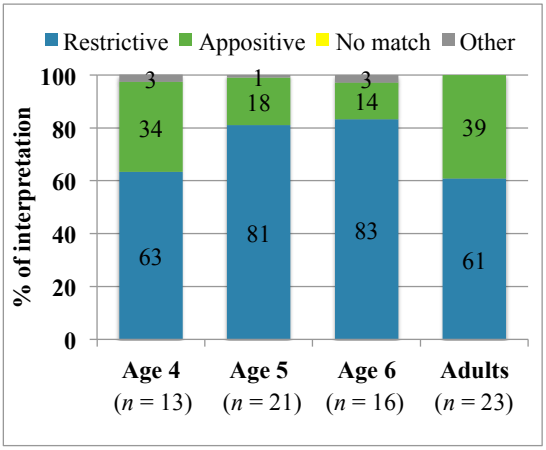


(b) Appositive prosody.

Figure 6.10.: Exp. 2 – Proportions of interpretations for relative clauses without discourse particle with restrictive and appositive prosody.



(a) Restrictive prosody.



(b) Appositive prosody.

Figure 6.11.: Exp. 2 – Proportions of interpretations for relative clauses with discourse particle with restrictive and appositive prosody.

6.10b ($\chi^2(3) = 10.2$, $p = .017$). The mean ranks for the age groups were 28.3 at age 4, 31.6 at age 5, 40.7 at age 6, and 44.3 in the group of adults. The mean ranks show that the proportions of restrictive interpretations increased with age. Post-hoc tests, however, showed only a significant difference between the amount of restrictive interpretations of the 4-year-olds and adults (U = -16.0, p = .045). The other pairwise comparisons of age groups did not reach significance (all ps > .09). For the proportions of restrictive interpretations in the other three conditions, no differences between the groups could be found (all ps > .13).

The same pattern was found for appositive interpretations. Differences between the participant groups were only found in the condition without discourse particle and with appositive prosody ($\chi^2(3) = 9.3$, $p = .026$; mean ranks: 46.9 at age 4, 40.3 at age 5, 33.6 at age 6, and 30.7 for adults). Pairwise post-hoc tests revealed that the group differences were due to the differences between 4-year-old children and adults ($U = 16.1$, $p = .031$; all other ps $> .20$). With regard to appositive interpretations, 4-year-old children showed higher rates than the adults. No differences between the groups were found for the other three conditions (all ps $> .08$).

Taken together, these results indicate that 4- to 6-year-old children showed similar interpretation patterns in this task with a descriptive preference for restrictive interpretations. In addition, differences between children and adults were found only for 4-year-olds and the control group. The performance of children at the age of 5 and 6 and of the adults did not differ significantly within the respective conditions. These findings is at least partial support for Hypothesis (H6) claiming that children and adults show the same interpretation patterns.

To address research question (Q1) asking which interpretation of relative clauses is preferred, the amount of restrictive and appositive interpretations within the different age groups were compared. The distribution of restrictive and appositive interpretations did not differ for children at the age of 4 in the four conditions (all ps $> .084$). For children at the age of 5 and 6, there were significantly more restrictive interpretations than appositive ones in all conditions (age 5, restrictive prosody, w/o *ja*: $Z = -3.59$, $p < .001$; appositive prosody, w/o *ja*: $Z = -3.32$, $p = .001$; restrictive prosody, with *ja*: $Z = -3.96$, $p < .001$; appositive prosody, with *ja*: $Z = -3.12$, $p = .002$; age 6, restrictive prosody, w/o *ja*: $Z = -2.75$, $p = .006$; appositive prosody, w/o *ja*: $Z = -3.48$, $p = .001$; restrictive prosody, with *ja*: $Z = -3.31$, $p = .001$; appositive prosody, with *ja*: $Z = -2.65$, $p = .008$). For adults, significant differences between the proportions of restrictive and appositive interpretations were found in the conditions without discourse particles (restrictive prosody, w/o *ja*: $Z = -4.12$, $p < .001$; appositive prosody, w/o *ja*: $Z = -4.25$, $p < .001$). In the conditions where *ja* was present, no significant differences were found (all ps $> .14$).

These results give further evidence for Hypothesis (H1) postulating a preference for restrictive over appositive interpretations. However, although restrictive interpretations were descriptively the predominant pattern in all age groups and conditions, significant differences were only found for children at the age of 5 and 6, as well as for adults in the conditions without discourse particles. For 4-year-old children, the descriptive differences between restrictive and appositive interpretations were not supported by the statistical analysis of the group results. In addition, the pattern was not confirmed for adults when the discourse particle *ja* indicated an appositive interpretation. This finding points to an effect of the lexical marker in the control group. Analyses on this disambiguating factor will be reported in more depth below. Furthermore, the data supports Hypothesis (H2) since both semantic functions of relative clauses were attested already at the age of 4 in at least 25% of the items across conditions.

In addition to comparisons within the individual conditions, the proportions of restrictive and appositive interpretations were compared across the experimental factors.

These analyses were performed to address research question (Q3) on the influence of the linguistic factors on the interpretation of relative clauses.

6.4.2.1. PROSODY*: the influence of prosodic differences*

To investigate the influence of prosody, the amount of restrictive and appositive interpretations were collapsed across the two levels of the factor LEXICAL MARKER. That is, the proportions of restrictive interpretations shown in the Figures 6.10a and 6.10a were compared to the amount of restrictive interpretations in the conditions with appositive prosody (Figures 6.10b and 6.10b). The presence or absence of the discourse particle was ignored for this analysis. The same comparison was performed for appositive interpretations in the two prosodic conditions.

The results of the pairwise comparisons showed no significant effect of prosody for restrictive interpretations. For all age groups, prosody did not influence the amount of restrictive interpretations (all ps $> .06$). For appositive interpretations, however, a significant influence of PROSODY was found for children at the age of 5 ($Z = 2.18$, $p = .03$). For the group of 5-year-olds, more appositive interpretations were observed when the relative clauses were presented with appositive prosody. In the other age groups, no differences due to the factor PROSODY were detected (all ps $> .34$).

Taken together, the prosodic differences between the conditions did not have a strong impact on the picture selections of the children and adults. Only at the age of 5, the rate of appositive interpretations increased in the conditions with appositive prosody compared to the conditions with restrictive prosody. Thus, the data only partially support Hypotheses (H3a) and (H3c).

6.4.2.2. LEXICAL MARKER*: the influence of the discourse particle*

To analyze the influence of the discourse particle *ja*, the proportions of the respective restrictive and appositive interpretations were collapsed across the two prosodic conditions. Thus, the performance in relative clauses without discourse particle displayed in the Figures 6.10a and 6.10b was combined and compared to the amount of restrictive or appositive respectively interpretations reported for the conditions where the discourse particle was present (see Figures 6.10a and 6.11).

For the three groups of children, no significant differences due to the presence of the discourse particle *ja* were obtained for restrictive interpretations (all ps $> .20$). In contrast to the children, the adults showed significantly fewer restrictive interpretations when the lexical marker was present ($Z =$ -2.89, $p = .004$). Similar results were found for appositive interpretations. The presence of the discourse particle did not lead to an increase of appositive interpretations in the groups of 4- and 5-year old children (ps $>$ .51). 6-year-old children and adults, however, selected the picture matching an appositive interpretation significantly more often in the condition where the discourse particle was present (age 6: $Z = 2.12$, $p = .034$; adults: $Z = 2.9$, $p = .004$).

These results show that adults were sensitive to the lexical content of the discourse particle *ja*. They selected appositive interpretations more often when the lexical marker

for an appositive reading was present. In addition, restrictive interpretations were chosen less often in this condition. This is in accordance with Hypothesis (H4a) on the disambiguating effect of discourse particles for adults. Six-year-old children showed a similar tendency but the effect was less robust. While the amount of appositive interpretations increased slightly for relative clauses with *ja*, the amount of restrictive interpretations statistically did not differ across conditions. For younger children, the presence of the discourse particle did not have any effect. This data adds evidence for Hypothesis (H4c) claiming that children cannot make use of a disambiguating cue that appears within the relative clause.

6.4.2.3. Individual interpretation strategies

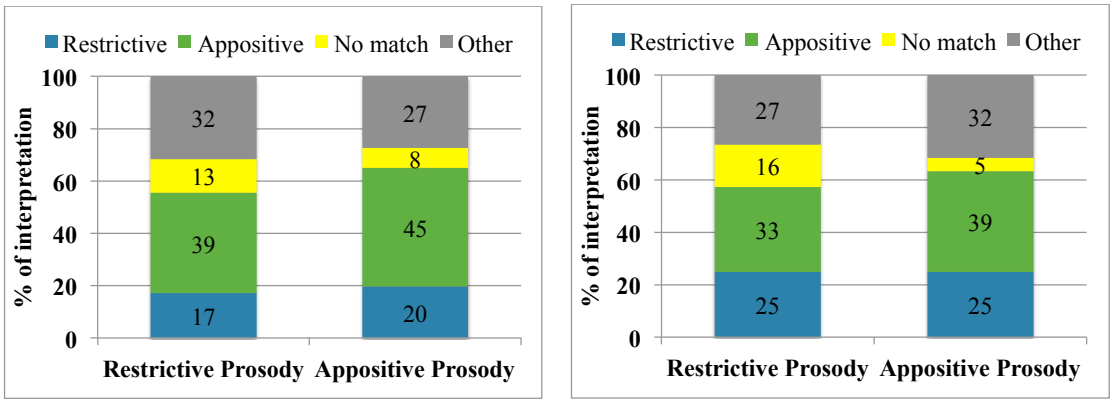
To address research question (Q1) asking which interpretation preferences are preferred on an individual level, the interpretation preferences were evaluated for each participant. A strategy was assigned when the participant had interpreted more than half of the items in one condition consistently. That is, at least 5 out of 9 items per condition had to be interpreted with the same reading to get classified with the respective strategy. This interpretation pattern, then, was the preferred reading in the respective condition. For a detailed overview of the individual results see Section B.2.2 in the appendix on page 368. The individual analysis revealed that for relative without the discourse particle *ja* 58 out of 73 participants (79%; 37 children and 21 adults) preferred restrictive interpretations independently of prosody. In addition, seven participants (6 children and 1 adult) went for the expected interpretation strategy in accordance with the prosodic marking. For relative clauses with the discourse particle *ja*, 53 out of 73 participants (73%; 40 children and 13 adults) chose a restrictive interpretation in the majority of items independently of the prosodic contour. In addition, 16 participants (7 children, 9 adults) showed appositive interpretation in the majority of items. Only four participants (3 children and 1 adult) selected their interpretation according to prosody. Across all conditions, the individual analysis showed that only two participants (1 child and one adult) showed sensitivity for both experimental factors. These participants determined the reading of the relative clause according to the prosody when no discourse particle was present but showed appositive interpretations consistently when the lexical marker indicated an appositive reading. This pattern was expected when participants rank the influence of a lexical marker higher than the prosodically conveyed information. In addition, two children selected pictures consistently according to the prosodic format of the stimulus sentences. Furthermore, the analysis showed that seven participants, all adults, interpreted the relative clauses according to the presence or absence of the discourse particle. They interpreted relative clauses without the lexical marker as restrictive modifiers; relative clauses with the discourse particle were interpreted appositively. The most frequently observed pattern was shown by 49 participants (67%; 36 children and 13 adults) with restrictive interpretations for the majority of all relative clauses in the experiment. In addition, seven participants (6 children and 1 adult) always chose appositive interpretations for the experimental stimuli. The latter two interpretation patterns are the only ones that were found in all age groups.

Taken together, the individual analysis adds further evidence to Hypothesis (H1) that restrictive interpretations are preferred over appositive readings. Like in Experiment 1, the individual analysis can also be used to address research question (Q2) asking which readings are available for children. Although this experiments assessed interpretation preferences the data showed that both semantic functions were used consistently by seven children, three 4-year-olds and four 5-year-olds.

The following section summarizes the results for children without mastery in the control condition Non-intersectivity. These results are presented to show how children that do not yet master the semantics of ordinal numbers perform in the relative clause test items, in which no picture that may correspond to their interpretation is present.

6.4.2.4. Results of children without mastery in the control condition Non-intersectivity

In the present experiment, only seven children at the age of 4 and six children at the age of 5 did not master the control condition Non-intersectivity. In Figure 6.12, the results of these children were collapsed. An overview of detailed percentages and standard deviations by age group are given in the appendix (see Table B.6 on page 372). Remember that in Experiment 1, intersective picture selections were the most frequent pattern for children without mastery in the control condition. In Experiment 2, the visual displays were changed such that no picture was displayed that matched the intersective reading. The lack of a fitting object may therefore result in a random choice of objects or the use of the 'no matching picture' button.



(a) Without discourse particle *ja*. (b) With discourse particle *ja*.

Figure 6.12.: Exp. 2 – Proportions of interpretations for relative clauses with and without lexical marker by prosody for children without mastery in the control condition Non-intersectivity ($n = 13$).

The data show that for relative clauses without lexical markers, picture selections corresponding to a restrictive, appositive or other interpretation appeared with similar rates. Statistic comparisons confirmed this observation. There were no significant differences between the distributions of restrictive, appositive and other picture selections

within three out of the four conditions (all *p*s > .262). Only in the condition without the lexical marker and with appositive prosody, significant differences were found ($\chi^2(2) = 8.79$, $p = .012$). Pairwise post-hoc tests show that there were significantly more appositive interpretations than restrictive ones in the condition with appositive prosody displayed in Figure 6.12a ($Z = -1.04$, $p = .024$).

An investigation of the factor PROSODY did not yield significant results for the group of children without mastery in the control condition. For this analysis, the proportions of restrictive and appositive interpretations were collapsed for the conditions with and without lexical marker respectively. There were no significant differences between the medians of restrictive or appositive interpretations in the two prosodic conditions (both *p*s > .26).

To investigate the influence of the factor LEXICAL MARKER, restrictive and appositive interpretations were collapsed across the different prosodic conditions. This factor had an effect on the interpretation patterns in this group, however, not in the direction that was expected. The median for restrictive interpretations was significantly higher in the condition with discourse particle than in the condition without the lexical marker ($Z = 2.23$, $p = .026$). The medians for appositive interpretations, however, did not differ ($Z = -1.02$, $p = .31$).

As expected, the results indicate that the children in this group did not interpret the relative clauses systematically. The children may have interpreted the ordinal numbers intersectively and did not find a matching picture for their reading, or they selected pictures more randomly when they did not yet know the semantics of ordinal numbers. To address this aspect in more depth, the spontaneous comments of the participants were analyzed.

The analysis of the individual interpretation patterns for children without mastery in the control condition reveals two different patterns. On the one hand, three 4-year-old children seem to interpret ordinal numbers as referring to the first position in a sequence. Two children selected the first element in 5 out of 6 items of the control condition Non-intersectivity; the third child selected the first picture in 4 out of 6 items in this condition. These children associated the meaning of the ordinal number words *second* and *third* with a fixed position in the sequence of objects. The correct relation between the ordinal and the described position, however, is not yet established.

On the other hand, four children intended an intersective interpretation in at least 23 instances. Since the children were not explicitly asked to explain their picture selections, the reasons for the picture choices of the remaining six children remain unclear. Examples of the comments are given in (7) and (8). In (7), the child indicated that she looked at position no. 3 for the target object. Since there was no matching picture at this position, the child selected the 'no matching picture' button. In the filler item in (8), the child searched for the target object at the last position overall. Instead of choosing the 'no matching picture' button, this child selected the object displayed at position no. 7, which resulted in a classification of the picture choice as *other*.

(7) Comment to a relative clause test item without discourse particle with restrictive prosody of Experiment 2 indicating an intersective reading instead of a 'no match' response

Visual context:

1 2 3 4 5 6 7

Comment:

Caru: Nimm die dritte Ente, die bunt ist, und leg' sie in den Koffer.
Child: Hä, die dritte? Die dritte is' nich bunt, nur die erste. Die dritte is' pink und nach der dritten is ne Uhr.

Caru: *Take the third duck, which is multicolored, and put it in the suitcase.*
Child: *Hä, the third one? The third one is not multicolored, only the first one is. The third one is pink and after the third one is a watch.*

04_GEH162, age 4;9

(8) Comment to an filler item of Experiment 2 indicating an intersective reading

Visual context:

1 2 3 4 5 6 7

Comment:

Caru: Nimm die letzte Kuh und leg' sie in den Koffer.
Child: Die letzte Kuh is'n Schal. Ich nehm' ein Schal einfach. Der hat ja auch letzten gesagt.

Caru: *Take the last cow and put it in the suitcase.*
Child: *The last cow is a scarf. So, I take the scarf. He did said last.*

04_HMG079, age 5;6

When the readings indicated by the comments were considered instead of the actual picture selections, the proportions of the categories *no match* and *other* reduced. Instead, 8% of intersective interpretations were found in both conditions with restrictive prosody. The amount of restrictive and appositive picture selections did not change based on the spontaneous comments of the participants.

In addition to the children's comments, their individual interpretation patterns were analyzed. The individual analysis corroborates the heterogeneity in the group of children

without mastery in the control condition. For 13 children, 12 different patterns were found. Frequently, the children did not interpret more than half of the items in one condition systematically. Only one child, who interpreted 4 out of 6 items correct in the control condition Non-intersectivity, consistently selected pictures matching a restrictive reading in all conditions. In addition, one child consistently selected pictures matching an appositive interpretation throughout the task. Furthermore, one child selected the 'no matching picture' button in more than half of the items per condition. Interestingly, appositive strategies were more often observed within the conditions than restrictive ones. This finding is comparable to the results of Experiment 1 for children without mastery of the semantics of ordinal numbers. Therefore it is addressed in the discussion of this chapter.

Overall the results of children without mastery in the control condition Non-intersectivity were heterogeneous. The spontaneous comments indicated that some of the children have not yet acquired the correspondence of ordinal numbers and cardinal numbers. These children selected the first element in the sequence. In addition, some of the children derived intersective readings for ordinal numbers. Nonetheless, both restrictive and appositive interpretations were found in this group without a systematic effect of the factors Prosody and Lexical Marker.

The results of the present experiment are discussed in the following section in more detail.

6.5. Discussion

Experiment 2 investigated the influence of discourse particles and prosody on the interpretation of relative clauses in a picture selection task. Due to scope differences of an ordinal number word, restrictive and appositive interpretations of relative clauses led to different picture selections in the experiment. As one factor, the prosodic format of the pre-recorded test sentences was varied in the experimental conditions. It was investigated whether an integrated, restrictive prosody or an unintegrated, appositive contour serves as a disambiguating factor for children between 4 and 6 years of age and adults. As a second factor, half of the relative clause stimuli included a discourse particle as a lexical marker for appositive interpretations. Relative clauses with the discourse particle *ja* should only allow an appositive interpretation. This interaction is accounted for by the theoretical assumption that discourse particles serve as a modifier of the speech act or proposition expressed by the appositive relative clause. Restrictive relative clauses, in contrast, are analyzed as simple predicates and do not express a proposition (see Section 2.3.1).

This section is structured as follows. First, the main results of Experiment 2 are summarized and are discussed with regard to the hypotheses formulated in Chapter 4. Second, the influence of the discourse particle as an indicator of appositive interpretations of relative clauses is addressed. In addition, the interaction of the two experimental factors are discussed. Furthermore, some consequences of the methodological changes from Experiment 1 to the present experiment are discussed. The section concludes with

further remarks on subsequent experiments of this thesis.

6.5.1. Evaluating the hypotheses

Sixty-four monolingual, German-speaking children between the age of 4 and 6 participated in the task. In addition, 23 adults were tested as control group. The results were analyzed for 63 children because one child had to be excluded due to missing data. In this experiment, the factors Prosody (restrictive vs. appositive) and Lexical Marker (with and without discourse particle *ja*) were crossed in a 2 × 2 within-subject factorial design. Nine relative clause test items were administered in each of the four experimental conditions. At the beginning of the experiment, a control condition tested whether the participants interpreted the ordinal numbers *zweite/r/s* 'second' and *dritte/r/s* 'third' as non-intersective modifiers. To vary the task demands, filler items without relative clauses were interspersed with the relative clause test items.

To obtain truth-functional differences between the semantic functions of the relative clause test items, a target-like interpretation of the ordinal number words was required. Different picture selections for restrictive and appositive readings of the relatives could have only been observed when the ordinal numbers were interpreted as non-intersective modifiers. Therefore, children were grouped according to their performance in the control condition Non-intersectivity. In the present experiment, 50 out of 63 children (79%) and all adults showed mastery in the control condition. In the relative clause test items, the participants with mastery showed a preference for restrictive interpretations. More than 60% of items in each of the four experimental conditions received a restrictive reading. However, age-related differences as well as differences between the four experimental conditions were observed.

Within three out of four experimental conditions all age groups performed alike statistically. The distribution of restrictive and appositive interpretations did not differ between the three groups of children and the adult control group in both conditions with restrictive prosody as well as in the condition with the lexical marker and appositive prosody. Within the condition testing relative clauses without the lexical marker and appositive prosody, the interpretation rates differed between the four age groups. In this condition, the distributions of both restrictive and appositive interpretations significantly differed between 4-year-olds and the adults. The youngest participants in this experiment selected more pictures matching an appositive reading than the adults (33% vs. 8%).

When the proportions of restrictive and appositive interpretations were compared within the individual age groups, 4-year-olds differed from the other groups. Within the children at age 4, restrictive and appositive interpretations were selected to the same extent in each of the four conditions. The result that both readings were found at the age of 4 confirms Hypothesis (H2) postulating the availability of both semantic functions for children. In contrast, 5- and 6-year-old children selected restrictive interpretations significantly more often than appositive readings in all conditions. This finding supports Hypothesis (H1) that claims that restrictive interpretations are preferred over appositive ones. Adults showed a pattern that indicated an influence of the discourse particle. In

the conditions without discourse particles, restrictive interpretations were preferred over appositive ones. This gives further support to Hypothesis (H1). In the conditions where the lexical marker for an appositive reading was present, no statistical differences between the distribution of restrictive and appositive readings were found.

These analyses already indicated that the three groups of children performed differently. Appositive interpretations were more frequently found in the youngest group of children than in children at the age of 5 and 6. Across the four experimental conditions, however, each group of children performed homogenously. This observation was corroborated with only few exceptions by the analyses on the influence of the experimental factors.

In general, the factor Prosody influenced the choice of interpretations in this experiment only marginally. The majority of participants chose restrictive and appositive readings independently of the prosodic format of the pre-recorded stimuli. This finding contradicts the expectations formulated in Hypothesis (H3a) and Hypothesis (H3c) proposing that adults and children use prosody to disambiguate between the two semantic functions. There was only one exception: Five-year-old children showed more appositive interpretations when the relative clauses were presented with an appositive than with a restrictive prosody (19% vs. 11%). In the other age groups including the adult control group, no differences were found due to the prosodic realization of the test sentences.

With regard to the factor Lexical Marker, the younger children differed from the older ones and the adults. The proportions of restrictive and appositive picture selections did not differ for 4- and 5-year-old children in the conditions with and without the discourse particle *ja*. This can be taken as evidence in support of Hypothesis (H4c) claiming that children do not use the discourse particle as disambiguating information within the relative clause. For 6-year-old children, the amount of appositive interpretations increased when the discourse particle was present. In the group of adults, the presence of the discourse particle led to a reduction of restrictive and an increase of appositive interpretations. This pattern had been expected since the discourse particles should only be compatible with appositive interpretations of relative clauses. Thus, Hypothesis (H4a) claiming that adults interpret discourse particles as a marker for appositive readings is supported.

An individual analysis showed highly consistent interpretation patterns of the participants. Two thirds of the participants (49 out of 73) selected the pictures in accordance with a restrictive interpretation of the relative clauses in more than 50% of items in each condition. In addition, seven participants selected a picture matching the appositive reading consistently in all conditions. These two groups of participants seemed to ignore both disambiguating cues. However, the results show that children and adults follow similar interpretation patterns, which supports Hypothesis (H6).

Only two participants adapted their interpretations to both factors conveying disambiguating information in this experiment. One 5-year-old child and one adult selected their interpretations according to the prosody when no discourse particle was present but chose only appositive interpretations for relative clauses including the discourse particle *ja*. This pattern was the one expected by linguistic theory when lexical information

is taken to be more informative than prosodic information. As the results show, this expected pattern was not frequently observed. In addition, two children adapt their interpretations exclusively to the disambiguating information conveyed by the prosodic contour of the stimuli. Taken together, the individual analysis adds further evidence to the weak influence of prosody on the interpretation of relative clauses in this experiment. In addition, the individual analysis showed that the statistical effect of the factor Lexical Marker was due to the performance of seven adults. They interpreted relative clauses without the discourse particle as a restrictive modifier but adopt an appositive reading when the lexical marker for appositivity were present.

The results for children without mastering the control condition Non-intersectivity diverged from those obtained from children that interpreted ordinal numbers consistently as non-intersective modifiers. In the group without mastery of the control condition, the picture selections showed no predominant pattern. Restrictive, appositive and other picture selections occurred with similar frequency. Only in one condition, appositive readings were found as the most frequent interpretation pattern. The similar rates of picture selections may be the result of unsystematic picture choices by the participants and to the fact that the 'no matching picture' button was not introduced openly in the warm-up items. Children could have chosen an incorrect picture because the core meaning of ordinal numbers had not yet been acquired at all. Alternatively children may had intended the deviant intersective reading of ordinal number words but did not find a matching picture. The comments of four children support the latter assumption. The comments indicated that the children interpreted ordinal numbers as intersective modifiers. As a consequence, no matching pictures were present for their interpretations in the visual context. In Experiment 1, this situation led children to use the 'no matching picture' button. In the present experiment, the separate button was not explicitly offered as a response option to the children. Only when children asked what to do when no matching picture was present, the experimenters explained the function of the button. Therefore, this response option was only used in 16% of items at maximum. Instead, the majority of children selected an object randomly although this was not requested by the puppet.

Taken together, the results of Experiment 2 support Hypothesis (H1) that restrictive interpretations are preferred over appositive ones. In addition, Hypothesis (H2) is confirmed. Children at the age of 4 showed restrictive and appositive interpretations statistically with the same distribution. For older children and adults, however, restrictive interpretations were the predominant reading. Furthermore, the results of Experiment 2 speak against Hypotheses (H3a) and (H3c). For the majority of participants, prosody was not a disambiguating factor. In the conditions where prosody was the only cue to disambiguate the relative clauses towards a restrictive or appositive reading, the majority of participants ignored the prosodic information. Overall, 58 out of 73 participants adopted restrictive interpretations consistently despite an appositive intonation of the stimuli. In contrast to Experiment 1, also the inverse pattern was observed. Seven participants interpreted relative clauses presented with restrictive prosody as appositive modifiers. These results are evidence against Hypotheses (H3a) and (H3c) claiming that adults and children use prosody to disambiguate the two semantic functions. Further-

more, Hypothesis (H4a) on the influence of discourse particles can only be confirmed for a subgroup of adults. No reliable effect was found for children between the age of 4 and 6 years, which is compatible with Hypothesis (H4c). Thus, children and adults showed different interpretation patterns in the conditions with the discourse particle *ja* as formulated in Hypothesis (H7). In the absence of a lexical marker, however, the majority of children and adults did not differ in their preferred interpretation, which is in line with the assumption formulated in (H6). In the following the influence of the discourse particle *ja* is discussed.

6.5.2. The contribution of the discourse particle *ja*

The results of Experiment 2 only partially support the claim that relative clauses containing a discourse particle need to receive an appositive interpretation. The data showed that adults but not children between the age of 4 and 6 followed this assumption. Moreover, even in the group of adults only 9 out of 23 participants (39%) interpreted relative clauses containing the lexical marker as appositive modifiers in more that half of the items. Thus, the effect of the discourse particle *ja* was less strong than expected by linguistic theory.

There are several possibilities to account for these results. In the following, four aspects are discussed: Late acquisition and low salience of the discourse particle used, a late point of disambiguation within the experimental stimuli, and interpretation strategies. The lack of influence of the lexical marker in the groups of children may be due to the fact that children up to age 6 have not yet acquired the meaning of the discourse particle *ja*. So far, no studies investigated the acquisition of discourse particles in German. A corpus search in the CHILDES database showed that *ja* is used already before the third birthday to modify propositions in child German (see Section 6.3.1 on page 210). However, these early occurrences in spontaneous speech cannot be taken as evidence that these lexical elements receive an adult-like interpretation at this age. Asymmetries between comprehension and production have been found to be a frequently observed phenomenon in language acquisition (see e.g., A. Grimm et al., 2011). Evidence for such an asymmetry was also found in the present experiment. Some spontaneous comments of the children suggested that the meaning of the discourse particle *ja* was not fully acquired in 4- to 6-year-old German-speaking children. In the present experiment, it happened frequently that the children repeated (parts of) the stimulus sentence before or while they selected an object from the cupboard. Interestingly, in the conditions including the lexical marker the discourse particle was not included in the majority of the children's repetitions. There was only one child that repeated some relative clauses with the discourse particle. In the respective items, the child selected an object matching the appositive interpretation. Some other children wondered about the presence of the lexical marker in the stimuli and argued that the puppet had made an error. This is exemplified in the following examples in (9) and (10).

(9) Comment to a relative clause test item expressing surprise about the presence of the discourse particle (I)

Caru: Nimm den zweiten Pullover, der ja bunt ist, und leg' ihn in den Koffer.
Child: Ja bunt ist. Das heißt doch nicht "ja bunt ist". Bunt ist. Der bunt ist.

Caru: *Take the second pullover, which is* PRT *multicolored, and put it in the suitcase.*
Child: PRT *is multicolored. You don't say "*PRT *is multicolored". Is multicolored. Which is multicolored.*

04_JTS102, age 6;1

In (9) the child complained about the puppet using the discourse particle *ja* in the relative clause. The child also 'corrected' the stimulus sentence and mentioned that the discourse particle should not be included. In the comment in (10), the child repeated the stimulus sentence and asked the experimenter why the puppet had used the discourse particle in his request. This comment indicates that in the child's view the particle had not been used appropriately by the puppet.

(10) Comment to a relative clause test item expressing surprise about the presence of the discourse particle (II)

Caru: Nimm die zweite Schere, die ja grün ist, und leg' sie in den Koffer.
Child: Die zweite Schere, die ja grün ist. Warum hat er wieder einmal "ja" gesagt?

Caru: *Take the second scissor, which* PRT *is green, and put it in the suitcase.*
Child: *The second scissor, which* PRT *is green. Why did he say "ja" again?*

04_BHT066, age 6;3

In addition to the comments expressing surprise about the use of the particle, the comment in (11) shows that *ja* was used by children in the sample. As the example indicates, the child seemed to ignore the particle in the stimulus sentence and interpreted the relative clause restrictively. At the same time, the child used the discourse particle twice to explain his restrictive picture selection. In his justifications (underlined), the particle was used with a similar meaning as in the relative clause stimulus.

(11) Comment to a relative clause test item illustrating the use of the discourse particle *ja*

Caru:	Nimm den zweiten Hut, der ja rot ist, und leg' ihn in den Koffer.
Child:	(selects the 6^{th} object, which matches a restrictive reading)
Exp:	Hast du von oben gezählt?
Child	mhm (nods). Es kann ja nur der unterste sein.
Exp:	Achso, warum?
Child	Weil es gab ja nur drei rote.

Caru:	*Take the second hat, which* PRT *is red, and put it in the suitcase.*
Child:	*(Selects the 6^{th} object, which matches a restrictive reading)*
Exp:	*Did you count from top to bottom?*
Child:	*mhm (nods). The one at the bottom is* PRT *the only possible one.*
Exp:	*Aha, why?*
Child:	*Because there are* PRT *only three red ones.*

04_GAV048, age 5;1

These examples show that some of the children had difficulties to make use of the particle in comprehension. At the same time, the discourse particle *ja* was used appropriately by a variety of children in spontaneous utterances in the experiment. These findings, and especially the comment in (11), suggest that there is an asymmetry between the production and comprehension of sentence-modifying particles in German. Further studies are necessary to investigate this observation in more detail.

Late acquisition of the meaning of the discourse particle is one possible reason to account for the results of the children in this experiment. However, this assumption cannot explain why only less than half of the adults performed as expected interpreting relative clauses with the discourse particle appositively.

It is important to note that the discourse particle that was used in this experiment is a word of short duration. It may be the case that *ja* was not salient enough to be recognized in the acoustic input by the participants. Perhaps other discourse particles like *übrigens* would have a stronger disambiguating effect on adults. The observation that children tended to omit the discourse particle when they repeated the stimulus sentence may point in this direction. However, the comments expressing surprise about the presence of the discourse particle question this assumption. In addition, 13 adults mentioned the presence of the particle in their comments. Some examples are given in (12).

(12) Comments of adults noticing the presence of the discourse particle *ja*

a) 04_ZCM257: Hat die 'die JA schwarz ist' gesagt?
Did she say 'which PRT *is black'?*

b) 04_ZSK248: Das JA gestreift ist... "nimm das zweite Handtuch, das JA gestreift ist"?
Which PRT *is striped... "take the second towel, which* PRT *is striped"?*

c) 04_ZNN252: Ok, jetzt ist es wieder 'das JA gestreift ist'.
Ok, now it's again 'which PRT *is striped'.*

What is important is that 6 out of the 13 participants who were commenting on the presence of the discourse particle did not change their restrictive interpretation pattern. The recognition of the discourse particle did not lead to a revision of their restrictive strategy to select the picture. Based on these findings, low acoustic salience does not seem to be responsible for the weak effect of the lexical marker.

A third line of explanation is based on results from processing. Previous studies on ambiguity resolution showed that the ease to recover from a garden-path is related to the position at which the wrong analysis can be detected (Frazier & Rayner, 1982). Previous research showed that participants recover more easily from an incorrect syntactic analysis when the cue indicating the erroneous parse appears early in the sentence and when parts of the sentence are not yet semantically analyzed. The relative clauses used in this experiment were short and not internally complex. The relative clauses did not contain multiple arguments or additional adjuncts. In all test items, the discourse particle appeared directly after the relative pronoun and before the color adjective. However, up to this point, the participants may have expected a restrictive relative clause to unfold. As the results show, prosody did not seem to be a cue strong enough to built up an appositive structure initially. Hence, it was only the discourse particle that could serve as an indicator for a reanalysis. For participants with low working memory capacity and especially for young children, this reanalysis may have been too taxing. These participants may have had difficulties to revise their initial syntactic structure and the associated referential choice. As a consequence, they may have stuck to the initial, restrictive analysis although they identified the discourse particle as being incompatible with their parse tree.

The forth option to explain the weak influence of the discourse particle in Experiment 2 is based on strategic decisions. This possibility was also discussed in Experiment 1. Since the visual context of the relative clause test items provided suitable pictures for both restrictive and appositive readings, the participants may have decided for one way to interpret the sentences although they were aware of the ambiguity. This assumption is supported by a variety of comments of the adults. At least eight adults noticed that the sentences were ambiguous and that they could in principle choose between two possible pictures. The examples in (13) illustrate the explanations of the participants.

(13) Comments of adults noticing the ambiguity of the relative clause test items

a) 04_ZCM257: Also die zweite der roten oder die zweite Mütze, welche rot ist?
Well, the second of the red ones or the second cap, which is red?

b) 04_ZSK248: Mit der Pause, die der da macht: "Nimm die dritte Hose ... die rosa ist", könnte man das auch anders verstehen. Das ist 'n bisschen doppeldeutig.

Because of the pause that he is making: "Take the third trouser ... which is pink", one could interpret it also differently. This is a little ambiguous.

In the following item:

Tja ... "Nimm den zweiten Stift ... der blau ist." Ich nehm' jetzt mal den zweiten von den blauen, weil ich die Version mehr mag.
Well, ... "Take the second pencil ... which is blue." I take the second of the blue ones because I like this version better.

c) 04_ZSR243: Moment, jetzt dämmert mir gerade irgendwas. "Der dritte Apfel, der ja gelb ist". Also den dritten Apfel, oder der dritte Apfel, der gelb ist. Ach! Ich bin die ganze Zeit darauf reingefallen!
Wait a minute, something just came to me. "The third apple, which PRT *is yellow". Is it the third apple or the third apple that is yellow? Oh, it's tricked me all the time!*

At least one of the participants commenting on the ambiguity maintained a restrictive strategy throughout the task. In addition, the comment in (13b) shows that the participant noticed the ambiguity but went back to the restrictive strategy that he adopted in previous items. Since the participants were not explicitly asked to explain the rationale behind their picture selections, it remains unclear how many of the participants noticed the ambiguity but decided to be consistent in their picture selections.

Based on the results of Experiment 2, it is not possible to distinguish between the different approaches accounting for the reduced influence of the discourse particle. This issue will be pursued further in light of the results from the acceptability task described in the following chapter. In the following section, the interaction of the experimental cues is addressed.

6.5.3. Interaction of the factors Prosody and Lexical Marker

The present experiment included one condition in which the cues from prosody and from the lexical marker contradicted each other. Relative clauses containing the discourse particle *ja* were presented with an integrated, restrictive prosody. The analysis of the spontaneous comments showed that there were no participants that expressed irritation or surprise about these contradicting information. With regard to the question which cue had been used to decide on the semantic function of the clause, only the data from participants using both readings is informative. The participants that used only one reading throughout the whole experiment cannot tell us anything about the strength of the factors Prosody or Lexical Marker. On the basis of the individual interpretation strategies, data of 15 participants can be analyzed with regard to the question which of the factors had been chosen to decide on the reading.

In the condition with contradicting cues, eight adults and one 5-year-old child selected a picture in accordance with the information delivered by the discourse particle and interpreted the clause appositively. In contrast, three participants (2 children at the age of 4, one child at the age of 5) selected restrictive readings in this condition but went for appositive readings when both cues, prosody and lexical marker pointed to an appositive reading. These children seemed to rely more heavily on the prosodic information. The three remaining children did not show an informative pattern. They chose restrictive readings for all sentences with the discourse particle although they interpreted the relative clauses without lexical marker in accordance with the prosodic information.

Taken together, the adults that used both readings seem to adhere to the information conveyed by the lexical material. In contrast, the few children that used both interpretations mainly relied on the information conveyed by the prosodic format of the stimuli. This may be further evidence that children had problems to use the meaning of the discourse particle as an indicator for appositive interpretations.

The following section compares the results from the present experiment to those obtained in Experiment 1. The comparison focuses on effects of the changes in the experimental design.

6.5.4. Effects of changes from Experiment 1 to Experiment 2

The design of Experiment 2 differed from that of Experiment 1 in four aspects. First, out of the pretest and the two control conditions of Experiment 1 only the control condition Non-intersectivity was included in Experiment 2. Second, the items of the control condition Non-intersectivity were placed at the beginning of the experiment instead of being intermixed with the relative clause test items. Third, the visual context for the relative clause test items and the items of the control condition did not contain a picture matching the deviant intersective interpretation. Fourth, filler items without relative clauses were included and intermixed with the relative clause test items. In what follows, three consequences of these changes are discussed in more detail. First, the absence of an influence of the test version, second, the amount of intersective interpretation, and third, the high rates of appositive interpretations in the group of children without mastery in the control condition.

In Experiment 1, the order of the prosodic parts had an influence on the performance of the children in the control condition Non-intersectivity. To prevent this confound in the actual experiment, the items of the control condition were moved to the beginning of the task. This change had the expected effect. The test version did not influence the picture selections in the control condition.

In contrast to Experiment 1, the visual contexts for both relative clause test items and items of the control condition in the present experiment did not comprise an intersective distractor picture. The rationale of this change was to reduce the task demands of the experiment. One possible source for the high rates of intersective interpretations in Experiment 1 were processing difficulties due to a preselection of the picture at the n^{th} position. Previous studies on the acquisition of processing showed that children have severe difficulties to recover from an incorrect selection of a syntactic structure or discourse

referent. A revision may be especially hard when the preselected object matches all the properties of the linguistic stimulus. The pilot study demonstrated that more children showed target-like non-intersective readings for ordinal numbers in the control condition when no intersective distractor picture was present. The preliminary result was confirmed in the present experiment. While in Experiment 1 only 40% of children mastered the control condition, almost twice as many children (79%) performed target-like in the control condition in Experiment 2. In addition, target-like interpretation of the ordinal numbers were also found for the more complex relative clause test items, which included two nominal modifiers. The interpretation patterns of the children with mastery in the control condition demonstrated systematic selections of restrictive or appositive readings in the relative clause test items.

Thus, the comparison of the results of Experiment 1 and 2 shows that the presence of an intersective distractor picture at the n^{th} position in the visual context – and thus processing difficulties – can be identified as one source of intersective interpretations. If children at the age of 4 to 6 have a deficient semantic representation of ordinal number in general, no facilitation due to the visual context would be expected from Experiment 1 to Experiment 2. Nonetheless, intersective readings were also observed in the present experiment. Those children that missed the mastery criterion in the control condition indicated in their spontaneous comments that they intended intersective interpretations despite the absence of a biasing visual context. This finding may suggest that the semantic representation of ordinal numbers are acquired stepwise. Children may assume initially that ordinal numbers are intersectively combined with the noun phrase. Only later, children may acquire that ordinal numbers are non-intersective modifiers that need to be evaluated with respect to a comparison class. As the results of the experiment showed, the identification of the comparison class seems to be vulnerable and can be affected by the visual context.

