Codistributivity and Reciprocals*

Uli Sauerland

Massachusetts Institute of Technology

1 Introduction

This paper is concerned with the interpretation of sentences containing more than one plural noun phrase or plural anaphors. It will focus on two topics that were not covered in Sauerland (1995): The syntactic annotation of codistributivity and the pragmatic mechanisms governing the interpretation of reciprocal sentences.

The first topic are the syntax and semantics of cumulative (or codistributive) readings (cf. Scha (1984)) in sentences like (1).

(1) The women face the men.

(2) a. The women each face the men.
    b. The women face the men each

This sentence can be true in a situation where neiher of the singly distibutive sentences in (2) is true. Such a situation would be one where the women and men are grouped in couples, and in each couple the woman faces the man. Rather what is needed is an operator that acts on the two-place *face* and gives the desired interpretation. In section 2 I will present an analysis of this phenomenon following that of Sternefeld (1993) but making use of only minimal resources. These are only the independently needed quantifier raising (or another form of LF-movement) and a single polyadic operator that is also the interpretation of the plural morpheme on nouns. I will present new data suggesting that in fact the availability of the cumulative/codistributive interpretation is governed by the same restrictions as the wide scope interpretation of quantifiers. E.g. in (3) the cumulative reading is not available.

*This paper developed out of Irene Heim's spring 1994 *Advanced Semantics* course at MIT. Irene Heim has helped me in many ways, and provided numerous valuable ideas for this work, for which I am very grateful. Furthermore I profited from the comments of Noam Chomsky, Diana Cresti, Piroska Csuri, Viviane Déprez, Wolfgang Sternefeld, and especially Danny Fox. The audiences at MIT, ESCOL '94 at the University of South Carolina, WECOL 1994 at UCLA, and at CONSOLE III at the University of Venice, where parts of this parts were presented, provided further stimulating discussion. All remaining errors are of course my own. Financial support was provided from the German academic exchange service DAAD with a grant in the second Hochschulsonderprogramm HSP II/AUFE.

(3) The fathers heard the rumour that the children succeeded.

In section 3 I will present an analysis of the English reciprocal *each other*. I will show that a complex lexical representation of *each other* can explain all the properties of the reciprocal. Hence there is no need for special *reciprocalization* rules. In particular the reciprocal interacts with codistibutivity in the expected way. This gives a straightforward account for Sternefeld's (1993) example:

(4) Byron and Chandos send these letters to each other.

This sentence posed a problem for the analysis of Heim *et al.* (1991) because on their account only the reading *Byron and Chandos each send these letters to the other* is possible, where all letters go both ways. However the natural reading of the sentence is one where some letters go one way and the others the other way.

The second topic of this paper are pragmatic influences on the interpretation of sentences containing multiple plural noun phrases or reciprocals. Schwarzschild (1991, 1992) established that many of the alledged different readings of sentences containing plurals, should in fact be viewed as differences that are due to pragmatics. I will make the same claim for reciprocal sentences. In particular I will give a pragmatic account of the *strongest meaning hypothesis* of Dalrymple *et al.* (1994a).

The general model this investigation is based on the following assumptions: Semantic interpretation takes as input the logical form of a principles and parameters style syntax, which is a binary branching tree. On the semantic side the possible expressions are given by a functional type theory, where for my purposes the two basic types e for individuals and groups and t for truth values are sufficient. Each terminal node of the tree is mapped either onto an expression of this type theory, or onto a λ-abstractor. The interpretation of a non-terminal node α is determined by the values of the two daugthers β and γ: If one of the daughter-nodes has the appropiate type to function as an argument for the other one, then the mother-node is interpreted by functional application $\beta(\gamma)$ or $\gamma(\beta)$. If both daughter-nodes have an identical type $\langle\delta, t\rangle$ that is a function into truth values, the mother-node is interpreted by intersecting the two as $\lambda x^{\delta}(\beta(x) \wedge \gamma(x))$, where x^{δ} is a variable of type δ. If one of the daughter-nodes is an abstractor λn, the mother-node derives from the other daughter-node as abstraction over this variable $\lambda n\beta$ or $\lambda n\gamma$. In all other cases the logical form is semantically ill-formed