Another consequence of the absence of intersective pictures is found for relative clauses in children without mastery of the control condition Non-intersectivity. The interpretation patterns in the relative clause conditions suggest that appositive interpretations can be derived by these children. While pictures matching a restrictive interpretation were selected at a maximum of 25% throughout the task, appositive interpretations were found in up to 45% of items with appositive prosody. Similar rates for restrictive and appositive interpretations were found in Experiment 1 in the group of children without mastery of the ordinal numbers. Although the distribution of restrictive and appositive interpretations did not differ significantly on a group level, the individual analysis showed that consistent appositive interpretations were found for 7 out of 13 children in at least one condition. Restrictive readings, in contrast, were found for only two children of this group in Experiment 2. The high availability of appositive interpretations is surprising. This preference task is based on the assumption that to derive an appositive interpretation, a target-like non-intersective interpretation of the ordinal number word is required. In Experiment 2, the 13 children without mastery of ordinal numbers, showed a maximum of two non-intersective interpretations with only one exception in the corresponding control condition. Thus, it is questionable whether the observed picture selections are a consequence of true appositive readings. Alternatively, they may result

from the internal order of pictures matching appositive and restrictive interpretations. This assumptions is put forward in the following.

It is important to note that within each relative clause test item, the picture matching the appositive reading precedes the picture corresponding to a restrictive interpretation. Imagine a child interprets the ordinal number word intersectively. The spontaneous comments indicated that some of the children indeed intended intersective interpretations for the relative clause items. In this case the child would focus first on the picture displayed at the n^{th} position. Then, the processing of the subsequent stimulus sentence reveals that the properties of this pre-selected object do not match the ones denoted by the head noun or the relative clause. Since children were trained to focus on the pictures in a direction from top to bottom, it is probable that they followed this pattern when they realized that their pre-selected object cannot be the correct one. In the following sequence of objects, the first picture that matches the properties of both the head noun and the relative clause is the one corresponding to the appositive reading in the majority of items. Thus, the high amount of appositive picture selections in the children without mastery in the control condition Non-intersectivity may be a result of a non-linguistic strategy. When their expectation of how to interpret the ordinal number word was not met, these children may have tried to find any other object matching the remaining properties instead of using the 'no matching picture' button. The first object they would encounter in their direction of search would be the one corresponding to an appositive reading.

In sum, the changes in the experimental design worked as expected. The confound due to an influence of the test version could be eliminated. In addition, processing difficulties could be identified as one source of intersective interpretations.

6.5.5. Open questions and remarks regarding further experiments of this thesis

One aim of this experiment was to investigate the availability of appositive interpretations in more detail in 4- to 6-year-old children and adults. To address this goal, discourse particles were included in the design as a lexical marker for the appositive reading. This modification did not have the expected effect. The children ignored the presence of the discourse particle *ja* or could not use it as an indicator of appositive interpretations. Moreover, less than half of the adults followed the expected pattern and interpreted relative clauses containing the lexical marker as an appositive relative clause.

Although this task was not a classical preference task, two readings were available syntactically and in the visual context. The results showed that some participants identified this ambiguity. Nonetheless, only for some participants the disambiguating cues had an influence on the picture selections. The majority of participants selected only restrictive interpretations across all conditions. For these participants the task seemed to be a real preference task and restrictive readings were preferred over appositive ones. On the basis of these results, it is still an open question, whether discourse particles may serve as an indicator of appositive readings when no interpretation preferences are involved. The acceptability task described in the following chapter sheds light onto this

question.

An acceptability task may also be informative on another open question. Despite the missing effect of discourse particles in the groups of children, the results of this experiment show that some of the 4-year-olds can derive appositive readings. Interestingly, appositive interpretations occurred more frequently in this age group than in the other groups of participants. The results of this experiment showed that the proportions of appositive readings decreased with age in the conditions disambiguated only by prosody. Furthermore, the individual analyses demonstrated that appositive readings were only found in 6 out of 13 children at the age of 4. Thus, it is still an open question, whether appositive interpretations are accessible in general for children at the age of 4 and older. An acceptability task or a truth-value judgement task in which children were confronted with an appositive interpretation of the relative clause could help to answer this question.

These open questions suggest that a different method should be used as a next step to investigate the acquisition of restrictive and appositive interpretations in German-speaking children. To be able to find out whether appositive interpretations can be derived in general by children and adults, the task should not test for preferred interpretations. On the contrary, it would be more informative to test the acceptability of restrictive and appositive readings separately.

6.6. Conclusion

The experiment reported in this chapter investigated the influence of a lexical marker for appositivity on interpretation preferences of German-speaking children between the age of 4 and 6 and adults. The experimental implementation was similar to the one of the first experiment. Again, the interaction of an ordinal number word and the relative clause led to different picture selections depending on the semantic function of the clause. In line with Experiment 1, the results of Experiment 2 showed a strong preference for restrictive interpretations independently of the prosodic format of the stimuli. Only for children at the age of 4, the distribution of restrictive and appositive interpretations did not differ, although descriptively more restrictive readings were observed. The presence of the discourse particle *ja* as a lexical marker for appositive interpretations did not increase the amount appositive readings in children. The comments of the participants indicated that the meaning of the discourse particle had not been fully acquired by the 4- to 6-year-old children. For adults, in contrast, the discourse particle led to an increase of appositive readings but did not change the general preference for restrictive readings. Overall, only 7 out of 50 children and 9 out of 23 adults used both semantic functions in more than half of the items in at least one condition. All other participants selected the pictures only in accordance with one of the readings in this experiment.

Taken together, the results of this chapter confirm the findings of Experiment 1. Children between the age of 4 and 6 as well as adults prefer restrictive interpretations of relative clauses in the picture selection design adopted in this thesis. The presence of a lexical cue disambiguating the relative clauses towards an appositive interpretation did not have an influence of the children's interpretation patterns.

In the following chapter, the results of an acceptability task are reported. Children between the age of 3 and 6 as well as adults were confronted with restrictive and appositive readings respectively. They had to judge whether a puppet selected an object in accordance with the stimulus sentence. The task aimed to explore whether children can derive appositive interpretations although this reading is not preferred.

7. Experiment 3: Acceptability of unambiguous relative clauses

Experiment 3 aimed to investigate whether German-speaking children and adults accept both semantic functions of relative clauses. In the previous experiments of this thesis, interpretation preferences for relative clauses were studied. The results from the preference tasks gave positive evidence that restrictive and appositive readings are found in children between the age of 4 and 6. However, the preference tasks could not provide information on whether the unfavored readings were acquired. Therefore, it is still an open question at which age both semantic functions are acquired on an individual level in pre-school children. To investigate restrictive and appositive interpretations of relative clauses independently of these interpretation preferences, an acceptability task was implemented in this experiment. Like a truth value judgement task, this task is based on the assumption that a child will assent to the truth of a sentence if she can derive the meaning (e.g., Gordon, 1996; Schmitt & Miller, 2010).

With this change of method, Experiment 3 addressed research question (Q2) asking which interpretations of contextually unambiguous relative clauses are accepted by children and adults. As in the previous experiments, two factors were varied to answer research question (Q3) on the influence of (non-)linguistic factors on the comprehension process. Experiment 3 used stimuli similar to those of Experiment 2. Relative clauses were disambiguated by prosody and by the presence or absence of a lexical marker, the discourse particle *ja*, towards a restrictive or appositive reading. The experiment also addressed research question (Q4) on interpretation differences between children and adults. Both children and adults participated in the task to investigate whether the acceptance of restrictive and appositive readings of relative clauses differs between the two groups.

The following sections describe the experiment in more detail. Section 7.1 gives an overview of the participants. The experimental conditions and the construction of the test items are described in Section 7.2. In Section 7.3, the results are reported. They are discussed in Section 7.4. The chapter ends with a conclusion in Section 7.5.

7.1. Participants

In this experiment, 119 monolingual German-speaking children between the age of 3;1 and 6;8 (mean age: 4;11, *SD*: 12.5 months) participated. The experiment was part of the research project CARU *Child Acquisition of Relative Clauses* headed by Petra Schulz and funded by the German Science Foundation. The group consisted of 51 girls and 68 boys. The children were recruited in 14 day-care centers in Frankfurt am Main, Germany. All parents gave their written consent to their children's participation in the study. Based on information from a parental questionnaire, only children without any history of language

and hearing problems were included in the study. As an additional inclusion criterion, a standardized language test was administered. One child at the age of 4 had to be excluded due to low performance in the standardized language test SETK 3-5 (H. Grimm, 2001). All other children reported here performed within age-appropriate norms (T-value above 40) of the SETK 3-5 (H. Grimm, 2001) or the TROG (A. V. Fox, 2006). The SETK 3-5 was used to asses 3- to 5-year-old children. The TROG was conducted with children at the age of 6.

Three children had to be excluded after participating in the experiment due to interruptions in the testing procedure and high rates of missing data. In sum, results are reported for 115 children.

In addition to the children, a group of 20 adults (10 women, 10 men) was tested as control group. The age ranged from 19;3 to 30;11 with a mean age of 24;3 years (*SD*: 43.9 months). The adults were mainly students of the Goethe University. Students of the linguistics faculty were excluded. Each adult received 7 € for the participation in the experiment. Detailed information about the five groups of participants are summarized in Table 7.1.

Table 7.1.: Exp. 3 – Overview of participants

	Age 3 $n = 28$	**Age 4** $n = 29$	**Age 5** $n = 33$	**Age 6** $n = 25$	**Adults** $n = 20$
Sex	15 boys 13 girls	19 boys 10 girls	16 boys 17 girls	16 boys 9 girls	10 men 10 women
Age range	3;1-3;11	4;0 - 4;10	5;0 - 5;11	6;0 - 6;8	19;3 - 30;11
Mean age	3;4	4;5	5;5	6;3	24;3
SD	3.2 months	3.3 months	3.6 months	2.7 months	43.9 months

Note. SD = Standard deviation.

7.2. Method

In contrast to Experiments 1 and 2, Experiment 3 is an acceptability task. Children had to judge whether a selected picture matched a pre-recorded stimulus. The experimental setting was similar to the one of Experiment 1 and 2. Like in the previous experiments, the task was implemented as a computer game. To create a situation suitable for an acceptability judgement task, a second puppet character was introduced to the design. This character, a robot, selected pictures according to the pre-recorded requests used in the previous experiments. The child's task was to decide whether the picture chosen by the robot matched the pre-recorded stimulus. The task was not a prototypical truth value judgement task as described e.g., in Schmitt and Miller (2010) or Gordon (1996). In a truth value judgement task, the participants have to evaluate the truth of an explicit statement with regard to a situation depicted or acted out in front of them. In Exper-

iment 3, the statement that had to be evaluated by the participants was the request made by the puppet. The task of the participants was to judge whether the subsequent action of the robot fulfilled the puppet's request. Thus, no overt declarative statement had to be evaluated but an implicit statement that could be inferred from the action of the puppet.

The typical procedure of a truth value judgement task was not chosen for two reasons. First, the test sentences would have differed from those used in the first two experiments of this thesis. Instead of an imperative clause, a declarative sentence would have been used. Second, to describe the picture selection of the robot felicitously, the test sentence had to be presented in past tense or present perfect tense. Using the past tense form is not very common in colloquial German. The more frequent tense to refer to past events is the present perfect. An example is given in (1).

(1) Er hat das dritte Auto, das blau ist, genommen.
He has the third car that/which blue is taken.

'He took the third car$_{(,)}$ that/which is blue.'

(2) Er hat das dritte Auto genommen, das blau ist.
He has the third car taken that/which blue is.

'He took the third car$_{(,)}$ that/which is blue.'

In German, the present perfect is a composed tense, as illustrated in (1). With this tense form, the relative clause would occur in a sentence medial position when it is attached adjacent to the head noun. Previous studies on the acquisition of relative clauses have shown that center-embedded relative clauses are more difficult to comprehend than relative clauses following the matrix clause. As an alternative to center-embedding, the relative clause could be extraposed like in (2). Although extraposition works for restrictive and appositive relative clauses in German, this change would have implemented an additional difference compared to the first two experiments of this thesis. To avoid these differences and additional complexities, the more implicit judgement task was chosen for Experiment 3. This task allowed to keep the experimental stimuli identical to those used in the previous experiments. The details of the experimental material and procedure are presented in the following sections.

7.2.1. Design and material

Overall, Experiment 3 comprised 62 items: 36 unambiguous relative clause test items in three conditions, 12 items of the control condition Non-intersectivity, 12 filler items, and two warm-up items. The construction of the items is described in the following subsections.

7.2.1.1. Relative clause test items

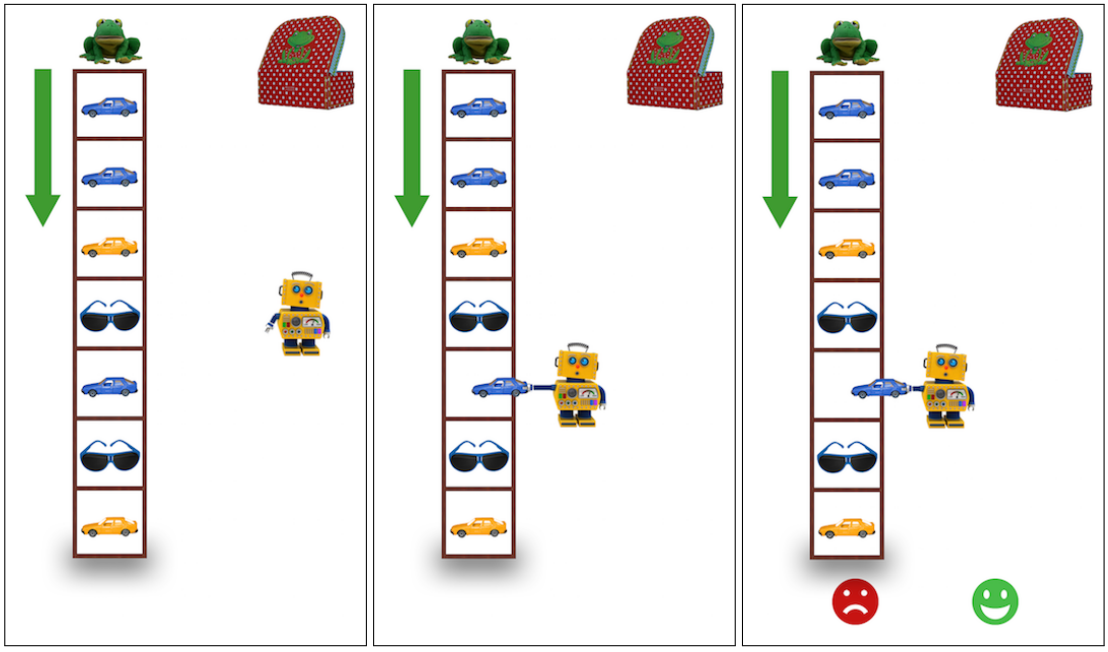
Eighteen relative clauses were presented in three conditions. Condition 1 explored whether children accepted a restrictive reading for relative clauses that were disambiguated by

prosody and the visual context. Conditions 2 and 3 addressed appositive readings of relative clauses. In Condition 2, children had to judge picture selections matching an appositive reading disambiguated by prosody and visual context. In the third condition, the presence of the discourse particle *ja* disambiguated towards an appositive reading in addition to prosody and visual context. In comparison to Experiment 2, the condition with contradicting cues (restrictive prosody with the discourse particle *ja*) was omitted. For these items, no clear expectations about the reading could be formulated because they would be compatible with both a restrictive and an appositive reading on the basis of the disambiguating cues.

Figure 7.1 shows an example test item in the restrictive condition of Experiment 3. The corresponding stimulus sentence is given in (3).

(3) Nimm das dritte Auto, das blau ist, und leg' es in den Koffer!
Take the third car that/which blue is and put it in the suitcase

'Take the third car that is blue and put it in the suitcase!'



(a) Before picture selection. (b) Picture selection. (c) Judgment.

Figure 7.1.: Exp. 3 – Experimental setting for a restrictive relative clause test item.

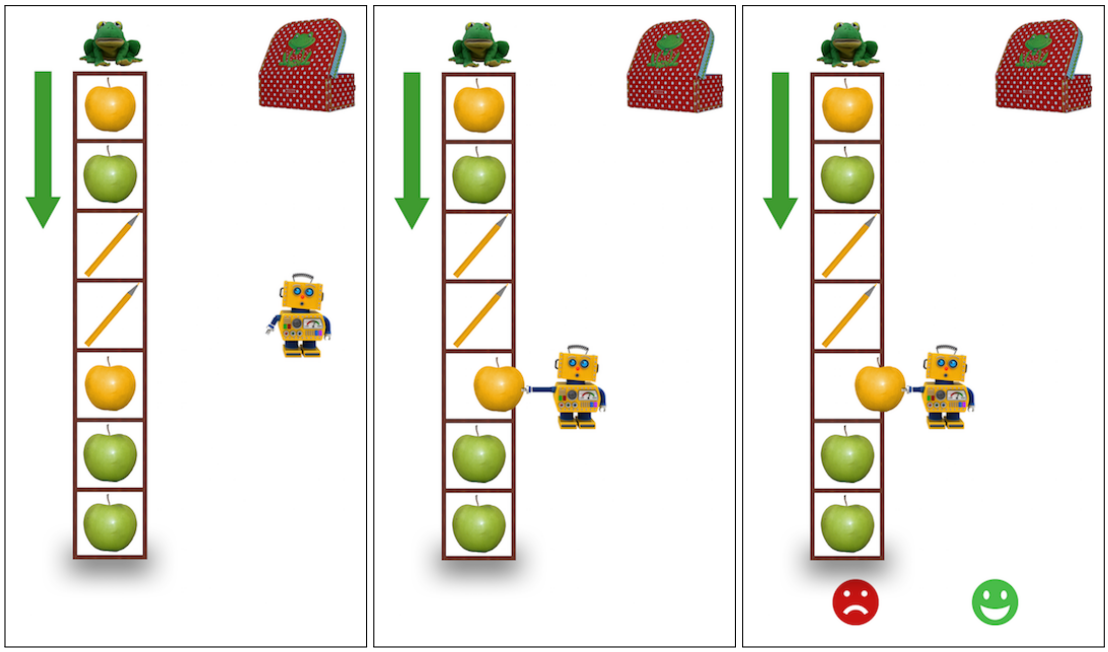
The example in Figure 7.1 shows that the visual context for the picture selection matched only a restrictive interpretation. There were three blue cars, so that the third of the blue ones could be selected. However, the third car overall was not blue, which excluded a picture selection matching an appositive reading. Furthermore, the car at the third position overall was not blue, which excluded the deviant intersective interpreta-

tion.

The items for the appositive conditions were constructed similarly. For the stimuli of Condition 2 and 3, the visual contexts were constructed alike. The items differed only with regard to the presence or absence of the discourse particle *ja* in the verbal prompts. Figure 7.2 illustrates an item of the appositive condition with the discourse particle *ja*. The corresponding stimulus is given in (4).

(4) Nimm den dritten Apfel, der ja gelb ist, und leg' ihn in den Koffer!
Take the third apple that/which PRT yellow is and put it in the suitcase

'Take the third apple, which is PRT yellow, and put it in the suitcase!'



(a) Before picture selection. (b) Picture selection. (c) Judgment.

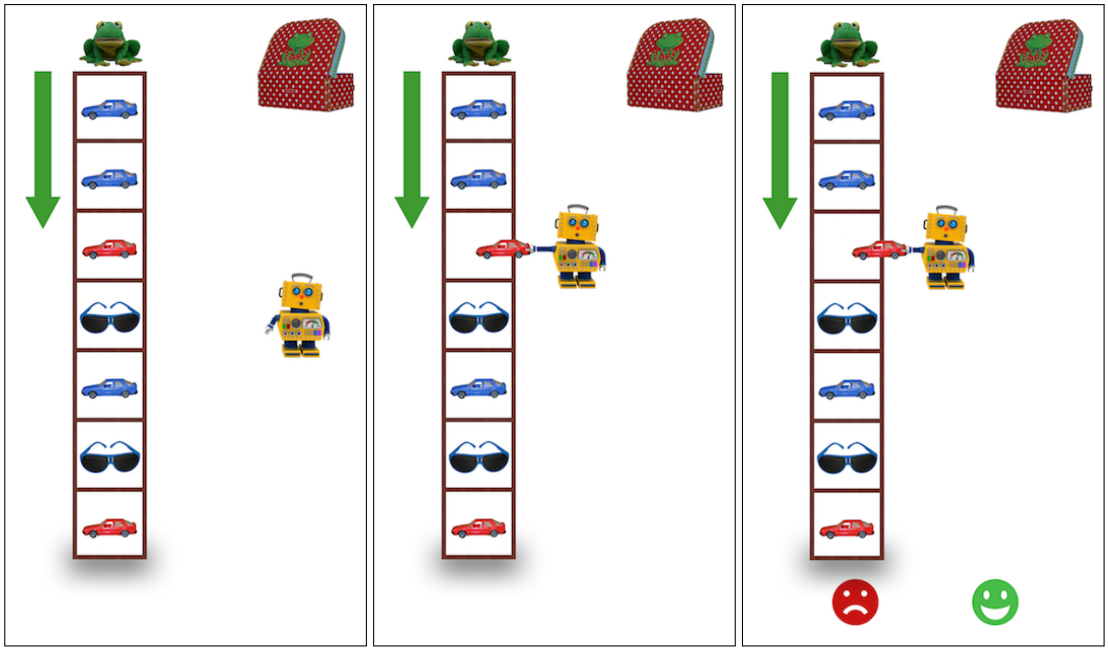
Figure 7.2.: Exp. 3 – Experimental setting for an appositive relative clause test item.

In all items of the appositive conditions, the visual context matched only an appositive reading of the stimuli. In the example in Figure 7.2 the third apple overall matched the puppets' request. However, there was no suitable object at position no. 3 overall, which would have been in line with an intersective reading of the utterance. In addition, the restrictive reading was not in agreement with the visual context because there were no three yellow apples displayed.

The pre-recorded stimuli of Experiment 3 were identical to those of Experiment 2. The 18 relative clauses constructed for Experiment 2 were used again and were split up into three sets, one for each of the three experimental conditions. As described in Section 6.3.1 of Experiment 2, relative clauses presented in the restrictive condition had

an integrated prosodic contour. There was no intonation phrase boundary between the head noun and the relative clause. In addition, main stress was placed on the color adjective within the subordinate clause. Items in the appositive prosody conditions were presented with an unintegrated prosodic format. Between the head noun and the relative clause was an intonation phrase boundary, and the pause was manually adjusted to 400 ms. In addition, both the head noun and the color adjective within the relative clause carried a pitch accent. For a list of the lexical material of the test sentences and an example of the prosodic formats, see Section 6.3.1 on page 209ff.

Within the three relative clause conditions, each test item was presented twice. Once the robot selected an object matching the pre-recorded stimulus as displayed in Figure 7.1 and 7.2. These items were expected to yield a *yes*-response in the judgement task when the reading was acquired. In addition, the robot selected a non-matching picture for each item once. The incorrect picture selection should lead to a *no*-response in the judgement task. The picture selections for the expected *no*-responses are displayed in the Figures 7.3 and 7.4 for the stimuli in (3) and (4).

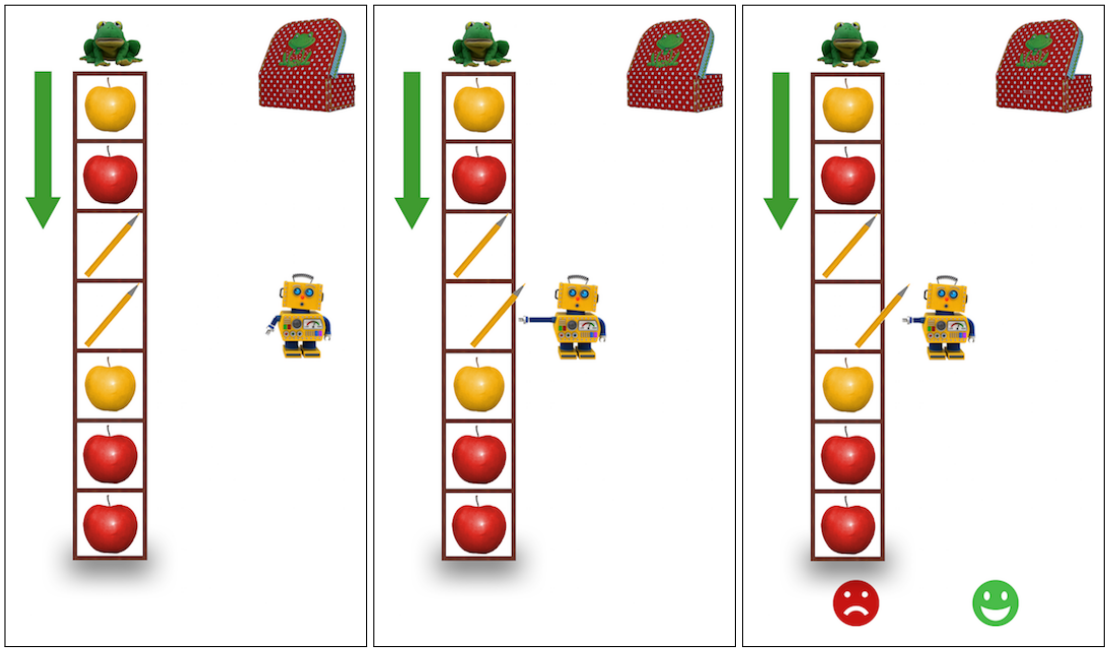


(a) Before picture selection. (b) Picture selection. (c) Judgment.

Figure 7.3.: Exp. 3 – Experimental setting for a restrictive relative clause test item with incorrect picture choice.

The nature of the incorrect picture selections differed. Either the color, type, position or a combination of the factors of the selected object did not match the pre-recorded request. In Figure 7.3, the robot selected the car at the third position overall. This selection did not match the request uttered by the puppet frog asking for the *third car*

that is blue. The selected car had a different color than the one requested in the pre-recorded prompt. In Figure 7.4, a non-target object was chosen, which, furthermore, was not at the requested position.



(a) Before picture selection. (b) Picture selection. (c) Judgment.

Figure 7.4.: Exp. 3 – Experimental setting for an appositive relative clause test item with incorrect picture choice.

As illustrated in the examples, the color of the non-target objects was varied between the two occurrences of each test item. Thus, while the acoustic stimulus and the structure of the visual context were identical, the items looked slightly different. This change was implemented to diversify the task and to divert the children's attention from the repetition of the items.

With regard to the acquisition of the two semantic functions, only the items with an expected *yes*-response were informative. An acceptance of the picture choice, i.e., a *yes*-response in the judgement task, showed that the respective reading was possible for the child. When a child rejected a picture selection for an item with an expected *yes*-response, this may indicate that the displayed reading could not be derived. The picture selections for items with expected *no*-responses were supposed to be rejected independently of the semantic function of the relative clause. In these items, the incorrect picture choices were not consistent with any possible reading of the relative clause sentences. Therefore, they could not be used as an indicator whether a restrictive or appositive reading had been acquired.

Table 7.2 gives an overview of the distribution of test items in the three experimental

conditions.

Table 7.2.: Exp. 3 – Overview of relative clause conditions

Factors	**Conditions**					
Prosody	Restrictive ($n = 12$)		Appositive ($n = 24$)			
Lexical Marker	Without *ja* ($n = 12$)		Without *ja* ($n = 12$)		With *ja* ($n = 12$)	
Target Response	*Yes* ($n = 6$)	*No* ($n = 6$)	*Yes* ($n = 6$)	*No* ($n = 6$)	*Yes* ($n = 6$)	*No* ($n = 6$)
	Set 1	Set 1	Set 2	Set 2	Set 3	Set 3

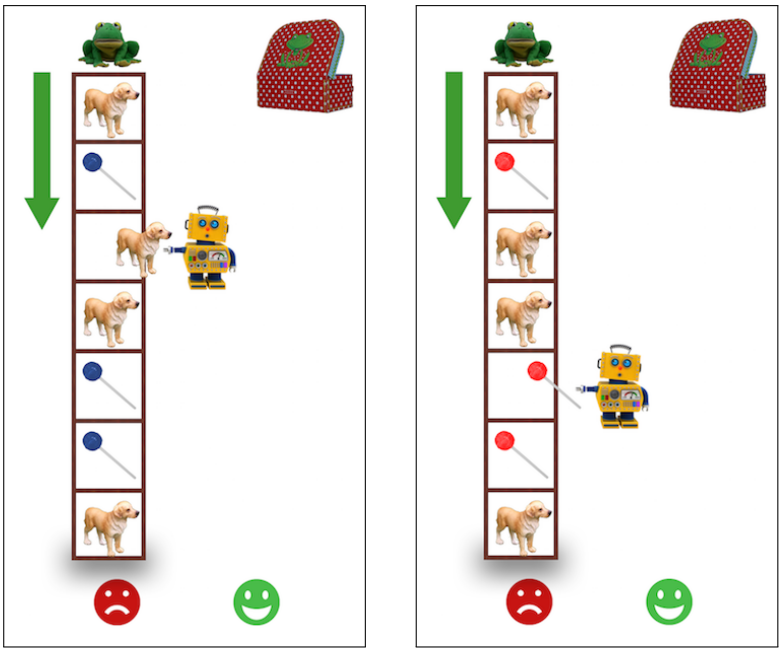
In the following section, the items of the control condition Non-intersectivity and the filler items are presented.

7.2.1.2. Control condition and filler items

Like in Experiment 2, six items tested the interpretation of ordinal numbers without the presence of a relative clause. The control condition Non-intersectivity was included to asses the prerequisites for a target-like interpretation of the relative clause test items. The task was based on the assumption that only non-intersective interpretations of ordinal numbers lead to different picture selections and thus to different judgements for restrictive and appositive interpretations in the relative clause conditions. Therefore, the semantic property of ordinal numbers was tested separately like in Experiment 1 and 2. Like the relative clause test items, each item of the control condition Non-intersectivity was presented twice. To balance the amount of *yes*- and *no*-responses across the experiment, each items was presented once with a correct picture selection and once with a non-matching picture selection.

For the control condition in the acceptability task, the six pre-recorded stimuli of Experiment 2 were used again. In addition, the visual contexts of the items of the control condition Non-intersectivity were identical to those in Experiment 2. Like in the previous experiments, the visual contexts for the items of the control condition included two different types of objects. Like in Experiment 2, no intersective distractor pictures were present. That is, at the n^{th} position, no matching object was displayed. This order of objects was chosen because a comparison of the outcomes of Experiment 1 and 2 showed that an intersective distractor increased the number of intersective misinterpretations overall. For some items, the colors were adjusted to make the two different kinds of objects more distinct from each other. The examples in Figure 7.5 show the correct and incorrect picture selection for an example item of the control condition Non-intersectivity. The corresponding prompt is given in (5).

(5) Nimm den zweiten Hund und leg' ihn in den Koffer!
Take the second dog and put it in the suitcase
'Take the second dog and put it in the suitcase!'



(a) Correct picture selection.

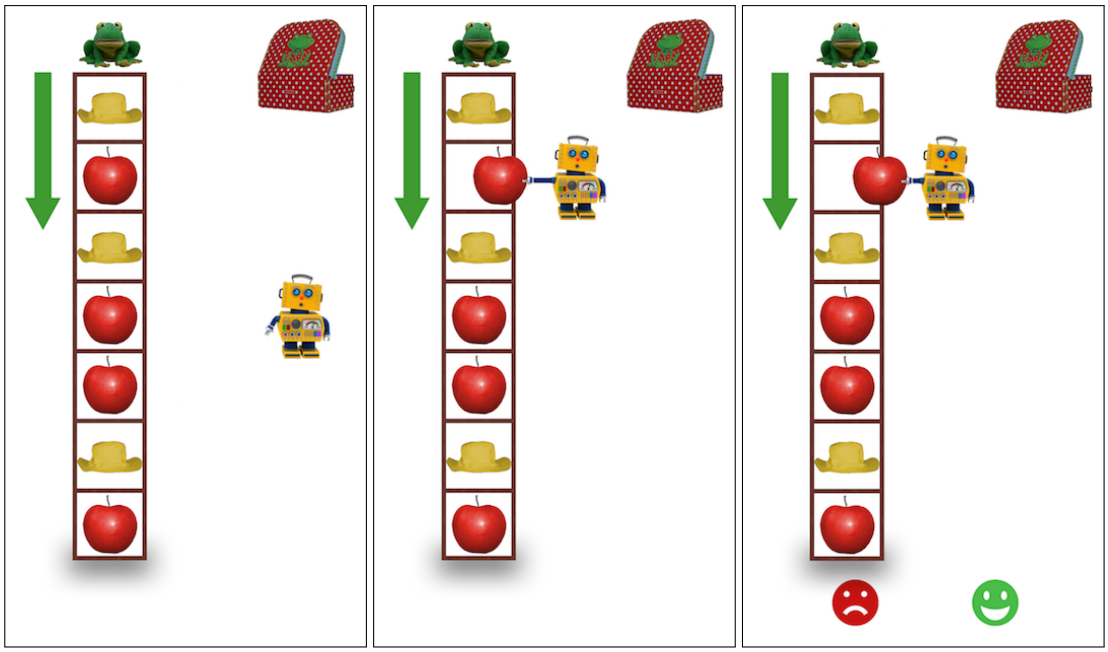
(b) Incorrect picture selection.

Figure 7.5.: Exp. 3 – Correct and incorrect picture selection for an item of the control condition Non-intersectivity.

The picture selection in Figure 7.5a was expected to yield a *yes*-response for children who knew that ordinal numbers are non-intersective modifiers. The situation in Figure 7.5b was expected to be rejected because an incorrect object was selected. Like in the relative clause test items, only correct interpretations to items with an expected *yes*-response were informative on whether the semantic properties of the ordinal number words had been acquired.

In addition to the control condition Non-intersectivity, 12 filler items were used. The items were identical to those in Experiment 2. Six filler items each tested the interpretation of *erste/r/s* 'first' and *letzte/r/s* 'last'. Half of them were presented with a correct picture selection. In the other half of the items, the robot selected an incorrect picture. An example matching the prompt in (6) is shown in Figure 7.6.

(6) Nimm den ersten Apfel und leg' ihn in den Koffer!
Take the first apple and put it in the suitcase
'Take the first apple and put it in the suitcase!'



(a) Before picture selection. (b) Picture selection. (c) Judgement.

Figure 7.6.: Exp. 3 – Experimental setting for a filler item with correct picture selection.

Like in the previous experiment, half of objects denoted by the *first X* or *last X* appeared at position no. 1 or 7 respectively. The other half of objects appeared mainly at position no. 2 and 6. Thus, 50% of the filler items allowed an intersective reading of the modifier.

The two warm-up items of Experiment 2 were used again. They served to test the perception and knowledge of the color terms used in the experiment. In addition, they introduced the experimental procedure described below in Section 7.2.2. In the first warm-up item, the robot selected a correct picture, in the second warm-up item the robot took a non-matching object out of the cupboard to introduce both *yes*- and *no*-responses.

7.2.1.3. Experimental setting

For all participants, the items of the control condition Non-intersectivity were presented at the beginning of the experiment. Like in Experiment 2, this order was used to test the semantics of ordinal number words without any interference due to the relative clause

test items. Comparable to Experiment 2, the relative clauses in the three conditions were presented in a block design and in two different experimental sessions. In one experimental session, the 12 items with restrictive prosody were presented. In the other experimental session, the 24 items with appositive prosody were presented. Within the appositive session, items without the discourse particle *ja* preceded those including the lexical marker. This order was chosen to prevent the items with the discourse particle to influence the interpretation of items without the lexical marker. In all parts of the experiment, the number of expected *yes*- and *no*-responses was balanced. The items with an expected *yes*- and *no*-response were ordered pseudo-randomly within the different conditions. Additionally, the filler items were evenly intermixed with the relative clause test items as well as with items of the control condition Non-intersectively. The sequence of the different conditions in the different versions is displayed in Table 7.3. The table shows that the two warm-up items were presented at the beginning of each experimental session.

Table 7.3.: Exp. 3 – Sequence of parts in the experimental versions

Version 1 & 3	**Version 2 & 4**
Session 1	*Session 1*
Warm-up items 1 and 2	Warm-up items 1 and 2
Control condition Non-intersectivity	Control condition Non-intersectivity
Restrictive relative clauses	Appositive relative clauses without *ja*
	Appositive relative clauses with *ja*[a]
Session 2	*Session 2*
Warm-up items 1 and 2	Warm-up items 1 and 2
Appositive relative clauses without *ja*	Restrictive relative clauses
Appositive relative clauses with *ja*[a]	

[a]This condition is not tested with children at the age of 3.

Across participants, it was balanced whether they saw items of the restrictive or appositive block first. Moreover, it was varied whether the button corresponding to an acceptance or a refusal of the picture choice was displayed to the left or right. Thus, four different versions of the experiment were constructed. In Version 1 and 2, the button corresponding to an acceptance of the picture selection appeared on the right hand side at the computer screen. In Version 3 and 4, the button signaling acceptance was displayed on the left.

Table 7.3 demonstrates that the experimental sessions were of different length. The session including the appositive conditions was longer than the one testing restrictive relative clauses. Especially session 1 of test version 2 and 4 was long. In this session,

the control condition Non-intersectivity as well as both appositive parts were presented. As the overview of the participants in Section 7.1 showed, 3-year-old children were also included in the experiment. According to Gordon (1996), running a judgement task with children at this age is unproblematic in principle. However, for children as young as 3 years the length of the task should be adapted. To reduce the duration of the task for children at the age of 3, a shorter version of the experiment was constructed. For the youngest group of participants, the condition testing appositive relative clauses with the discourse particle *ja* was omitted. These children were only tested on relative clauses disambiguated by prosody and visual context for both semantic functions. With children between the age of 4 and 6 and the control group, the full experiment was conducted.

The full list of items is given in the appendix on page 375. Table 7.4 shows the distribution of test versions across the participants within the individual age groups.

Table 7.4.: Exp. 3 – Distribution of test versions by age group

Distribution of test versions	**Age 3** ($n = 28$)	**Age 4** ($n = 29$)	**Age 5** ($n = 33$)	**Age 6** ($n = 25$)	**Adults** ($n = 20$)
Version 1	15x	8x	9x	6x	5x
Version 2	13x	7x	8x	6x	5x
Version 3		7x	9x	7x	5x
Version 4		7x	7x	6x	5x

7.2.2. Procedure

The testing took part in a quiet room of the day-care facilities for each child individually. Trained student assistants administered the experiment and the standardized language tests. At the beginning of the first test session, the computer game was introduced. The experimenter told the child a background story to motivate the task. The puppet frog Caru and the robot Robbi wanted to go on holiday together. Robbi had to help Caru to pack the suitcase because Caru could not do that alone. Thus, the frog told the robot what to take and then the robot had to take the respective object from the cupboard and pack it into the suitcase. Importantly, the robot had just arrived from the robot manufactory and did not yet know German properly. The child's task was to ensure that the robot had taken the correct object. In addition, the child had to name the objects in the cupboard at the beginning of each item to make sure that Robbi knew what had been placed on the shelves.

For each item, the procedure was the following. i) The child had to name the objects in the cupboard. ii) The child or the experimenter clicked on the image of Caru the frog to play the pre-recorded audio file. iii) The robot moved to a shelf and took out an object. iv) The two buttons appeared at the bottom of the screen and the child had to decide whether Robbi had taken the correct object. To elicit a judgement, the experimenter asked: *Hat Robbi das Richtige genommen?* 'Did Caru take the right one?'. The child had to answer to the question verbally. v) To enter the judgement of the child,

the experimenter clicked to the respective button. In case the choice matched Caru's request, the smiling, green button was selected. When Robbi selected an incorrect object, the red, unhappy smiley was pressed. After the judgement task, the buttons disappeared and new objects were displayed in the cupboard. Then the procedure started again.

No feedback contingent on the child's reaction was given by the experimenter. When a participant got distracted or the procedure had to be interrupted, the pre-recorded utterances were repeated. Furthermore, when the child corrected herself after the judgement had been entered, the item could be repeated to change the judgement.

The two test sessions were administered at different days for the children. The adult participants carried out both experimental sessions at the same day with an unrelated experiment in between. All test sessions were audio- and video-taped for later analyses. In addition to the recordings, the experimenter marked the participant's judgments on a protocol. The data analysis and coding procedure is laid out in the following section.

7.2.3. Data analysis and coding

The experiment was implemented as a computer game that ran locally within the Google Chrome web-browser. The judgements were stored automatically in a database on the laptops and potential comments of the participants were recorded in the video file. The analysis of the responses proceeded in a two-step process. First, the button presses were automatically analyzed. Second, the data coming from the button presses were adjusted in case spontaneous comments of the participants clearly showed that the participants applied an interpretation that differed from the one tested in the items.

Thus, first, the raw data was extracted as a csv-file to be analyzed within the statistics software package SPSS. The raw scores in the database encoded a boolean value indicating whether the picture selection of the robot had been accepted or rejected by the participants. In a following step, the judgments were evaluated with regard to whether they corresponded to the expected responses. For items with an expected *yes*-response, a positive judgement was classified as *correct*. For items with an expected *no*-response, a rejection of the picture selection was classified as *correct*. A judgement that violated the expected response was classified as *incorrect*. In addition to the automatic evaluation process, the videos were double-checked for experimental errors or comments of the participants.

Since in this experiment, all relative clauses were presented with an unambiguous visual context, only the target-reading of the relative clauses in the respective condition could be associated with a correct picture selection. The children were supposed to reject a picture selection when they could not derive the associated meaning. However, the spontaneous comments of the participants showed that for some children this situation did not lead to a rejection of the picture selection. Instead, the infelicitous situation led to an acceptance of the picture selection, although the children explained that Robbi's action was not correct. Moreover, the children said that the robot could not have taken a correct picture because there was no such picture displayed. Similar reactions have been reported by Matthei (1982) in the corresponding unbiased conditions. Since the main aim of this acceptability judgement task was to investigate whether restrictive and

appositive readings could be derived by the participants, judgements in which a comment clearly contradicted the acceptance signaled by the button press were manually recoded according to the verbal line of argumentation. The inverse case, a button press signaling the rejection of an utterance although the child verbally stated that the picture selection was correct, did not occur in the experimental data.

The following section reports the results of Experiment 3.

7.3. Results of Experiment 3

In this section, the results of the acceptability task are presented. The children's performance in the control condition Non-intersectivity and in the filler items is reported in Section 7.3.1. In Section 7.3.2, the results for the relative clause test items are reported. Since the data was not normally distributed, non-parametric statistical test were performed on the data. To compare a dependent variable across multiple independent groups (e.g., performance across age groups or test versions), Kruskal-Wallis H tests were conducted. When two independent groups were compared, a Mann-Withney-U test was used. Friedman tests were performed when a dependent variable was compared across multiple related samples (e.g., proportion of acceptance rates across experimental conditions). Wilcoxon tests were used to compare two related samples. The p-values were corrected for multiple testings when post-hoc tests were carried out.

As argued in Section 7.2.1, only the acceptance of items with correct picture selections, i.e., with an expected *yes*-response, were informative on the interpretation of ordinal numbers and relative clauses. However, if only the items with an expected *yes*-response were considered for an analysis of the results, a *yes*-bias of participants could have remained unnoticed. A child could have accepted all picture selections independently of whether they matched the puppet's request. To prevent such a bias, items with an expected *no*-responses are presented, too, to determine target-like interpretation patterns.

In contrast to the previous experiments of this thesis, the level of chance performance could be determined easily in this experiment. In the acceptability task, participants had to answer a yes-no question. The chance level for a binary distribution is based on the binomial distribution. In all conditions including relative clauses, control condition and filler items, six items were used with an expected *yes*-response. To perform statistically above chance, at least 5 out of 6 items had to be judged correctly. When 2 to 4 items were accepted, the performance could not be distinguished from chance. However, when 0 or 1 items were accepted, this performance was significantly below chance level and a reading could have been rejected on purpose.

The definition of mastery of a reading on an individual level was based on these considerations. For Experiment 3, a reading was taken to be acquired or available when at least 5 out of 6 items with an expected *yes*-response were accepted. In addition, at least 5 out of 6 items with an expected *no*-response had to be rejected, i.e., judged correctly, to exclude a *yes*-bias for the participants. In the following, the results for the control condition and the filler items are presented.

7.3.1. Control condition Non-intersectivity and filler items

In the control condition Non-intersectivity two judgements had to be manually recoded since the acceptance of a picture choice signaled by the button press did not match the comment of the participants.[1] In the filler items, all button presses and comments were congruent.

Table 7.5 shows the proportions of correct interpretations for the control condition Non-intersectivity and the filler items.

Table 7.5.: Exp. 3 – Percentage of correct judgements (*SD*) in filler items and control condition Non-intersectivity by age group

	Age 3 ($n = 28$)	**Age 4** ($n = 29$)	**Age 5** ($n = 33$)	**Age 6** ($n = 25$)	**Adults** ($n = 20$)
Non-intersectivity					
expected *yes*	70.8%	74.1%	92.9%	92.7%	100%
	(33.5)	(30.7)	(22.5)	(21.0)	(0.0)
expected *no*	60.7%	78.2%	95.5%	99.3%	100%
	(33.4)	(28.6)	(15.2)	(3.3)	(0.0)
Filler					
expected *yes*	75.6%	90.8%	94.4%	96.0%	100%
	(17.8)	(14.5)	(13.6)	(11.1)	(0.0)
expected *no*	36.9%	79.9%	93.4%	96.7%	100%
	(23.3)	(23.7)	(15.0)	(8.3)	(0.0)

The data is subdivided for items with an expected *yes*- and *no*-response. As described in Section 7.2.3 above, a judgement had been classified as *correct* when the judgement matched the expected response. Since the performance within the control condition was not influenced by the test version within the age groups (for expected *yes*-responses all $ps > .384$; for expected *no*-responses all $ps > .068$), the data was collapsed for all subsequent analyses.

The data in Table 7.5 show that the performance overall increased with age. Three-year-old children accepted the picture selection for 70.8% of items correctly in the control condition. Items with an expected *no*-response were rejected correctly in 60.7% of items. The amount of correct judgements increased to approximately 75% at the age 4, and to above 90% at the age of 5 and 6. Adults accepted and rejected the sentences as expected in all items of the control condition Non-intersectivity. The increase in performance for the rate of correct acceptances in the different age groups was corroborated statistically

[1] The two mismatches both occurred in the first item of the control condition. Although the button press indicated an acceptance of the correct picture choice of object no. 3, it was verbally rejected by a statement like *Es gibt keinen zweiten Hund, es gibt nur den zweiten Lolli.* 'There is no second dog, there is only a second lollipop' when the robot was asked to take the second dog out of the cupboard and the order of objects was DOG – LOLLIPOP – DOG... .

($\chi^2(4) = 38.0$, $p < .001$). The mean ranks for the groups were 46.9 at age 3, 49.2 at age 4, 80.8 at age 5, 78.2 at age 6, and 91.0 in the adult control group. The results of the pairwise post-hoc tests in Table 7.6revealed that on the one hand 3- and 4-year-old children showed similar distributions of correct responses in items with an expected *yes*-response. On the other hand, 5- and 6-year olds as well as adults patterned alike. Between these two bigger groups, the distribution of correct acceptance rates differed significantly.

Table 7.6.: Exp. 3 – Results of pairwise comparisons of age groups for control condition Non-intersectivity

Compared groups	**Expected *yes*-response**		**Expected *no*-response**	
	U	***p***	**U**	***p***
Age 3 – Age 4	-2.38	1.0	-19.73	.173
Age 3 – Age 5	-33.90	.001**	-41.20	< .001***
Age 3 – Age 6	-31.34	.005**	-48.01	< .001***
Age 3 – Adults	-44.14	< .001***	-50.13	< .001***
Age 4 – Age 5	-31.52	.002**	-21.47	.070
Age 4 – Age 6	-29.96	.013*	-28.28	.009**
Age 4 – Adults	-41.76	< .001***	-30.40	.008**
Age 5 – Age 6	-2.56	1.0	-6.80	1.0
Age 5 – Adults	-10.24	1.0	-8.92	1.0
Age 6 – Adults	-12.80	1.0	-2.12	1.0

*Significant at a level of .05. **Significant at a level of .01. ***Significant at a level of .001.

Similar results were obtained for correct rejections of incorrect picture selections in the control condition. There were significant differences between the groups for expected *no*-responses ($\chi^2(4) = 49.6$, $p < .001$) with mean ranks of 37.4 at age 3, 57.1 at age 4, 78.6 at age 5, 85.4 at age 6, and 87.5 in the adult control group. The pairwise comparisons in Table 7.6 show again that 3- and 4-year-old children did not significantly differ from each other. In addition, 5- and 6-year-old children as well as adults showed similar distributions of correct interpretations. The comparisons between the younger and the older participants, however, were significant.

These results show that children at the age of 3 were more ready to accept a picture selection than to reject it. However, the rejection rate in this group was already above 60%. Thus, a general *yes*-bias cannot be found in any of the age groups in the control condition.

With regard to the filler items, again, age-related differences were found between the

groups. Significant differences were found for both the distribution of correct judgments in items with an expected *yes*-response ($\chi^2(4) = 55.5$, $p < .001$, mean ranks: 29.4 at age 3, 67.1 at age 4, 78.1 at age 5, 80.5 at age 6, 91.0 in the adult control group) and for correct judgement in items with an expected *no*-response ($\chi^2(4) = 83.8$, $p < .001$, mean ranks: 18.8 at age 3, 62.11 at age 4, 83.4 at age 5, 87.5 at age 6, and 95.5 in the adult control group). Table 7.7 gives an overview of the results of the pairwise comparisons of the post-hoc tests.

Table 7.7.: Exp. 3 – Results of pairwise comparisons of age groups for filler items

Compared groups	**Expected *yes*-response**		**Expected *no*-response**	
	U	***p***	**U**	***p***
Age 3 – Age 4	-37.78	<.001***	-43.30	<.001***
Age 3 – Age 5	-48.76	<.001***	-64.60	<.001***
Age 3 – Age 6	-51.16	<.001***	-68.72	<.001***
Age 3 – Adults	-61.64	<.001***	-76.68	<.001***
Age 4 – Age 5	-10.98	1.0	-21.30	.160
Age 4 – Age 6	-13.38	1.0	-25.42	.074
Age 4 – Adults	-23.86	.123	-33.38	.010*
Age 5 – Age 6	-2.40	1.0	-4.12	1.0
Age 5 – Adults	-12.88	1.0	-12.08	1.0
Age 6 – Adults	-10.48	1.0	-7.96	1.0

*Significant at a level of .05. **Significant at a level of .01. ***Significant at a level of .001.

The pairwise comparisons for the filler items showed significant differences between the group of 3-year-olds and all other age groups for expected *yes*- and *no*-responses. The distribution of correct acceptance rates for the other groups did not differ statistically. For correct rejections, 4-year-olds also differed from adults. The results of the filler items demonstrated adult-like acceptance rates already at the age of 4. Thus, the items fulfilled their purpose and served as simple filler items among the relative clause test items. No further analyses were conducted on the filler items.

Like in the previous experiments of this thesis, a target-like interpretation of ordinal numbers was required to yield truth-functional differences between restrictive and appositive interpretations. To differentiate between children with and without robust knowledge of the semantics of ordinal numbers, the performance in the control condition Non-intersectivity was used as a grouping factor. The individual acceptance patterns in the control condition Non-intersectivity are displayed in Table 7.8 for items with a correct picture selection.

Table 7.8.: Exp. 3 – Cross-table on the number of participants with n correct judgements of items with expected *yes*-response in control condition Non-intersectivity by age group

No. of correct interpretations	**Age 3** ($n = 28$)	**Age 4** ($n = 29$)	**Age 5** ($n = 33$)	**Age 6** ($n = 25$)	**Adults** ($n = 20$)
0	3	2	2	1	-
1	1	1	-	-	-
2	1	1	-	-	-
3	3	4	-	-	-
4	3	2	-	1	-
5	7	8	3	3	-
6	10	11	28	20	20

The individual performances shown in Table 7.8 demonstrate that 90 children (78%), i.e., more than half of the children in all age groups, accepted at least 5 out of 6 picture selections correctly. For children at the age of 5 and 6 a bimodal distribution was found like in the previous experiments. The children in these age groups accepted either zero items correctly or at least four of them. An analysis of the spontaneous comments of the participants was performed to assess the reasons for the children's incorrect rejections. The analyses suggested that at least four children rejected correct picture selections consistently in the control condition because they intended an intersective interpretation of the ordinal number words. This is illustrated in the examples given in (7).

(7) Comments to an item of the control condition indicating an intersective reading
Visual context:

1 2 3 4 5 6 7

Comments:

Caru: Nimm das dritte Handtuch und leg' es in den Koffer!
Child: Des dritte Handtuch...
Exp: Hat Robbi das Richtige genommen?
Child: Nein, hier (no. 3) war das Dritte. Wenn ich eins (no. 1), zwei (no. 2), drei (no. 3), dann is' drei hier (no. 3).

Caru: *Take the third towel and put it in the suitcase!*
Child: *The third towel...*
Exp: *Did Robbi take the right one?*
Child: *No, here (points at no. 3) was the third. If I one (no. 1), two (no. 2), three (no. 3), then three is here (no. 3).*

04_GLG402, age 4;10

Caru: Nimm das dritte Handtuch und leg' es in den Koffer!
Child: Nee, es gibt nur eine dritte Zahnbürste.
Exp: Hat Robbi das Richtige genommen?
Child: Ich weiß nich, guck hier, der soll des dritte Handtuch nehmen, aber es gibt hier kein drittes Handtuch.

Caru: *Take the third towel and put it in the suitcase!*
Child: *No, there is only a third toothbrush.*
Exp: *Did Robbi take the right one?*
Child: *I don't know, look, he was supposed to take the third towel but there is not third towel.*

04_MMR115, age 5;10

Caru: Nimm das dritte Handtuch und leg' es in den Koffer!
Child: Des is 'ne Zahnbürste.

Caru: *Take the third towel and put it in the suitcase!*
Child: *That is a toothbrush.*

04_CEU067, age 5;11

To rule out the possibility of a *yes*-bias on an individual level of the participants, mastery in the control condition was defined based on correct interpretations of items with an expected *yes*- and *no*-response. In both sets of items, at least 5 out of 6 items had to be judged correctly. That is, in both types of judgements, children had to perform above chance level.

Table 7.9 gives an overview of the number of children reaching the mastery criterion.

Table 7.9.: Exp. 3 – Mastery of non-intersectivity of ordinal numbers by age group

	Age 3 ($n = 28$)	**Age 4** ($n = 29$)	**Age 5** ($n = 33$)	**Age 6** ($n = 25$)	**Adults** ($n = 20$)
Mastery[a]	21.4% (6/28)	41.4% (12/29)	90.9% (30/33)	92.0% (23/25)	100% (20/20)

[a]Mastery defined as at least 5 out of 6 items correct.

Table 7.9 demonstrates that six children at the age of 3 and 12 children at the age of 4 meet the mastery criterion. From age 5 onwards, the majority of children in the age groups performs target-like. In total, 71 out of 115 children (62%) and all adults reached the combined mastery criterion in the control condition Non-intersectivity. A comparison of Table 7.8 and Table 7.9 indicates that especially the younger children were more willing to accept correct picture selections than to reject incorrect ones. Eighteen 3- and 4-year-old showed high acceptance rates but missed the mastery criterion due to insufficient rejection rates.

In the following section, the results of the three conditions testing relative clauses are presented.

7.3.2. Relative clause test items

In this experiment, relative clauses were tested in three conditions. Syntactically ambiguous relative clauses were disambiguated by prosody and visual context as restrictive or appositive. Furthermore, the discourse particle *ja* disambiguated in a third condition in addition to prosody and visual context towards an appositive reading. In all three conditions, items were presented with a correct and an incorrect picture selection. With regard to research question (Q2) asking whether a semantic function of the relative clauses is available for children, mainly the performance in items with correct picture selection, i.e, an expected *yes*-response was informative. In these items, children were expected to accept the reading when they were able to derive the semantic function that was tested. However, 48 children did not always perform in line with this expectation. In 105 instances they signaled acceptance of the relative clause interpretation by the button presses but rejected the reading verbally.[2] These instances of the type *Yes, but there is no matching picture* were manually recoded as rejections. This incongruent response pattern was limited to the children's groups. Only two instances occurred in the restrictive condition. In these two cases, two participants indicated by their comments that they applied an appositive interpretations to the respective stimuli. All other mismatches occurred in the two appositive prosody conditions. Eighty-five out of the 105 mismatches were documented in the appositive condition without discourse particle (72 for children with mastery in the control condition Non-intersectivity; 13 for children without mastery in the control condition); 18 mismatches were found in the appositive condition with discourse particle (out of these 15 for children with mastery in the control condition, 3 for children without mastery in the control condition). For children that mastered the control condition the argumentation within all of the *Yes, but ...*-comments in the appositive conditions indicated that the children derived a restrictive interpretation for the test items. Examples and further information about the distribution of the comments are given in the appendix on page 378.

[2] In total, 77 participants gave 315 comments that indicated that the participants derived a reading different from the one tested in the respective condition. Out of these, 210 were congruent with the button press, i.e. participants rejected the picture selection as expected based on the non-matching interpretation they derived. The remaining 105 comments by 48 children were incongruent, i.e. the button press signaled acceptance but the comment indicated a verbal rejection of the picture selection.

This section is structured as follows. First, the results for children with mastery in the control condition Non-intersectivity are reported for items with an incorrect picture selection, i.e., with an expected *no*-response are presented to ensure that no *yes*-bias confounds the data. In the second part of this section, the results for items with correct picture selections are reported for children with mastery in the control condition. Third, the results for children without mastery of the semantics of ordinal numbers are summarized.

7.3.2.1. Judgements on relative clauses with incorrect picture selections for children with mastery in the control condition

The results for items with an expected *no*-response are shown in Figure 7.7. In these items, the picture selections were definitely false, independently of the reading of the relative clause. A detailed overview of the percentages and standard deviations is given in Table C.2 in the appendix on page 382.

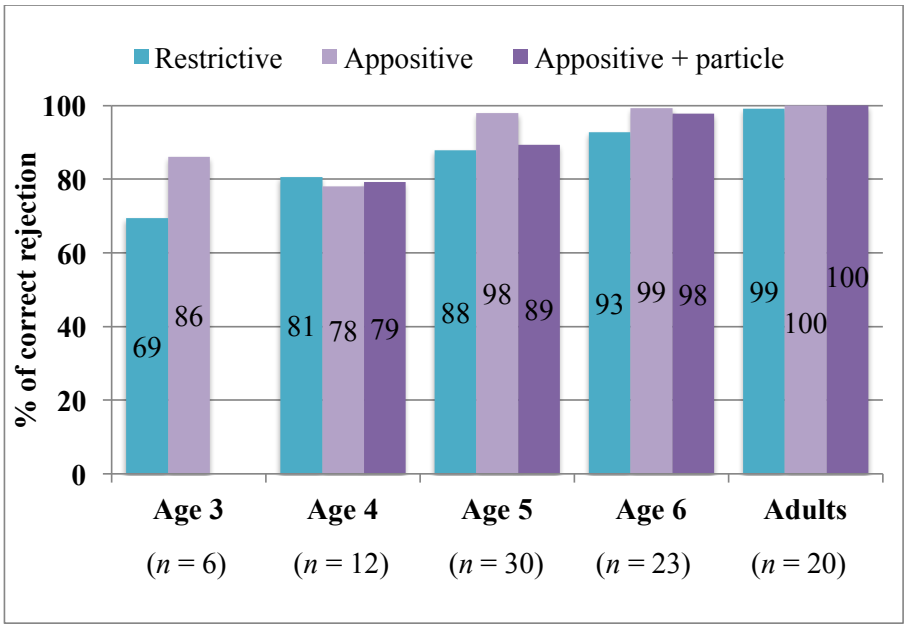


Figure 7.7.: Exp. 3 – Rejection rates for relative clause test items with incorrect picture selections (expected *no*-responses).

The data show that the proportions of correct judgements increased with age for all relative clause conditions. These observations are supported by a statistical analysis. Significant differences between the different groups were found for all conditions (Restrictive relatives: $\chi^2(4) = 16.76$, $p = .002$, mean ranks: 29.7 at age 3, 31.6 at age 4, 43.9 at age 5, 47.9 at age 6, and 60.6 in adults; Appositive relatives: $\chi^2(4) = 26.18$, $p < .001$, mean ranks: 36.8 at age 3, 25.5 at age 4, 47.4 at age 5, 51.2 at age 6, and 53.0 in adults; Appositive relatives with discourse particle: $\chi^2(3) = 11.38$, $p = .010$, mean ranks: 31.4

at age 4, 41.7 at age 5, 45.5 at age 6, and 49.0 in adults).

The results of pairwise post-hoc test are reported in Table 7.10. For restrictive relative clauses with an expected *no*-response, the pairwise comparisons revealed that children at the age of 3 and 4 differed from the adult control group. The performance increased significantly from the youngest groups of children to the adults. For appositive relative clauses with incorrect picture selections, 4-year-old children showed the lowest proportion of correct judgements. As Table 7.10 shows, children at the age of 4 differed significantly from 5- and 6-year-old children as well as from adults in their rejection rate of incorrect picture selections. For appositive relative clauses with the discourse particle *ja*, again, the rate of correct rejections increased with age. However, the judgements of the 4-year-old children differed significantly from only those of the 6-year-olds and the adults.

Table 7.10.: Exp. 3 – Results of pairwise comparisons of age groups in relative clause conditions with expected *no*-responses

Compared groups	**Restrictive relative clauses**		**Appositive relative clauses**		**Appositive relatives with *ja***	
	U	***p***	**U**	***p***	**U**	***p***
Age 3 – Age 4	-1.96	1.0	-11.21	1.0	–	–
Age 3 – Age 5	-14.18	1.0	-10.65	1.0	–	–
Age 3 – Age 6	-18.23	.784	-14.42	.576	–	–
Age 3 – Adults	-30.91	.033*	-16.25	.352	–	–
Age 4 – Age 5	-12.23	1.0	-21.86	.001*	-10.33	.258
Age 4 – Age 6	-16.27	.431	-25.63	<.001***	-14.17	.046*
Age 4 – Adults	-28.95	.004**	-27.46	<.001***	-17.63	.007**
Age 5 – Age 6	-4.04	1.0	-3.77	1.0	-3.84	1.0
Age 5 – Adults	-16.73	.103	-5.60	1.0	-7.30	.543
Age 6 – Adults	-12.68	.662	-1.83	1.0	-3.46	1.0

*Significant at a level of .05. **Significant at a level of .01. ***Significant at a level of .001.

In a next step, the results in the three conditions were compared within the individual age groups. This was done to investigate whether prosodic or lexical differences of the pre-recorded stimuli had an influence on the rejection rates. The comparison did not yield significant differences for children at the age of 3, 4, and for the adults (all ps $>$ .063). Thus, these groups rejected incorrect picture selections to the same extent in all three conditions. Children at the age of 5 and 6, however, differed statistically in their rejection rates in the three conditions (age 5: $\chi^2(2) = 7.96$, $p = .019$; age 6: $\chi^2(2) = 8.96$, $p = .011$). However, pairwise post-hoc tests showed no significant differences between the

three conditions in both groups when the p-values were adjusted for multiple testing (all ps $> .140$). Taken together, these results suggest that both children and adults rejected incorrect picture selections independently of the prosodic and lexical differences of the pre-recorded stimuli.

In the last step of the analyses, the rejection rates within the groups and conditions were compared against a chance level of 50%. The results show that only 3-year-old children in the condition with restrictive relative clauses did not differ from chance ($Z = 1.38$, $p = .167$). In all other conditions and age groups, the participants' rejections were above chance level. For an overview of the statistical details of these comparisons, see Table C.3 in the appendix on page 383.

The items in this condition were analyzed to investigate a potential *yes*-bias. The results reported so far indicate that no such bias was present for children with mastery in the control condition Non-intersectivity. However, the analyses performed before were based on the group data. To analyze this aspect in more detail, an individual analysis was performed. On an individual level, all children at the age of 3, who were tested only on two relative clause conditions, rejected at least four items correctly. Children from age 4 onwards were tested in all three conditions. They rejected at least seven items correctly on an individual level. These results show that children of the tested age range were able to perform the task. High acceptance rates were not the result of a general bias to accept the actions of the robot in the experiment. Thus, a *yes*-bias due to exceeding task demands could be ruled out. Hence, the judgements for items with an expected *yes*-response could be interpreted as intentionally given acceptances or rejections.

7.3.2.2. Judgements on relative clauses with correct picture selections

The proportions of correct judgements in the three relative clause conditions with correct picture selections are displayed in Figure 7.8 on the following page. For details and standard deviations see Table C.2 in the appendix on page 382.

Figure 7.8 shows that the acceptance rates for correct picture selections differed between the restrictive and the two appositive relative clause conditions. For restrictive relatives, the acceptance rates increase; for appositive relative clauses with and without the discourse particle *ja*, the acceptance rates drop from above 90% at age 3 to chance performance at age 5 and 6 before they increase again for the adults.

To address these patterns and thus research question (Q4) asking whether children and adults differ in their interpretation patterns, the acceptance rates were compared between the different groups. Significant differences between the different age groups were found for restrictive relative clauses and appositive relative clauses with the discourse particle *ja* (Restrictive relatives: $\chi^2(4) = 12.83$, $p = .012$, mean ranks: 19.4 at age 3, 36.3 at age 4, 48.3 at age 5, 51.6 at age 6, and 49.9 in adults; Appositive relatives with discourse particle: $\chi^2(3) = 14.69$, $p = .002$, mean ranks: 45.2 at age 4, 32.8 at age 5, 42.3 at age 6, and 57.8 in adults). No significant differences between the groups were found for the acceptance rates of appositive relative clauses without the discourse particle *ja* ($p = .063$).

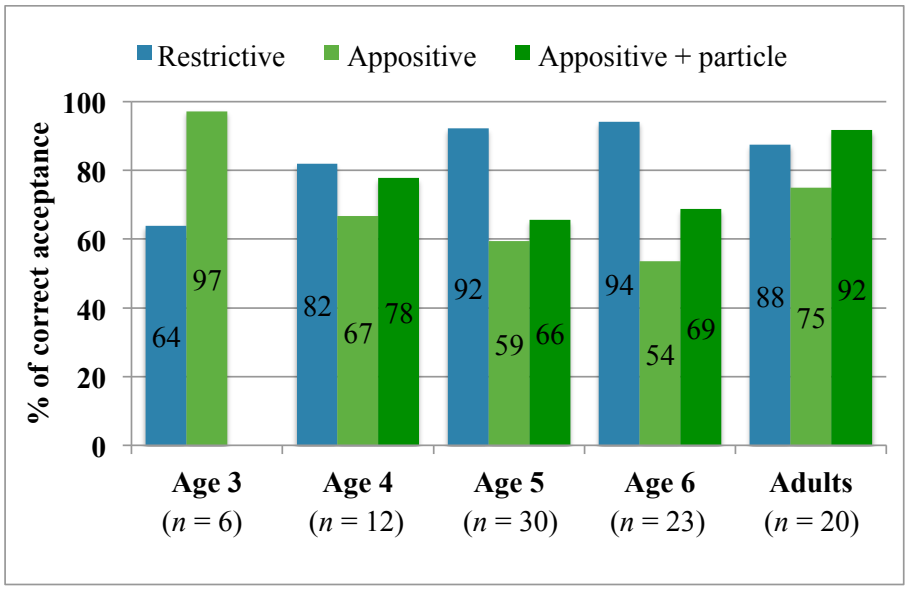


Figure 7.8.: Exp. 3 – Acceptance rates for relative clause test items with correct picture selections considering the comments of the participants.

The results of the post-hoc tests are reported in Table 7.11 on the following page. The pairwise comparisons reveal that for restrictive relative clauses, children at the age of 3 differed from the other age groups. The rate of correct acceptances was significantly lower in 3-year-olds than in children at the age of 5 and 6 as well as in the adult control group. No other significant differences between the groups were found.

For appositive relative clauses with the discourse particle *ja*, only the 5-year-olds differed significantly from the adults regarding their acceptance rates. They accepted significantly fewer appositive readings than the adults. Between the children's groups, no reliable differences were found in the appositive condition with discourse particles. Taken together, these results confirm Hypothesis (H7) postulating that children and adults differ in their interpretation pattern of unambiguously marked relative clauses.

Table 7.11.: Exp. 3 – Results of pairwise comparisons of age groups in relative clause conditions with expected *yes*-responses

Compared groups	**Restrictive relative clauses**		**Appositive relatives with *ja***	
	U	***p***	**U**	***p***
Age 3 – Age 4	-16.83	1.0	–	–
Age 3 – Age 5	-28.92	.043*	–	–
Age 3 – Age 6	-32.21	.019*	–	–
Age 3 – Adults	-30.43	.039*	–	–
Age 4 – Age 5	-12.08	1.0	-12.39	.659
Age 4 – Age 6	-15.38	.563	-2.95	1.0
Age 4 – Adults	-13.60	.998	-12.59	.771
Age 5 – Age 6	-3.30	1.0	-9.44	.799
Age 5 – Adults	-1.52	1.0	-24.98	.001**
Age 6 – Adults	-1.78	1.0	-15.54	.151

*Significant at a level of .05. **Significant at a level of .01.

In a next step, the group results in the three conditions were compared against a chance level of 50%. These analyses were performed to address research question (Q2) asking which of the readings is available for children at a group level. Conditions that were significantly different from chance level are marked by a star in the chart in Figure 7.9. The detailed results of the statistic tests are listed in Table C.3 on page 383 of the appendix.

As shown in Figure 7.9, only for adults all conditions differed from chance. At the age of 3, only acceptance rates for appositive relative clauses were above chance level. For children between 4 and 6 years of age, in contrast, the acceptance rates for restrictive relatives were above chance level. In addition, none of the children's groups reached above-chance performance for relative clauses in the appositive condition disambiguated only by prosody and visual context. For appositive relatives with the discourse particle *ja*, 4- and 5-year-old children were above chance level. Six-year-olds, however, did not reach above-chance-performance at a group level.

These results indicated that at a group level, restrictive but not appositive readings were accepted by 4- to 6-year-old children. In addition, the discourse particle *ja* led to a mild increase of the acceptance rates for appositive relative clauses. In contrast, 3-year-old children accepted appositive but not restrictive readings. These differences point to differentiated judgements between the different relative clause conditions within the individual age groups. Therefore, as a third step of the analysis, the acceptance rates

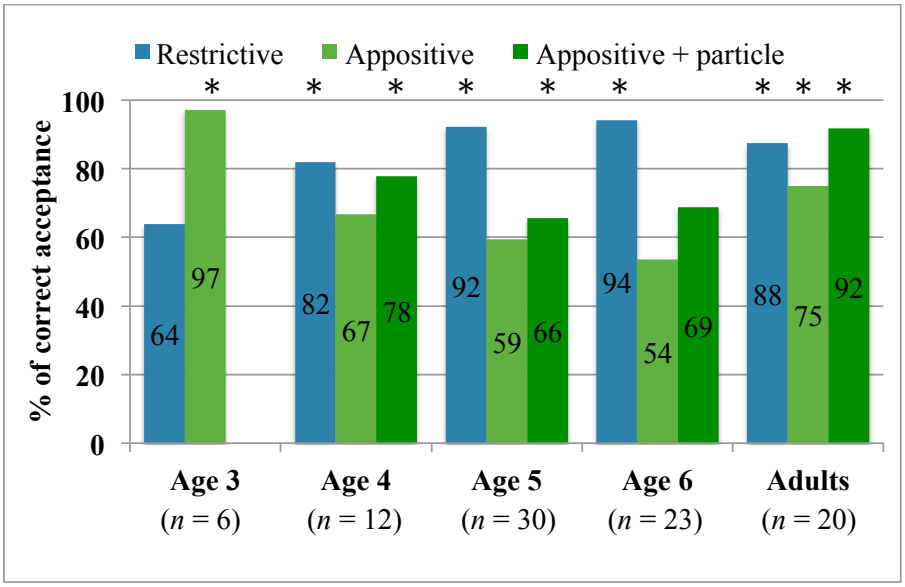


Figure 7.9.: Exp. 3 – Acceptance rates above chance (*) for relative clause test items with correct picture selections

of the three conditions were compared within the age groups. This analysis addressed research question (Q3) on the influence of (non-)linguistic factors on the interpretation of relative clauses.

A comparison of the acceptance rates for restrictive and appositive relative clauses at the age of 3 did not yield a significant result (p = .066). This may be due to the low number of participants in this group. Also for children at the age of 4, no significant differences were found between the acceptance rates in the three conditions (p = .187). Thus, restrictive and appositive relative clauses were statistically accepted to the same extent. Moreover, the presence of the discourse particle *ja* did not increase the acceptance rate for appositive relative clauses. At the age of 5, differences were found between the acceptance rates of the three conditions ($\chi^2(2) = 14.81$, p = .001). Post-hoc tests showed that restrictive relative clauses were accepted more often than appositive relative clauses with and without the discourse particle *ja*. (Restrictive vs. appositive: Z = -3.23, p = .004; Restrictive vs. appositive with *ja*: Z = -2.78, p = .017). Between the two appositive conditions, no differences were found (p = 1.0). Similarly, significant differences were obtained for 6-year-old children and their distributions of judgements in the three conditions ($\chi^2(2) = 8.12$, p = .017). However, pairwise post-hoc tests did not yield significant differences between the conditions after the p-value was corrected for multiple testing (all ps > .055). This lack of significant results may be due to the high variability of acceptance rates in this age group.

Furthermore, the distribution of correct judgements differed between the three relative clause conditions in the adult control group ($\chi^2(2) = 10.51$, p = .005). Pairwise comparisons showed significant differences between the two appositive conditions. Ap-

positive relative clauses including the lexical marker *ja* were accepted significantly more often than appositive relatives without the discourse particle (Z = -2.45, p = .043). Pairwise comparisons between the rates of restrictive relative clauses and the two types of appositive relatives did not yield significant differences (both ps > .342).

Taken together, the results on the acceptance rates of correct picture selections were informative with regard to a variety of aspects. First, they showed that children at the age of 3 accepted appositive but not restrictive relative clauses above chance level as a group. Second, children at the age of 4 and 5 accepted both restrictive readings as well as appositive readings when the discourse particle *ja* was present. Although comparisons within the groups of 4- and 5-year-olds did not yield significant results between the two appositive conditions, the discourse particle, which was supposed to highlight an appositive reading, mildly influenced the acceptance rate with regard to chance performance in these groups. This finding does not support Hypothesis (H4c) on the missing influence of the discourse particles as a marker for an appositive reading in children. Prosody and the visual context alone did not seem to cue appositive readings reliably. This supports Hypotheses (H3c) and (H5c) claiming that prosody and visual context respectively do not serve as a disambiguating factors in children. Third, children at the age of 6 accepted only restrictive relative clauses above chance level. In this group of children, the discourse particle *ja* did not lead to an increase of positive judgements for appositive relative clauses giving full support to Hypothesis (H4c). Overall, only adults showed the expected pattern. They performed above chance in all conditions. In addition, the discourse particle led to higher acceptance rates for appositive relative clauses confirming Hypothesis (H4a). The acceptance rate for appositive relative clauses with the lexical marker was as high as the rate for restrictive relative clauses. Furthermore, the analysis of the spontaneous comments showed an influence of the visual context in the group of adults. The comments show that at least for five adults the unambiguous visual context was the relevant cue to derive appositive interpretations as expected by Hypothesis (H5a). This is shown in the comments in (8).

(8) Comments of adults noticing the ambiguity of the relative clause test items

a) 04_ZFR274: Ja, das ist nicht möglich.
Exp: Hat Robbi das Richtige genommen?
04_ZFR274: Eine Frage: Bei “Nimm den dritten Schal”. Ist damit der dritte Schal, der grün ist, gemeint? Oder “nimm den dritten Schal” und dann wird spezifisch auf die Eigenschaft eingegangen, dass dieser Schal grün ist? Oder ist das das, was unter anderem hier getestet wird, wie das verstanden wird?
Exp: Ja, musst du dir überlegen, ob du des, wie du das verstehst hier. Ob der Robbi das Richtige genommen hat oder nicht, je nachdem.
04_ZFR274: Naja, wenn das so ist, dann habe ich in der ersten einiges falsch gemacht. “Nimm den dritten Schal, der grün ist.” Ja, gut.
Exp: Hat er das richtige genommen?
04_ZFR274: (hesitates) Ja, dann sage ich, das hat er richtig gemacht.

04_ZFR274: *This is not possible.*
Exp: *Did Robbi take the right one?*
04_ZFR274: *A question: “Take the third scarf” Does this mean the third scarf that is green? Or “take the third scarf” and then one goes into detail on the property that this scarf is green? Is this what is tested here? How you interpret that?*
Exp: *Well, you have to decide how you interpret this. Whether Robbi took the right one or not.*
04_ZFR274: *Well, if that’s how it is then I did many things wrong in the first part. “Take the third scarf, which is green”. Yes, fine.*
Exp: *Did he take the right one?*
04_ZFR274: *(hesitates) Yes, then I would say that he did it right.*

b) 04_ZPF276: Häh? Es gibt keinen dritten grünen Schal. “Nimm den dritten Schal, der grün ist”, na jetzt wird’s hier voll verarsch mäßiger, gibt ja gar kein dritten, der grün ist. Moment, stop! “Nimm den dritten ...” Oah! Also es ist zwar der dritte Schal ..., “Nimm den dritten Schal, der grün ist ...”. Na dann ... hääh? Aber das ist jetzt ein ganz anderes Prinzip, aber dann stimm’s ja auch, weil es ist der dritte Schal und er ist grün. Kann ich die Ansage nochmal machen? (Repetition of the item) Joar, dann stimmt’s ja wieder.
Exp: Also hat er das Richtige genommen?
04_ZPF276: Ja, “nimm den dritten Schal, der grün ist”, ja. Leute, jetzt macht ihr’s hier echt schwierig.

04_ZPF276: *Pardon? There is no third green scarf. "Take the third scarf that/which is green". well, he is kidding me, there is no third one that is green. Wait a minute, stop! "Take the third ..." Oah! So it's the third scarf ... "Take the third scarf, that/which is green ..." Well, ... pardon? But this is a completely different principle. But then it's right because it is the third scarf and it is green. Can I do the judgement once more? (Repetition of the item) Yes, then it's correct.*

Exp: *So, did he take the right one?*

04_ZPF276: *Yes, "take the third scarf, that/which is green", yes. Guys, now you make it really hard.*

The comments in (8) demonstrate that the adults noticed the ambiguity of the stimuli. Furthermore, they show that the participants derived a restrictive interpretation initially but adapted their judgements when they noticed the conflict of their interpretation and the visual context. For children, no comparable comments were found. This finding can be taken as evidence that the visual context influences the interpretation patterns of adults in line with Hypothesis (H5a), although this factor was not explicitly explored in this experiment.

7.3.2.3. Individual analysis

In addition to the analysis of the group results, individual judgement patterns were analyzed. The individual analysis aimed to investigate whether chance performance in the conditions may result from different interpretation strategies of the participants or whether the majority of children performed at chance level individually. The inspection of the individual performance showed that the participants with knowledge of the semantics of ordinal numbers performed very systematically in this experiment. For detailed results see the appendix on page 384. To explore the individual performance, a mastery criterion was defined for each condition. Mastery for a condition was defined if a participant judged at least 5 out of 6 of items correctly for both items with an expected *yes*- and *no*-response. The results are summarized in Table 7.12. In the table, both appositive conditions were combined. Participants were classified as having mastery of the appositive reading when they reached the mastery criterion in at least one out of the two conditions.

Based on the mastery criterion, i.e. above-chance performance, seven participants up to age 5 did not show mastery in any of the relative clause conditions. Twenty-two participants starting from age 4 showed mastery only in the restrictive condition. In contrast, none of the 3-year-olds performed above chance level in restrictive relative clause items. For appositive relative clauses, however, four children at the age of three performed target-like. As a consequence, mastery of both semantic functions was only found for children starting at age 4. Overall, 43 participants (47%) mastered restrictive relative clauses and appositive ones in at least one of the two appositive conditions.

A further analysis showed that, across all age groups, refusals, i.e., below-chance performance, were found more often for appositive relative clauses than for restrictive rel-

Table 7.12.: Exp. 3 – Summary of mastery patterns across relative clause conditions

Mastery		Age 3	Age 4	Age 5	Age 6	Adults	Total
Restrictive	**Appositive**	($n = 6$)	($n = 12$)	($n = 30$)	($n = 23$)	($n = 20$)	($n = 91$)
−	−	2	3	2	-	-	7
+	−	-	2	11	7	2	22
−	+	4	3	6	3	3	19
+	+	-	4	11	13	15	43

Note. + = Mastery criterion reached; − = Mastery criterion not reached.

atives. Restrictive readings were rejected systematically by only two adults. Appositive readings, in contrast, were rejected by 19 participants when prosody and visual context disambiguated the clause, and by 12 participants when the discourse particle was present additionally. The analysis of the spontaneous comments suggested that the participants who refused the appositive readings arrived at a restrictive interpretation of the relative clause (see the appendix on page 384).

On an individual level, the mastery patterns of restrictive and appositive relative clauses show different distributions. While the acceptance of appositive readings drops from 66% at age 3 to 57% at age 5 before it rises again, the acceptance of restrictive relative clauses increases steadily with age. This is shown in Table 7.13.

Table 7.13.: Exp. 3 – Distribution of Mastery of restrictive and appositive interpretations across age groups

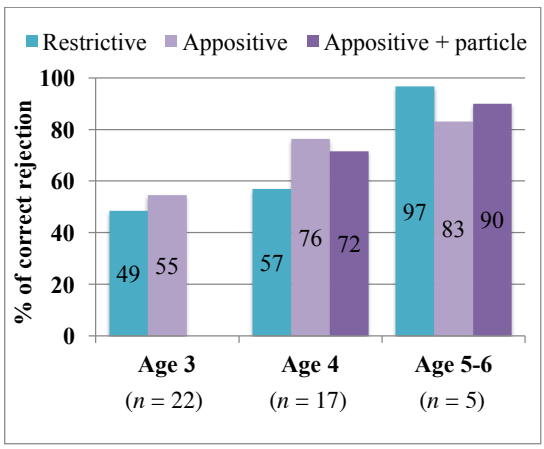
Semantic function	**Age 3** ($n = 6$)	**Age 4** ($n = 12$)	**Age 5** ($n = 30$)	**Age 6** ($n = 23$)	**Adults** ($n = 20$)	**Total** ($n = 91$)
Restrictivity						
n	0	6	22	20	17	65
%	0%	50%	73%	87%	85%	71%
Appositivity						
n	4	7	17	16	18	62
%	66%	58%	57%	70%	90%	68%

In the following section, the results for children without mastery in the control condition Non-intersectivity are summarized.