The plural ontology I assume is, with some notational differences, the *union theory* that Schwarzschild (1991) argues for extensively. What he concludes is that all plural DPs should be represented sets of individuals, since all the reasons that lead e.g. Link (1991) and Landman (1989) to postulate structured groups seem to be merely pragmatic effects, whereas binding facts undermine the structured groups approach. I will make one notational simplification of Schwarzschild's system, namely that I write groups as mereological sums, not as sets. In a mereological setting the basic assumption of the union theory can be expressed as the postulate that the mereological sum operation $\oplus$ is associative. Now, calling the type e that of individuals is somewhat misleading because groups are contained within the same type-domain, but I will continue with this usage. In addition I assume that the mereological sum operator also applies to n-tuples of individuals, where $(a_1, \ldots, a_n) \oplus (b_1, \ldots b_n)$ is defined as $(a_1 \oplus b_1, \ldots, a_n \oplus b_n)$.

2 (Co-)distributivity with Sternefeld's $\star$-operator

Sentences with single plurals DPs can be interpreted in at least two ways: distributively and collectively. E.g. can sentence (5) be interpreted distributively as the men each weighing 300 lbs. or collectively as the men together weighing 300 lbs.

(5) The men weigh 300 lbs.

Since Scha (1984) it is known that multiple plural noun phrases in a sentence like (6-a) can give rise to codistributive[1] readings, namely the reading paraphrased in (6-b).

(6) a. The women face the men. (cf. Schwarzschild (1992))
b. For each of the women there is a man who she faces, and for every man there is a woman who faces him.

As we saw in the introduction these examples cannot be explained using only a one-place distributor. Following Sternefeld (1993) I will subsume the examples (5) and (6-a) under a general distributivity operator that applies to predicates. This operator is defined for sets of n-tuples as follows:[2]

(7) For a set M of n-tuples let $\star M$ be the smallest set M' such that $M \subset M'$ and $\forall a, b \in M' \colon a \oplus b \in M'$.

Intuitively this operator can be understood as closing the set under the operation $\oplus$, the result M' is a collection of all items that can be constructed from elements of the original set M by applying the mereological sum operation $\oplus$.[3]

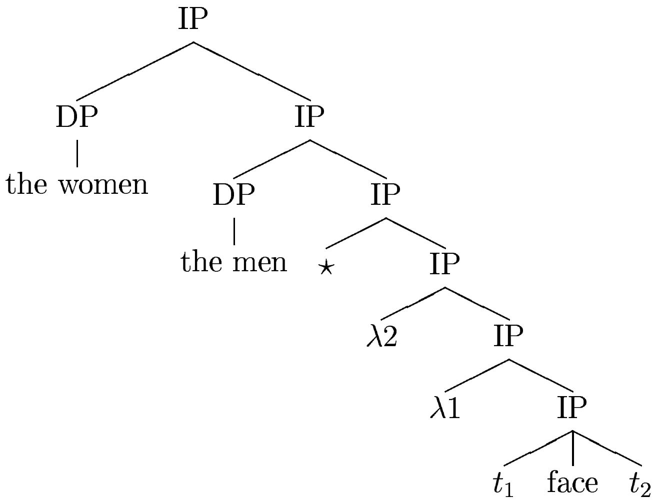
[1]Scha actually uses the term *cumulative*, but in my opinion *codistributive* reflects better that these readings involve distribution over two arguments 'in parallel', as explained below.

[2]Since I use a functional type theory the actual definition would be not the one given here, but its (less transparent) equivalent using one-place functions instead of sets.