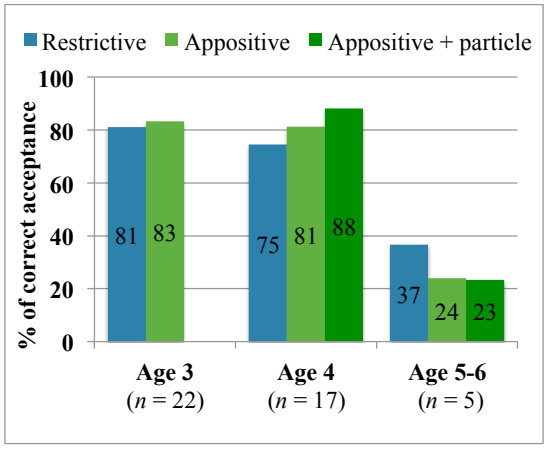
7.3.2.4. Results of children without mastery in the control condition Non-intersectivity

In this experiment, 44 children between the age of 3 and 6 did not reach the mastery criterion in the control condition Non-intersectivity. These children failed to judge at

least 5 out of 6 items correctly for items with an expected *yes*- and/or *no*-response. For the summary of their judgement patterns in this section, data of the five 5- and 6-year-old children were combined. Figure 7.10 displays the performance in the relative clause test items. In Figure 7.10a, the performance for items with an incorrect picture selection is displayed. Figure 7.10b shows the performance for items with an expected *yes*-response. Like in the previous sections, the data was based on acceptance rates considering the spontaneous comments of the participants. Detailed results on percentages and standard deviations are given in Table C.6 on page 386 in the appendix.



(a) Incorrect picture selection.



(b) Correct picture selection.

Figure 7.10.: Exp. 3 – Proportions of correct judgement for relative clause test items of children without mastery in control condition Non-intersectivity.

The results in Figure 7.10 demonstrate that children without mastery in the control condition showed an opposite pattern for items with correct and incorrect picture selections. Three- and 4-year-old children seemed to be ready to accept picture selections in items with an expected *yes*-response, but they were at chance level rejecting incorrect picture selections. The inverse performance is found for children at the age of 5-6. These children seemed to reject incorrect picture selections target-like but they did not accept correct restrictive and appositive picture choices. This pattern was investigated in more detail.

As a first step, age-related differences were investigated in items with correct and incorrect picture selections. For items with an incorrect picture selection, i.e., an expected *no*-response, significant differences between the rejections rates were found for restrictive relative clauses ($\chi^2(2) = 10.05$, $p = .007$, mean ranks: 19.1 at age 3, 22.0 at age 4, and 39.0 at age 5-6). Pairwise post-hoc tests revealed that children at the age of 5 to 6 performed significantly better than the younger groups in items with an expected *no*-response (Age 3 vs. age 5-6: $U = -19.86$, $p = .005$; Age 4 vs. age 5-6: $U = -17.0$, $p = .025$). Three- and 4-year-old children did not differ from each other ($p = 1.0$). In addition, differences between the groups were found for appositive relatives ($\chi^2(2) = 7.78$, $p = .020$, mean ranks: 17.3 at age 3, 26.9 at age 4, and 30.2 at age 5-6). However,

no significant differences were found between the age groups in pairwise post-hoc tests for appositive readings (all *p*s > .052). For appositive relative clauses with the lexical marker *ja*, no significant difference were found between the 4-year-old children and those at the age of 5-6 (U = 55.5, p = .319). In sum, the rejection rates increased between 4-year-old children and those at the age of 5-6 for restrictive and appositive relative clauses when an incorrect picture had been selected by the robot.

When a correct picture had been chosen by the robot, the inverse pattern was found. No significant differences between the age groups were found for the acceptance of restrictive relative clauses (p = .122). For appositive relative clauses, however, the acceptance rates differed ($\chi^2(2)$ = 9.89, p = .007, mean ranks: 25.4 at age 3, 23.4 at age 4, 6.6 at age 5-6). Post-hoc comparisons showed that the 5- to 6-year-olds accepted appositive relative clauses significantly less often than their younger peers (Age 3 vs. age 5-6: U = -18.81, p = .005; Age 4 vs. age 5-6: U = -16.8, p = .020). Three- and 4-year-old did not differ from each other (p = 1.0). Also for appositive relatives with the discourse particle *ja*, 5-6-year-old children showed significantly lower acceptance rates than the 4-year-olds (U = 12.0, p = .015).

Taken together, the statistical results confirmed the descriptive pattern. In the group without mastery of ordinal numbers, 3- and 4-year-old children showed comparable acceptance and rejection rates for restrictive and appositive relative clauses. The few children at the age of 5 and 6 differed from their younger peers. 5- and 6-year old children rejected incorrect picture selection more often than the 3- and 4-year-olds. At the same time, they accepted restrictive and appositive relative clauses significantly less often than the younger children.

To investigate whether the different conditions influenced the rejection and acceptance rates, the judgement rates were compared across conditions for the individual age groups. For items with an incorrect picture selection, no significant differences are found between the conditions for children at the age of 3 and for children at the age of 5-6 (both p >.156). For 4-year-old children, the conditions had an influence on the rejection rates ($\chi^2(2)$ = 7.55, p = .023). Pairwise post-hoc tests, however, did not show significant differences between the groups when the p-values were corrected for multiple testings (all *p*s > .062). Taken together, these results showed no reliable influence of the conditions on the rejection rates of the children without mastery in the control condition Non-intersectivity. The same holds for items with correct picture selections. No significant differences can be found between the acceptance rates of the different relative clause conditions within the age groups (all *p*s > .587). Thus, the prosodic differences, or the presence of the lexical marker did not lead to different acceptance or rejection rates within the groups.

In a next step, the rates of correct judgements were compared against a chance level of 50%. For items with an incorrect picture selection, the performance of the 3-year-olds could not be distinguished from chance (both *p*s > .517). At the age of 4, the rejection rates in the appositive conditions were significantly above chance level (Appositive: Z = 3.09, p = .002; Appositive with *ja*: Z = 2.62, p = .009). For children at the age of 5-6, the rates of correct rejections were above chance in the restrictive condition and in appositive items with the lexical marker (Restrictive: Z = 2.12, p = .034; Appositive

with *ja*: $Z = 2.06$, $p = .039$). This mixed performance points to an unsystematic rejection of items by children without mastery in the control condition Non-intersectivity.

Again, the opposite pattern was found for items with an expected *yes*-response. Children at the age of 3 and 4 were above chance in their acceptance rates in all conditions (Age 3, Restrictive: $Z = 3.37$, $p = .001$; Appositive: $Z = 3.78$, $p < .001$; Age 4, Restrictive: $Z = 2.60$, $p = .009$; Appositive: $Z = 3.40$, $p = .001$; Appositive with *ja*: $Z = 3.54$, $p < .001$). In contrast, 5-6-year-old children did not differ significantly from chance in their acceptance rates (all ps $> .174$).

These analyses support the finding that children at the age of 3 and 4 did not reliably reject incorrect picture selections. In contrast, they tended to accept picture selections more often than their older peers. This unsystematic pattern was also confirmed in an individual analysis. Like for children with mastery in the control condition Non-intersectivity, mastery in the relative clause test items was based on above-chance performance for items with correct and incorrect picture selections. At least 5 out of 6 items had to be judged correctly to reach the mastery criterion for each response category. A reading was classified as refused when at maximum one item of a condition was accepted.

Contrary to the high acceptance pattern at a group level, the individual analysis showed that only few children reached the mastery criterion in the relative clause conditions (for detailed results see page 387 in the appendix). For restrictive relative clauses, only one 3-year-old and two 5-6-year-olds performed target-like. This finding is not unexpected because the children analyzed here did not show reliable knowledge of the prerequisites for the judgement task. For appositive relative clauses, mastery was reached by more children compared to the restrictive condition. At the age of 4, seven children performed target-like in this condition. However, overall the mastery criterion was missed by the grand majority of children. Overall, 28 out of 44 children (64%) did not reach the mastery criterion in any of the three conditions. In contrast to children with reliable knowledge of ordinal numbers, no child showed mastery in all relative clause conditions. What is interesting is that six children rejected restrictive readings systematically. In addition, four children actively rejected appositive readings. A similar pattern was found for appositive relative clauses with the discourse particle.

This individual analysis is further evidence for the inconsistent interpretation patterns in the group of children without mastery in the control condition Non-intersectivity. Especially the youngest children did not reject incorrect picture selections consistently, which is why their acceptance patterns could not be interpreted as a reliable measure for the availability of the relative clause readings. The high acceptance rates in these children may have been due to a general tendency to accept the picture selection of the robot. Five- and 6-year-old children, however, showed a different pattern. Three out of 5 children actively rejected both semantic functions of relative clauses. This finding suggests that these children arrived at another interpretation of the relative clauses. Like in the control condition Non-intersectivity, these children seemed to interpret ordinal numbers as intersective modifiers.

This assumption was supported by an analysis of the spontaneous comments of the children. The comments of the three children that rejected all readings of the relative clauses clearly indicate that they arrived at an intersective interpretation of the clause.

Two examples are given in (9) and (10).

(9) Comment to a relative clause test item indicating an intersective reading
Visual context:

1 2 3 4 5 6 7

Caru: Nimm die dritte Ente, die bunt ist, und leg' sie in den Koffer!
Child: Die dritte Ente, die bunt ist? Hehe, des is 'ne Grüne.

Caru: *Take the third duck that is multicolored, and put it in the suitcase!*
Child: *The third duck that is multicolored? Hehe, that's a green one.*
04_CEU067, age 5;11

(10) Comment to a relative clause test item indicating an intersective reading (II)
Visual context:

1 2 3 4 5 6 7

Caru: Nimm den dritten Ball, der gestreift ist, und leg' ihn in den Koffer!
Child: Es reicht. Ganz falsch, ganz falsch, ganz falsch.
Exp: Hat Robbi das Richtige genommen?
Child: Nein, es gab ja gar keinen dritten Ball, der gestreift ist. Hier (points at position no. 3) hätte er ihn rausnehmen sollen.

Caru: *Take the third ball that is striped and put it in the suitcase!*
Child: *That's enough. Completely wrong, completely wrong, completely wrong.*
Exp: *Did Robbi take the right one?*
Child: *No, there was no third ball that/which is striped. Here (points at position no. 3), he should have taken it out.*
04_MMR115, age 5;10

The comments show that the children expected that the picture at the n^{th} position overall was selected. Since there was no matching picture, the children rejected the picture selections of the robot consistently.

In the following section, the results of Experiment 3 are discussed.

7.4. Discussion

The third experiment of this thesis was an acceptability task. This change of method allowed to test whether a restrictive or appositive interpretation was accepted by German-

speaking children and adults although the reading may not have been the preferred interpretation of the participants. In this task, relative clauses were tested in three conditions. Syntactically ambiguous relative clauses were disambiguated by an integrated or unintegrated prosody as restrictive or appositive. The visual context in all relative clause conditions was only compatible with the target-reading and served as second disambiguating factor. The third condition tested the acceptance of appositive relative clauses that contained the discourse particle *ja*. In this condition, the unintegrated prosody, the visual context, and the lexical marker disambiguated the relative clause as appositive modifier.

To test the acceptance of restrictive and appositive readings, an animated robot selected objects out of a cupboard following a pre-recorded request of a puppet frog. The request of the puppet contained the relative clause. Children had to compare the picture selection of the robot to their internal semantic representation of the frog's request. To be able to make the judgement, the participants had to derive the restrictive or appositive interpretation on their own to which the action of the robot could then be compared. Six items were presented twice in each relative clause condition. In one version of the item, the robot selected an object that corresponded to the target-reading. This picture selection was expected to elicit a *yes*-response in the acceptability task when the reading could have been derived by the children. In addition, each item was presented with an incorrect picture selection. These choices were supposed to yield a *no*-response independently of the reading that had been derived. In addition to the relative clauses, a control condition assessed the meaning of the ordinal numbers *zweite/r/s* 'second' and *dritte/r/s* 'third', and filler items were intermixed to vary the task demands in the experiment.

Unlike in the first two experiments, the age range of the children tested varied from 3 to 6 years. 3-year-old children were included in the study because in Experiment 2 the majority of children at the age of 4 mastered the task and showed knowledge of the ordinal number words. As the results of this study show, the acceptance patterns of the youngest participants were informative on the acquisition path of restrictive and appositive readings.

In the following, the main results of Experiment 3 are summarized. Subsequently, the results are discussed with regard to the hypotheses and to the results of Experiments 1 and 2. In the remainder of this discussion, three aspects are discussed in more detail. First, the influence of the discourse particle *ja* as an indicator for appositive readings is addressed. Second, the results of the 3-year-old children are discussed in more depth. The third aspect focuses on consequences of the design regarding the results. Additionally, changes of the design are proposed for further experiments.

Experiment 3 investigated 115 typically-developing German-speaking children between the age of 3;1 and 6;8. In addition, 20 adults participated as a control group. For the analysis of the results, the participants were grouped according to whether they performed above chance level in the control condition for the non-intersectivity of ordinal numbers. Above-chance performance in the control condition was a prerequisite to yield truth-functional differences between restrictive and appositive readings in the relative clause test items. Mastery, i.e., above-chance performance, was defined as at least 5 out of 6 correct judgements each in items with an expected *yes*- and *no*-response. Seventy-

one out of 115 children (62%) mastered the semantics of the ordinal number words used in the relative clause test items. Among these were six children at the age of 3. In the control group, all adults mastered the control condition.

Like in the previous experiments of this thesis, the performance of children that did not master the control condition Non-intersectivity was heterogeneous. An analysis of the spontaneous comments of the participants showed that some of the children interpreted ordinal numbers as intersective modifiers. In addition, there were children that had problems to reject incorrect picture selections although they performed above chance level in accepting correct picture choices. Similar patterns were found for the relative clause conditions. The grand majority of children was at chance level in all relative clause conditions on an individual level. Furthermore, three of the oldest participants rejected both restrictive and appositive readings of relative clauses because they derived intersective readings. Interestingly, when mastery was achieved for a relative clause condition, it was found more often for relative clauses in the appositive conditions than for restrictive relative clauses. Overall, there was only one child that mastered both semantic functions. This 5-year-old child had problems to reject incorrect picture selections in the control condition but seemed to recover from the positive bias in the relative clause test items.

The data of children with mastery in the control condition for the non-intersectivity of ordinal numbers was more homogenous. An analysis of the rejection patterns for items with an incorrect picture selection, i.e., with an expected *no*-response, showed that these children performed above chance as a group in all conditions. The only exception were the rejection rates for restrictive relative clauses in 3-year-old children. Restrictive relative clauses were accepted in 64% of items at the age of 3 and the distribution of the acceptance patterns over all participants in this age group was not distinguishable from chance. On an individual level, however, no participant in any of the age groups showed a *yes*-bias. The observation that a *yes*-bias could be ruled out for the relative clause conditions was a precondition to interpret the acceptance rates as meaningful data on the acquisition of the semantic functions restrictivity and appositivity.

An investigation of the spontaneous comments in the relative clause conditions revealed 105 instances of incongruence between the acceptance of a reading signaled by the button press response and the verbatim justification. Especially 4- and 5-year-old children perceived the request to take the $n^{th}X$ in the appositive relative clause conditions as a presupposition failure. The comments of the children indicated that they arrived at a restrictive reading of the sentence, which was not supported by the visual context. The acceptability task was grounded in the assumption that a displayed reading would be rejected when a participant was not able to derive a mental representation matching that interpretation. However, some of the children in Experiment 3 accepted the robot's picture choice in items with an expected *yes*-response although they could not derive the meaning. The children argued that the robot could not do it right because there was no matching object depicted. Consequently, the robot could take any object he likes best. These instances of false acceptances concealed the problems that some children had with appositive interpretations of relative clauses. To clean the data, the false-positive judgements of the children were recoded as rejections for items where the children's comments clearly showed that they did not derive the appositive interpreta-

tion of the clause. What is interesting is that fewer comments of this sort were found for appositive relative clauses including the discourse particle *ja* than for those test items without the lexical marker for an appositive reading. Moreover, only two comments were found for items testing restrictive relative clauses.

The cleaned data for children with mastery in the control condition demonstrated that the acceptance rates for restrictive relative clauses increased with age. Three-year-old children were still at chance level in their judgements of restrictive test items. Children at the age of 4 and older accepted restrictive interpretations in 82% to 94% of items. For appositive interpretations, no age-related development could be found statistically. Descriptively, however, the acceptance rate of appositive relative clauses dropped from 97% at the age of 3 to 54% at the age of 5. Due to the small number of participants in the group of 3-year-olds, this difference did not reach significance. For appositive relative clauses that contained the discourse particle *ja* as a lexical marker for an appositive reading, the acceptance rates differed between children and adults. For adults, the discourse particle led to an acceptance rate of 92%. Compared to appositive relative clauses without the lexical marker, this was an increase by 17%. In contrast to adults, the lexical marker did not raise the acceptance rates of appositive relative clauses in children to a level above 78%. In addition, no significant differences were found for children, when the acceptance rates were compared in the two appositive conditions within the age groups. However, differences were found between the two appositive conditions in the children's groups when the acceptance rates were compared against chance performance. Children at the age of 4 and 5 accepted appositive relative clauses with the lexical marker but not appositive relative clauses without *ja* above chance level as a group. This pointed to differences in the individual interpretation patterns of the participants in the two conditions testing appositive relative clauses.

These differences were explored in an individual analysis. Like for the control condition Non-intersectivity, mastery was defined as judging at least 5 out of 6 items correctly in each relative clause condition both for items with correct and incorrect picture selections. The individual mastery patterns across all three conditions showed that 43 out of 91 participants (47%) accepted both readings in this acceptability task. Out of these, 19 participants, among them eight of the adults, accepted appositive readings only when the lexical marker was present as a cue for appositive interpretations. In addition to participants with mastery of both readings, 22 participants accepted only restrictive interpretations of relative clauses. These participants often rejected appositive readings above chance level. Furthermore, there were 19 participants that accepted only appositive readings in one or both conditions. Among them were four of the children at the age of 3, who showed consistent readings. Chance level in all conditions was only found for seven children up to the age of 5. The individual mastery patterns for restrictive and appositive readings show a different distribution across the age groups. While the number of children with mastery in restrictive relative clauses increases with age, the distribution for appositivity drops from age 3 to age 5 before it rises again.

The results of Experiment 3 are informative with regard to research question (Q2). The question asks which interpretations of unambiguous relative clauses are accepted by children and adults. In contrast to the results from the picture selection tasks, which

investigated interpretation preferences, the results of Experiment 3 showed higher rates of appositive interpretations in all groups of participants. One third of the 4-year-old children reached the strict mastery criterion for both semantic functions. In addition, the group performance at the age of 4 and 5 was above chance level for appositive relative clauses with the discourse particle *ja* and for restrictive relatives. In Experiment 2, in contrast, only 2 out of 13 children at the age of 4 mastered both readings. Thus, the change of the method led to higher rates of appositive readings observed in the children's groups. These results support Hypothesis (H2) claiming that both readings are acquired in children at the age of 4 to 6.

In Experiment 3, both semantic functions were disambiguated at least by the prosodic format of the pre-recorded stimulus and the visual context. As a consequence, the corresponding hypotheses, (H3a) and (H3c) on prosody and (H5a) and (H5c) on the visual context as (non-)disambiguating factors could not be evaluated independently from each other. However, the influence of the combination of these factors to disambiguate either for restrictive or appositive interpretations could be analyzed. In the group of adults, 17 participants mastered restrictive readings but only 10 mastered appositive readings when prosody and visual context disambiguated the semantic functions. In Experiment 1, similar stimuli and unambiguous visual contexts were used. In comparison to the results from Experiment 1, the proportions of appositive readings disambiguated by the interplay of both factors increased in the acceptability task. In unambiguous test items of Experiment 1, 28% of interpretations indicated an appositive reading. In the acceptability task, 75% of sentences were accepted with an appositive reading. However, the two cues did not seem to be strong enough to disambiguate restrictive and appositive readings for all items and participants in the appositive condition. Thus, the results only partially support Hypotheses (H3a) and (H5a) for the control group. Similar results were found for children at the age of 4 to 6. Compared to Experiment 1, the rates of appositive interpretations increased slightly in the acceptability task (32% at age 5-6 in Experiment 1 vs. 54% at the age of 6 in Experiment 3). Like for adults, the results of the acceptability task showed that there were almost twice as many children that mastered restrictive readings than those that mastered appositive readings of relative clauses disambiguated by prosody and visual context. Hence, prosody and visual context did not fulfill the function to disambiguate the two readings reliably in the groups of children. This finding contradicted the expectation formulated for prosody in Hypothesis (H3c) but supports the assumption that children do not use the visual context as disambiguating factor formulated in Hypothesis (H5c). Thus, the results obtained for children and adults in these respects were in accordance with Hypothesis (H7) claiming that children and adults differ in their interpretation of unambiguously marked relative clauses.

A comparison of the two appositive conditions served to evaluate the influence of the discourse particle as a lexical marker for appositive interpretations. When the discourse particle was present, 18 adults instead of 10 mastered appositive readings. Moreover, three to four children more in each age group from age 4 onwards reached the mastery criterion for appositive readings when the lexical marker was present. These data showed that the lexical marker served as a disambiguating cue for adults and also partially for children in Experiment 3. Thus, the data is in accordance with Hypothesis (H4a)

for adults. For children, however, the corresponding Hypothesis (H4c) assuming that children do not use discourse particles as disambiguating factor receives partial support. These results are discussed in more detail in the following subsection.

Hypothesis (H7) claims that children and adults differ in their interpretation patterns of unambiguously marked relative clauses. With regard to this hypothesis, Experiment 3 does not give a uniform answer. For restrictive relative clauses, the interpretation patterns of children at the age of 4 to 6 and those of adults were very similar. For appositive relative clauses, children and adults differed as mentioned above. Furthermore, children at the age of 3 differed in their interpretation patterns from older children as well as from adults. This aspect is addressed after the next subsection.

7.4.1. Influence of the discourse particle *ja*

As reported above, differences were found for the amount of appositive interpretations between the conditions with and without the lexical marker *ja* for children and adults. Overall, the acceptance rates in the acceptability task were higher for appositive relative clauses when the discourse particle was present. The statistical tests, however, yielded conflicting results for the groups of children. When the performance was compared across the two conditions within each age group, no significant differences were found in 4- to 6-year-old children. In contrast, when the acceptance rates were compared against chance performance, the conditions patterned differently from each other. While appositive relative clauses were accepted at chance level when the group performance was analyzed, appositive relative clauses with the lexical marker were accepted above chance level. These findings may suggest that the discourse particle functions as a cue for appositive readings in children.

The individual analysis showed that this increase was due to the performance of 13 children. They accepted appositive relatives with the discourse particle *ja* but performed at chance level for appositive relative clauses without the lexical marker. In Experiment 2, only one child adapted her interpretation strategy when the discourse marker pointed to an appositive reading. The increase of influence of the discourse particle between the two Experiments may be due to the change of method on the one hand but could also result from the interplay of prosody and the visual context on the other hand. In Experiment 2, the visual contexts were ambiguous. The arrangement of the objects offered different pictures for restrictive and appositive interpretations. Thus, children could favor a restrictive reading, when the appositive reading was more difficult for them to derive. In Experiment 3, all three cues prosody, visual context, and discourse particle pointed to the same reading. In addition, no alternative reading was visually salient. The multiple cues may have facilitated the derivation of an appositive reading and may have led to higher acceptance rates than when only prosody and visual context disambiguated the clauses.

Evidence that the presence of the lexical marker may have had a more far-reaching effect in the groups of children came from their spontaneous comments. For appositive relative clauses without the lexical marker, 40 children expressed that they intended a restrictive reading of the stimulus sentence in 191 of the items. For appositive clauses

that contained the discourse particle, only 17 children verbalized in 52 items that they interpreted the stimulus sentence restrictively. This advantage for appositive relative clauses in the condition with the lexical marker, however, has to be interpreted with care. It could have been an experimental artifact. The items of the condition with *ja* were presented subsequently to appositive relatives that were disambiguated only by prosody and visual context. At this point of the experiment, children may have been tired to argue that the puppet's request did not make sense. They may have accepted the picture selection matching an appositive reading although they could not derive the reading. Further experiments are needed to investigate this finding in more detail.

Taken together, the data of this experiment may overestimate the children's semantic knowledge in the appositive condition with the discourse particle *ja* due to the lower amount of comments. However, as long as this is not proven by follow-up experiments, there is evidence that the discourse particle could be used as a cue for an appositive interpretation at least by 13 out of 71 children between age 4 and 6.

For the remaining children, different reasons could be responsible for the finding that the discourse particle did not have the expected effect on the interpretation of relative clauses. As discussed in Experiment 2 (see page 231), the meaning of the discourse particle might not have been acquired in the age range tested in Experiment 2 and 3. Although the children used the discourse particle in their own productions in both experiments reported here, they may not yet have a target-like interpretation of this lexical element as a modifier of propositions or sentence types. Also in Experiment 3, children used the particle in their explanations why an appositive reading for a sentence was not possible. For an example, see the comment in (11).

(11) Comment to an appositive relative clause test item indicating a restrictive reading

Caru: Nimm die dritte Hose, die rosa ist, und leg' sie in den Koffer.
Child: Er soll die Dritte nehmen, es gibt aber keine dritte Rosane. Er hat zwar ne Rosane genommen, aber er konnte keine Richtige nehmen, weil es ja keine dritte gab. Er konnte es nur falsch machen.

Caru: *Take the third trouser, which is pink, and put it in the suitcase.*
Child: *He is supposed to the third one, but there is no third pink one. Yes, he took a pink one, but he could not have taken a right one because the is no third one. He could only make it wrong.*

04_NFS117, age 5;1

Moreover, like in Experiment 2, children often omitted the discourse particle when they repeated the sentence before they made their judgements. Furthermore, one child at the age of 4;3 asked explicitly why the particle was used (*Warum "die ja grün ist"?* 'Why 'that/which PRT green is?'). The omissions suggest that the children could not integrate the discourse particle in their mental representation of the clause. Only five children out of all 115 participants repeated the discourse particle at least once when they repeated the stimulus sentence. A repetition of the discourse particle, however, did not lead to an acceptance of the appositive reading in all of the items.

Taken together, the results of Experiment 3 were in line with the results obtained in Experiment 2 with regard to the influence of the lexical marker. The data indicated that the meaning of the discourse particle *ja* had not been fully acquired by the majority of children between the age of 4 and 6 years. When the discourse particle had not yet been represented semantically as a modifier of propositions or speech acts, it is not surprising that the majority of children did not use this cue as an indicator of an appositive reading. Further studies are necessary to investigate the acquisition path of the lexical marker in more detail.

For adults, the presence of the discourse particle in unambiguous visual contexts led to acceptance rates of 92% for appositive readings compared to 75% in the condition without the discourse particle. Compared to Experiment 2, the lexical marker worked as expected in the control group of the acceptability task. Only two adults did not accept appositive readings in this condition above chance level. The differing results obtained in the experiments using different methods point to a strong influence of interpretation preferences. When a restrictive preference was ruled out by the task and multiple cues biased towards an appositive reading, this interpretation could be derived in the control group. Based on these results, the assumption formulated in Hypothesis (H4a) that adults use the discourse particle as an indicator of appositive readings can be confirmed for the control group. In the next subsection, the surprising results of children at the age of 3 are addressed.

7.4.2. Appositive interpretations of relative clauses at the age of 3

This is the only experiment in this thesis in which 3-year-old children were included in the sample. Out of 28 children, 6 performed target-like in the control condition testing the non-intersectivity of ordinal numbers. The results of the control condition showed that children starting from the age of 3;6 interpret the ordinal numbers *zweite/r/s* 'second' and *dritte/r/s* 'third' correctly as semantically complex, non-intersective nominal modifiers.[3] In the relative clause conditions, these six children differed in their performance from children at the age of 4 and older. In contrast to all other age groups, the youngest participants accepted appositive but not restrictive relative clauses above chance level as a group. The predominance of appositive readings was further corroborated on an individual level and by the comments some of the children made. On an individual level 4 out of the 6 children mastered appositive readings but stayed at chance level for restrictive readings. Moreover, for items of the restrictive condition the four children rejected incorrect picture selections in at least 5 out of 6 items. Correct picture selections in contrast were only accepted 2 to 4 times per participant in the restrictive condition. These data showed that a general *yes*-bias could be ruled out as a source for the interpretation pattern in this group. The comments and actions of three children show that they counted objects independently of the color. One child at the age of 3;6 pointed in three items to the object matching an appositive interpretation before the robot selected a picture.

[3]The six 3-year-olds with mastery in the control condition Non-intersectivity were 3;6, 3;7, 3;7, 3;10, 3;11and 3;11 years old.

Furthermore, two children indicated their appositive interpretations for restrictive test items. This is illustrated in (12) and (13).

(12) Comment to a restrictive relative clause indicating an appositive reading (I)
Visual context:

1 2 3 4 5 6 7
selected

Caru: Nimm die zweite Jacke, die schwarz ist, und leg' sie in den Koffer!
Child: Das is die dritte.
Exp: Hat der Robbi das Richtige genommen?
Child: Das is schwarz aber die dritte.
Exp: Also hat er das Richtige genommen?
Child: Nein. Er sollte die zweite nehmen.

Caru: *Take the second jacket that is black, and put it in the suitcase!*
Child: *That is the third one.*
Exp: *Did Robbi take the right one?*
Child: *This is black but the third.*
Exp: *So, did he take the right one?*
Child: *No. He should have taken the second.*

04_JCL420, age 3;10

(13) Comment to a restrictive relative clause indicating an appositive reading (II)
Visual context:

1 2 3 4 5 6 7
selected

Caru: Nimm die dritte Ente, die bunt ist, und leg' sie in den Koffer!
Child: nein, hier (points to object no. 5) ist die dritte Ente.

Caru: *Take the third duck that is multicolored, and put it in the suitcase!*
Child: *No, here (points to object no. 5) is the third duck.*

04_GEB155, age 3;11

Thus, it needs to be explained why the four children at the age of 3 showed this complementary pattern compared to the older children. These children were able to derive a representation that corresponded to an appositive reading but at the same time, they could not derive a representation that led to a restrictive interpretation of the

stimulus. The remaining two children at the age of 3 did not reach any mastery criterion because they did not reject items with an incorrect picture selection reliably.

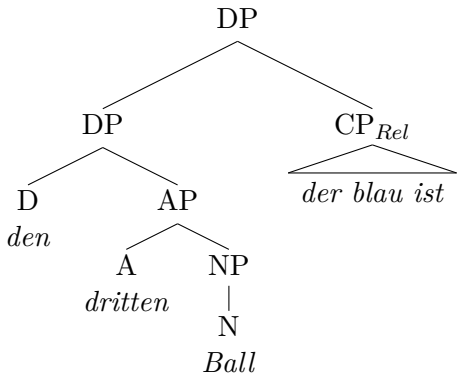
The proportions of this pattern, appositivity only, decreased with age. Two thirds of the 3-year-olds, one third of the 4-year-olds, one fifth of the 5-year-olds and less than one sixth of the children at the age of 6 accepted only appositive readings of relative clauses. In contrast, the acceptance of restrictive relative clauses increased with age. Interestingly, in the group of children without mastery in the control condition Non-intersectivity a similar tendency was observed. Three children at the age of 3 and 10 children at the age of 4 mastered appositive relative clauses, i.e., they accepted and rejected items with correct and incorrect pictures target-like. In contrast, mastery of restrictive relative clauses but chance performance for appositive relative clauses was documented for only one child at the age of 3. These children did not reach the mastery criterion in the control condition, i.e., they did not show stable acceptance and rejection patterns on items testing ordinal numbers. The results for the appositive relative clause conditions, however, showed that later in the experiment, some of them were able to reject incorrect picture selections reliably. Like the four 3-year-olds with mastery in the control condition, the 13 children up to age 4 seemed to be able to arrive at a semantic representation that corresponded to an appositive reading. Restrictive readings, however, could not be derived by this group of children.

As reported in Chapter 2, formal approaches on the syntax and semantics of relative clauses propose that restrictive and appositive relative clauses are either of the same complexity or that appositive relative clause involve a more complex derivation than restrictive ones. Results on language processing suggest, too, that due to their higher attachment appositive relative clauses may be the more complex linguistic structure. On the basis of the theoretical assumptions, it is surprising that children at the age of 3 show mastery of appositive readings before restrictive interpretations of relative clauses. If 3-year-old children were able to derive an appositive representation the adult-like way – including a propositional analysis as proposed by Del Gobbo (2003) or as an presupposition like in the analysis proposed by von Stechow (2007) – it is an open question why the preference and acceptance for appositive readings decreased in children at the age of 4 to 6. In addition, it is unclear for what reasons older children actively rejected appositive readings when they had to judge the corresponding picture choices. These observations suggest that the 3-year-old children in Experiment 3 arrived at a reading corresponding to an appositive interpretation by different means than the older children and adults. This assumption is also supported by the distribution of children with mastery for appositivity across age groups, which drops from age 3 to age 5 before it rises again.

Different proposals may account for the high rates of appositive interpretations and the simultaneous lack of restrictive interpretations at the age of 3. For instance, they may be due to an incorrect, high attachment of the relative clause or to processing strategies such as an early selection of a referent. These two options are spelled out in the following.

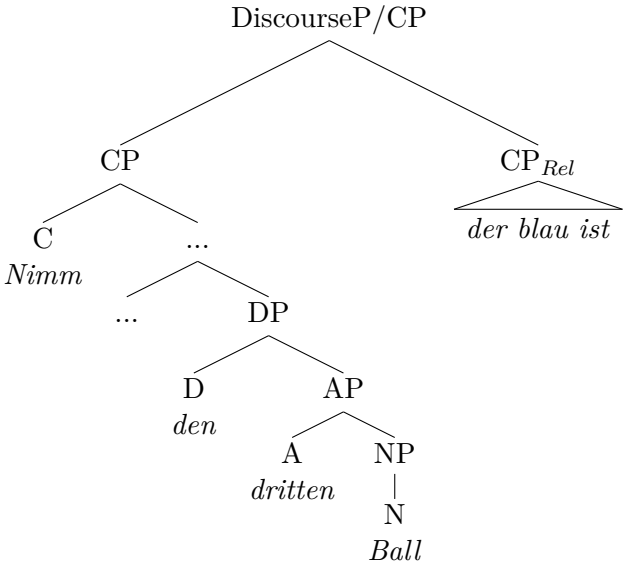
The syntactic target structure proposed in the literature for an appositive relative clause is displayed in (14). The relative clause is adjoined at the DP-layer.

(14)



Instead of integrating the relative clause into the preceding matrix clause, children might close the initial CP earlier and begin a new sentence when they encounter the relative clause. This high attachment as a separate sentence is illustrated in (15).

(15)

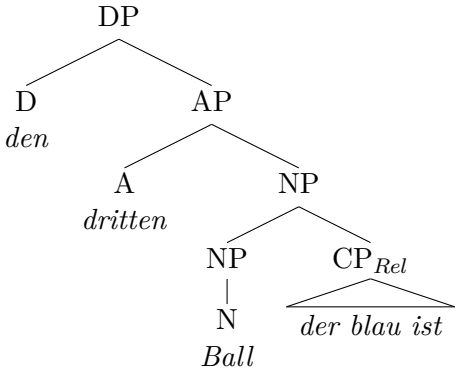


This analysis may be chosen because the theta grid of the verb *nehmen* 'to take' is satisfied when the noun *Ball* 'ball' is processed. That is, all necessary elements are present to close the object DP and the main clause in general. Additionally, the pause between the head noun and the relative clause in items of the appositive condition may favor the postulation of a new sentence. This structure would be interpreted like two subsequent main clauses: *Take the third ball. (And) that is blue.* This sequence would lead to a selection of the third ball overall independently of the color, which is comparable to the result of a true appositive derivation like in (14). Interestingly, the structure in (15) is reminiscent to the one proposed by Del Gobbo (2003, 2007) for appositive relative clauses at LF. The relative pronoun would be interpreted as a referential discourse anaphora and the relative clause would constitute an independent proposition. In (15), this representation is achieved without movement at LF, the relative

clause is detached from its head noun already in the syntactic representation. However, the verb placement within the relative clause CP would contradict the main clause analysis in (15). The finite verb appears in sentence final position. This cue may trigger the integration of the relative clause into the matrix clause at a later point in the acquisition process, a prerequisite for a proper appositive structure like (14).

An alternative derivation to yield an appositive-like interpretation is described in the following. Previous research has shown that the working memory capacity of children is reduced compared to that of adults. To avoid working memory load, children may start with the interpretation process as soon as possible in an incremental, linear fashion. In contrast to adults, children may not have enough working memory capacity to delay the search for a referent until they are sure that no restructuring has to apply to the initial syntactic representation. Instead, they may directly start to interpret the structure that is initially built up. An incremental processing may lead to a selection of the third ball when the head noun is processed. After the pause, the relative clause is integrated. Following the principle of Late Closure, the structure in (16) would be derived as initial parse tree.[4]

(16)



For adults, the structure in (16) would lead to a restrictive interpretation. When children, however, directly interpret the noun phrase before the relative clause is attached, a singleton set containing the referent for the *third ball* would be selected. Then the relative clause would be integrated into or at the NP. The predicate of the relative clause may be combined with the single element denoted by the *third ball*. Both predicates may be combined via the predicate modification rule. This composition would lead to a conjunction of the color information and the referent of the head noun. Again the interpretation *Take the third ball. (And) that is blue* would be derived, although a restrictive structure was the basis for the derivation.

When this derivation is pursued by a child, all prerequisites to derive a restrictive interpretation are in place. The only missing component would be the ability of the child to wait with the interpretation of the noun phrase until she is sure that no subsequent modifiers appear in the acoustic input stream. Semantic approaches assume that such a

[4]Note that the account proposed here does not depend on the assumption that the relative clause is integrated as an adjunct or argument. Both possibilities may lead to the same non-target interpretation, when the head noun is interpreted without taking the relative clause into account.

derivation, a predication on a singleton set, is ruled out due to a pragmatic constraint. It is assumed that a singleton set cannot be further restricted. It may, however, be conceivable that children at the age of 3 do not yet adhere to this pragmatic principle to rule out illicit semantic compositions.

When children follow either one of the two derivations above, an appositive-like interpretation of the relative clause would be the only possible reading these children could derive. Restrictive picture selections would not be correct according to their internal semantic representation. This has been demonstrated by the comments of two of the children. These proposals are taken up again in Section 8.2 of the general discussion when the model how children acquire the semantics of relative clauses is discussed in more depth. The following subsection addresses a different topic. It discusses some consequences of the chosen design of Experiment 3 and proposes modifications for additional experiments.

7.4.3. Remarks on the design

This section focuses on the use of unambiguous stimuli in the experiment and the consequences on the results and on the interpretation of the data. Based on this discussion, recommendations for further experiments are formulated.

The aim of this task was to investigate whether children accept appositive interpretations of relative clauses although these readings may not be the preferred interpretation of the participants. The results of Experiment 1 and 2 demonstrated that children and adults showed a strong preference for restrictive interpretations when they could choose a reading on their own. The design of Experiment 3 tried to reduce the influence of interpretation preferences on the judgement task. To prevent interpretation preferences to overwrite the displayed target reading, an unambiguous visual context was chosen for all items of the relative clause conditions. As a consequence, the visual context did not match any alternative reading. This construction of the visual context was supposed to rule out rejections due to a salient visual option of an alternative reading. If the context was ambiguous and matched both a restrictive and an appositive reading, participants could have rejected a reading by arguing *'No, Robbi should have taken this object'*.

Thus, the design of Experiment 3 forced the participants to judge the coherence of a specific picture selection with their mental representation of the puppet's request. As the results showed, this was an unproblematic task for relative clauses in the restrictive condition. For items of the appositive relative clause conditions, however, the use of an unambiguous visual context led to unforeseen problems in the group of children. For children without access to the appositive interpretation, items in the appositive condition did not simply constitute an instance of an incorrect picture selection. Instead, these items caused presupposition failures. Without access to the appositive reading, it was not possible to judge the truth or falsity of the robot's selection because the request itself could not be fulfilled. A differentiation between the correct acceptance of an appositive reading and the acceptance due to a presupposition failure was only possible when a child explained her judgements. Since in this experiments justifications for judgements were not elicited systematically, it remains open to which extent the observed acceptance

patterns reflect the knowledge to derive an appositive semantic representation. It may be the case that the actual ability to interpret relative clauses appositively is overestimated in the group of children.

This problem is a consequence of the unambiguous visual context. As one way out of this infelicitous situation, the 'no matching picture' button could be used. The option to explicitly state that the request could not be fulfilled had not been implemented in the design because the possibility of a presupposition failure was not considered. It was expected that participants who cannot derive a specific reading would judge the corresponding picture selection as not matching the pre-recorded request. This is how some of the adults reacted in the appositive condition.

An alternative way to circumvent the occurrence of a presupposition failure is offered by the classical design of a truth value judgement task (TVJT). According to recommendations how to design a TVJT, both readings of a sentence should be available in the context (Schmitt & Miller, 2010; Gordon, 1996). Moreover, both readings should be possible outcomes of a lead-in sentence or story to the test items. As Schmitt and Miller (2010) notes, such a design, however, may lead to exactly the problems of preferences that were the motivation for an unambiguous visual context in the present experiment. Schmitt and Miller (2010, p. 37) states that

> "although, it is assumed in the literature (Crain & Thornton, 1998) that the TVJT always taps into more than a preference, this is not always the case. When there are two possible interpretations, depending on details of the set-up, adults may or may not be biased towards one of the interpretations, which of course does not mean that they have an impaired grammar".

Furthermore,

> "if one of the interpretations is not plausible, subjects may not even consider the ambiguity. In other words, we will get the preferential reading dictated by the context, which may or may not be the default or less complex interpretation. It will be very dangerous to infer from there that the child does not have the alternative interpretation" (Schmitt & Miller, 2010, p. 50).