[3]The $\star$-operator is also the interpretation of the plural morpheme. So for example the interpretation of *students* is $\star$student. If $[\![\text{student}]\!]$ were {Hubert, Orin} then $[\![\text{students}]\!]$

Using this operator we can represent the codistributive reading of the sentence in (6-a) as follows:

(8)



Before we turn to the derivation of such a logical form, let us check that it is indeed true in a situation where Mary faces John, Carol faces Martin, and Lucy faces Tim, and these are all men and women present. The crucial step of the calculation is the application of the ⋆-operator given in (9). This adds to the denotation of the two-place predicate *face*, amongst others, the pair where the first component is the group of the women and the second the group of the men. Hence the sentence (6-a) is true in the described situation.

(9) $\star[\![\text{face}]\!] = \star\{(\text{Mary,John}),(\text{Carol,Martin}),(\text{Lucy,Tim})\}$
$= \{(\text{Mary} \oplus \text{Carol} \oplus \text{Lucy}, \text{John} \oplus \text{Martin} \oplus \text{Tim}), \ldots\}$

Now we need to describe how the logical form could be derived from the surface structure of the sentence (6-a). For this derivation the following two rules are needed:

(10) **Quantifier Raising:** Target a segment of a maximal projection XP to which first an abstractor then the raising DP are adjoined.[4]

(11) **optional ⋆-insertion rule:** Insert a ⋆-operator above any predicate.[5]

---

would be {∅, Hubert, Orin, Hubert⊕Orin}. For plurals as well the star operator with more than one place is needed for

(i) the six parents of Martha, Heidi, and Danny

[4]Of course QR may apply only if the relevant locality and/or economy conditions are obeyed. The precise formulation of these restriction is however of little concern here.

[5]Instead of having this rule optionally applying, there is a possibility of having the ⋆ as an entry in the lexicon, especially in a system of incremental phrase structure generation as

Two properties of the above rule of quantifier raising are usually not explicitly assumed, but are clearly needed for the generation of the logical form in (8). Firstly, the assumption that, along with the raising of a DP, an abstractor is generated that binds the trace that the raising operation leaves behind. Secondly, that raising cannot only target the topmost segment of a maximal category, but can adjoin to any position between the segments of a maximal category. Or, more generally I claim that QR and maybe covert movement in general doesn't obey a strict cycle condition. Only these two assumptions enable us to generate the logical form (8). The steps of this derivation are the following:

1. Adjoin the abstractor $\lambda 1$ to IP and then raise *the women* to the position above it.

2. Now quantifier raising targets the position between the abstractor generated before and *the women*. Between these two, the abstractor $\lambda 2$ and then *the men* are adjoined.

3. Insert a star immediately above the two abstractors $\lambda 1$ and $\lambda 2$.

The use of quantifier raising for these examples could be described as forming the right predicate – in this case a two place predicate – for $\star$-insertion.[6] Note that the quantifier raising between an abstractor and its binder as in step 2 above has no semantic effect unless the $\star$-operator is inserted.

The obvious question to ask here is about the locality conditions of codistributivity. The prediction is that the availability of the codistributive interpretation obeys the same locality restrictions that quantifier raising in other cases obeys. For quantifier raising the consensus in the literature is that it is largely clause-bound, although not all the judgements are unproblematic. We would hence expect to find the same clause-boundedness with respect to codistributive interpretation. As the example in (12-a) shows this prediction is in principle borne out, although the data is not always so clear. But all speakers agree that some locality restriction obtains, and the example (12-a) is not possible with a codistributive interpretation of *the fathers* and *the children* paraphrased in b):

(12) a. #The fathers heard the rumour that the children succeeded.
b. *The fathers each heard the rumour that their child succeeded.*

The contrast between codistributive interpretation and variable binding here between (12-a) and b) is instructive. An otherwise imaginable alternative

described in Chomsky (1994).

[6]The view that distributive interpretation is quantificational whereas collective interpretation is not, was recently supported by the findings of Avrutin & Thornton (1994).

account of codistributive readings would involve a link between the two plurals that is mediated by variable binding of some sort. On such an analysis however we should not expect any locality restrictions, since a c-command relation is enough to allow binding of a variable.

However in the space between the impossible complex NP-island (12-a) and the unproblematic sentence (6-a) with the two plurals in subject and object position, the judgements are far from clear. Another contrast that proves to be quite robust is the minimal pair in (13). If we here imagine a context, where the fathers watch their children playing a game, that only one of them can possibly succeed, the codistributive reading is the pragmatically salient one, as the other reading ascribes contradictory expectations to the fathers. In this context the tensed clause in b) is more odd than the ECM-clause in a) as we expect.

(13) a. The fathers expected the children to succeed.
b. #The fathers expected the children would succeed.

At this point the reader may wonder whether quantifier raising is necessary in examples like (6-a) at all, since we would achieve the same interpretation by simply applying the $\star$-operator to the predicate *face*, which is already the necessary two-place predicate, and moreover that it would be sufficent to always apply the $\star$-operator to verb-heads.[7] This works fine for the above example, but for examples like (14-a), such an account cannot generate a reading where distribution takes place twice, over two different argument positions of the verb as for example the reading papraphrased in b):

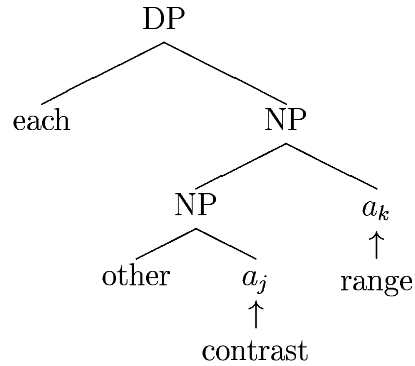
(14) a. The fathers taught the ten commandments to the eldest sons.
b. For each pair of a father and his eldest son the father taught each of the ten commandments to his eldest son.

3 The Representation of the Reciprocal

The internal structure I propose for the reciprocal is given in (15). It can be paraphrased as: *each one other than himself*$_j$ *among themselves*$_k$. The two arguments of *other* are the contrast argument a_j and the range argument a_k, where a stands for a base-generated empty anaphoric element (like a trace of DP-movement). The question whether this complex is the actual lexical entry of the reciprocal or generated in the syntax from the parts which correspond to lexical entries, is difficult to answer and not crucial for anything I will say. For now I will just assume that it is a grammatical necessity for an item that has the complex referential properties of a reciprocal to have a correspondingly

[7]In Sauerland (1995) I mistakenly claimed this was Sternefeld's (1993) proposal.

complex structure.[8]

(15) 

The semantic interpretation of *each* and *other* in this structure does not differ from that of *each* or *other* when they are free-standing, namely it is:

(16) a. $[\![\text{other}]\!](x)(y)(z) = 1$ iff z is part of y and z is not part of x

b. $[\![\text{each}]\!](X)(Y) = 1$ iff $\forall x(x$ a smallest element of $X \Rightarrow x \in Y)$

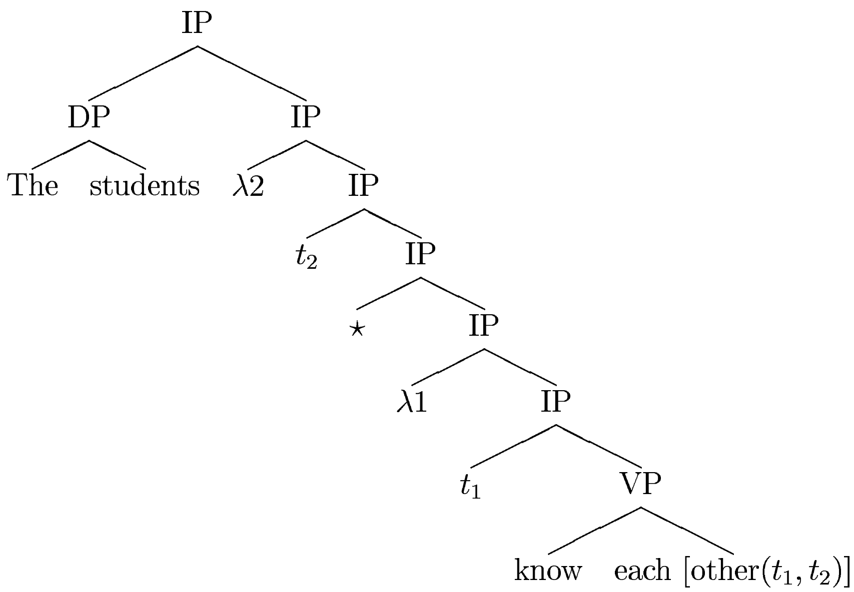
In the following I will abbreviate the structured representation in (15) with *each* [*other*(a_1, a_2)]. Furthermore I will never represent in the logical forms that the reciprocal, as it is headed by a quantifier, actually might raise to a scope position.