Thus, when the visual context would be ambiguous, the confound of unexpected reactions caused by a presupposition failure could be avoided. However, as stated in the latter quote, an ambiguous context may not hinder a bias towards restrictivity hiding the actual competence of the participants to derive appositive interpretations. The spontaneous comments of the adults displayed in (8) on page 267 suggest that such a bias existed in Experiment 3. Moreover, the comments showed that at least for five adults the unambiguous visual context was the relevant cue to overcome this bias for restrictivity. The comments in (8) demonstrated that the adults recognized the ambiguity of the stimuli. Furthermore, they showed that the participants derived a restrictive interpretation initially but adapted their judgements when they noticed the conflict of their interpretation and the visual context.

As pointed out in the second quote from Schmitt and Miller (2010), different reasons may lead to a bias in the experimental design. For Experiment 3, semantic complexity

and/or processing routines as well as the experimental context could be put forward to explain such a bias for restrictivity.

The reactions of the adults were reminiscent of a garden-path phenomenon. Initially, a restrictive reading of the stimulus had been derived. Then the participants revised the representation when they noticed the mismatch of their interpretation and the visual context. No comparable comments on revisions had been found for the children in this experiment. Unlike the control group, the children's comments and acceptance patterns showed that they maintained the restrictive reading when they perceived a presupposition failure. To account for very similar findings in Experiment 1 and 2, I argue in favor of a processing explanation. When the relative clause is attached locally according to the principle of Late Closure, a structure matching a restrictive reading would be constructed first. For an appositive reading, further movements would be required to attach the relative clause at a position higher up in the syntactic tree. The same reasons may be responsible for the finding observed for the adults to start out with a restrictive interpretation of the clause. The missing effect for children could also be due to processing factors. Also this aspect had been discussed in the previous chapters. The results of Trueswell et al. (1999) and subsequent studies on the attachment of PPs in locally ambiguous contexts (see Section 3.3) showed that children may not be able to revise their initial structural representation although the visual context is not in accordance with the resulting interpretation. In the acceptability task reported here, the child seemed to encounter the same problem. Based on contradicting information coming from the visual context, adults but not children were able to change their initial interpretations.

As Schmitt and Miller (2010) pointed out, the interpretation favored due to an experimental bias does not necessarily have to be the less complex interpretation. Also the context can induce a bias strong enough to discard all other potential interpretations. In Experiment 3, the context cannot be excluded as a factor inducing a restrictive bias. As discussed in Section 4.2, the use of the imperative and the selection task itself may have established a pragmatic bias towards a restrictive reading in this experiment. Based on the Grice's conversational maxims, all information delivered by the stimulus sentence could be assumed to be informative. The color information within the relative clause, however, would only be informative with a restrictive interpretation of the clause. With an appositive interpretation, the color information would just be an additional remark and would not be used to select the denoted referent. Thus, restrictive readings of the relative clauses could be favored due to pragmatic reasonings of the participants.

Proposals how to adapt the present experiment to explore these aspects are formulated in the following section.

7.4.4. Proposals for further experiments

In Experiment 3, unambiguous visual contexts were used with the purpose to reduce the influence of interpretation preferences. The results of this experiment showed, however, that this cue did not help children up to age 6 to access the appositive interpretation reliably. Instead, the data may have been confounded due to false acceptances as a way to deal with presupposition failures. To avoid this confound, a regular truth value

judgement task could be used. According to general recommendations to set up a TVJT (Schmitt & Miller, 2010; Gordon, 1996), both readings should be available in the context. Thus, an ambiguous visual context offering a picture matching both a restrictive and an appositive interpretation of the sentence should be used. In addition, a lead-in sentence should be implemented. In TVJTs the lead-in serves to highlight the two interpretation options as a linguistic context for the test sentence. With regard to our experimental setting, the lead-in sentence could introduce openly the two ways to cluster the objects. The context sentence could point to the fact that either the general type of objects could be used to form sets, or that color information could be used to form subsets. A potential lead-in sentence is exemplified in (17) for an example test item in (18). The visual context in Figure 7.11 allows a restrictive and an appositive picture selection. The chosen object in the example corresponds to a restrictive interpretation of the test sentence.

(17) Look, in the cupboards are balls and cars. There are one, two, three blue cars and one, two yellow cars. In total, there are one, two, three, four, five, six cars and two sun glasses.

The order of the counting in the lead-in could be varied systematically to make either the subset or the superset more salient. In addition, the prompt could be changed into a declarative sentence. As mentioned in the methods section of this chapter, a prompt in the past tense or present perfect may lead to further complications of the stimuli. However, a descriptive sentence in the present tense would be compatible with the state that is displayed in Figure 7.11b and Figure 7.11c. To yield the order of a prototypical TVJT, the procedure has to be changed. After the lead-in sentence, the robot has to act first. He would take an object out of the cupboard as displayed in Figure 7.11b. Then the puppet frog would interrupt the selection process and describe the action of the robot with a correct or incorrect statement like (19).

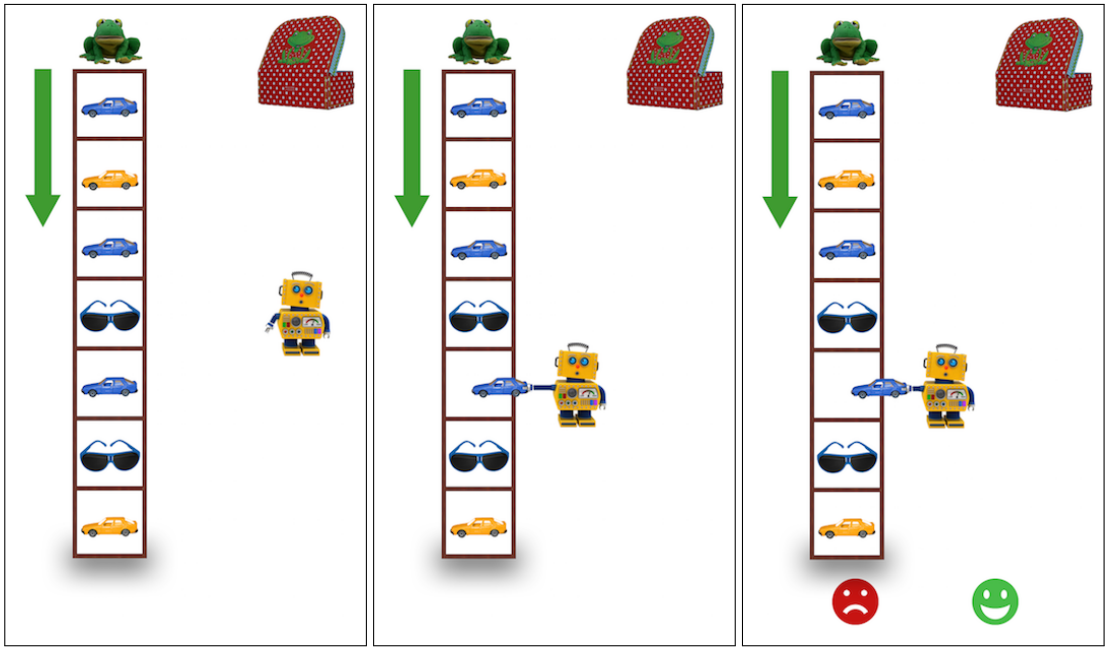
(19) Robbi nimmt das dritte Auto, das blau ist und legt es in den Koffer.
Robbi takes the third car that/which blue is and puts it in the suitcase.

'Robbi is taking the third car$_{(,)}$ that/which is blue$_{(,)}$ and is putting it in the suitcase.'

Alternatively, the puppet could ask a question like *Nimmt Robbi das dritte Auto, das blau ist?* 'Is Robbi taking the third car that/which is red?'. As a description of the ongoing process, the present tense would be appropriate. Thus, it would be possible without further complexity of the stimuli that the child has to judge a declarative sentence or she has to answer a question like in the normal procedure of a truth value judgement task.

This modification could also be informative with regard to the question whether a pragmatic bias facilitates restrictive interpretations. The declarative sentence may reduce the pragmatic bias for restrictive relative clauses hidden in the selection task. In the declarative version a discourse referent would have been introduced by the object

(18) Nimm das dritte Auto, das blau ist, und leg' es in den Koffer!
Take the third car that/which blue is and put it in the suitcase
'Take the third car that is blue and put it in the suitcase!'



(a) Before picture selection. (b) Picture selection. (c) Judgment.

Figure 7.11.: Exp. 3 – Example test item for a truth value judgement task.

selection of the robot. The declarative statement follows this selection and would be naturally evaluated with regard to the selected object. As a consequence, it would be pragmatically more appropriate that the description of the action contained additional, redundant information. If a pragmatic bias and not processing routines are the reason for the restrictive preference observed in the experiments of this thesis, a reduction of the pragmatic bias due to the use of a TVJT should facilitate the access to appositive readings.

With these modifications of the procedure, it would also be possible to include follow-up questions in a systematic way. The puppet frog could ask after every second or third item why the child says that his statements are right or wrong. It would be easy to motivate the questions in the background story. A possible scenario could be the following. The puppet frog cannot speak German very well and asks the child for help to improve its language skills. Therefore he asks for reasons why he said things right or wrong. The follow-up questions could elicit explanations for the judgements of the participants that allow a more systematic evaluation than the spontaneous comments in the present experiment.

7.5. Conclusion

The third experiment of this thesis investigated whether restrictive and appositive interpretations of relative clauses are accepted by 3- to 6-year-old German-speaking children and by adults. To my knowledge, this experiment was the first in acquisition research investigating the availability of restrictive and appositive relative clauses systematically. The experiment used a design similar to those of the preference tasks reported in the previous two chapters. Instead of choosing an object corresponding to a pre-recorded restrictive or appositive prompt themselves, children had to judge whether the picture selection of a robot was correct.

The results show that the control group of adults performed target-like. Restrictive and appositive relative clauses were accepted above chance level. In addition, the presence of the discourse particle *ja* as a lexical marker for appositive interpretations led to higher acceptance rates of appositive relative clauses. Children between the age of 4 and 6 in contrast, accepted only restrictive relative clauses between 80% and 94% of cases correctly. Appositive relative clauses were accepted only at chance level. The presence of the discourse particle led to an increase in the children's performance to accept appositive readings above chance level but the overall rates did not exceed 78%. The individual mastery patterns showed that 28 out of 71 children accepted both readings systematically. In addition, 15 out of 20 adults performed target-like and accepted both readings. Three-year-old children, on the contrary, accepted only appositive readings of relative clauses, for restrictive relatives, the six children were at chance level as a group and on an individual level.

The results for the 4- to 6-year-old children and adults are in line with the findings from the picture selection tasks reported earlier. Restrictive interpretations were judged more often correctly than appositive ones. However, both semantic functions were attested from the age of 4 onwards. In addition, the change of method showed that more children had access to both readings in the acceptability task than in the preference tasks. Interestingly, 3-year-old children showed a complementary pattern compared to the older children. Restrictive interpretations of relative clauses were not yet available to them. A comparison of the distribution of mastery patterns for restrictive and appositive relative clauses showed different patterns for the two semantic functions. While the number of children with mastery of restrictive readings increased, the distribution for appositive readings dropped from age 3 to age 5. Taken together, these results suggest that appositive interpretation of relative clauses in the group of 3-year-olds are not derived from the same formal representation than in older children and adults.

In the following chapter, the results of Experiments 1 to 3 are summarized. In addition to an evaluation of the hypotheses, an account for the acquisition path of restrictive and appositive relative clauses is proposed in Section 8.2.

8. General discussion

This thesis focuses on the acquisition of restrictive and appositive relative clauses. Three experiments were carried out as a first step to investigate the acquisition of the two semantic functions empirically. Two studies investigated interpretation preferences for relative clauses and found a predominance of restrictive readings in 4- to 6-year-old German-speaking children as well as in adults. The third experiment tested the acceptance of the two semantic functions of relative clauses in 3- to 6-year-old children and adults. While 3-year-olds accepted only appositive readings of relative clauses, both readings were available for children at the age of 4 and older.

This chapter aims to integrate the theoretical and empirical observations on restrictive and appositive relative clauses reported in this thesis. The experimental findings described in Chapters 5, 6, and 7 are discussed in light of the theoretical background of Chapter 2 and the previous findings from acquisition studies in Chapter 3. Based on these findings, a model for the acquisition of restrictive and appositive relative clauses is proposed.

This chapter is structured as follows. Section 8.1 links the empirical findings to the research questions and hypotheses formulated in Chapter 4. Based on the empirical findings, a model is proposed in Section 8.2 of how children acquire restrictive and appositive relative clauses. Further implications of the empirical results and the acquisition path are discussed in Section 8.3. Section 8.4 focuses on the acquisition of ordinal numbers as an additional result of the experiments conducted for this thesis. The chapter closes with a summary of the discussed topics in Section 8.5.

8.1. Addressing research questions and hypotheses

The experimental part of this thesis comprised three experiments, two picture selection tasks and an acceptability study, to address the central research question of this thesis formulated in (Q): How do typically developing German-speaking children acquire the semantic functions *restrictivity* and *appositivity* of relative clauses? To my knowledge, the experiments reported here are the first to study the interpretation of restrictive and appositive relative clauses in detail.

Importantly, the term *appositive relative clause* is used in this thesis in the sense of Holler (2005). It refers to non-restrictive relative clauses with a nominal antecedent that do not establish a continuating discourse relation or a maximalization reading with regard to their antecedents. Restrictive relative clauses serve to identify and to restrict the referents denoted by the head noun. Appositive relatives, in contrast, add information on an already identified referent. Thus, the two types of relative clauses differ in the type of head nouns they can be attached to.

The crucial aspect of the experimental design constitutes the interaction of an ordinal number word and the interpretation of the relative clause. This idea dates back to Roeper (1972) and Matthei (1979) studying the interpretation of sequences of adjectives. The scope of the ordinal number reveals whether the relative clause had been attached restrictively at the NP-level or whether it had been attached higher up at the DP shell. All experiments reported here used stimuli like the one in (1). In combination with visual contexts like the one in Figure 8.1, it was possible to explore the interpretation that children derived for the stimulus sentences.

(1) Nimm das dritte Auto, das rot ist, und leg' es in den Koffer!
Take the third car which red is and put it in the suitcase

'Take the third car$_{(,)}$ that/which is red$_{(,)}$ and put it in the suitcase!'

Figure 8.1.: Exp. 1-3 – Ambiguous visual display to test the interpretation of relative clauses.

With regard to the sentence in (1), a picture selection of object no. 6 indicates a restrictive reading of the relative clause. An appositive interpretation would result in a picture choice of the object at position no. 4. The visual context displayed in Figure 8.1 is also compatible with a third, ungrammatical reading of the stimulus sentence. When the ordinal number is interpreted as an intersective modifier, the third object overall could be selected. This interpretation could be paraphrased by an intersection of all three properties *The thing that is third and a car and red.* Therefore it is labeled as an *intersective* reading. To exclude children with this non-target reading of ordinal number words, a control condition was included in all experiments of this thesis to test the interpretation of sentences like *Take the second/third X and put it in the suitcase.* In the following, the results of Experiments 1 to 3 are discussed with regard to the research questions and hypotheses of this thesis.

The first two experiments aimed to answer research question (Q1) asking: Which interpretation of syntactically and contextually ambiguous relative clauses is preferred at a given age? The results of Experiment 1 and 2 for children between age 4 and 6 as well as for adults showed a strong preference for restrictive readings of relative clauses like *Take the third car$_{(,)}$ that/which is red.* This preference is found within the group data and is mirrored by the results of an individual analysis. The preference for restrictivity is in line with Hypothesis (H1) claiming that restrictive interpretations are preferred over appositive interpretations. This hypothesis had been motivated by assumptions about structural complexity from semantics, syntax, typology and human

language processing. The finding that restrictive interpretations are clearly preferred corroborates the assumption that a less complex representation would be preferred over a more complex one. Furthermore, this finding supports the syntactic and semantic analyses to account for restrictive and appositive readings of relative clauses.

The majority of syntactic approaches does not make clear predictions with regard to the degree of complexity associated with the two semantic functions. However, the different syntactic representations for restrictive and appositive relative clauses, attachment at NP or DP, allowed predictions from a sentence processing perspective. A restrictive but not an appositive syntactic structure would be in accordance with the initial syntactic parse tree derived from an incrementally working parser. This assumption is confirmed by the results reported here. Four- to six-year-old children as well as adults derive restrictive interpretations without effort and this interpretation is not reconsidered in general when the prosodic format or visual context of the stimuli favor an appositive interpretation. These aspects will be addressed in the discussion of research question (Q3) below. Furthermore, the comments of the adults revealed that a restrictive interpretation is preferred even when the participants noticed the ambiguity of the stimuli. To derive the syntactic structure for an appositive interpretation, the relative clause cannot be integrated in the syntactic phrase, the NP, that is processed at the moment when the relative clause occurs. In contrast, the relative clause has to be moved to a position higher up within the parse tree to attach at the DP shell. This reanalysis seems to be avoided whenever possible by children and adults. Thus, the strong preference for restrictive readings found in the first two experiments of this thesis are well accounted for by the interaction of syntactic assumptions and processing principles.

Additionally, the preference for restrictive readings supports the assumptions from semantic theory regarding restrictive and appositive relative clauses. Independently of the semantic account, restrictive relative clauses are analyzed as predicates of type <e,t> that attach to the noun phrase, which is also of type <e,t>. A low, restrictive attachment of the relative clause can be interpreted by applying the predicate modification rule to combine the two elements of type <e,t>. This composition rule is independently motivated, for instance to account for the interpretation of adjective-noun sequences that are found very early in children's multi-word utterances. In addition, the ability to interpret restrictive relative clauses target-like demonstrates that the abstraction operation within restrictive relative clauses can already be computed by children. More difficult and complex composition rules have been postulated for appositive relative clauses. The preference for restrictive readings in both children and adults may be taken as evidence that the additional complexity of appositive relatives is avoided whenever possible.

Across experiments, the percentages of appositive picture selections were similar. In addition, the results reported here for relative clauses correspond to the rate of appositive picture selections in the tasks testing two prenominal modifiers (e.g., Hamburger & Crain, 1984). Both for adjectives and for relative clauses about 25% of the readings at group level were appositive. This may point to the fact that the mechanisms to compose appositive readings are not limited to one of the two phenomena, but that the preference for restrictive readings that is found for relative clauses may also hold for the interpretation of adjectives. Moreover, the results of this thesis are in line with the

preferences reported by Schubö et al. (2015) for German-speaking adults. Schubö et al. showed that one third of the participants in a perception task interpreted all relative clauses restrictively independent of the prosodic contour of the stimuli.

In the second experiment, six children and one adult showed a preference for appositive interpretations in all conditions. Three of the children were 4-year-olds. As a start, this pattern contradicts Hypothesis (H1) and the overall finding that the grand majority of participants in both experiments using the picture selection method favored restrictive interpretations. As will be discussed with regard to research question (Q2), I propose that appositive-like interpretations are derived by young children based on a non-target-like syntactic integration of the relative clause. As soon as relative clauses can be integrated within the matrix clause, the preference for restrictivity is found.

In addition to interpretation preferences, research question (Q2) asked which interpretations of syntactically and contextually unambiguous relative clauses are accepted at a given age. Experiment 3 was designed to address this question. The null hypothesis was formulated in (H2): Participants can derive restrictive and appositive interpretations for relative clauses. This hypothesis is based on the assumption that restrictive and appositive relative clauses have different formal representations. In addition, I do not assume that the truth conditions of restrictive and appositive relative clauses necessarily stand in an entailment relation as proposed by Frosch (1996) and that one reading is derived from the other. Therefore, in principle, both readings may be acquired independently of each other.

The results of Experiment 3 support Hypothesis (H2) only partially. Four findings need to be considered with regard to this hypothesis. First, 3-year-old children accepted only appositive interpretations of relative clauses, thus, falsifying Hypothesis (H2). Second, for 4- and 5-year-old children, the hypothesis is confirmed at a group level, but only partially when the individual acceptance patterns are considered. The majority of children in these age groups mastered restrictive but not appositive relative clauses on an individual level. Third, for 6-year-olds and adults, Hypothesis (H2) is confirmed for the majority of the participants also at the individual level. However, fourth, appositive but not restrictive interpretations are rejected above chance by one fourth of children between the age of 4 and 6. In sum, compared to the number of participants that mastered both semantic functions, about the same number of participants showed mastery for only one of the readings across all age groups. Thus for children below age 6 these observations do not corroborate the assumption that both semantic functions of relative clauses are present in parallel.

The results of Experiment 3 could lead to the conclusion that appositive interpretations are acquired before restrictive interpretations. However, this inference cannot be fully supported by the data. The results of the acceptability task show that the proportion of participants accepting only appositive interpretations decreased with age. In contrast, the number of children accepting only restrictive interpretations of relative clauses increased. Like in Experiment 2, the younger participants of the sample showed higher rates of appositive interpretations than the older children. When appositive readings are derived initially and are acquired before restrictive readings, it would be an open question why the acceptance of appositive readings dropped at the age of 4 and

5 before it rose again at the age of 6. Furthermore, the high acceptance rates of appositive interpretations in 3- and 4-year-old children are incompatible with the finding that appositive readings are rejected above chance by some children starting at age 4. The data of Experiment 3 points to the fact that appositive interpretations are the only interpretation possible for 3-year-olds, but the data also suggests that this reading is not available anymore for the majority of children between 4 and 5 years.

Moreover, the assumption that appositive readings are acquired before restrictive interpretations is questionable from a learnability perspective and from observations from formal linguistics. It is questionable why the competence of the complex semantic derivation of appositive readings is found for children lacking the simpler and independently motivated composition rule for restrictive relative clauses. Although a preference for restrictivity may develop at the age of 4, it would be an open question why children at this age then reject appositive interpretations in the acceptability task. Moreover, based on assumptions from semantic theory and processing, rather the opposite expectation – acquisition of restrictivity before appositivity – would be motivated. From a semantic perspective, it seems plausible that restrictive readings are acquired first. To derive appositive readings for relative clauses, children have to learn a new modification rule specific to this structure (the Principle of Independent Computation associated with covert movement of the relative clause at LF in the approach of Del Gobbo, 2003, 2007, or, the derivation of a presupposition according to von Stechow, 2007). As long as this additional rule has not yet been acquired, restrictive but not appositive interpretations could be derived. It can be assumed that the rule of predicate modification necessary for restrictive relative clauses is already acquired to interpret adjectives in the nominal domain. Also observations from child processing may suggest that restrictive readings are acquired before appositive ones. As described with regard to research question (Q1), the structure of the initial parse tree would be compatible with a restrictive reading. To derive the syntactic structure as a basis for an appositive interpretation, the position of the relative clause has to be reanalyzed and the relative clause has to be moved to a new position higher up in the tree. Previous research showed that such a structural reanalysis is very difficult for children up to age 8. Thus, even when the semantic concepts to derive appositive interpretations would be in place, processing difficulties could delay the access to this reading in comprehension up to a later age. Furthermore, typological arguments based on the cross-linguistic availability of the two readings suggest that either both readings are acquired together, or only a restrictive reading is available to the children at some point in the acquisition process (Hawkins, 2007). Taken together, the acquisition of appositivity before restrictivity seems implausible due to several factors. In addition, the finding that the amount of appositive judgments decreased with age within the children's groups leads me to conclude that the availability and acceptance of appositive readings by young children is not the result of a target-like syntactic and semantic composition. Instead, a non-target-like derivation may result in an interpretation that has similar truth conditions compared to the true appositive interpretation. Different proposals to account for appositive-like interpretations in young children will be discussed in Section 8.3.2.

When the early occurrences of appositive readings are explained by non-target deriva-

tions, the answer to research question (Q2) is again open. The observations that both semantic functions are accepted above chance level by 4- and 5-year-old children may speak in favor of Hypothesis (H2) postulating that both semantic functions can be derived by children. The results of the individual analysis, however, weaken this argument. Only one third of the 4- and 5-year-olds mastered both semantic functions. And at the age of 5, more children master restrictive than appositive readings. This could be taken as evidence that restrictivity is acquired before appositivity. The possibility that restrictive readings are acquired before true appositive interpretations could find additional support in the rejection patterns of the children. Rejections of appositive interpretations were only found for children starting from age 4, i.e., at the age when restrictive interpretations emerge. When children can derive only restrictive interpretations, appositive picture selections would be perceived as false. However, this argument is weak since the complementary pattern is not found for children that only accept appositive readings of relative clauses. Although some of the 3-year-olds argued for appositive picture selections, they did not reject restrictive readings systematically.

Taken together, the null hypothesis that both readings are available can neither be clearly rejected nor confirmed on the basis of the data. In addition, arguments can be found for both alternatives, restrictivity before appositivity or appositivity before restrictivity. However, as discussed in Section 8.2 I argue that restrictivity is acquired before appositivity. Further studies are necessary to investigate research question (Q2) in more depth.

Research question (Q3) asks: Do linguistic and contextual cues influence the choice of interpretation? In the three experiments reported here, two linguistic cues, prosody and the presence of a lexical marker, as well as one non-linguistic cue, the visual context, were investigated.

Syntactic approaches frequently assume prosodic differences between restrictive and appositive readings. Therefore, Hypotheses (H3a) and (H3c) were formulated claiming that adults and children use prosody to disambiguate between restrictive and appositive relative clauses. The results of the experiments reported in this thesis do not confirm these hypotheses. The results of Experiments 1 to 3 are the first to show that for children between the age of 4 and 6, prosody does not reliably disambiguate between restrictive and appositive readings. In none of the preference tasks, prosodic differences alone led to a change of the interpretation patterns for more than four children. Moreover, some of the adults noticed the different prosodic contours and identified the ambiguity of the stimuli, but they maintained their restrictive interpretation pattern also for items with an appositive prosody.

These findings are in line with previous research on the influence of prosody as a disambiguating factor regarding the semantics of relative clauses for adults (Auran & Loock, 2006, 2011; Birkner, 2008; Dehé, 2007, 2009, 2014; Döring, 2007; Kaland & van Heuven, 2010; Schaffranietz, 1999; Schubö et al., 2015; Weinert, 2004). Previous studies have shown heterogeneous results for adults and raised doubts about the validity of the assumptions from theoretical syntax (cf., Section 2.5). Both in production and comprehension, the prototypical prosodic formats for the two semantic functions were not found to be used consistently to disambiguate relative clauses. These findings are corroborated

by the data reported here. Thus, the general claim from syntactic theory on the strong impact of prosodic formats cannot be supported by the data of this thesis.

One reason for the missing influence of prosody as disambiguating cue may come from the observation that prosodic phrases tend to be of equal length (Dehé, 2007; Fodor, 1998a; Hemforth et al., 2015). The studies showed that shorter epenthetic material is often included into the previous prosodic phrase to balance the length of the intonation phrases. As a consequence, the prosodic phrasing may not be an unambiguous predictor for the detection of a syntactic boundary. Therefore, children as well as adults may not rely on this cue as strong as it is expected by syntactic theory.

The second linguistic factor explored whether a lexical marker for appositivity influences the choice and acceptance of appositive readings. In German, discourse particles like *ja* or *übrigens* can be used in appositive but not in restrictive relative clauses. They are analyzed as modifiers of propositions or speech acts (see Section 2.4). Their occurrence in appositive relative clauses speaks in favor of a propositional analysis of these relative clauses at some level of the formal representation. So far, no studies have investigated the impact of a discourse particle on the interpretation of relative clauses. Based on the formal analyses of these lexical markers for appositivity, Hypothesis (H4a) proposed that adults interpret relative clauses with discourse particles as appositive modifiers. A different assumption was put forward for children. Hypothesis (H4c) stated that children do not use discourse particles as a marker for appositive interpretations of relative clauses because they may have difficulties to reanalyze an initial, restrictive parse in the course of processing.

Hypothesis (H4a) for adults can only be partially confirmed. Overall, the influence of this marker was weaker in the preference than in the acceptability task. The data from Experiment 2 and 3 showed that at least one third of the adults, but not the whole group, used the lexical marker as a cue to derive appositive interpretations. However, when the lexical marker was present in the acceptability task, the acceptance rates rose above 90% in the group of adults compared to 75% for appositive relative clauses without discourse particle. Thus, they were statistically indistinguishable from the acceptance rates for restrictive interpretations.

For children, i.e., Hypothesis (H4c), the evidence is mixed, but for the majority of children the hypothesis can be confirmed. In line with the hypothesis, the presence of the discourse particle did not change the interpretation preferences of the children. Moreover, the data and comments of the children indicated that the discourse particle was ignored by the majority of participants. However, it had a small influence on the acceptance pattern of appositive relative clauses in Experiment 3. One sixth of the children between age 4 and 6 mastered appositive relative clauses when the discourse particle *ja* was included but not when it was absent. One reason for this observation may be that the meaning of the discourse particle *ja* is acquired later than in the tested age range. Alternatively, the lack of influence could be accounted for by the underlying assumption that children indeed have difficulties to use this information to initiate a reanalysis of their initial, restrictive representation.

A comparison of the influence of the two markers, prosody and discourse particle shows that the lexical marker is a stronger cue than prosodic information. This finding is in ac-

cordance with results from human language processing. Previous studies on garden-path structures have shown that a structural reanalysis is facilitated when an unambiguous cue points to the source of the erroneous attachment (Frazier & Rayner, 1982; Frazier, 1999). Since discourse particles can only be interpreted in appositive relative clauses[1], their presence should allow to change the attachment site of the relative clause from the NP- to the DP-level directly. The data from the preference task, however, indicated that the presence of the lexical marker is not as strong as expected by linguistic theory. The interpretation preferences of children and adults suggest that the discourse particle can be ignored when restrictive interpretations are possible in the context of the utterance. This leads me to the third factor investigated with regard to research question (Q3), the visual context.

Based on studies investigating the incremental nature of the human parser, Hypothesis (H5a) claimed that adults use the visual context to disambiguate between restrictive and appositive readings of relative clauses. Previous studies have shown that adults use linguistic information as soon as possible to restrict the set of potential referents in the course of processing (Eberhard et al., 1995; Sedivy et al., 1999). At the same time, the visual context can be used to initiate a reanalysis in case the initial syntactic representation cannot be interpreted in light of the contextual information. Experiment 1 investigated whether restrictive and appositive interpretations are favored when the visual context corresponds to only one of the readings respectively. This expectation was borne out only partially. For adults, the amount of appositive picture selections increased significantly by 11% in items with an unambiguous appositive context, which is evidence for Hypothesis (H5a). On an individual level, however, the information delivered by the visual context did only marginally change the interpretation preferences of the participants. Compared to the condition with ambiguous visual context, only two adults more showed a preference for appositive interpretations for items with an unambiguous context. The majority of participants maintained their restrictive preference. Thus, Hypothesis (H5a) is supported at a group level, but not reliably at an individual level. In the acceptability task, prosody and visual context were used together to point towards restrictive or appositive interpretations of the relative clauses. In this setting, higher amounts of appositive interpretations were observed than in the preference tasks, corroborating the assumption of Hypothesis (H5a). Moreover, in contrast to the children, some adults noticed the possibility of an appositive interpretation due to the unambiguous visual contexts.

For children, previous research on the processing of linguistic stimuli showed that they need more time, compared to adults, to integrate non-linguistic information. For instance, Trueswell et al. (1999) showed that the visual context could not be used by 5-year-old English-speaking children to reanalyze an incorrect attachment of a prepositional phrase. Based on these results, Hypothesis (H5c) claimed that children do not use the visual context as disambiguating factor for the semantics of relative clauses. At a

[1] As described in Section 2.4 on pages 22 and 61, discourse particles do not only occur in appositive relative clauses but also in main clauses and other types of subordinate clauses. However, in the context of the experiments reported here, discourse particles can only be used in appositive but not in restrictive relative clauses.

group level, the data of Experiment 1 does not corroborate this hypothesis. As for adults, the preference for appositive readings rose significantly by 20% in the unambiguous compared to the ambiguous visual context condition. However, on an individual level, only six children more at the age of 5 to 6 showed a preference for appositive interpretations in the condition with unambiguous context. Moreover, in Experiment 3, the unambiguous visual context did not lead to an acceptance of appositive readings above chance level for the children's group between age 4 and 6. Furthermore, for 3-year-old children only appositive readings were possible and an unambiguously restrictive context did not lead to acceptance rates above chance level for this reading. Thus, Hypothesis (H5c) can be confirmed for the majority of participants.

Taken together, the empirical results of this thesis showed that restrictive interpretations were accessible easily for participants starting from the age of 4. Appositive interpretations were more difficult to derive at this age and above. The more cues pointed towards an appositive interpretation, the more (adult) participants were able to derive the interpretation. In this respect, however, children and adults differed. The observed similarities and differences are discussed in the following to answer research question (Q4).

The last question guiding the research conducted for this thesis, (Q4), asks: Do children and adults differ in their interpretation patterns? The null hypothesis with regard to ambiguous relative clauses is formulated in Hypothesis (H6): Children and adults do not differ in their preferred interpretation for ambiguous relative clauses. For unambiguous contexts, Hypothesis (H7) claims that children and adults differ with respect to their interpretation of unambiguously marked relative clauses.

In the preference tasks, the majority of both children between the age of 4 and 6 and adults clearly preferred restrictive interpretations over appositive ones. In this respect, the participant groups did not differ corroborating Hypothesis (H6). The only exception at the group level were the 4-year-olds in the second experiment. In this group, the distribution of restrictive and appositive interpretations did not differ statistically despite a descriptive predominance of restrictive readings. On an individual level, however, 9 out of 13 children preferred restrictive interpretations in the majority of conditions in Experiment 2 confirming the overall pattern. Furthermore, children and adults showed a similar pattern with regard to the factor Prosody. As discussed above, only very few children and adults used the prosodic information of the stimuli to guide their interpretation patterns. Regarding these aspects, Hypothesis (H6) is clearly confirmed.

Hypothesis (H7) is also supported by the data. Based on the differences regarding the influence of the disambiguating factors summarized above, children and adults pattern differently in their interpretation of unambiguously marked relative clauses. Especially the presence of a lexical marker for appositive interpretations is used by adults but not by children to adopt an appositive interpretation of relative clauses.

Table 8.1 summarizes the findings for the individual hypotheses.

Table 8.1.: Summary of results regarding the hypotheses of this thesis

			Experiments		
Research Questions & Hypotheses			**Exp. 1**	**Exp. 2**	**Exp. 3**
(Q1)	Interpretation preference for ambiguous relative clauses?				
	(H1)	Preference for restrictive interpretations	✓	✓	
(Q2)	Acceptance of restrictive and appositive interpretations?				
	(H2)	Restrictive and appositive interpretations available	(✓)	(✓)	C: (✓) A: ✓
(Q3)	Do linguistic and contextual cues influence the choice of interpretation?				
	(H3a/c)	Adults and children use prosody to disambiguate between restrictive and appositive relative clauses	–	–	–
	(H4a/c)	Adults but not children interpret relative clauses with discourse particles appositively		C: ✓ A: (✓)	C: (✓) A: ✓
	(H5a/c)	Adults but not children use the visual context to disambiguate between restrictive and appositive interpretations	C: – A: (✓)		C: (✓) A: (✓)
(Q4)	Do children and adults differ in their interpretation patterns?				
	(H6)	Children and adults do not differ in their preferred interpretation for ambiguous relative clauses	✓	✓	
	(H7)	Children and adults differ in their interpretation of unambiguously marked relative clauses	✓	✓	✓

Note. C: = Children; A: = Adults; ✓= Hypothesis confirmed for majority of participants; (✓) = Hypothesis confirmed for some participants; – Hypothesis not confirmed.

8.2. An acquisition path for restrictive and appositive relatives

In this section, the main research question, (Q) How do typically developing German-speaking children acquire the semantic functions *restrictivity* and *appositivity* of relative clauses? is addressed. Based on the results discussed so far, a proposal regarding the acquisition path of restrictive and appositive relative clauses is put forward. I argue that the acquisition of the two semantic functions proceeds in a stepwise fashion in three stages as displayed in Table 8.2: nontarget-like appositive interpretations are found at Stage 1, at Stage 2 restrictive readings can be derived target-like, and at Stage 3 both semantic functions are represented target-like. In the following, the syntactic and semantic derivations at the three stages are described in detail.

Table 8.2.: Acquisition path for restrictive and appositive relative clauses

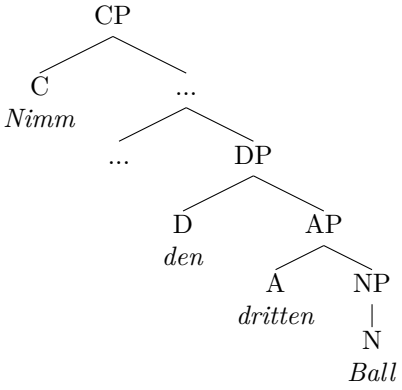
Stage	**Syntactic integration of relative clause**	**Interpretation**	**Age**
Stage 1	Adjunction at CP	Sentence coordination	Age 3
Stage 2	Attachment at NP	Restrictive interpretations only	Age 4
Stage 3	Initial attachment at NP with reanalysis to DP if necessary	Restrictive and appositive interpretations	Age 4?

Stage 1: As mentioned before, 3-year-old children showed a different pattern compared to their older peers in the acceptability task. They accepted only appositive interpretations above chance level as a group and at an individual level. A preference for appositivity was also found for some of the 3- and 4-year-olds that had not mastered the control condition for the non-intersectivity of ordinal numbers as well as for some 4-year-olds in the picture selection tasks. Four-year-olds, on the contrary, showed above-chance performance for restrictive but not for appositive relative clauses without the discourse particle *ja*. Thus, the pattern appositivity without restrictivity, is mainly found for young children up to age 4. As discussed before, this pattern does not seem to indicate a target-like semantic composition of appositivity in terms of an attachment of the relative clause to a referential head noun of type e. Instead, I proposed two alternative structures that may underly the appositive judgements of the children at this age.

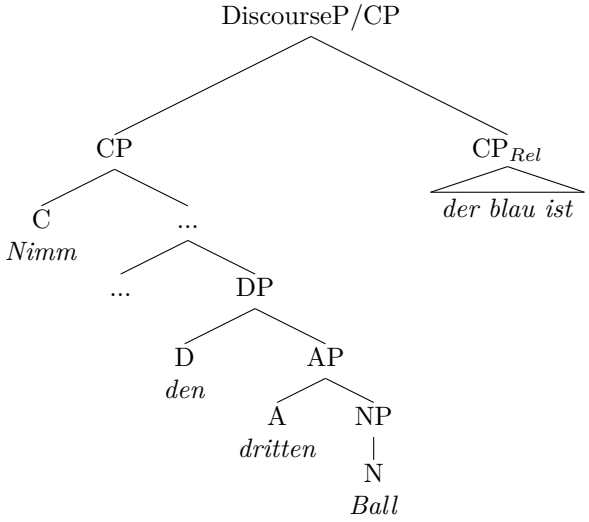
I assume that children at the age of 3 have problems to identify subordinated sentences in the input stream. The recognition of embedding may be especially demanding when the subordinate clause follows the main clause and when prosody is not considered as a cue for syntactic and semantic integration. This situation is met by the relative clause stimuli in the appositive conditions in the series of experiments reported above. In these instances, it may be the case that children closed the CP of the matrix clause after all obligatory arguments were integrated into the parse tree. Contrary to older children and

adults, 3-year-old children may pursue a strategy of Early Closure, which is accompanied by a direct and incremental interpretation of the lexical items. The presence of suitable referents may enforce the referential decisions and reinforces the validity of the syntactic and semantic representation. When the main clause is processed, a structure like in (2a) would be derived. In addition, the DP *der dritte Ball* 'the third ball' can be interpreted by the semantic component and the third ball displayed in the array of objects can be selected as a suitable referent.

(2) a. Nimm den dritten Ball.
'Take the third ball'



b. Nimm den dritten Ball, der blau ist.
'Take the third ball, which is blue'



Since the six 3-year-olds showing appositive interpretations mastered the control condition for ordinal numbers, it can be assumed that these children selected the referent for the complex noun phrase *der dritte Ball* 'the third ball' target-like. At this point, the relative clause is identified in the input stream. However, it is not directly identified as an embedded sentence. Instead, it may be represented like any other subsequent main clause and be linked to the previous sentence via some discourse head. Alternatively to a representation as subsequent clause at discourse level, the relative clause may be adjoined to the CP (see discussion in Section 8.3.2). This derivation is displayed in (2b). According to this syntactic representation, the relative clause is interpreted like a subsequent main clause that refers to the object of the preceding clause. The relative pronoun would receive a referential interpretation, which is possible for children at the age of 3. Following this line of argumentation, the truth conditions for this sequence of sentences correspond to the truth conditions of an appositive relative clause in the experiments conducted for this thesis. No contrastive reading of the relative clause could arise and the color information could not be used to restrict the set of referents denoted by the noun phrase *ball*. This assumption is corroborated by the comments of the children. They counted the objects independently of their color. Based on the structure in (2b), the "relative clause" could have independent illocutionary force and it would be independent of scope-taking elements within the matrix clause. Relative clauses attached

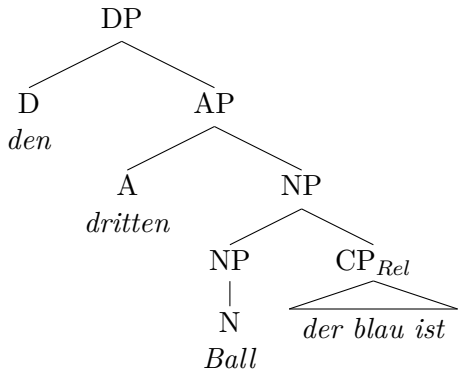
via this high attachment could also serve to modify proper names of type e. Since the relative clause would not be embedded and directly attached to the DP, no complex composition rules are necessary to interpret the sentence. The derivation displayed in (2b) corresponds to any other sequence of sentences containing an anaphoric element. In addition, the truth or falsity of the relative clause could be judged since – like a simple main clause – it receives an independent truth value. Consequently, a direct negation of the appositive relative should be possible at age 3 when this derivation is built up. An incorrect picture selection can be rejected due to two sources of falseness. Either the object selected by the robot does not correspond to the referent for *the third ball* in the child's representation, or, the third ball does not have the color asserted in the "relative clause". In case the semantics of discourse particles is already acquired by the children at this age, the presence of discourse particles would be semantically licensed in this derivation. However, the presence of the discourse particle would not have any effect on the interpretation of the sequence of sentences because it would deliver only redundant information. The relative clause would have been analyzed already as a proposition, which is why the discourse particle could not serve as a cue that a propositional analysis is necessary.