The first example is given to demonstrate the above definition, before we get to the more difficult examples. For the simple reciprocal sentence in (17-a) I assume the simplified logical form in b).

(17) a. The students know each other

[8]Under this assumption it is not surprising that a reciprocal-anaphor with a radically different surface realization like Chicheŵa *an* shows exactly the same behavior as English *each other* (cf. Dalrymple *et al.* (1994b)). Notice that *each* does not seem to be logically necessary, which might lead us to expect differences relating to this between e.g. Chichŵa, Turkish, where *each* isn't visible, and English.

b.



The derivation of this logical form is straightforward. First we apply QR as discussed in the previous section twice to the students. In the first application we generate the lower abstractor $\lambda 1$, which binds the contrast argument of *each other*. In the second application we generate $\lambda 2$, which binds the range argument. Then we adjoin the $\star$ above the predicate $\lambda 1$, which introduces the distributive interpretation of the antecedent of *each other* and the contrast argument.

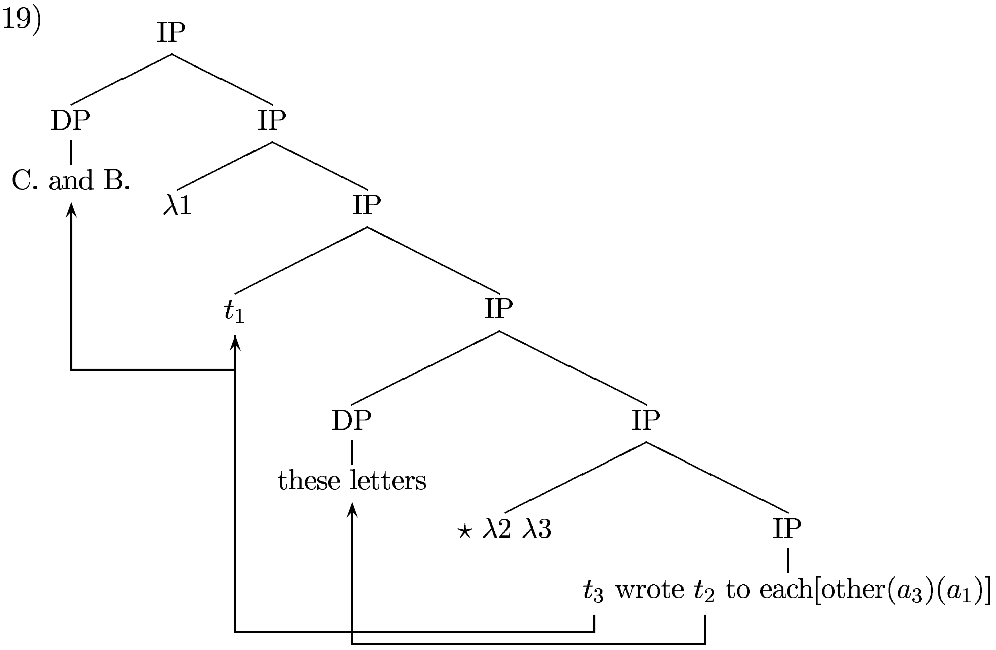
To account for Sternefeld's example (4) (repeated in (18)) all we have to do now is to put the account of codistributivity from section 2 and the above proposal for the reciprocal together. The logical form that receives the desired interpretation is given in (19).[9]

(18) Chandos and Byron wrote these letters to each other.