The attempt to analyze the relative clause as a subsequent main clause may fail when the relative clause is prosodically integrated into the matrix clause. The prosodic integration of the restrictive relative clause may lead to difficulties to close the CP of the matrix clause. If the child does not yet know how additional material should be integrated into the NP, the computation crashes and no suitable semantic interpretation could be derived. This could explain the chance performance of children at this stage for relative clauses in the restrictive condition. When a child is not able to derive an interpretable semantic representation, neither correct nor incorrect picture selections could be judged as such. This lack of a basis for the judgements may also explain why the young children do not argue consistently that no matching picture is present in items of the restrictive condition. They may not reach the point in processing where they could actively search for a suitable referent of *the third ball*. According to this line of argumentation, the derivation of both the matrix and the relative clause would crash before the DP could be interpreted.

However, the children may notice that the position of the finite verb does not fulfill the requirements of a German main clause. In the relative clause, the V2 property is violated. This aspect may lead to a reanalysis as an embedded clause if the child has enough processing resources. When the need to interpret phrases as soon as possible is relaxed due to higher working memory capacity, the relative clause may be integrated into the matrix clause.

In Section 7.4, a second possibility to derive appositive-like interpretations by means of a non-target structure was proposed. When children are able to recognize a finite verb in sentence final position as an indicator for structural embedding, they may attach the relative clause to the most recently processed phrase, the NP like in (3).

(3)



The structural embedding in (3) does not necessarily prevent the child from starting to interpret the structure that has been built up. As described above, the child may interpret the DP *the third ball* before the relative clause is fully processed and attached. In items with an appositive visual context, a suitable referent is present and the third ball can be identified as referent. Then the relative clause is processed. The DP may be reinterpreted as the unique element that fulfills two properties, being a third ball and being blue. Due to the pre-selection of the third ball as a possible referent for *the third ball* the set of third balls may contain only one element. When the two properties are intersected, the reference of the entity denoted by the full DP does not change and the derivation converges. In this case, the derivation of the appositive reading would be based on a restrictive structure. As discussed by Hulsey and Sauerland (2006) this may happen as one possible interpretation at LF for restrictive relatives. They "would like to suggest that representations as these are ruled out by a pragmatic condition blocking a restrictive relative clause that expresses a function that is defined for only one individual" (p. 128f.). However, it may be the case that this pragmatic condition is not yet established in the acquisition process at the age of 3 to 4.

According to this derivation, the relative clause is analyzed as a predicate of type <e,t>. This analysis should prohibit some properties typically associated with appositive readings. No independent illocutionary force could be derived and the presence of discourse particles would not be semantically licensed. In addition, operators in the matrix clause could scope over elements within the relative clause. In contrast to the derivation in (2b), it would not be possible to derive appositive interpretations for referential head nouns of type e such as proper names. Furthermore, the relative clause would not receive a truth value on its own. When the property denoted by the relative clause does not hold of the preselected referent, a presupposition failure would arise. This could explain the chance performance in items of the unambiguous restrictive condition in Experiment 3. The impossibility to restrictively modify referential head nouns may trigger the reanalyses of relative clauses when they are attached to proper names. These instances may serve as a cue for the child to identify the additional composition rule for appositive relative clauses.

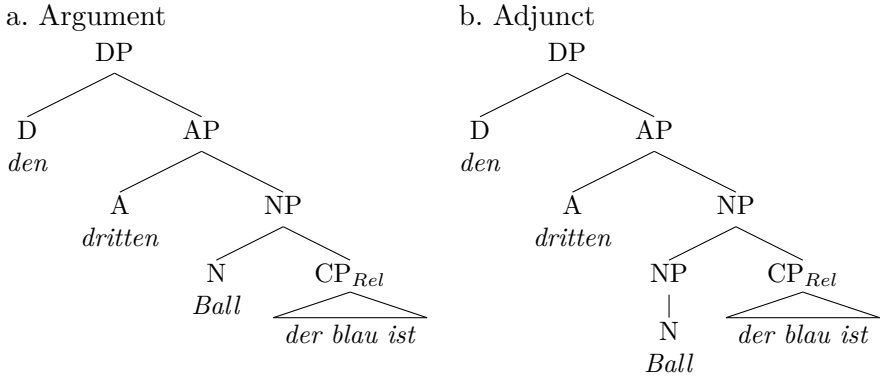
Both options rely on the assumption that the referent for the head noun is chosen rapidly without considering additional postnominal modifiers by children at the age of 3. Since it has been reported that children have severe problems to reanalyze syntactic

structures and to change referential decisions, the appositive reading may not be discarded in light of contextual mismatches. Based on the data of the experiments reported in this thesis, the two options in (2b) and (3) cannot be distinguished. It may be the case that only one of them is derived. However, it may also be the case that they form a sequence that all children go through. In this case, Stage 1 could be subdivided into Stage 1a with a structural representation like in (2b) and into Stage 1b with a representation like the one in (3). As a test case to explore this proposal in more depth, appositive relative clauses could be investigated that attach to proper names. These sentences could receive an appositive-like interpretation in the first but not in the latter representation. In the following, Stage 2 in the acquisition path of restrictive and appositive relative clauses is described.

Stage 2: At the second stage in the acquisition of relative clause semantics, I propose that restrictive readings are acquired. The core aspect of restrictivity is to restrict the set of possible referents for the head noun. Due to the restriction, the relative clause helps to identify the referent of the head noun and may establish a contrastive set of alternatives. To restrict the set of possible referents, the property denoted by the head noun and the property of the relative clause have to be intersected. An intersection of the two properties is only possible when the relative clause is attached at the NP-level and when the head noun has not yet received a referential interpretation. For the relative clause test sentences used in this thesis, such a low attachment and interpretation is the only way to let the ordinal number word have scope over the restricted head noun. Thus, I assume that only a target-like syntactic and semantic representation can lead to restrictive interpretations.

The results of Experiments 1 to 3 demonstrate that restrictive readings are available for children at the age of 4. I propose that participants derive a restrictive structure as a structural default due to the processing principles of Minimal Attachment and Late Closure. A necessary prerequisite for restrictive interpretations is a processing capacity large enough to postpone or to reanalyze the interpretation of the parse tree until all nominal modifiers are processed. When the interpretation can be delayed in such a way, I assume that restrictive readings are found and that they are the preferred interpretation. The structures in (4) display the integration at the NP level either as an argument or as an adjunct. Based on the results obtained in this thesis, there is no additional evidence with regard to the question whether restrictive relatives are integrated as adjuncts or arguments.

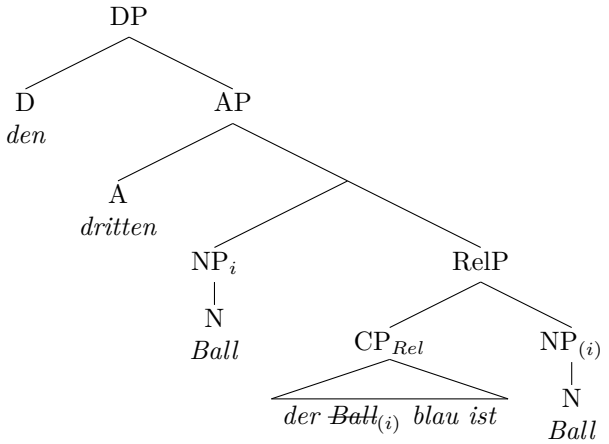
(4) Nimm den dritten Ball, der blau ist, und leg' ihn in den Koffer!
'Take the third ball$_{(,)}$ that/which is blue$_{(,)}$ and put it in the suitcase!'



I propose that at Stage 2 restrictive interpretations are computed target-like. In contrast, appositive relative clauses cannot be derived. All relative clauses that are identified in the input stream are attached at the NP-level and are interpreted via the composition rule of predicate modification. Consequently, the presence of the discourse particle *ja* does not change the proportion of appositive interpretations in children at this stage of development. Even if the discourse particle is integrated into the relative clause structure at a syntactic level and has a target-like lexical entry in the mental lexicon, it would not be possible for the semantic component to interpret the particle within the relative clause. Since all relative clauses at this stage of development would be interpreted as predicates of type <e,t>, the proposition-modifying element cannot receive an appropriate interpretation. Therefore, it may be disregarded by the majority of children, as the comments of the children suggest.

The structural preference for restrictivity can also be derived in a cartographic approach, in which the relative clause has to be integrated as a prenominal modifier. In this case, the relative clause is attached like in (4) above and then the head noun has to be reconstructed below the relative clause like in (5). The noun will be identified as an active filler that has to be located to the right of the relative clause and that is attached as soon as possible to a postulated gap position. Like in (4), the denotation of the noun and the relative clause are intersected at a semantic level and then combined with the ordinal and the definite article. This will lead to a selection of the third of the blue balls.

(5)



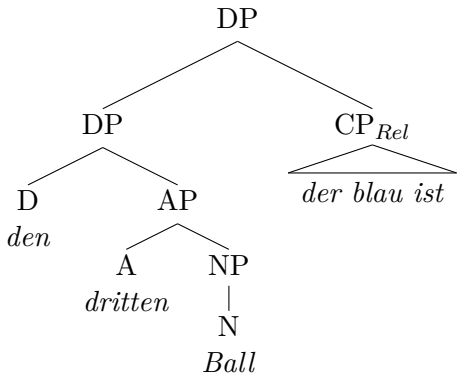
The structure in (5) is compatible with both a raising and a matching derivation. The head noun can be reconstructed either inside or outside of the relative clause. According to Cinque (2008a) and Poletto and Sanfelici (2014) it has to be reconstructed at both positions. The difference between the two derivations would be which of the reconstructed NPs, the one inside or outside the relative clause, would be co-indexed with the overt head noun. However, the test sentences used in the three experiments of this thesis are compatible with both derivations. Therefore, the data reported here are not informative with regard to the question of the underlying syntactic representation of restrictive relative clauses in German-speaking children. However, one aspect that can be clearly inferred from the acquisition patterns documented here is that the majority of children at the age of 4 are able to attach and to interpret relative clauses restrictively at the NP level.

This restrictive representation may lead to a rejection of appositive interpretations of relative clauses for children at this stage, as it is frequently found in Experiment 3. At this stage, the resources for processing are large enough to attach the relative clause within the matrix clause and to delay the interpretation of the noun phrase until all modifiers have been encountered. Therefore, an appositive-like representation as illustrated in (2b) would not be derived any longer. In addition, an appositive interpretation of a restrictive parse tree is not possible any more because children know how to integrate the relative clause semantically. This aspect is pursued further in Section 8.3. The comments of a large number of children indicated that they derived restrictive readings for items tested in the appositive conditions. Especially for children at the age of 4, neither prosody nor the presence of the discourse particle had an effect on their restrictive preference.

Stage 3: At this stage, appositive interpretations are derived target-like. Although the majority of syntactic and semantic approaches does not assume that appositive relative clauses are derived from restrictive representations, this dependency may occur when relative clauses are processed. I assume that all relative clauses are initially attached at the NP level according to the Principle of Late Closure. In case of conflicting information pointing towards an appositive interpretation of the relative clause, a reanalysis has to apply. Cues for a necessary restructuring may be, e.g., a proper name as head noun[2], the presence of lexical markers like discourse particles, or a (visual) discourse context in which a suitable discourse referent is highly salient. Also prosody may serve as an indicator for some of the participants. I propose that these cues initiate a reanalysis of the attachment of the relative clause in the parse tree. As a consequence, the relative clause is attached at the DP layer above strong quantifiers. Where and how the appositive relative is attached depends on the syntactic approach. Based on the data from the three experiments, no details can be inferred about the position and mode of the attachment of the appositive. The resulting tree according to the syntactic standard assumption is displayed in (6).

[2]If the head noun is a proper name, the relative clause may also be directly attached to the DP-layer. This possibility depends on the theoretical assumption of whether further internal structure is assumed for proper names, see e.g., Longobardi (2005) and Sturm (2005) for discussion.

(6)



The parsing process to represent an appositive relative clause is more costly due to the reanalysis (Fodor, 1998a, 1998b). Based on the necessary reanalysis to derive appositive readings, the preference for restrictivity is accounted for in the model. Although participants may have enough processing resources and the appositive composition rules at their disposal, they are predicted to prefer restrictive relative clauses in ambiguous settings or contexts with only few cues for appositivity.

The data reported in Experiments 1 to 3 suggest that Stage 3 is reached by some participants at the age of 4. Both semantic functions are found for one third of the participants at age 4 and 5. However, based on the picture selections and acceptance rates only, it is difficult to analyze at which age appositive-like and true appositive interpretations are found. This topic is addressed in the following section again. In addition, the following section discusses further implications of the acquisition path for restrictivity and appositivity.

8.3. Implications of the acquisition path

The developmental path described in the previous section has some implications. In the following, five aspects are discussed. First, the developmental path is linked to general assumptions about human language processing and to the age at which the three stages are reached. Second, the assumption of high attachment is discussed with regard to other phenomena. Third, expectations about the acquisition of restrictivity and appositivity are discussed from a cross-linguistic perspective. Fourth, the acquisition of restrictive and appositive interpretations is discussed for adjectival modifiers. The last subsection addresses the notion of semantic complexity in language acquisition.

8.3.1. Focusing on Stage 2 and 3

The acquisition path for the semantic functions of relative clauses proposed in this thesis is built on two core assumptions. On the one hand, I follow Fodor (1998a, 1998b) in postulating that language processing in children is guided by the same principles as in adults. On the other hand, I assume that the two semantic functions of relative clauses do not stand in an entailment relation and may be acquired independently of

each other. Based on these assumptions, I claim that at an early step in the acquisition process, children can only derive restrictive readings of relative clauses. At first sight, this proposal contradicts the assumption that restrictive and appositive relative clauses may be acquired independently. Furthermore, the results of this thesis do not necessarily support this claim, for restrictive readings are first attested at age 4 in the series of experiments reported here. Acceptance of appositive readings, in contrast, is found for 3-year-old children. Moreover, the individual mastery patterns in Experiment 3 show an equal distribution of children at the age of 4 for all possible combinations of readings. Three children do not master any semantic function, two children master only restrictive readings, three children only appositive ones and four children master both semantic functions of relative clauses at age 4. This data could also be taken as evidence for a different acquisition path, namely that target-like appositive readings are acquired before restrictive ones, and that both readings are available when restrictive readings are documented for a child.

At the beginning of the previous section it was discussed that the acquisition of appositivity before restrictivity runs into conceptual problems. Therefore, the complementary proposal is argued for in this thesis. Based on the interaction of human language processing and syntactic and semantic analyses, I predict an earlier acquisition and a preference for restrictivity. However, two aspects need to be discussed. First, what arguments speak in favor of Stage 2? And second, at which age are appositive relative clauses interpreted target-like, i.e., at which age do children reach Stage 3?

There is only limited evidence for Stage 2, in which only restrictive readings are possible for children. General considerations based on the learnability of readings in ambiguous settings cannot be used to account for the acquisition of relative clause semantics (e.g., Crain, Ni, & Conway, 1994; Gualmini & Schwarz, 2009). Contrary to the assumptions of Frosch (1996), I argue that the two semantic functions do not form a subset-superset relation like readings of other ambiguous sentences. For phenomena with entailment relations, learnability may be a topic to discuss. It would be necessary to explain how a child could learn the meaning of the subset reading, when in all of its situations also the superset reading is true. In this respect, for instance, wide VP-focus or narrow object-focus interpretations due to the presence of the focus particle *only* in front of the VP have been discussed (Crain et al., 1994; Gualmini & Schwarz, 2009). The question of learnability is also relevant to explain the acquisition of the interaction of universal quantification and negation as in sentences like *Every horse is not jumping over the fence* (Gualmini & Schwarz, 2009). For these so-called *privative ambiguities*, Crain et al. (1994) argue that children have to learn the subset reading first, but see Gualmini and Schwarz (2009) for a different approach. At first sight, a similar relation may hold for restrictive and appositive interpretations. In many situations, appositive readings entail restrictive interpretations, i.e., whenever the appositive reading holds, the restrictive reading is true, too. However, the test sentences used in this thesis show that such a subset-superset relation does not hold for relative clauses in general. The truth conditions for restrictive and appositive interpretations frequently overlap, but their relation is better thought of as a true intersection of sets. Based on these considerations, learnability cannot serve as an argument in favor of an order in which restrictive and

appositive readings are acquired.

However, evidence for Stage 2 comes from children that master only restrictive readings. Twelve out of 20 children with this mastery pattern in Experiment 3 rejected appositive interpretations systematically. Such a consistent rejection of a reading is not found for any other mastery pattern. The consistent rejection of appositive readings is accounted for by the assumption that only restrictive readings can be derived. In the alternative acquisition scenario – appositivity before restrictivity – it remains unexplained why the reading that is acquired first would be rejected systematically. In addition, the low rates of appositive readings at the age of 4 and 5 are difficult to account for when appositive readings are the default interpretation children start with. Furthermore, if appositive representations were derived target-like from the age of 3, the lacking influence of the discourse particle for children needs to be accounted for. All these findings can be captured naturally under the acquisition model advocated in this thesis. A u-shaped curve for the availability of appositive readings is expected under my account. The number of appositive readings should decrease from Stage 1 to Stage 2, and it should increase again at Stage 3. But remember that at Stage 1 sentence coordination and not true appositivity is the source for appositive-like interpretations. When, at Stage 2, restrictive relative clauses are the only representation children are able to build up, appositive interpretations are not consistent with this representation. Consequently, appositive picture selections should be consistently rejected. Also the lacking influence of the discourse particle *ja* can be accounted for. Moreover, the observed asymmetry between the production and comprehension of this particle in the experimental data could be captured. The comments of the children showed that the discourse particle *ja* was used in the explanations why appositive readings of relative clauses were not possible for the children. Interestingly, the particle was also used in comments on items in which this particle was present as a marker for appositivity. Despite the appropriate use of the particle, it did not serve as an indicator for an appositive reading for the children. As discussed before, this finding could be due to a general asymmetry between the comprehension and production and a late acquisition of this discourse particle. In addition, this finding may be due to children's difficulties to reanalyze parsing decisions. However, also the assumption that relative clauses are initially analyzed as predicates of type <e,t> could serve as an explanation for this finding. Since the discourse particle modifies propositions or speech acts, it cannot be interpreted within a relative clause, the latter being a predicate. Therefore, the particle may be discarded at the interface to interpretation when no alternative structure is available in which the particle could be interpreted. On the contrary, the particle may be used and interpreted target-like in main clauses that are interpreted as propositions. To explore this aspect, studies on the acquisition of discourse particles in different sentence types are needed. Up to now, no research has been conducted on the use and interpretation of discourse particles in child language.

Taken together, although limited there is evidence in the data from the experiments reported here that support the assumption that restrictivity is acquired before adult-like appositive structures. In addition, this assumption makes a number of predictions that could be explored in further experiments.

The influence of discourse particles may also be taken as evidence for the transition from Stage 2 to Stage 3. One third of the children at age 4 and 5 show mastery of both semantic functions. Based on the acquisition path described in Section 8.2, these children may have reached Stage 3. Alternatively, these children may be at an intermediate state between Stage 1 and Stage 2. It is conceivable that there is a phase in which children incorrectly attach or interpret prosodically unintegrated relative clauses similar to appositive modifiers but integrate restrictive relative clauses target-like. Due to the unintegrated prosody of appositive relative clauses, children may attach them high as independent sentences or start immediately with the interpretation of the head noun. However, when the relative clauses are prosodically integrated, the children may be able to integrate the sentences below the NP level of the matrix clause. At this stage, prosodic integration would be the cue for structural integration. When this cue is missing, the relative clause may not be integrated into the representation of the matrix clause. This assumption may be weakened by the strong preference for restrictive readings in the preference tasks. However, additional evidence for this assumption may be found also in the individual analysis of Experiment 2. Overall, there were two participants that adapted their picture selections to the prosodic format of the stimuli. Interestingly, this pattern was only found for children. One child was 4;5 and the other one 5;7. The observed sensitivity for the prosodic differences may be due to the different integration patterns at the transition from Stage 1 to Stage 2.

Whether such a transitional stage exists is difficult to prove. Different properties of appositive relative clauses would need to be investigated to be able to differentiate between appositive-like interpretations at Stage 1 and target-like appositive readings at Stage 3. One indicator for target-like appositive interpretations may be the influence of discourse particles. As argued in Section 8.2, the presence of these lexical markers should not change the proportion of appositive interpretations at Stage 1. However, it may have an influence at Stage 3 when the participants have the structural resources to perform structural revisions. Depending on the age at which the function of the particles is fully acquired, these particles should raise the readiness to derive appositive readings. However, for this comparison, two other phenomena would need to be investigated first. Data on the acquisition of discourse particles is necessary as well as studies that show at which age structural reanalyses of a comparable type can be performed by children. Thus, more studies are needed to investigate these aspects.

In sum, both proposals, Stage 3 or a transitional state between Stage 1 and 2 could account for the finding that one third of the children at age 4 and 5 mastered both semantic functions of relative clauses. Based on the data reported here, it can be assumed that both semantic functions are acquired at the age of 4. Further studies using different experimental designs are needed to investigate these options in more detail. Moreover, the use of a longitudinal design would be promising to explore the hypotheses of this acquisition path in detail.

In the following section, the assumption that children start out with high attachment of unexpected linguistic material is discussed.

8.3.2. High attachment of new material

For Stage 1 of the acquisition path, I assume that children start out with high attachment of the relative clause. This assumption is in line with proposals by Lebeaux (1990, 2000), Roeper (1992, 2014), and Roeper, Pearson, and Grace (2011). I argue that the high attachment of the relative clause leads to a non-restrictive reading without a syntactic and semantic representation for appositivity. According to Roeper (1992, 2014), adjunction at the root is the general procedure in language acquisition to integrate new material. Many studies have shown that children attach a variety of elements such as negation, quantifiers, question markers, or modal verbs to a fixed sentence initial or final position in production (Roeper, 1992). Often, these elements are used with non-target scope relations and incomplete semantic representations. For instance, the element *No* in English or *nee* in Dutch is used sentence initial or final to negate propositions as well as constituents in the early multi-word phase (Roeper, 1992). However, high attachment of new material in the acquisition process is also postulated for comprehension. As a result, quantifiers may be interpreted incorrectly as having scope over multiple DPs (e.g., Roeper et al., 2011). This phenomenon is called quantifier spreading and has been documented for a variety of languages.

Roeper (2014) argues that high attachment is an option to integrate material that cannot receive a label yet. Located in the framework of Minimalism, Roeper assumes that children start out with the operation *merge* to combine two elements at the two-word stage for production. The resulting element receives a label, which in the simplest case corresponds to the projecting element. In the acquisition process, the child needs to find out which label has to be assigned when new material is encountered and is produced. That is, the child needs to analyze the scope and c-command relations to decide which of the combined elements projects when two elements are combined. Through the acquisition process the new element receives a label. Only when a label is assigned, additional material can be merged to the resulting structure. Adjunction at the root, in contrast, would always be possible, because no higher structure has to be built up and thus, no label has to be assigned to the resulting node. Therefore, elements without a label can attach at this position, like, e.g., expressives. Semantically, the new elements would contribute only minimally to the context of the clause. Roeper (2014) assumes that they may be either adjoined or interpreted as predicates.

A similar concept has been proposed by Lebeaux (1990, 2000) for the acquisition of grammatical operations. Lebeaux assumes for instance that coordination is acquired before subordination to combine constituents and sentences. Additionally, he assumes that when children encounter a subordinate clause they cannot integrate syntactically or semantically they will use coordination to link the sentences instead of establishing a subordination relation.

These assumptions fit well with the analysis of relative clauses at the age of 3. It is conceivable that 3-year-old children do not directly identify relative clauses as modifiers of the nominal domain. Therefore, children may not know how to integrate these structures syntactically and semantically. Contrary to the situation for complement clauses, relatives do not serve to saturate the subcategorization requirements of the verb. It is

not the case that the parser could link the relative clause to an open position in the theta grid. Therefore, relative clauses may appear unexpectedly subsequent to a nominal projection and the child does not know what type of structure it is. As a way to deal with the incoming lexical material when hearing a relative clause, the unknown structure may be attached at the root like any other unknown lexical element – or it may be integrated as a subsequent matrix clause. Following Roeper (2014), the relative clause may be attached at the CP-level without being labeled as relative clause. At this position, the relative clause is interpreted as a conjunct unless it is identified as a subordinate clause. This would be in line with the assumption of Lebeaux (1990, 2000). I assume that at a later stage in acquisition, the child identifies the relative clause as a subordinated element. At this point, the clause receives a corresponding label and is integrated syntactically at a lower position. Once the relative clause gets a label, I assume that it is integrated similarly by children and adults (Fodor, 1998a, 1998b). Hence, it would be subject to the general processing rules and would be integrated according to the Principle of Late Closure. As described above in Section 8.3.1, an integrated relative clause receives a restrictive interpretation initially.

The acquisition path described may thus be in accordance with assumptions about how unknown lexical material is integrated in a syntactic representation. As an indicator how the adjoined material should be classified, different cues may be of use for the child. In German, the position of the finite verb may serve as a cue to identify the subordinated status of the relative clause. The finite verb appears in sentence final position, which speaks against an integration at the discourse level as a subsequent main clause. In English, the complementizer *that* or a *wh*-pronoun in a sentence without question intonation may serve a similar function. In addition, prosodic integration may point to the fact that the sentence is not independent of the preceding matrix clause.

Such a scenario may also be compatible with the finding that center-embedded relative clauses are acquired later than right-branching relative clauses. An attachment at the root for a sentence medial structure may be possible but is more demanding because the matrix clause has to be stored in parallel to be continued later on. In addition, the proposed model suggests that extraposed relative clauses are interpreted as adjuncts at Stage 1. Moreover, because extraposed relative clauses appear outside of the matrix clause it may be more difficult for the children to identify the position at which they need to be interpreted. The assumption that restrictive readings are automatically derived when the relative clause is identified as such and is integrated according to the Principle of Late Closure does not hold for extraposed relative clauses. When they are integrated into the phrase that is actually being processed, extraposed relatives would be attached to the VP shell. In languages that allow pseudo-relative clause readings, this attachment may result in such an interpretation (see Section 2.4 page 13). In languages that, like German, do not license such an event interpretation of the relative clause, the parser needs to lower the relative clause and may opt for the least demanding integration. According to the argumentation above, this results in an integration of the relative clause underlying a restrictive reading. In contrast to relative clauses that appear adjacent to their head nouns, the model suggests that, for extraposed relatives, children remain longer at Stage 1 before they reach Stage 2 and 3.

The postulated acquisition path may also have implications for the acquisition of other types of subordinate clauses. It may be the case that initially all subordinate sentences are attached as unlabeled structures at the root. Once the type of subordinate clause is identified and the structure receives a label, it is integrated lower in the syntactic structure. The identification of the function and attachment site of the subordinate clause may be easier when the subordinate clause is subcategorized by the verb, or when another salient relation holds between the matrix and the subordinated clause, like e.g., with conditionals. In case of high attachment, the unidentified subordinate clause may be interpreted independently of the matrix clause. Except for cases with extractions, i.e., missing constituents within the clause, a subordinate clause may be interpreted as a proposition similar to main clauses. As a consequence, all subordinate clauses receive a truth value and may be interpreted as assertions at this initial stage of the acquisition path.

This scenario may explain a finding for complement clauses of factive verbs like *forget*. The acquisition path proposed here would predict that initially children are not able to identify false complements. Instead all complement clauses are interpreted as true statements. This corresponds to findings in the literature for factive verbs. As summarized in Pérez-Leroux and Schulz (1999), previous studies have shown that children at the age of 3 interpret all verbs as factive verbs. That is, 3-year-old children assume complement clauses to be true propositions (e.g., Abbeduto & Rosenberg, 1985). From the age of 4 onwards, children can distinguish factive from non-factive complements (Schulz, 2003). At this age, the children know that a complement clause of a non-factive verb is not presupposed to be true. This developmental step is frequently linked to the acquisition of Theory of Mind (Wimmer & Perner, 1983). However, it could also be associated with a transition from Stage 1 to Stage 2 and be explained as a reflex of the syntactic integration. When any complement clause is attached at the matrix clause CP first, it may be interpreted as an independent (true) proposition. The clause receives a truth value that is not dependent on the verb type within the matrix clause. Once the subordinate clause is identified as such, it receives a label and can be integrated as an argument of the verb. Only at this stage, a child can compute the truth conditions of the complex sentence and may consider specific properties of the verb with regard to its complement. Thus, when the child reaches Stage 2 for factive complements, differences between factive and non-factive verbs can start to emerge and false complements can be considered. At Stage 1, no verb-specific semantics of the matrix clause can influence the composition and truth-functional evaluation of the complement clause. The high attachment of complement clauses as an initial step may also explain why the content of the complement clause is not influenced, for instance, by a negative operator in the matrix clause as found for factive complements. Since the matrix clause does not scope over the subordinated clause, operators cannot bind into the complement clause.

It is important to note that the age at which children start to discriminate between factive and non-factive complements is similar to the age at which children start to derive restrictive interpretations in the experiments of this thesis. This link could be captured by the assumption that both phenomena result from the fact that the subordinate clauses can be fully integrated within the matrix clauses only at Stage 2. To reach this stage,

the child has to identify subordinated sentences based on verb placement or based on the lexical information of specific complementizers. The identification of subordination markers may lead to the ability to assign labels to a variety of different subordinated elements. However, sentential arguments that saturate the subcategorization frame of the verb may be identified and integrated earlier than other subordinate clauses.

In the following, cross-linguistic implications of the acquisition path are addressed.

8.3.3. Cross-linguistic implications

The acquisition path proposed in Section 8.2 is based on interpretation patterns from German-speaking children. In addition, the processing account of how restrictive and appositive readings are derived is based on the German data. However, the basic assumptions on which the postulation of the developmental path and the composition of the readings is based are not language specific. Both underlying concepts, different syntactic and semantic representations for restrictive and appositive relative clauses as well as similar processing routines for children and adults, are not specific to German. In contrast, they should hold for the processing of restrictive and appositive relative clauses independently of the language.

The typological overview in Section 2.2.1 showed that the semantic function appositivity, but not restrictivity, is limited to languages with postnominal relative clauses. In addition, an implication is reported to hold implying the existence of restrictive readings in a language that has appositive relative clauses. This implication is in line with the proposal on the derivation of restrictive and appositive relative clauses in this thesis. The proposal how restrictive and appositive relative clauses are processed cannot account for the fact that only postnominal relative clauses can receive a restrictive and appositive interpretation. However, the universal implication may be a consequence of the processing mechanisms implemented in the acquisition path. The implication may follow from the assumption that postnominal relative clauses are integrated as a modifier of the NP in the initial syntactic parse tree. For the derivation of appositive relative clauses, this initial analysis has to be modified. Consequently, whenever a language allows appositive interpretations, a restrictive syntactic structure would be derived automatically as an initial step. Furthermore, the semantic operation to interpret the attachment of a relative clause at the NP level, predicate modification, is independently motivated in order to integrate e.g., adjectives. Thus, the rule of predicate modification can be assumed to be available in these languages. Hence, when a language derives appositive interpretations it seems plausible that structures underlying restrictive interpretations are derived as an intermediate processing step, too. For relative clauses that are attached to common nouns, a restrictive reading of the relative in this class of languages cannot be ruled out. In principle, the derivation of restrictive interpretations as an intermediate step to appositive representations is reminiscent of the assignment of a moved constituent to its base position. According to the Active Filler Hypothesis (Clifton & Frazier, 1989), the parser always postulates a gap at the subject position. Only in light of contradicting evidence, i.e., the presence of a lexical subject, this gap is removed and postulated further down in the syntactic tree. Based on the Active Filler Hypothesis, an interpretation as

a subject would always be preferred over an interpretation of an object for extractions out of ambiguous sentences. Likewise, the model above predicts that restrictive interpretations are preferred over appositive ones in ambiguous contexts cross-linguistically because restrictive readings are based on the less demanding computation.

Like the universal implication of the readings for languages with postnominal relative clauses, the acquisition path of restrictive and appositive readings should be identical cross-linguistically. Despite language specific differences with regard to the lexical inventory of relative pronouns and complementizers, the general assumptions are not language-dependent. The assumption that unlabeled merge allows the adjunction of new material at the root should hold cross-linguistically. Likewise, the principle of Late Closure should not be language-specific (see Section 2.6). Thus, the prerequisites for the acquisition path described above are not restricted to German. Non-restrictive interpretations should be found for relative clauses before restrictive readings are documented. Full-fledged appositive readings with the corresponding semantic consequences, however, should follow the acquisition of restrictivity.

A further consequence of the postulated acquisition path may be an asymmetry between the production and comprehension of restrictive and appositive relative clauses. Independently of the language, relative clauses may be produced correctly before they are interpreted target-like. This may hold for each semantic function – restrictivity as well as appositivity. The acquisition path described in Section 8.2 is based on the interaction of syntactic and semantic knowledge on the one hand and processing mechanisms on the other hand. It may be possible that a child has acquired the syntactic and semantic representations for restrictivity or for both semantic functions but that processing limitations impede their correct derivation during processing. The studies described in Section 3.5 showed that children have difficulties changing initial assumptions about attachment positions or referential assignments. For language production, the intended interpretation guides the structure building (e.g., Levelt, 1993). At the conceptual level it is planned which proposition shall be expressed on specific discourse referents. Then, the conceptual message is encoded using lexical items. Thus, for the speaker, the reference of the lexical items is fixed in the mental representation of the utterance. Therefore, the relative clause is not ambiguous for the speaker like it may be for the hearer. When building up the syntactic tree for production, the relative clause should be merged directly at the target position when all syntactic and semantic prerequisites are acquired. Although a child may be able to produce restrictive and appositive relative clauses, limited working memory capacity may prevent children from accessing the corresponding semantic representations in the comprehension process. It may be easier for the child to encode a message containing an appositive relative clause than to identify the semantic function of a modifier during comprehension. As mentioned above, a syntactic parse tree underlying an appositive reading requires reanalyses and more complex semantic computations. These additional steps in the parsing process may not be performed by children unless they have clear evidence that it is necessary. In addition, prosodically unintegrated relative clauses may not be identified as embedded clauses or need a structural revision to be integrated target-like in the comprehension process. The asymmetry between production and comprehension can be expected both for stage 2 and 3 of the

acquisition path. Although the child has the knowledge how to compose appositive readings in principle, these readings may not be derived during comprehension because they are more effortful. The initial restrictive attachment may be difficult to reanalyze for a child despite multiple cues for appositivity. The lack of reanalysis would result in a restrictive interpretation.

Taken together, it seems plausible that the parsing principle Late Closure influences comprehension more strongly than production. This suggests that production precedes comprehension in the acquisition of restrictive and appositive relative clauses cross-linguistically. Further studies are needed to investigate the semantic functions of relative clauses across both modalities in child language. In the following section, some additional findings with regard to restrictivity and appositivity are discussed.

8.3.4. Restrictivity and appositivity in adjectival modification

As described in Section 2.3.3, also adjectives can receive restrictive and appositive interpretations, which may be derived by similar mechanisms as applied for relative clauses. I assume that the acquisition path postulated for restrictive and appositive interpretations of relative clauses may be transferred also to the acquisition of adjective semantics.

Let us first focus on postnominal adjectives like e.g., in Brazilian Portuguese. For postnominal adjectives, the situation is most comparable to the processing of relative clauses in German. In Brazilian Portuguese, ordinal number words precede the noun while restrictive color terms like relative clauses follow the noun phrase (Marcilese et al., 2011, 2013). The phrase *the second green ball* would have the surface word order *the second ball green*[3]. According to the acquisition path described in Section 8.2, appositive readings may be expected for postnominal adjectives at Stage 1. Initially, children may not be able to integrate postnominal modifiers syntactically or semantically. It may be possible that the postnominal modifier is attached at the CP and that it is interpreted like a silent copular construction, i.e., *the second ball. (And it is) green.* Alternatively or subsequently, a conjoined appositive-like interpretation may be derived from a structure in which the adjective is integrated postnominally in the NP. A conjoined appositive-like interpretation may be derived from the restrictive structure when the elements of the DP are interpreted highly incrementally based on their surface order without considering postnominal elements for referential decisions. Such an interpretation would be similar to the one described in (3) on page 306 yielding appositive interpretations of relative clauses despite a restrictive syntactic representation. Children may select the second ball as referent and then intersect the single element denoted by the predicate *second ball* with the color term *green* via predicate modification.

Like for relative clauses, Stage 1a and 1b cannot be clearly distinguished for adjectives. Either difficulties to label the new element or a non-target-like interpretation procedure may lead to a conjoined interpretation. To reach Stage 2 for the interpretation of adjectives, the children need to be able to wait with the selection of a referent until the

[3]The surface order Adj-N-Adj in Romance languages is frequently analyzed as being a result of movement (e.g., Cinque, 2014). The noun is raised across the adjective that appears to its right. To receive the underlying structure, the noun needs to be reconstructed below the adjective.

postnominal modifier is encountered. When the necessary processing capacity is reached, restrictive readings for adjectives can be derived. Thus, also for postnominal adjectives, an acquisition path comparable to the one for relative clauses is predicted.

However, a similar acquisition path does not imply a temporally parallel acquisition of restrictivity in adjectives and relative clauses. I would rather propose that restrictive interpretations for adjectives may be acquired before the corresponding readings of relative clauses. This may be due to processing reasons. It may be easier for the parser to reanalyze the initial parse tree and to integrate one adjectival element than to wait until a relative clause is completely processed and integrated.

Whether a corresponding acquisition path can also be postulated for languages with multiple prenominal adjectives like German or English is an open question. An incremental processing of *the second green ball* would in principle be compatible with a restrictive interpretation. Syntactically, the two modifiers need to be integrated in a hierarchical representation to derive a restrictive reading. This would be possible based on the linear order. However, to achieve a restrictive reading, the ordinal has to scope over the intersection of the color word and the noun. With regard to an incremental interpretation, the interpretation of the ordinal number has to be delayed until the second adjective is intersected with the noun. When a child does not delay the interpretation of the ordinal number and follows the Principle of Late Closure strictly, the two adjectives may be integrated in the adjective phrase together. Since they modify the noun together, the may be interpreted as conjuncts like in *second and green ball*. Consequently an appositive-like interpretation would be found in a picture selection task as proposed by Roeper (2009).

First evidence that 3-year-old German-speaking children interpret two prenominal modifiers as a coordination of modifiers is given in Hubert (2009). Testing the interpretation of elliptic statements referring to sequences like *ein großes rotes Auto* 'a big red car', Hubert suggests that children at the age of 3 derive only conjoined interpretations. Four-year-old children, in contrast, were able to derive a hierarchical restrictive structure. Additional evidence for this interpretation pattern is found for one 3-year-old child in Experiment 3 of this thesis. The child rephrased an appositive picture selection by using the color term as prenominal modifier. This is shown in (7). Such a conjoined use of the prenominal modifiers was documented twice in the spontaneous comments of the child in Experiment 3.

(7) Paraphrase for an appositive relative clause at age 3

1 2 3 4 5 6 7

selected

Caru: Nimm die zweite Mütze, die rot ist, und leg' sie in den Koffer.
Child: Die zweite rote Mütze.

Caru: *Take the second cap, which is red, and put it in the suitcase.*
Child: *The second red cap.*

04_TTS453, age 3;7

Importantly, this child does not have difficulties to restrict the ordinal number to the set of caps. Thus, the ordinal number is interpreted as a non-intersective modifier but is coordinated to the second modifier. Four-year-old children of Experiment 3, in contrast, never used two prenominal adjectives to paraphrase an appositive test sentence. On the contrary, the 4-year-olds used such a phrase frequently to paraphrase restrictive interpretations of relative clauses.

These findings suggest that non-restrictive interpretations may be found initially for languages with restrictive adjectives in prenominal positions, too. Similar to the interpretation of relative clauses, these readings may result from an interpretation as coordinated elements corresponding to the assumptions of Lebeaux (1990). Like for relative clauses, these conjoined interpretations may not have a semantic representation of true appositive modifiers. Thus, a similar acquisition path may be assumed for adjectives and relative clauses with regard to their semantic functions. The reasons why children arrive at non-restrictive interpretations initially, however, may differ between the two constructions.