[9] Notice that an interpretation that does not involve codistributivity is also available, although it is not the preferred on for (18). This is a reading where all the letters have to go both ways. If the cardinality of the antecedent-group as in (i) exceeds two there are five readings distinguishable. This arise just as in the ditransitive example (14-a), from the different possibilities of codistributivity.

(i) The diplomats sent these notes to each other.

(19)



4 Capturing Pragmatic Effects

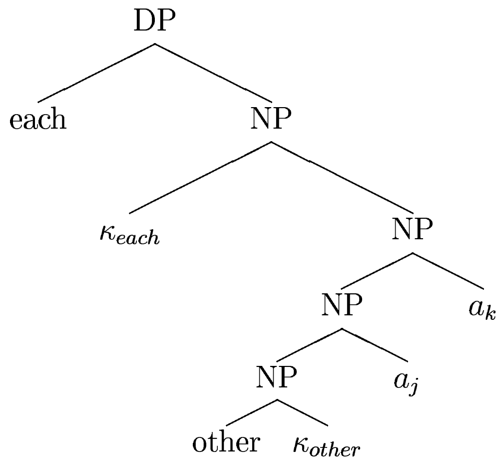
Schwarzschild (1991) showed the great influence of the context on the interpretation of plural noun phrases in general. To give an example, imagine a context where a dance instructor says (20) (repeated from (6-a)) to his students. What the instructor expects is that the woman of each couple faces her partner, not just some other man in the room. Schwarzschild captures the contextual influence by defining context sensitive operators. I will here employ a simplification of Schwarzschild's account suggested by Heim (p.c.). Instead of complicating the operator definitions with context-sensitive parts, she assumes contextual restrictors that are functions from individuals or tuples of individuals onto truth values. The contextual restrictors are true of the contextually relevant individuals or tuples of individuals. In the logical form the contextual restrictors will be represented as κ_n, that adjoin to the predicates they restrict. Using this idea we can acount for the contextual influence on the interpretation of (20) using the logical form in (21-a). If we assume the contextual relevance expressed by the function in (21-b) the desired interpretation arises for the situation in question.

(20) For the next dance, the women face the men, please.

(21) a. [the women] [the men] $\star\kappa_{12}\lambda 2\lambda 1[t_1$ face $t_2]$

b. $\kappa_{12}(x, y) = 1$ iff x and y are a couple.

Now the question arises in which positions at logical form such contextual restrictors can occur, or rather in which positions we are driven to assume them. I assume here that they can occur above any predicate, but there are only three positions where they are really needed for the following arguments. The first one of these positions is below a $\star$-operator, as in (21-a). In addition we are driven to assume two contextual slots within the representation of the reciprocal, such that the new structure for *each other* is the following:



The function of the restrictor κ_{each} is to determine what counts as an individual, and is possible with every occurence of *each*, not just the one in the reciprocal. Such a restriction necessary in view of examples like the following from Moltmann (1992) where *each* can quantify over groups, because *mingle* is only compatible with group arguments:

(22) The cows and sheep mingled with each other.

The need for the restrictor κ_{other} will be discussed below.

The next question is how the value of such a restrictor gets set. I will assume that there are two possibilities for this. One is that, as illustrated with (20), the restrictor reflects what is relevant or prominent in the extralinguistic context. The second possibility to set the value of a restrictor I assume is similar to the mechanism of presupposition accomodation, as it is described in Lewis (1979): In order to keep the conversation going a participant, even though he does not know the relevant contextual restriction, just assumes the existence of an appropiate restriction. I will refer to this mechanism as *restrictor accomodation*.