8.3.5. Semantic complexity in language acquisition

Roeper (1992, 2014) suggested that new material is integrated without a fully specified semantic representation in acquisition. This assumption is in line with syntax-first proposals argued for in the literature on human language processing (Frazier, 1987; Friederici & Mecklinger, 1996, cf. Section 2.6). As described in Section 2.6, semantic information is necessary in these models to initiate a reanalysis of the syntactic parse tree. Thus, although syntactic representations are built up initially in an encapsulated way, there is a tight interaction with the semantic module as an instance of controlling and modifying the syntactic representations. Consequently, the semantic repertoire is crucial to enlarge the range of syntactic representations that can be derived. Both lexical semantics regarding the theta grid and scope domains as well as semantic composition rules are needed to broaden the syntactic structures available to a child. Without sufficient semantic knowledge, reanalyses may not be initiated, and the syntactic component may remain at stages with elements being unlabeled and unintegrated. This would block more complex derivations.

Take the case of appositivity as an example. When no appropriate semantic representation can be derived since the necessary composition rule is not yet acquired, the syntactic repertoire remains limited (Van Geenhoven, 2006). The children could only derive restrictive readings since the semantics module would not initiate a reanalysis of this interpretable structure. If, however, a child is confronted with structures that she cannot interpret, this situation may trigger further acquisition steps and elaborations of the grammatical system. Thus, the additional complexity of a semantic representation could be an option to initiate (syntactic) developmental steps in acquisition. The

acquisition of the more complex composition rule for appositivity may be triggered by the attachment of relative clauses to proper names in the input. Proper names are clear instances of type e. Therefore, predicate modification cannot be used to interpret the relative clause at this position. This positive evidence for the availability of an attachment at the DP level may lead to the acquisition of appositivity.

As proposed by Lebeaux (1990), composition rules may be acquired from simple to more complex rules. How semantic complexity could be captured is a difficult question. The data reported in this thesis corroborate the assumptions of Lebeaux (1990) that coordination is acquired before subordination. However, as the experiments showed, different types of subordination (restrictivity and appositivity) may be acquired in a sequence. I propose that the composition rule to intersect predicates like restrictive relative clauses is acquired before the composition rule for appositivity. The intersection of predicates may even be acquired before the coordination of propositions since it is necessary to integrate elements like adjectives at a sub-sentential level, for instance within the DP. The idea that the intersection of sets may be a default operation that is acquired very early is pursued in the next section.

8.4. A remark on the acquisition of ordinal numbers

The results of Roeper (1972), Matthei (1982), Hamburger and Crain (1982, 1984), and Marcilese et al. (2013) showed high rates of conjoined interpretations for phrases like *the second green ball*. The authors mainly explained these findings as a preference to coordinate multiple modifiers instead of integrating them into a hierarchical structure necessary for restrictive readings. However, the conjoined or intersective interpretations were also found in conditions with only one prenominal modifier like in *the second teddy* (see Section 3.4.1 and 4.3.3). In addition, Hamburger and Crain (1984) showed that intersective interpretations need to be distinguished from appositive-like conjoined interpretations. Hamburger and Crain combined two different types of elements in the array of objects. As a consequence, they could distinguish the second position overall from the position displaying the *second X*. The results showed that children selected pictures at both positions. Thus, children interpreted the phrase *the second green ball* either as a coordination of properties like in *the second and green ball*, or as *the thing that is second and a ball and green*. The latter reading is called *intersective* in this thesis. This second reading can be explained as a misclassification of the ordinal number word. Ordinal numbers may be represented as intersective modifiers, i.e., as modifiers lacking a comparison class. The missing comparison class may result from an underspecified lexical entry of ordinal number words. As a consequence, the underspecified representation leads to an absolute interpretation of ordinal number words. Thus, ordinal numbers are interpreted like adjectives such as *green* or *French*.

Both, Matthei (1982) and Marcilese et al. (2013) suggested that the problems children encounter with phrases like *the second green ball* may not exclusively be due to the syntactic integration of the modifiers. Based on the results from the *second green ball* tasks, Roeper proposes that children start out with intersective interpretations of non-

intersective adjectives in general. Only later children acquire relative readings involving a comparison class. This assumption is corroborated by the results of this thesis.

Based on the data from Experiment 1 to 3, I propose that at least three steps can be found in the acquisition of ordinal numbers. First, the core meaning needs to be acquired. Children need to establish the relation of the ordinal number to cardinal numbers to be able to detect the n^{th} element in a sequence. At an initial step, children seem to know that the ordinal number word denotes a fixed position in a sequence. Which position, however, is still unknown to the child because she cannot link the ordinal number to the corresponding cardinal number. The individual interpretation patterns of three 4-year-old children in Experiment 2 suggest that children may initially interpret ordinal numbers as referring to the first position in a sequence. Two children selected the first element in 5 out of 6 items of the control condition Non-intersectivity; the third child selected the first picture in 4 out of 6 items in this condition. These children associated the meaning of the ordinal number words *second* and *third* with a fixed position in the sequence of objects. The correct relation between the ordinal and the described position, however, was not yet established.

Second, the core meaning of ordinal numbers is acquired but the modifier is interpreted without reference to a comparison class. Intersective interpretations arise. Again, the data of the control condition Non-intersectivity is informative in this respect. In Experiment 1, 27 out of 82 4- to 6-year-old children selected intersective pictures in at least 5 out of 6 items. This was demonstrated in an error analysis of the control condition Non-intersectivity. In addition, 13 4- to 5-year-old children out of a total of 50 children in Experiment 2 did not master the control condition for ordinal numbers. At least four of them showed in their spontaneous comments that they intended intersective interpretations of the ordinal number word. Similarly, 10 out of 90 children rejected correct picture selections for *the second ball* above chance level in Experiment 3. That is, they accepted correct picture selections at most only once. Four of these children justified the rejections on the basis of intersective readings in their spontaneous comments. Thus, in all three experiments intersective interpretations of the type *the thing that is second and a ball* are found consistently at an individual level. Moreover, these intersective interpretations were not limited to the control condition. For items involving relative clauses as additional modifiers, these children selected the second or third element overall in the array of objects, too.

At a third step of the development, the comparison class is included in the semantic representation of ordinal number words and ordinal numbers are interpreted target-like. At this stage, children can restrict the set of elements on which the ordinal number operates. They consider only elements of the set denoted by the noun phrase. In combination with other adjectives, this target-like semantic representation may lead to conjoined (appositive) interpretations like *the second and green ball* as well as to restrictive readings depending on the syntactic integration of the modifiers. Nevertheless, intersective interpretations may be found despite a target-like semantics of ordinal numbers at this stage. It seems as if processing demands can mask target-like semantic representations. High task demands and a visual context containing distractor items (e.g., a ball at position 2, which is not the second ball overall) may lead to intersective picture selections although

children have acquired the non-intersective semantics of the modifiers.

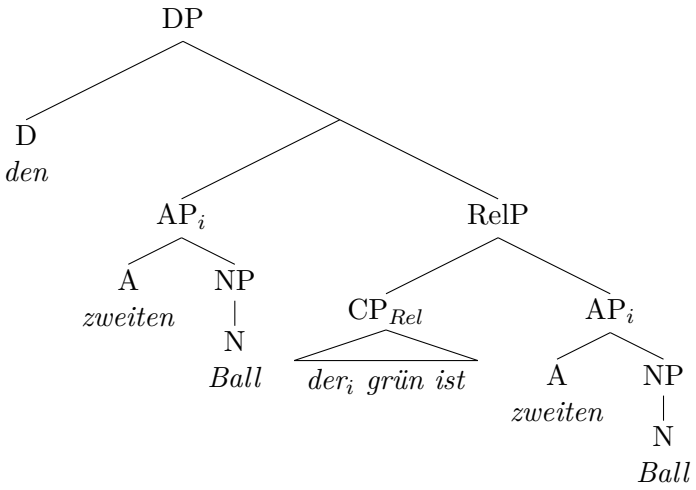
The data obtained in Experiment 1 and 2 as well as the previous studies on adjectival modifications showed that the amount of intersective interpretations can be modulated by the structure of the visual context. Children are more prone to interpret an ordinal number word intersectively when a matching picture is displayed in the context. Thus, when the first ball in a sequence is displayed at the second position, children tend to select this object when they shall select *the second ball*. When no ball is displayed at the second position, in contrast, children show target-like non-intersective picture selections. The absence of a distractor picture in Experiment 2 for instance led to an increase by 39% of correct interpretations in the control condition Non-intersectivity compared to Experiment 1, where a distractor was present.

I propose that children showing an unstable pattern depending on the visual context have a target-like representation of ordinal numbers. I assume that these children interpret ordinal numbers with respect to a comparison class. However, limited processing capacities may let the children resort to a direct interpretation of the incoming lexical elements. When these children identify an ordinal number word in the input, it is integrated into the syntactic parse tree target-like. To be able to interpret the ordinal number word without any delay, the child may fill the comparison class with an semantically empty noun like *thing* or *one*. A direct identification of a referent may result in an interpretation like *the second thing. It is a ball*. When a matching referent is displayed at the second position, this immediate interpretation succeeds. When no appropriate element is displayed at the second position, the children have direct evidence that the unconstrained comparison class was not felicitous. Thus, the comparison class needs to be changed to the denotation of the noun.

Evidence for such a processing-based explanation for high rates of intersective interpretations comes from the few errors of the adults. One adult in Experiment 1 selected the picture corresponding to an intersective reading. In addition, Marcilese et al. (2011) demonstrated that adults focused erroneously on the n^{th} element in a visual context when they had to process stimuli like *the second green ball* rapidly.

These three steps in the acquisition of ordinal numbers can also be modeled syntactically. When a transparent syntactic-semantic representation according to Cinque (2010) is adopted, different positions for adjectives of different semantic classes or modification types are assumed. Intersective adjectives would occur below non-intersective adjectives in the structure of the DP. An underspecified semantic representation of ordinal numbers may correspond to an attachment at a lower position within the DP structure in this approach. Under the assumption of Cinque (2008a) relative clauses can only be attached as prenominal modifiers. Therefore, the head noun has to be reconstructed with all other intersective modifiers below the relative clause. The corresponding structure is exemplified in (8).

(8)



In the structure in (8), the relative clause is interpreted relative to the second object in total, which is a ball. This results in an intersective interpretation. Thus, the assumption that ordinal numbers are interpreted initially as intersective modifiers lacking a comparison class explains the selection of the nth element overall in the picture selection tasks of Experiment 1 to 3, as well as in the studies investigating phrases like *the second green ball*. This assumption is independent of the syntactic approach to relative clauses or adjectives.

At the third step in the acquisition of ordinal numbers, children consider the comparison class. Based on a target-like semantic representation, *second* and *third* are interpreted relative to the set denoted by the head noun. Other elements displayed in the visual context are not considered for the evaluation of the ordinal number word. When multiple modifiers are encountered, both a conjoined appositive-like interpretation as well a restrictive interpretation can be derived at this stage. The interpretation depends on the syntactic integration of the two modifiers (coordinated or hierarchically layered) and is not specific to the ordinal number words.

The proposed acquisition path may not be limited to ordinal numbers. It may be the case that all adjectives are interpreted intersectively at an early stage in acquisition as e.g., put forward by Roeper (2009). Further research is needed to develop experiments that are able to discriminate intersective interpretations due to a missing comparison class from conjoined readings resulting from a different syntactic integration of (non)-intersective modifiers.

8.5. Summary

The central question of this thesis was how typically developing German-speaking children acquire the semantic functions *restrictivity* and *appositivity* in relative clauses. As a first answer to this question, I proposed an acquisition path of at least three steps for restrictive and appositive readings of relative clauses. I proposed that restrictive readings constitute a precondition for the derivation of target-like appositive structures. I

argued that the appositive interpretations observed at the age of 3 do not correspond to a formal representation of appositive relative clauses derived by adults. Instead, the acceptance of appositive readings is the result of a high attachment of the relative clause at the root of the matrix clause. As soon as children are able to attach the relative clause within the matrix clause, restrictive readings are derived. This stage is reached by the majority of children at the age of 4. Furthermore, I argued that appositive interpretations can only be derived subsequently to restrictive readings. Due to the attachment at the DP-level, the derivation of appositive relative clauses requires a reanalysis of the initial (restrictive) parse tree. The relative clause has to be moved from the NP-level to the DP shell. This structural reanalysis is demanding and requires additional processing resources. Therefore, such a reconstruction is avoided if possible and restrictive relative clauses are preferred over appositive ones in language comprehension by children and adults. At which age appositive readings are derived target-like is still an open question. This third stage may be achieved at the age of 4 by some children, or the appositive interpretations observed at this age are due to children in transition phase from Stage 1 to Stage 2.

The postulated acquisition path is assumed to hold cross-linguistically for languages with postnominal relative clauses. Thus, the order of non-restrictive readings (i.e., conjoined readings) before restrictive interpretations before appositive ones is expected to be found in other languages, too. This developmental path may also be transferred to the acquisition of adjectival modification. Furthermore, high attachment at the root may not be limited to relative clauses. This way to deal with unidentified or uncategorized linguistic material may be an initial step to integrate all kinds of subordinated clauses. The high attachment may for instance account for the observation that children interpret all complement clauses as factive complements at the age of 3.

In addition to the results on the acquisition of relative clauses, the last section of the discussion focused on the acquisition of ordinal numbers. I proposed that these non-intersective modifiers are acquired in a stepwise fashion. Initially, these modifiers may be interpreted to refer to the first position of a sequence. Subsequently they are interpreted as intersective modifiers without a comparison class. This leads to a selection of the n^{th} element overall without restricting the set to elements denoted by the modified noun phrase. Target-like interpretations can be expected only for a minority of children up to age 4. Five- and 6-year-old children master non-intersective interpretations of ordinal numbers when no intersective distractor picture is present in the items.

The following chapter concludes this thesis with a number of open questions and suggestions for further experiments to investigate the acquisition of restrictivity and appositivity in more detail.

9. Conclusion

This thesis investigated the acquisition of restrictive and appositive interpretations of relative clauses in German-speaking children between the ages of 3 and 6. Based on the results of three experiments, I proposed an acquisition path postulating that non-restrictive interpretations are derived before restrictive readings. Because of the syntactic and semantic complexity of appositive readings, I argue that the non-restrictive readings that were found for children at the age of 3 are not the result of a target-like appositive derivation. I propose that 3-year-old children do not yet identify relative clauses as nominal modifiers. Therefore, relative clauses are incorrectly integrated as adjuncts at the matrix clause CP and receive a conjoined interpretation. At the age of 4, the syntactic structure underlying a restrictive interpretation can be derived by the majority of children. I assume that appositive representations are acquired later than restrictive readings.

The experiments demonstrated a strong preference for restrictive interpretations in 4- to 6-year-old children as well as in the adult control groups. Moreover, neither a prototypical unintegrated prosodic contour nor the presence of a lexical marker, the discourse particle *ja*, or a visual context biasing for appositivity led to an increase of appositive interpretations in the children's groups. Adults, in contrast, were sensitive to the presence of the discourse particle and the cues from the visual context. As for children, the prosodic format of the relative clauses did not systematically change the interpretation preferences of adults.

The proposed acquisition path predicts the acquisition of restrictivity before appositivity for relative clauses. Moreover, the advocated order of acquisition may be transferred to the acquisition of adjectives, another type of nominal modifiers. It is important that the notion of appositivity should not be confused with (non-restrictive) coordinated interpretations that are predicted to appear even before restrictive interpretations for both phenomena. Furthermore, conjoined interpretations may also be found for other types of subordinate clauses like for instance for complements of factive and non-factive verbs. The high attachment of unidentified material may explain deviant interpretation patterns observed at an early stage in acquisition. It has to be mentioned that the model is put forward to capture the comprehension of relative clauses. For production, the derivation of restrictive or appositive relative clauses as modifiers of the nominal domain may not be as difficult. The major obstacle that has to be mastered in comprehension is the identification of the subordinated clause in the input stream and its correct syntactic integration into the matrix clause. Due to the role of processing principles that are assumed to guide the formation of a parse tree, children may have more difficulties to derive a restrictive or appositive interpretation in comprehension than in production. During language production the function of the modifier results from the intended message to be transferred and the attachment site does not have to be inferred but can be

planned accordingly, when relative clauses are already part of the grammatical repertoire of the child.

Further studies are needed to explore the predictions coming from the acquisition path postulated here. A longitudinal design would be informative to corroborate the acquisition stages postulated above. Especially the question when target-like appositive interpretations are acquired needs further investigation. Based on the data from the three experiments, it is an open question whether Stage 3, i.e., true appositivity, is reached at the age of 4 or whether this stage is reached only after the age of 6. This question may be explored with designs testing the interpretation of relative clauses attached to proper names or other elements of type e. It would be necessary to find out whether 4- and 5-year-old children with restrictive interpretations for relative clauses attached to common nouns are able to interpret relative clauses that are attached to proper names. Additionally, other properties that distinguish restrictive and appositive relative clauses (like e.g., independent illocutionary force or the influence of operators) would need to be implemented in experimental designs to be able to distinguish conjoined appositive-like interpretations from target-like appositive ones.

Furthermore, the interaction of working memory or executive functions and the interpretation of relative clauses should be explored. The acquisition path is based on the assumption that processing capacity may be a limiting factor regarding the range of possible interpretations that can be derived. I argued that there may be an intermediate step between Stage 1 and Stage 2, in which a restrictive structure is derived syntactically. Due to limited processing capacities, however, the syntactic structure may be interpreted immediately without considering postnominal modifiers to establish the reference of the nominal head. Such an interpretation strategy may result in a conjoined, i.e., non-restrictive, interpretation although a target-like restrictive representation was derived. Correlations with working memory measures may shed light onto the question whether working memory is (at least partially) responsible for specific interpretation patterns. Eye-tracking studies could be used to investigate the search pattern of children and adults while they listen to the stimuli. The use of this method may show that adults in contrast to young children are able to recover from an initial misanalysis and adapt their interpretation when postnominal modifiers are encountered. Eye-tracking studies may also be useful to investigate the influence of cues for restrictive and appositive interpretations. Discourse particles as markers for appositive readings led to a reanalysis of the interpretations for some adults in Experiment 2 and 3. Fixation data could help to reveal whether participants fixate the picture corresponding to a restrictive reading until a lexical marker is identified as an indicator for an appositive interpretation.

In addition, a reduced working memory capacity may be responsible for the proposed asymmetry in the availability of relative clause functions in production and comprehension. As discussed in the previous chapter, it may be the case that children can produce but not comprehend relative clauses with a specific semantic function. To investigate this aspect, experiments would need to investigate both the production and comprehension of unambiguous restrictive and appositive relative clauses to investigate the suggested asymmetry on an individual level. Furthermore, it may be conceivable that there exist intermediate stages in which children are able to derive restrictive or appositive inter-

pretations in simple but not in complex contexts. In more demanding settings involving time pressure or additional tasks, they may fall back to the preceding acquisition stage. Such findings may not be accounted for by the acquisition of syntactic or semantic operations. However, they may be expected based on the core assumptions underlying the postulated acquisition path.

Further research may also address the interaction of restrictive and appositive interpretations and the pragmatics of the task. As discussed in Chapter 4, the experimental setting used in the series of experiments in this thesis may bias subjects towards restrictivity. The test sentences are imperatives that ask the participant to select an object from a shelf. According to the maxims of Grice (1989), the relative clause may be interpreted as an informative and relevant part of the utterance. To investigate the influence of pragmatics on the interpretation preferences, a truth value judgment task as proposed at the end of Section 7.4 may be useful. I suggest that an influence of pragmatics may only be observed for children at stage 3. Before, the children are only able to derive one reading and cannot change it even if it is pragmatically infelicitous. However, even for adults it is an open question how strong the pragmatics of an experimental setting like the one chosen in the picture selection tasks influences the choice of interpretations. Furthermore, different experimental settings should be designed to explore the interpretation of relative clauses with different types of head nouns like proper names, quantified head nouns or bare plurals. This may also allow to vary the pragmatic contexts.

In sum, the experiments reported in this thesis are a first step to understand the acquisition of the semantic functions of relative clauses. The results suggest a close interaction of syntactic and semantic knowledge in the acquisition process. The experiments reported here may serve as a starting point for further studies investigating more specific properties of restrictive and appositive relative clauses. In addition, they may motivate cross-linguistic studies as well as comparative studies on the acquisition of restrictivity and appositivity in different types of nominal modification.

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A. Experiment 1

A.1. List of items

Table A.1.: List of items by condition

Warm-ups:	
Nimm den zweiten Schlüssel und leg ihn in den Koffer.	
Nimm die dritte Tasche und leg sie in den Koffer.	
Pretest Ordinal numbers:	
Nimm dritten Pullover und leg ihn in den Koffer.	
Nimm das zweite T-Shirt und leg es in den Koffer.	
Nimm den dritten Stift und leg ihn in den Koffer.	
Nimm die zweite Hose und leg sie in den Koffer.	
Control Condition Non-intersectivity:	
Nimm das dritte Handtuch und leg es in den Koffer.	
Nimm die zweite Hose und leg sie in den Koffer.	
Nimm den zweiten Lutscher und leg ihn in den Koffer.	
Nimm den zweiten Ball und leg ihn in den Koffer.	

Continued on next page

Table A.1 – continued from previous page

Nimm den dritten Apfel und leg ihn in den Koffer.	
Nimm die dritte Zahnbürste und leg sie in den Koffer.	
Control Condition Subsectivity:	
Nimm den dritten Hut und leg ihn in den Koffer.	
Nimm die zweite Jacke und leg sie in den Koffer.	
Nimm die dritte Uhr und leg sie in den Koffer.	
Nimm den dritten Schal und leg ihn in den Koffer.	
Nimm die zweite Schere und leg sie in den Koffer.	
Nimm die zweite Mütze und leg sie in den Koffer.	
Relative clauses - Ambiguous visual context:	
Nimm die zweite Ente, die grün ist, und leg sie in den Koffer.	
Nimm das dritte Auto, das rot ist, und leg es in den Koffer.	
Nimm das zweite T-Shirt, das gestreift ist, und leg es in den Koffer.	
Nimm den dritten Pullover, der blau ist, und leg ihn in den Koffer.	
Nimm die zweite Sonnenbrille, die gelb ist, und leg sie in den Koffer.	

Continued on next page

Table A.1 – continued from previous page

Nimm den dritten Stift, der schwarz ist, und leg ihn in den Koffer.	
Relative clauses - Restrictive visual context:	
Nimm die zweite Jacke, die bunt ist, und leg sie in den Koffer.	
Nimm den zweiten Apfel, der gelb ist, und leg ihn in den Koffer.	
Nimm die dritte Zahnbürste, die rosa ist, und leg sie in den Koffer.	
Nimm die dritte Uhr, die schwarz ist, und leg sie in den Koffer.	
Nimm den dritten Ball, der rosa ist, und leg ihn in den Koffer.	
Nimm den zweiten Hut, der bunt ist, und leg ihn in den Koffer.	
Relative clauses - Appositive visual context:	
Nimm die zweite Mütze, die grün ist, und leg sie in den Koffer.	
Nimm die zweite Hose, die blau ist, und leg sie in den Koffer.	
Nimm den dritten Lutscher, der rosa ist, und leg ihn in den Koffer.	
Nimm den dritten Schal, der bunt ist, und leg ihn in den Koffer.	
Nimm die dritte Schere, die rot ist, und leg sie in den Koffer.	
Nimm das zweite Handtuch, das gestreift ist, und leg es in den Koffer.	

A.2. Additional results for children with mastery in the control condition Non-intersectivity

A.2.1. Tables of results with percentages and standard deviations

Table A.2 gives an overview of the results for all contextually ambiguous relative clause items by age groups and prosody.

Table A.2.: Exp. 1 – Proportions (*SD*) of interpretations for contextually ambiguous relative clauses by prosody and age group

	Restrictive prosody			**Appositive prosody**		
Interpretation	**Age 4** ($n = 9$)	**Age 5-6** ($n = 24$)	**Adults** ($n = 20$)	**Age 4** ($n = 9$)	**Age 5-6** ($n = 24$)	**Adults** ($n = 20$)
			Ordinal *third* ($n = 3$)			
Restrictive	100% (0.0)	83.3% (24.1)	91.7% (23.9)	77.8% (23.6)	73.6% (39.3)	71.7% (42.7)
Appositive	-	11.1% (16.1)	3.3% (10.3)	-	13.9% (21.8)	16.7% (27.6)
Intersective	-	2.8% (9.4)	5.0% (22.4)	14.8% (24.2)	12.5% (27.5)	8.3% (14.8)
No match	-	-	-	-	-	-
Other	-	2.8% (9.4)	-	7.4% (14.7)	-	-
Ordinal *second* – One picture for intersective & appositive reading ($n = 2$)						
Intersective/ Appositive	-	16.7% (31.9)	-	22.2% (36.3)	14.6% (31.2)	22.5% (38.0)
Restrictive	100% (0.0)	81.3% (35.5)	100% (0.0)	77.8% (36.3)	79.2% (35.9)	75.0% (38.0)
No match	-	2.1% (10.2)	-	-	-	2.5% (11.2)
Other	-	-	-	-	6.3% (22.4)	-

Continued on next page

Table A.2 – continued from previous page

	Restrictive prosody			**Appositive prosody**		
Interpretation	**Age 4** ($n = 9$)	**Age 5-6** ($n = 24$)	**Adults** ($n = 20$)	**Age 4** ($n = 9$)	**Age 5-6** ($n = 24$)	**Adults** ($n = 20$)
Ordinal *second* – One picture for appositive & restrictive reading ($n = 1$)						
Intersective	22.2% (44.1)	4.2% (20.4)	-	-	-	10.0% (30.8)
Appositive/ Restrictive	77.8% (44.1)	95.8% (20.4)	100% (0.0)	100% (0.0)	100% (0.0)	90.0 (30.8)
No match	-	-	-	-	-	-
Other	-	-	-	-	-	-

Table A.3 gives a detailed overview of the results for the interpretation of relative clauses in the conditions with unambiguous visual contexts.

Table A.3.: Exp. 1 – Percentages (*SD*) of interpretations for contextually unambiguous relative clauses by prosody and age group

	Restrictive prosody			**Appositive prosody**		
Interpretation	**Age 4** ($n = 9$)	**Age 5-6** ($n = 24$)	**Adults** ($n = 20$)	**Age 4** ($n = 9$=	**Age 5-6** ($n = 24$)	**Adults** ($n = 20$)
Restrictive	85.2% (13.0)	86.8% (20.8)	99.2% (3.7)			
Appositive				33.3% (41.7)	47.2% (48.1)	28.3% (42.3)
No match	1.9 % (5.6)	1.4% (4.7)	0.8% (3.7)	64.8% (43.7)	52.8% (48.1)	71.7% (42.3)
Other	13.0% (11.1)	11.8% (20.0)	-	1.9% (5.6)	-	-

A.2.2. Analysis of spontaneous comments in unambiguous relative clauses

To investigate the high amount of 'no match' responses in relative clause items with appositive prosody and appositive visual context, the spontaneous comments of the participants were analyzed. Note that within the experiment, participants were not explicitly prompted to explain their actions. Thus, this additional analysis can only explain a limited amount of 'no match' interpretations, namely those instances in which participants reacted spontaneously and explained their surprise or their intended reading.

In 92 instances of the unambiguous appositive condition, i.e., for 44% of items in this condition, children stated their intended meanings. In their comments, children showed that they had an interpretation for the relative clause that was not supported by the visual context. An example is illustrated in (9). The comment clearly shows that the child interpreted the relative clause restrictively although the stimulus was presented with an appositive prosody and in a context that only allowed an appositive picture selection. It corresponds to the example test item depicted in (6) and Figure 5.7 on page 166.

(9) Comment on an unambiguous appositive test item of Experiment 1 indicating a restrictive reading in contrast to the *no matching picture* choice

Caru:	Nimm die zweite Mütze, die grün ist, und leg' sie in den Koffer.
Child:	Die zweite Mütze, die grün ... Da gibt's aber nur eine grüne Mütze.
Exp:	Was soll ich machen?
Child:	Hier drauf drücken. (points at the 'no matching picture' symbol)
Caru	*Take the second cap, which is green, and put it in the suitcase.*
Child:	*The second cap that/who green ... But there is only one green cap.*
Exp:	*What shall I do?*
Child:	*Click here.* (points at the 'no matching picture' symbol)

04_JJR101, age 4;9

The comments did not only concern changes from selections coded as *no matching picture* to *restrictive* interpretations as shown in (9), but also from *appositive* picture selections to *intersective* or *restrictive* readings. Comments indicating these changes are illustrated in (10) and (11) respectively.

(10) Comment on an unambiguous appositive test item of Experiment 1 indicating an intersective reading instead of an appositive picture choice

Caru: Nimm die zweite Mütze, die grün ist, und leg' sie in den Koffer.
Child: (points at position 2) Da ist doch keine Mütze. Dann nehmen wir die grüne Mütze.

Caru *Take the second cap, which is green, and put it in the suitcase.*
Child: (points at position 2) *There is no cap. Then we take the green cap.*
04_ELR021, age 4;2

(11) Comment on an unambiguous appositive test item of Experiment 1 indicating a restrictive reading instead of an appositive picture choice

Caru: Nimm den dritten Lutscher, der rosa ist, und leg' ihn in den Koffer.
Child: Den dritten? Da sind nicht drei. Dann nehm' ich einfach den zweiten.

Caru *Take the third lollypop, which is pink, and put it in the suitcase.*
Child: *The third? There aren't three. Then I simply take the second one.*
04_BHT066, age 5;0

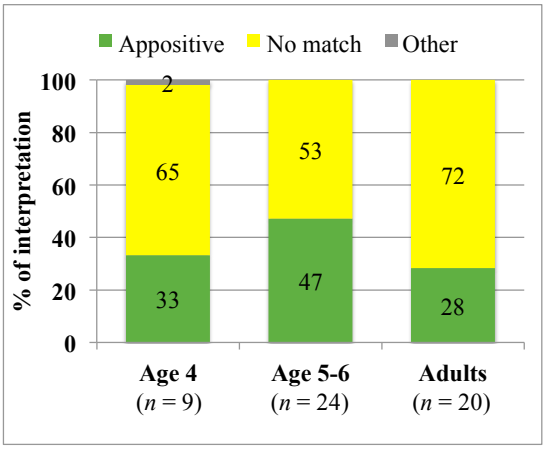
Also adults commented on their readings when their interpretation deviated from the options displayed in the visual array. In 17 instances of *no matching picture* selections, i.e., in 14% of items in this condition, adults made explicit that they derived a restrictive interpretation for the unambiguous appositive test items. This is exemplified in (12).

(12) Comment on an unambiguous appositive test item of Experiment 1 indicating a restrictive reading in contrast to the *no matching picture* choice by an adult participant

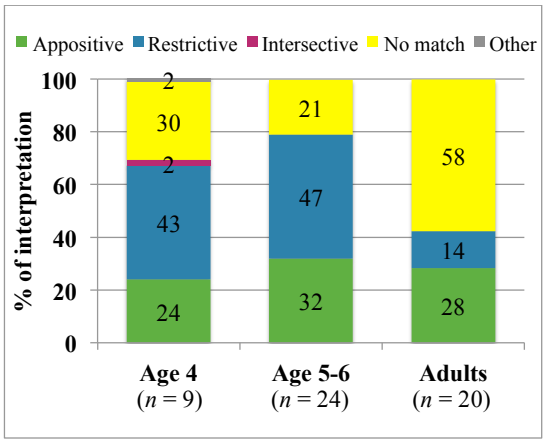
Caru: Nimm die zweite Mütze, die grün ist, und leg' sie in den Koffer.
Adult: Gibt nur eine grüne Mütze, also muss ich falsch anklicken.

Caru *Take the second cap, which is green, and put it in the suitcase.*
Adult: *There is only one green cap. Thus, I have to click on 'false'.*
04_ZCH210, age 24;7

In sum, the analyses of the participants' comments led to 109 changes in the classification of interpretations. The graphs in Figure A.1 contrast the distribution of interpretations based solely on the picture selections (see Figure A.1a) and the distribution based also on the verbal comments (Figure A.1b). As Figure A.1b demonstrates, the proportions of appositive and 'no match' interpretations reduced in favor of restrictive interpretations.



(a) Picture selection.



(b) Picture selections and comments.

Figure A.1.: Exp. 1 – Comparison of interpretations for relative clauses with appositive prosody and unambiguous appositive visual context on the basis of spontaneous comments of the participants.

A.2.3. Individual interpretation strategies

To address the research questions (Q1) on differences between children and adults and (Q2) on the availability of both semantic function in more depth, individual interpretation patterns were analyzed for the four conditions. For each condition, a participant was classified as having a *restrictive* (RES), *appositive* (APP), *intersective* (INT), *other* (Other), or *no-match strategy* (No match). A strategy was assigned when the participant interpreted more than half of the items in one condition consistently. When no strategy could be identified for the interpretation pattern in a condition, the label *none* (None) was assigned.

Table A.4 gives an overview of the observed interpretation strategies in the two conditions with ambiguous visual context by age groups. The strategy listed in the first row corresponds to the expected interpretation pattern. The strategies in the subsequent rows are ordered according to their frequency.

Table A.4 shows that the predominant interpretation strategy, restrictivity in both prosodic conditions (line 2), was found for 38 participants. The expected pattern (line 1), an interpretation according to the prosodic contour of the pre-recorded stimuli, was found only for four participants, three adults and one child at age 5-6. In addition, four

Table A.4.: Exp. 1 – Individual interpretation strategies for relative clauses with ambiguous visual context by age group

	Condition		**Age 4**	**Age 5-6**	**Adults**	**Total**
	P: Res	**P: App**	($n = 9$)	($n = 24$)	($n = 20$)	($N = 53$)
Interpretation strategy[a]	RES	APP	-	1	3	4
	RES	RES	8	16	14	38
	RES	INT	1	3	-	4
	RES	None	-	1	2	3
	None	RES	-	2	-	2
	INT	APP	-	-	1	1
	None	APP	-	1	-	1

Note. P: Res = Restrictive Prosody; P: App = Appositive Prosody; RES = Restrictive strategy; APP = Appositive strategy; INT = Intersective strategy; None = No strategy can be assigned.
[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

children but no adults were restrictive in items with restrictive prosody but showed consistent intersective interpretations for items of the appositive prosody condition. The table reveals that no participant adopted an appositive strategy in items with restrictive prosody. The inverse, however, is frequently documented. Items with appositive prosody were consistently interpreted as restrictive modifiers by 40 out of the 53 participants.

Table A.5 shows the distribution of consistent interpretations for the items in the unambiguous visual context conditions. The analysis is based on the picture selection data and the analysis of the spontaneous comments of the participants.[1] The expected interpretation pattern is listed in the first row. The other strategies are ordered according to their frequency. The asterisk in the second strategy indicates that this restrictive strategy resulted from consistent comments of the participants. Although no picture matching the restrictive reading was present, the comments showed that these participants intended a restrictive reading in more than half of the items.

Fourteen participants performed in accordance with the prosody and the visual context. Within each age group, about one quarter of the participants showed this first interpretation pattern. The predominant interpretation patterns, however, were the second and the third one. Out of the 53 participants, 16 participants each interpreted items of the restrictive condition target-like but chose either the 'no matching picture' button

[1]When the spontaneous comments of the participants were not considered, the second strategy could not have been detected. Therefore the observed patterns changed. The main change regarded the strategy in row 3. When the comments were ignored, 15 participants were classified additionally as showing this strategy.

Table A.5.: Exp. 1 – Individual interpretation strategies for relative clauses with unambiguous visual context by age group

	Condition		Age 4	Age 5-6	Adults	Total
	Res	**App**	(n = 9)	(n = 24)	(n = 20)	(N = 53)
Interpretation strategy[a]	RES	APP	2	6	6	14
	RES	RES*	4	10	2	16
	RES	No match	2	4	10	16
	RES	None	1	2	2	5
	Other	APP	-	1	-	1
	None	APP	-	1	-	1

Note. Res = Restrictive condition; App = Appositive condition; RES = Restrictive strategy; RES* = Restrictive strategy based on participant's comments; APP = Appositive strategy; INT = Intersective strategy; No match = 'No matching picture' strategy; Other = Non-target picture strategy; None = No strategy can be assigned.

[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

in the appositive condition or indicated by their comments that they intended a restrictive reading. When only the unambiguously appositive items were considered, 16 out of 53 participants (30%) interpreted relative clauses consistently as appositive modifiers.

Table A.6 gives an overview of the strategies across all four conditions. As in the previous tables, the expected interpretation pattern according to the prosodic realization of the stimuli is listed in the first row. The following patterns are ordered according to their frequency. In Table A.5, an asterisk in the condition with unambiguous visual context and appositive prosody indicates that the restrictive interpretation was identified by the comments of the participants. In this condition, there was no picture present that corresponded to a restrictive reading.

Table A.6 shows that only 4 participants (1 child at age 5-6 and 3 adults) used the prosodic contour as the relevant cue to disambiguate the relative clauses across all conditions. The most frequently observed patterns were the strategies in row 2 and 3. Fifteen out of 53 participants (28%) each chose the 'no matching picture' button or verbalized that they intended restrictive interpretations in the condition with unambiguous appositive visual context and prosody. Thus, 15 participants pursued a restrictive strategy to interpret relative clauses in all four conditions of this experiment. This restrictive interpretation was not discarded on the basis of contradicting prosodic and visual information. Four other children interpreted relative clauses appositively when this was the only interpretation available in the visual context (see row 4). In all other conditions, these children opted for a restrictive reading.

Table A.6.: Exp. 1 – Individual interpretation strategies for relative clauses across conditions by age group

	Condition				**Age group**			
	VC: Ambiguous		**VC: Unambiguous**		**Age 4**	**Age 5-6**	**Adults**	**Total**
	P: Res	**P: App**	**P: Res**	**P: App**	($n = 9$)	($n = 24$)	($n = 20$)	($N = 53$)
Interpretation strategy[a]	RES	APP	RES	APP	-	1	3	4
	RES	RES	RES	RES*	4	9	2	15
	RES	RES	RES	No match	2	3	10	15
	RES	RES	RES	APP	2	2	-	4
	RES	RES	RES	None	-	2	2	4
	RES	INT	RES	APP	-	3	-	3
	RES	None	RES	APP	-	-	2	2
	RES	INT	RES	None	1	-	-	1
	RES	None	None	APP	-	1	-	1
	INT	APP	RES	APP	-	-	1	1
	None	APP	Other	APP	-	1	-	1
	None	RES	RES	RES*	-	1	-	1
	None	RES	RES	No match	-	1	-	1

Note. VC = Visual context; P: Res = Restrictive prosody; P: App = Appositive prosody; RES = Restrictive strategy; RES* = Restrictive strategy based on participant's comments; APP = Appositive strategy; INT = Intersective strategy; No match = 'No matching picture' strategy; Other = Non-target picture strategy; None = No strategy can be assigned.

[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

A.3. Additional results for children without mastery in the control condition Non-intersectivity

A.3.1. Tables of results with percentages and standard deviations

Table A.7 gives an overview of the interpretation of contextual ambiguous relative clause items of the children without mastery in the control condition Non-intersectivity.

Table A.7.: Exp. 1 – Percentages (*SD*) of interpretations for contextually ambiguous relative clauses by prosody in children without mastery of control condition Non-intersectivity

	Restrictive prosody			**Appositive prosody**		
Interpretation	**Age 4** ($n = 27$)	**Age 5** ($n = 14$)	**Age 6** ($n = 8$)	**Age 4** ($n = 27$)	**Age 5** ($n = 14$)	**Age 6** ($n = 8$)
			Ordinal *third* ($n = 3$)			
Restrictive	14.8% (21.4)	2.4% (8.9)	-	13.6% (26.6)	-	4.2% (11.8)
Appositive	25.9% (29.8)	7.1% (19.3)	-	23.5% (31.8)	2.4% (8.9)	4.2% (11.8)
Intersective	45.7% (41.5)	90.4% (27.5)	95.8% (11.8)	50.6% (36.2)	97.6% (8.9)	91.7% (23.6)
No match	2.5% (12.8)	-	-	2.5% (12.8)	-	-
Other	9.9% (24.1)	-	4.2% (11.8)	7.4% (16.9)	-	-
			Ordinal *second* – One picture for intersective & appositive interpretation ($n = 2$)			
Intersective/ Appositive	46.3% (41.4)	92.9% (26.7)	100% (0.0)	55.6% (42.4)	89.3% (21.3)	93.8% (17.7)
Restrictive	25.9% (37.6)	7.1% (26.7)	-	20.4% (31.8)	3.6% (13.4)	6.3% (17.7)
No match	5.6% (21.2)	-	-	7.4% (22.8)	3.6% (13.4)	-
Other	22.2% (34.9)	-	-	16.7% (31.0)	-	-

Table A.7 – continued from previous page

	Restrictive prosody			**Appositive prosody**		
Interpretation	**Age 4** ($n = 27$)	**Age 5** ($n = 14$)	**Age 6** ($n = 8$)	**Age 4** ($n = 27$)	**Age 5** ($n = 14$)	**Age 6** ($n = 8$)
Ordinal *second* – One picture for appositive & restrictive interpretation ($n = 1$)						
Intersective	48.2% (50.9)	71.4% (46.8)	100% (0.0)	37.0% (49.2)	78.6% (42.6)	100% (0.0)
Appositive/ Restrictive	40.7% (50.1)	28.6% (46.8)	-	48.2% (50.9)	21.4% (42.6)	-
No match	-	-	-	-	-	-
Other	11.1% (32.0)	-	-	14.8% (36.2)	-	-

Table A.8 gives an overview over the interpretations in unambiguous test items.

Table A.8.: Exp. 1 – Percentages (*SD*) of interpretations for contextually unambiguous relative clauses by prosody of children w/o mastery in control condition Non-intersectivity

	Restrictive prosody			**Appositive prosody**		
Interpretation	**Age 4** ($n = 27$)	**Age 5** ($n = 14$)	**Age 6** ($n = 8$)	**Age 4** ($n = 27$)	**Age 5** ($n = 14$)	**Age 6** ($n = 8$)
Restrictive	24.1% (28.2)	9.5% (19.3)	2.1% (5.9)			
Appositive				51.2% (37.5)	28.6% (36.1)	25.0% (37.8)
No match	26.5% (41.4)	70.2% (46.3)	79.2% (34.2)	29.0% (38.0)	64.3% (39.1)	68.8% (45.8)
Other	48.8% (39.2)	20.2% (35.9)	18.8% (28.8)	19.8% (28.5)	7.1% (18.2)	6.3% (17.7)

A.3.2. Individual interpretation strategies

Table A.9 gives an overview of the individual interpretation strategies in the two conditions with ambiguous visual context by age groups. In the first row, the expected interpretation pattern is shown. The other interpretation strategies are ordered by frequency. The superscript "b" in the groups of 4-year-olds identifies the six children that interpreted 4 out of 6 items of the control condition non-intersectively.

Table A.9.: Exp. 1 – Individual interpretation strategies of participants without mastery in control condition Non-intersectivity for relative clauses with ambiguous visual context by age group

	Condition		**Age 4**	**Age 5**	**Age 6**	**Total**
	P: Res	**P: App**	($n = 27$)	($n = 14$)	($n = 8$)	($N = 49$)
Interpretation strategy[a]	RES	APP	1	-	-	1
	INT	INT	10^b	13	7	30
	APP	RES	2^{bb}	-	-	2
	APP	INT	1^b	1	-	2
	INT	None	1	-	1	2
	None	None	2	-	-	2
	RES	INT	1^b	-	-	1
	APP	APP	1	-	-	1
	APP	Other	1	-	-	1
	APP	None	1	-	-	1
	INT	APP	1	-	-	1
	INT	RES	1^b	-	-	1
	None	APP	1	-	-	1
	None	INT	1	-	-	1
	Other	APP	1	-	-	1
	Other	INT	1	-	-	1

Note. P: Res = Restrictive prosody; P: App = Appositive prosody; RES = Restrictive strategy; APP = Appositive strategy; INT = Intersective strategy; Other = Non-target picture strategy; None = No strategy can be assigned.

[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

[b]Child with 4 out of 6 items correct in control condition Non-intersectivity.

Table A.9 shows 16 different interpretation patterns. Thirteen of them were only found for 4-year-old children. Overall, only one of the patterns was observed for more than two children. This predominant strategy is displayed in row 2. Thirty out of 49 children (61%) interpreted the relative clause intersectively in more than half of the items in each prosodic condition. The table reveals that the Strategy RES was almost exclusively found for children with 4 out of 6 non-intersective interpretations in the control condition. Although these children missed the mastery criterion in the control condition, they showed non-intersective interpretations of ordinal numbers in the relative clauses items. The Strategy APP, however, was also found for children with less than four non-intersective interpretations of ordinal numbers.

Table A.10 shows the interpretation strategies for items of the unambiguous context condition. The first row displays the expected pattern by prosody and visual context. The following interpretation strategies are ordered by their frequency of occurrence.

Table A.10.: Individual interpretation strategies of participants w/o mastery in control condition Non-intersectivity for contextually unambiguous relative clauses

	Condition		**Age 4**	**Age 5**	**Age 6**	**Total**
	Res	**App**	($n = 27$)	($n = 14$)	($n = 8$)	($N = 49$)
Interpretation Strategy[a]	RES	APP	3	1	-	4
	No match	No match	3	9	5	17
	Other	APP	8	1	-	9
	Other	None	2	-	1	3
	None	No match	3	-	-	3
	No match	APP	1	1	1	3
	Other	No match	1	1	-	2
	Other	Other	1	1	-	2
	None	None	2	-	-	2
	No match	None	1	-	1	2
	RES	No match	1	-	-	1
	No match	Other	1	-	-	1

Note. Res = Restrictive condition; App = Appositive condition; RES = Restrictive strategy; APP = Appositive strategy; No match = 'No matching picture' strategy; Other = Non-target picture strategy; None = No strategy can be assigned.

[a]Strategy assigned when > 50% of items of a condition are interpreted with one reading by a participant.

B. Experiment 2

B.1. List of items

Table B.1.: List of items by condition

Warm-ups:	
Nimm den zweiten Schlüssel und leg ihn in den Koffer.	
Nimm die dritte Spielfigur und leg sie in den Koffer.	
Control Condition Non-intersectivity:	
Nimm den zweiten Hund und leg ihn in den Koffer.	
Nimm das dritte Handtuch und leg es in den Koffer.	
Nimm die dritte Katze und leg sie in den Koffer.	
Nimm die zweite Uhr und leg sie in den Koffer.	
Nimm den dritten Affen und leg ihn in den Koffer.	
Nimm das zweite T-shirt und leg es in den Koffer.	
Filler:	
Nimm den ersten Apfel und leg ihn in den Koffer.	
Nimm den letzten Elefanten und leg ihn in den Koffer.	

Continued on next page

Table B.1 – continued from previous page

Nimm das erste Auto und leg es in den Koffer	
Nimm den letzten Lutscher und leg ihn in den Koffer.	
Nimm das erste Pferd und leg es in den Koffer.	
Nimm die letzte Ente und leg sie in den Koffer.	
Nimm die letzte Kuh und leg sie in den Koffer.	
Nimm den ersten Tiger und leg ihn in den Koffer.	
Nimm den letzten Ball und leg ihn in den Koffer.	
Nimm die erste Schere und leg sie in den Koffer.	
Nimm die letzte Giraffe und leg sie in den Koffer.	
Nimm das erste Känguruh und leg es in den Koffer.	
Relative clauses - Ambiguous visual context:	
Nimm den zweiten Hut, der (ja) rot ist, und leg ihn in den Koffer.	
Nimm das dritte Auto, das (ja) blau ist, und leg es in den Koffer.	
Nimm den dritten Ball, der (ja) gestreift ist, und leg ihn in den Koffer.	
Nimm die zweite Jacke, die (ja) schwarz ist, und leg sie in den Koffer.	

Continued on next page

Table B.1 – continued from previous page

Nimm die dritte Ente, die (ja) bunt ist, und leg sie in den Koffer.	
Nimm den zweiten Lutscher, der (ja) gelb ist, und leg ihn in den Koffer.	
Nimm die zweite Schere, die (ja) grün ist, und leg sie in den Koffer.	
Nimm den dritten Apfel, der (ja) gelb ist, und leg ihn in den Koffer.	
Nimm den zweiten Pullover, der (ja) bunt ist, und leg ihn in den Koffer.	
Nimm das zweite Handtuch, das (ja) gestreift ist, und leg es in den Koffer.	
Nimm die zweite Mütze, die (ja) rot ist, und leg sie in den Koffer.	
Nimm die dritte Hose, die (ja) rosa ist, und leg sie in den Koffer.	
Nimm die dritte Sonnenbrille, die (ja) schwarz ist, und leg sie in den Koffer.	
Nimm den zweiten Stift, der (ja) blau ist, und leg ihn in den Koffer.	
Nimm das dritte T-shirt, das (ja) bunt ist, und leg es in den Koffer.	
Nimm die zweite Uhr, die (ja) gelb ist, und leg sie in den Koffer.	
Nimm den dritten Schal, der (ja) grün ist, und leg ihn in den Koffer.	

Continued on next page

Table B.1 – continued from previous page

Nimm die dritte Zahnbürste, die (ja) rosa ist, und leg sie in den Koffer.	

B.2. Additional results for children with mastery in the control condition Non-intersectivity

B.2.1. Table of results with percentages and standard deviations

Table B.2 shows the interpretation rates for the relative clause items in the four experimental conditions including standard deviations for the individual age groups.

Table B.2.: Exp. 2 – Proportions of interpretations (*SD*) in relative clause conditions by prosody and age group

	Restrictive prosody				**Appositive prosody**			
Interpretation	**Age 4** (n = 13)	**Age 5** (n = 21)	**Age 6** (n = 16)	**Adults** (n = 23)	**Age 4** (n = 13)	**Age 5** (n = 21)	**Age 6** (n = 16)	**Adults** (n = 23)
				Without *ja*				
Restrictive	74.4% (40.7)	85.7% (25.1)	84.7% (33.9)	93.7% (21.1)	66.7% (38.5)	76.7% (33.9)	86.1% (30.0)	92.3% (25.8)
Appositive	24.8% (41.1)	11.6% (23.7)	12.5% (34.2)	5.8% (21.2)	33.3% (38.5)	19.6% (30.2)	9.7% (24.6)	7.7% (25.8)
No match	-	-	-	-	-	-	-	-
Other	0.9% (3.1)	2.7% (7.8)	2.8% (7.6)	0.5% (2.3)	-	3.7% (8.1)	4.2% (16.7)	-
				With *ja*				
Restrictive	72.7% (40.0)	87.3% (19.0)	84.0% (29.0)	62.3% (48.3)	63.3% (42.6)	81.0% (31.8)	83.3% (34.4)	60.9% (43.9)
Appositive	25.6% (40.7)	10.0% (19.2)	12.5% (30.1)	37.7% (48.3)	34.2% (44.6)	18.0% (32.3)	13.9% (33.8)	39.1% (43.9)
No match	-	-	-	-	-	-	-	-
Other	1.7% (4.2)	2.7% (4.8)	3.5% (5.3)	-	2.6% (4.9)	1.0% (3.3)	2.8% (11.1)	-

B.2.2. Individual interpretation strategies

For each condition, the interpretation patterns of the children and adults were classified as a *restrictive* (RES), *appositive* (APP), *other* (Other), or *no-match* (No match) strategy. A strategy was assigned when the participant had interpreted more than half of the

items in one condition (at least 5 out of 9 items) consistently. When no strategy could be identified in a condition, the label *none* (None) was assigned.

Table B.3 shows the distribution of interpretation strategies across age groups for relative clauses without the discourse particle *ja*. Prosody was the only factor disambiguating the two semantic functions. The expected pattern is displayed in the first row of the table. The remaining strategies are ordered by their frequency of occurrence.

Table B.3.: Exp. 2 – Individual interpretation strategies for relative clauses without discourse particle *ja* by age group

	Condition		**Age 4**	**Age 5**	**Age 6**	**Adults**	**Total**
	P: Res	**P: App**	(n = 13)	(n = 21)	(n = 16)	(n = 23)	(N = 73)
Interpretation strategy[a]	RES	APP	2	4	-	1	7
	RES	RES	8	16	13	21	58
	APP	APP	3	1	2	1	7
	RES	Other	-	-	1	-	1

Note. P: Res = Restrictive Prosody; P: App = Appositive Prosody; RES = Restrictive strategy; APP = Appositive strategy; Other = Non-target picture strategy.

[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

The individual analysis in B.3 demonstrates that the participants were very consistent in their interpretations. The participants interpreted the majority of items in the two prosodic conditions either as restrictive or appositive. One child at the age of 5 selected an incorrect picture in more than half of the items of the appositive prosody condition and received the label *other*. Fifty-eight out of 73 participants (79%) consistently selected pictures matching a restrictive interpretation. In addition, seven participants went for the expected interpretation strategy (first row) and selected the pictures according to the prosodic format of the relative clauses. Furthermore, seven participants selected pictures matching an appositive interpretation independently of the prosody. Three of them were from the youngest group of participants.

Table B.4 illustrates the interpretation strategies for items including the discourse particle *ja* as lexical marker for an appositive interpretation. In these conditions, two patterns could be expected: a) the pattern according to the prosodic information is shown in the first row. b) In the second row of the table, the pattern that is expected when the lexical information of the discourse particle is used is displayed.

As Table B.4 shows, the majority of participants, 53 out of 73 (73%), selected pictures matching a restrictive reading of the clause in both prosodic conditions. Only four participants followed the prosodic information and chose restrictive readings when the relative clauses were presented with restrictive prosody but chose appositive readings when the relative clauses had an appositive prosodic format. In addition, 16 participants acted in accordance with the information conveyed by the discourse particle. They selected pictures matching an appositive interpretation consistently.

Table B.4.: Exp. 2 – Individual interpretation strategies for relative clauses with discourse particle *ja* by age group

	Condition		**Age 4**	**Age 5**	**Age 6**	**Adults**	**Total**
	P: Res	**P: App**	(n = 13)	(n = 21)	(n = 16)	(n = 23)	(N = 73)
Interpretation strategy[a]	RES	APP	2	1	-	1	4
	APP	APP	3	2	2	9	16
	RES	RES	8	18	14	13	53

Note. P: Res = Restrictive Prosody; P: App = Appositive Prosody; RES = Restrictive strategy; APP = Appositive strategy.

[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

Table B.5 gives an overview of the strategies when all four conditions were considered. When all conditions are considered, three patterns could be expected. The participants could interpret relative clauses according to the both factors Prosody and Lexical Marker, or they could follow only one of the cues.

Table B.5.: Exp. 2 – Individual interpretation strategies for relative clauses across conditions by age groups

	Condition				**Age group**				
	Without *ja*		**With *ja***		**Age 4**	**Age 5**	**Age 6**	**Adults**	**Total**
	P: Res	**P: App**	**P: Res**	**P: App**	(n = 13)	(n = 21)	(n = 16)	(n = 23)	(N = 73)
Interpretation strategy[a]	RES	APP	APP	APP	-	1	-	1	2
	RES	APP	RES	APP	1	1	-	-	2
	RES	RES	APP	APP	-	-	-	7	7
	RES	RES	RES	RES	7	16	13	13	49
	APP	APP	APP	APP	3	1	2	1	7
	RES	RES	RES	APP	1	-	-	1	2
	RES	APP	RES	RES	1	2	-	-	3
	RES	Other	RES	RES	-	-	1	-	1

Note. P: Res = Restrictive Prosody; P: App = Appositive Prosody; RES = Restrictive strategy; APP = Appositive strategy; Other = Non-target picture strategy.

[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

Table B.5 shows that overall, only two participants showed sensitivity for both experimental factors. The two children in row 1 determined the reading of the relative clause according to the prosody when no discourse particle was present but showed appositive interpretations consistently when the lexical marker indicated an appositive reading. This pattern was expected when participants rank the influence of a lexical marker higher than the prosodically conveyed information. In addition, two children selected pictures consistently according to the prosodic format of the stimulus sentences (row 2). In addition, seven participants, all adults, interpreted the relative clauses according to the presence or absence of the discourse particle. They interpreted relative clauses without the lexical marker as restrictive modifiers; relative clauses with the discourse particle were interpreted appositively. The most frequently observed pattern is the one in row 4. Forty-nine participants (67%) showed restrictive interpretations for the majority of all relative clauses in the experiment. In addition, seven participants always chose appositive interpretations for the experimental stimuli (row 5). The latter two interpretation patterns are the only ones that were found in all age groups.

B.3. Additional results for children without mastery in the control condition Non-intersectivity

B.3.1. Table of results with percentages and standard deviations

Table B.6 shows the interpretation rates for the relative clause items in the four experimental conditions including standard deviations for the individual age groups.

Table B.6.: Exp. 2 – Proportions (*SD*) of interpretations in relative clause conditions by prosody and age group for children without mastery in control condition Non-intersectivity

	Restrictive prosody		**Appositive prosody**	
Interpretation	**Age 4** ($n = 7$)	**Age 5** ($n = 6$)	**Age 4** ($n = 7$)	**Age 5** ($n = 6$)
		Without *ja*		
Restrictive	7.9% (16.6)	27.8% (37.0)	12.7% (14.9)	27.8% (37.7)
Appositive	42.9% (11.9)	33.3% (24.3)	55.6% (12.8)	33.3% (33.7)
No match	7.9% (21.0)	18.5% (40.2)	-	16.7% (40.8)
Other	41.3% (22.0)	20.4% (27.6)	31.8% (14.9)	22.2% (30.6)
		With *ja*		
Restrictive	14.3% (16.6)	37.0% (49.5)	19.1% (17.8)	31.5% (36.8)
Appositive	41.3% (31.2)	22.2% (27.2)	46.0% (29.7)	29.6% (21.8)
No match	14.3% (37.8)	18.5% (40.2)	-	11.1% (27.2)
Other	30.2% (29.2)	22.2% (28.1)	34.9% (23.5)	27.8% (26.1)

B.3.2. Individual interpretation strategies

Table B.7 displays the interpretation patterns for the 13 children without mastery in the control condition Non-intersectivity. The interpretation strategies are ordered by the frequency of occurrence. The asterisk indicates that the intersective strategy is based on the comments of the participant. The superscript "b" identifies the child that interpreted 4 out of 6 items of the control condition non-intersectively.

Table B.7.: Exp. 2 – Individual interpretation strategies for relative clauses across conditions for children without mastery in control condition Non-intersectivity

	Condition				**Group**
	Without *ja*		**With *ja***		**Age 4-5**
	P: Res	**P: App**	**P: Res**	**P: App**	(n = 13)
Interpretation strategy[a]	Other	APP	Other	Other	2
	RES	RES	RES	RES	1[b]
	APP	APP	APP	APP	1
	No match	No match	No match	No match	1
	RES	None	RES	None	1
	APP	APP	None	APP	1
	APP	APP	APP	None	1
	INT *	None	INT*	None	1
	Other	Other	APP	APP	1
	Other	None	Other	None	1
	None	APP	None	APP	1
	None	Other	APP	Other	1

Note. P: Res = Restrictive prosody; P: App = Appositive prosody; RES = Restrictive strategy; APP = Appositive strategy; INT = Intersective strategy; No match = 'No matching picture' strategy; Other = Non-target picture strategy; None = No strategy can be assigned.

[a]Strategy assigned when > 50% of items of a condition interpreted with one reading by a participant.

[b]Child with 4 out of 6 items correct in control condition Non-intersectivity.

*Strategy is based on the participant's comments.

The individual analysis corroborates the heterogeneity in the group of children without mastery in the control condition. For 13 children, 12 different patterns were found. Frequently, the label *None* had been assigned because the children did not interpret more than half of the items in one condition systematically. Only one child consistently

selected pictures matching a restrictive reading in all conditions (row 2). This 5-year-old child interpreted 4 out of 6 items correct in the control condition Non-intersectivity and was the only child that missed the mastery criterion by only one item. In addition, one child consistently selected pictures matching an appositive interpretation throughout the task (row 3). Furthermore, one child selected the 'no matching picture' button in more than half of the items per condition (row 4). Interestingly, appositive strategies were more often observed within the conditions than restrictive ones. This finding is comparable to the results of Experiment 1 for children without mastery of the semantics of ordinal numbers.

C. Experiment 3

C.1. List of items

Table C.1.: List of items by condition

Warm-ups:	
Nimm den zweiten Schlüssel und leg ihn in den Koffer.	
Nimm die dritte Spielfigur und leg sie in den Koffer.	
Control Condition Non-intersectivity:	
Nimm den zweiten Hund und leg ihn in den Koffer.	
Nimm das dritte Handtuch und leg es in den Koffer.	
Nimm die dritte Katze und leg sie in den Koffer.	
Nimm die zweite Uhr und leg sie in den Koffer.	
Nimm den dritten Affen und leg ihn in den Koffer.	
Nimm das zweite T-shirt und leg es in den Koffer.	
Filler:	
Nimm den ersten Apfel und leg ihn in den Koffer.	

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Table C.1 – continued from previous page

Nimm den letzten Elefanten und leg ihn in den Koffer.	
Nimm das erste Auto und leg es in den Koffer	
Nimm den letzten Lutscher und leg ihn in den Koffer.	
Nimm das erste Pferd und leg es in den Koffer.	
Nimm die letzte Ente und leg sie in den Koffer.	
Nimm die letzte Kuh und leg sie in den Koffer.	
Nimm den ersten Tiger und leg ihn in den Koffer.	
Nimm den letzten Ball und leg ihn in den Koffer.	
Nimm die erste Schere und leg sie in den Koffer.	
Nimm die letzte Giraffe und leg sie in den Koffer.	
Nimm das erste Känguruh und leg es in den Koffer.	
Relative clauses - Restrictive visual context:	
Nimm den zweiten Hut, der rot ist, und leg ihn in den Koffer.	
Nimm das dritte Auto, das blau ist, und leg es in den Koffer.	
Nimm den dritten Ball, der gestreift ist, und leg ihn in den Koffer.	

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Table C.1 – continued from previous page

Nimm die zweite Jacke, die schwarz ist, und leg sie in den Koffer.	
Nimm die dritte Ente, die bunt ist, und leg sie in den Koffer.	
Nimm den zweiten Lutscher, der gelb ist, und leg ihn in den Koffer.	
Relative clauses - Appositive visual context:	
Nimm den dritten Schal, der grün ist, und leg ihn in den Koffer.	
Nimm die zweite Mütze, die rot ist, und leg sie in den Koffer.	
Nimm die dritte Zahnbürste, die rosa ist, und leg sie in den Koffer.	
Nimm den zweiten Stift, der blau ist, und leg ihn in den Koffer.	
Nimm die zweite Uhr, die gelb ist, und leg sie in den Koffer.	
Nimm das dritte T-shirt, das bunt ist, und leg es in den Koffer.	
Nimm die zweite Schere, die ja grün ist, und leg sie in den Koffer.	
Nimm den dritten Apfel, der ja gelb ist, und leg ihn in den Koffer.	
Nimm den zweiten Pullover, der ja bunt ist, und leg ihn in den Koffer.	
Nimm das zweite Handtuch, das ja gestreift ist, und leg es in den Koffer.	
Nimm die dritte Hose, die ja rosa ist, und leg sie in den Koffer.	

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Table C.1 – continued from previous page

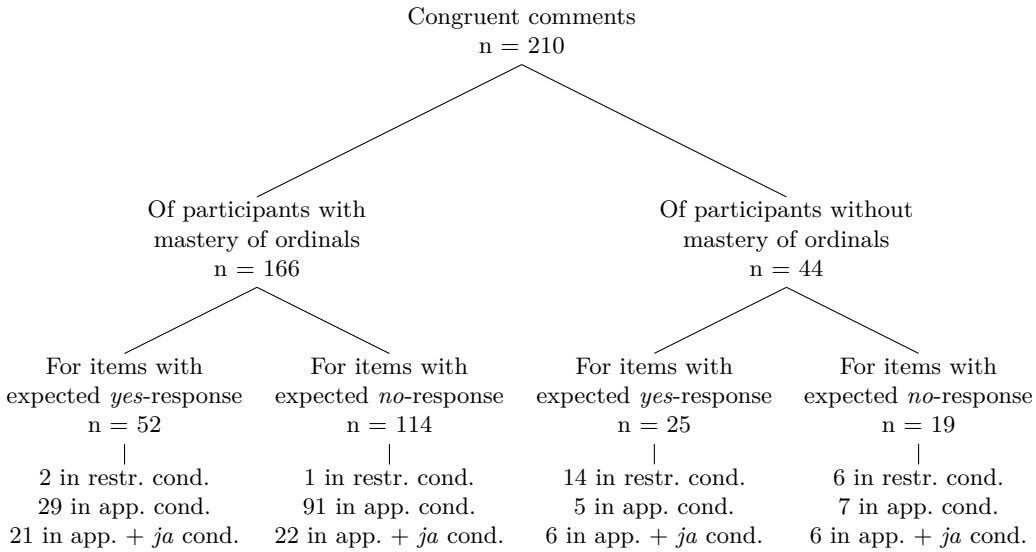
Nimm die dritte Sonnenbrille, die ja schwarz ist, und leg sie in den Koffer.	

C.2. Additional results for children with mastery in the control condition Non-intersectivity

C.2.1. Participants' comments incongruent with button press responses

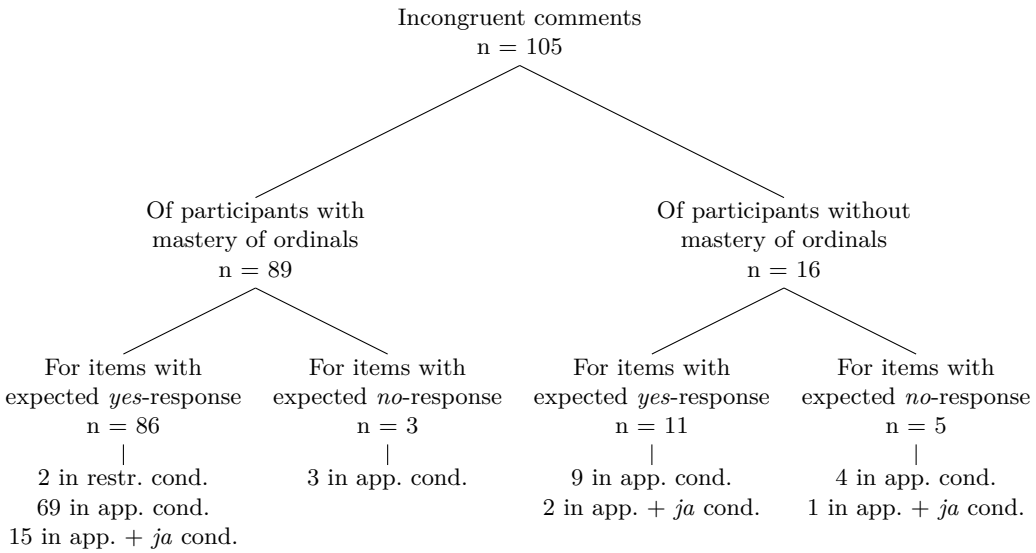
For the analysis of the results, the spontaneous comments of the participants were analyzed in detail. A comment was classified as congruent when it matched the judgement signaled by the button press. These comments did not influence the analysis of the results. In case of an incongruent comment the judgment by the button press did not correspond to the reading expressed in the verbal comment. The corresponding button presses were recoded as rejections of the reading under investigation. Overall, 315 comments indicated a reading different from the one tested in the respective relative clause condition. They were uttered by 77 participants in total (by 72 children: 60 children with mastery of ordinal numbers and 12 without mastery; and by 5 adults). Out of these, 210 were congruent and 105 were incongruent. The incongruent comments were given by 48 children (by 40 children with mastery and 8 children without mastery of ordinal numbers). The diagram in (13) shows the number and occurrence of the congruent comments participants gave during the experiment.

(13)



The diagram in (14) shows the distribution of incongruent comments that were recoded as rejections for the analysis of the results.

(14)



In case of the incongruent comments children mainly looked for a picture matching the restrictive interpretation of the appositive relative clause. Due to the unambiguous visual context, such a picture was not present in the appositive conditions. Contrary to my expectations, this situation did not lead to a rejection of the picture selection. Instead, the infelicitous situation led to an acceptance of the appositive picture selection, although the children explained that Robbi's action was not correct. Moreover, the children said that the robot could not have taken a correct picture because there was no such picture displayed. The following examples (15) illustrate this unexpected pattern.

(15) Comments to an appositive relative clause test item indicating an restrictive reading
Visual context:

1 2 3 4 5 6 7

Comments:

a) Caru: Nimm den dritten Schal, der grün ist, und leg' ihn in den Koffer!
Exp: Hat der Robbi denn das richtige genommen?
Child: Nein. Der muss den.
Exp: Hast du's gehört, was er gesagt hat?
Child: Ja, den dritten grünen, aber da gibt's nur zwei grüne.
Exp: Also hat er das richtige genommen?
Child: Ja, weil's gibt keinen dritten grünen.
Exp: Also gehe ich auf grün?
Child: Ja, weil's gibt kein dritten grünen.

Caru: *Take the third scarf, which is green, and put it in the suitcase!*
Exp: *Did Robbi take the right one?*
Child: *No. He has to take this one.*
Exp: *Did you hear what he said?*
Child: *Yes, the third green one, but there are only two green ones.*
Exp: *So did he take the right one?*
Child: *Yes, because there is not third green one.*
Exp: *Thus, I'll go for the green button?*
Child: *Yes, because there is not third green one.*

04_LEG093, age 5;9

b) Caru: Nimm den dritten Schal, der grün ist, und leg' ihn in den Koffer!
Child: Der dritte Schal, der grün is? Des geht ja gar nicht.
Exp: Hat Robbi das Richtige genommen?
Child: Ja, der hat aber gesagt den dritten grünen Schal, gab nur zwei grüne Schale.

Caru: *Take the third scarf, which is green, and put it in the suitcase!*
Child: *The third scarf, that/which is green? That is not possible.*
Exp: *Did Robbi take the right one?*
Child: *Yes, but he said the third green scarf. There were only two green ones.*

04_TLH447, age 6;8

c) Caru: Nimm den dritten Schal, der grün ist, und leg' ihn in den Koffer!
Child: Da sind zwei grüne Schale.
Exp: Was meinst du? Hat er das Richtige genommen? Ja oder nein? Was kriegt er für ein Smiley? Entscheide dich.
Child: Ich weiß es nicht.
Exp: Wollen wir's noch mal hören? (Repetition of Caru's request)
Child: Wenn's nur zwei gibt, dann muss man den zweiten nehmen.
Exp: Hat Robbi das Richtige genommen?
Child: Dann ja.

Caru: *Take the third scarf, which is green, and put it in the suitcase!*
Child: *There are two green scarfs.*
Exp: *What do you think? Did he take the right one? Yes or No? What smiley does he get? Decide!*
Child: *I don't know.*
Exp: *Shall we listen to it once more? (Repetition of Caru's request)*
Child: *If there are only two, then one has to take the second one.*
Exp: *Did Robbi take the right one?*
Child: *Yes then.*

04_CPK068, age 5;2

In six instances adults also had problems to recognize the appositive reading in items

of the appositive condition without discourse particle. Like the children, some of the adults remarked that the picture selection was not possible. An example is given in (16). Unlike for some of the children, the presupposition failure led to a rejection of the clause in those adults that maintained a restrictive reading of the clause. This was the expected pattern in this task when a reading was not accessible.

(16) Comment of an adult rejecting the appositive interpretation of a relative clause test item
Visual context:

1 2 3 4 5 6 7

04_ZAS270: Dritter Schal, der grün ist . . . Moment, der (points at object no. 5) ist aber nich grün, das (points at object no. 2) ist grün. Den dritten Schal, der grün ist, den gibt's gar nicht.

The third scarf, that/which is green ... Wait a minute, this one (points at object no. 5) isn't green. That one (points at object no. 2) is green. The third scarf that is green does not exist.

C.2.2. Tables of results with percentages, standard deviations, and statistical outcomes

Table C.2 shows the proportions and standard deviations of correct judgements in the relative clause conditions.

Table C.2.: Exp. 3 – Percentage (*SD*) of correct judgements in relative clause test items by age group

	Age 3 ($n = 6$)	**Age 4** ($n = 12$)	**Age 5** ($n = 30$)	**Age 6** ($n = 23$)	**Adults** ($n = 20$)
Restrictive					
Expected *yes*	63.9% (24.5)	81.9% (21.9)	92.2% (12.2)	94.2% (10.8)	87.5% (27.0)
Expected *no*	69.4% (35.6)	80.6% (19.9)	87.8% (19.5)	92.8% (11.0)	99.2% (3.7)
Appositive					
Expected *yes*	97.2% (6.8)	66.7% (36.2)	59.4% (32.6)	53.6% (44.7)	75.0% (3.4)
Expected *no*	86.1% (22.2)	77.8% (25.0)	97.8% (5.8)	99.3% (3.4)	100% (0.0)
Appositive with discourse particle					
Expected *yes*		77.8% (33.6)	65.6% (33.6)	68.8% (43.6)	91.7% (26.2)
Expected *no*		79.2% (33.4)	89.4% (26.8)	97.8% (7.6)	100% (0.0)

Table C.3 give the statistical results for the comparisons of percentages of correct judgements against chance level. The medians of the groups are compared to a median of 50%.

Table C.3.: Exp. 3 – Results of comparisons against chance level in relative clauses by expected response type

	Expected *no*-response		**Expected *yes*-response**	
Condition	***Z***	***p***	***Z***	***p***
Age 3				
Restrictive relative clauses	1.38	.167	1.29	.197
Appositive relative clauses	2.12	.034*	2.33	.020*
Appositive relatives with *ja*	-	-	-	-
Age 4				
Restrictive relative clauses	2.90	.004**	2.85	.004**
Appositive relative clauses	2.63	.009**	1.63	.103
Appositive relatives with *ja*	2.28	.023*	2.23	.026*
Age 5				
Restrictive relative clauses	4.67	<.001***	4.97	<.001***
Appositive relative clauses	5.20	<.001***	1.65	.099
Appositive relatives with *ja*	4.69	<.001***	2.23	.026*
Age 6				
Restrictive relative clauses	4.35	<.001***	4.41	<.001***
Appositive relative clauses	4.71	<.001***	0.00	1.0
Appositive relatives with *ja*	4.63	<.001***	1.71	.088
Adults				
Restrictive relative clauses	4.38	<.001***	3.85	<.001***
Appositive relative clauses	4.47	<.001***	2.29	.022*
Appositive relatives with *ja*	4.47	<.001***	3.88	<.001***

*Significant at a level of .05. **Significant at a level of .01. ***Significant at a level of .001.

C.2.3. Additional results of individual performance patterns

In Experiment 3, above-chance performance was reached when 5 out of 6 items within one condition were judged correctly. When a *yes*-bias has been ruled out, above-chance performance in an acceptability task can be taken as an indicator that the judged reading is acquired. Below-chance performance, i.e., accepting at a maximum 1 out of 6 items, may signal that a reading had not yet been acquired or that it was intentionally rejected. When a picture selection was accepted in 2 to 4 instances, this pattern may result from a random judgement procedure. Chance performance may indicate that the corresponding reading of the sentence could not (yet) be derived.

Mastery for a condition was defined if a participant judged at least 5 out of 6 of items correctly for both items with an expected *yes*- and *no*-response. In addition, the refusal of a reading was defined as a rejection of at least 5 out of 6 items with correct and incorrect picture selections by a participant. Thus, a refusal of a reading was based on below-chance performance in items with an expected *yes*-response but on target-like performance in items with incorrect picture selections. A refusal strategy may signal that a reading had been intentionally rejected.

Table C.4 gives an overview of how many participants in each age group reached the mastery and refusal criterions in the three conditions.

Table C.4.: Exp. 3 – Number of participants above, below, or at chance level in relative clause conditions by age group

Condition	**Age 3** ($n = 6$)	**Age 4** ($n = 12$)	**Age 5** ($n = 30$)	**Age 6** ($n = 23$)	**Adults** ($n = 20$)
Restrictive relatives					
Mastery	-	6	22	20	17
Refusal	-	-	-	-	2
None	6	6	8	3	1
Appositive relatives					
Mastery	4	4	11	12	10
Refusal	-	2	5	9	3
None	2	6	14	2	7
Appositive relatives with *ja*					
Mastery		7	13	15	18
Refusal		1	4	6	1
None		4	13	2	1

Note. Mastery = above chance level; Refusal = below chance level; None = at chance level.

Table C.4 shows that for restrictive relative clauses the majority of participants reached the mastery criterion. The six 3-year-olds were the only exception. On an individual level, none of the 3-year-olds performed above chance level in restrictive relative clause items.

For appositive relative clauses, four children at the age of three performed target-like. In the older groups, in contrast, fewer children mastered appositive relatives compared to restrictive ones. Furthermore, seven adults did not reach the mastery criterion for appositive relative clauses. This may indicate that some participants had problems to access the meaning of the sentences reliably in this condition. This assumption is supported by the number of participants classified as showing refusals of a reading. Across all age groups, refusals, i.e., below-chance performance, were found more often for appositive relative clauses than for restrictive relatives. Restrictive readings were rejected systematically by only two adults. Appositive readings, in contrast, were rejected by 19 participants when prosody and visual context disambiguated the clause, and by 12 participants when the discourse particle was present additionally. The analysis of the spontaneous comments suggested that the participants who refused the appositive readings arrived at a restrictive interpretation of the relative clause.

Whether both semantic functions were available for each of the participants, was the next step of the analysis. Table C.5 shows the mastery patterns of the participants across all three conditions. The pattern '– – –' indicates that mastery was not reached in any of the three conditions. The pattern '+ – –' encodes mastery in the restrictive condition but not in the two appositive conditions, and so forth. In Table C.5 the participants are listed according to which mastery pattern they demonstrated.

Table C.5.: Exp. 3 – Individual mastery across the three relative clause conditions

Mastery			**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Adults**	**Total**
Res	**App**	**App with *ja*[a]**	($n = 6$)	($n = 12$)	($n = 30$)	($n = 23$)	($n = 20$)	($n = 91$)
–	–	–	2	3	2	-	-	7
+	–	–	-	2	11	7	2	22
–	+	–		-	4	-	-	4
–	–	+		1	1	-	-	2
+	+	–		-	-	1	-	1
–	+	+	4	2	1	3	3	13
+	–	+		2	5	4	8	19
+	+	+	-	2	6	8	7	23

Note. Res = Restrictive condition; App = Appositive condition; App with *ja* = Appositive condition with discourse particle; + = Mastery criterion reached; – = Mastery criterion not reached.
[a]Condition 'App. with *ja*' had not been tested in children at the age of 3.

Table C.5 shows that all logical combinations of mastery patterns were found in the groups of participants. Four patterns occurred with higher frequency. Twenty-two participants reached the mastery criterion only in restrictive relative clauses. Twelve of them

mastered restrictive readings and rejected all appositive items in both conditions systematically. The inverse pattern, mastery only in one or both of the appositive conditions (line 3, 4, and 6), was observed for 13 participants. Three of the 6-year-olds were among them. Nineteen participants, among them eight adults, reached the mastery criterion for restrictive relative clauses and appositive relative clauses with the discourse particle *ja*. The most frequent pattern is the one in the last row with mastery in all three conditions. Overall, 23 out of 91 participants (25%) accepted both semantic functions of relative clauses in all conditions of the experiment.

C.3. Additional results for children without mastery in the control condition Non-intersectivity

Table C.6 displays the proportions of correct judgements in the relative clause conditions for children without mastery in the control condition Non-intersectivity.

Table C.6.: Exp. 3 – Percentage (*SD*) of correct judgements in relative clauses for children without mastery in control condition Non-intersectivity

	Age 3 ($n = 22$)	**Age 4** ($n = 17$)	**Age 5-6** ($n = 5$)
Restrictive			
Expected *yes*	81.1% (29.2)	74.5% (30.7)	36.7% (50.6)
Expected *no*	48.5% (32.9)	56.9% (29.5)	96.7% (7.5)
Appositive			
Expected *yes*	83.3% (24.1)	81.2% (21.1)	24.0% (34.4)
Expected *no*	54.5% (30.5)	76.4% (21.3)	83.3% (23.6)
Appositive with discourse particle			
Expected *yes*		88.2% (17.4)	23.3% (43.5)
Expected *no*		72.5% (30.6)	90.0% (14.9)

C.3.1. Individual performance patterns

Table C.7 gives an overview of the number of participants reaching the mastery or refusal criterions in the group of children without robust knowledge of ordinal number words.

Table C.7.: Exp. 3 – Number of participants with mastery in relative clause conditions by age group for children without mastery in control condition Non-intersectivity

Condition	**Age 3** ($n = 22$)	**Age 4** ($n = 17$)	**Age 5-6** ($n = 5$)
Restrictive relatives			
Mastery	1	-	2
Refusal	2	1	3
None	19	16	-
Appositive relatives			
Mastery	3	6	-
Refusal	1	-	3
None	18	11	2
Appositive relatives with *ja*			
Mastery		9	1
Refusal		-	3
None		8	1

The mastery patterns in Table C.7 show that only few children reached the mastery criterion in the relative clause conditions. For restrictive relative clauses, only one 3-year-old and two 5-6-year-olds performed target-like. This finding is not unexpected because the children analyzed here did not show reliable knowledge of the prerequisites for the judgement task. For appositive relative clauses, mastery was reached by more children compared to the restrictive condition. At the age of 4, seven children performed target-like in this condition. However, overall the mastery criterion was missed by the grand majority of children. In addition, six children rejected restrictive readings systematically. Furthermore, four children actively rejected appositive readings. A similar pattern was found for appositive relative clauses with the discourse particle *ja*.

Table C.8 shows the individual mastery patterns across the three relative clause conditions for children without mastery in the control condition Non-intersectivity. The analysis revealed that 28 out of 44 children (64%, mostly 3-year-olds) did not reach the mastery criterion in any of the three conditions. In addition, 10 children showed mastery in only one relative clause condition. Furthermore, five 4-year-olds accepted all appositive relative clauses but were at chance level in items of the restrictive condition. In contrast to children with reliable knowledge of ordinal numbers, no child showed mastery in all

relative clause conditions. There was only one child in the group of 5-6-year-olds that showed mastery of both semantic functions when the discourse particle served as an additional cue for an appositive interpretation.

Table C.8.: Exp. 3 – Individual Mastery across relative clause conditions for children without mastery in control condition Non-intersectivity

Mastery			**Age 3**	**Age 4**	**Age 5-6**	**Total**
Res	**App**	**App with *ja*[a]**	($n = 22$)	($n = 17$)	($n = 5$)	($n = 44$)
−	−	−	18	7	3	28
+	−	−	1	-	1	2
−	+	−	3	1	-	4
−	−	+		4	-	4
+	+	−		-	-	-
−	+	+		5	-	5
+	−	+		-	1	1
+	+	+	-	-	-	-

Note. Res = Restrictive condition; App = Appositive Condition; App with *ja* = Appositive condition with discourse particle; + = Mastery criterion had been reached; − = Mastery criterion had not been reached.

[a]Condition 'App with *ja*' had not been tested in children at the age of 3.