Restrictor accomodation offers a way to give a pragmatic explanation for the *strongest meaning hypothesis* of Dalrymple *et al.* (1994a). Their generalization is that for a elementary reciprocal sentence of the form "SUBJECT VERB *each other*" the reciprocal can be interpreted using one reading out of certain finite set of possible interpretations. The possible readings are ordered according to their logical strength – the number of pairs that are required to stand in the relation denoted by the verb to make the sentence true. However, the speaker also knows that some verbs have logical properties like being *asymmetric* that make them incompatible with the strongest readings. The strongest meaning hypothesis now states that from the possible readings the strongest one is chosen that could be true given the independently known logical properties of the verb.[10] An example of how this works is the following: The contradictory feeling that example (23) has in contrast to (24), is explained as the fact that *know* expresses a relation that is not necessarily asymmetric, whereas *follow* expresses a asymmetric relation. Hence for the interpretation of (23) the strongest possible interpretation for the simple reciprocal sentence is chosen; i.e. the one where all pairs of non-identical willow-school-fifth-graders have to stand in the relation *know.* For the interpretation of (24) however a weaker interpretation of the sentence is chosen because the verb *follow* expresses an asymmetric relation. Hence the claim Harry didn't follow any of his classmates does not contradict the preceeding claim.

(23) #The willow school fifth graders know each other, but the oldest doesn't know the youngest.

(24) The willow school fifth graders followed each other into the class room, and Harry went first.

Since this statement of the generalization involves real world knowledge, a pragmatic account of it is desirable, independently of what my proposal forces me to say. A sketch of how this effect, to the extent that it is correct, can be derived from pragmatic principles, goes as follows: The two pragmatic principles that are relevant are – roughly stated – the following: Firstly, be charitable; try to enable a true interpretation. Secondly, the antagonist of this principle is: Be economical; don't insert pragmatic operators if it doesn't seem necessary. The interplay of these two principles ensures that in a neutral context no restrictor is inserted for example (23), whereas for example (24) the relevant restrictors, especially κ_{other}, are inserted. So example (23) receives the strongest possible interpretation.

To account for the sentence (24) we need yet another pragmatic operator, namely a version of Bach's ENOUGH-operator. Informally the reason that

[10]The actual formulation of Dalrymple *et al.* (1994a:p. 73) is:

(SMH) The Strongest Meaning Hypothesis
A reciprocals sentence is interpreted as expressing the logically strongest candidate truth conditions which are not contradicted by known properties of the relation expressed by the reciprocal scope when restricted to the group argument.

the contextual restrictors do not suffice is that whereas all the children have to be the antecedent for the range argument of *each other*, there is actually a child that doesn't follow any other child. The definition of this operator is:

(25) $\text{E}\textsc{nough}(P)(y) = 1 \Leftrightarrow y$ is a big part of some x with $P(x) = 1$

The insertion of this operator into the LF of the example (24), a simplified repetition of (24), results in the logical form (27).

(26) The children follow each other into the room.

(27) [the children] [$\lambda 1$ [t_1 $\text{E}\textsc{nough} \star \lambda 2$ [t_2 follow each [other κ_{other}]$(t_1)(t_2)$]]]

By the process of restrictor accomodation the person hearing (26) will induce that there is a value of κ_{other} such that the logical form is true. This value of κ_{other} will be:

(28) $\kappa_{other}(x)(y)(z) = 1$ iff x follows z

Even though it superficially looks now as if this restrictor trivializes the truth conditions of (26), this is in fact not the case. The actual value of κ_{other} given above need never be known to the listener of sentence (26). Only the existence of such a restrictor has to be induced.

One argument in favor of a pragmatic account of this observation is that the effect of the *strongest meaning hypothesis* is absent in a 'loaded' context as in (29-a). Another argument is that the asymmetry of *procreate* doesn't rescue example (29-b). On my account if the order is unknown the person accomodates the presupposition that such an order exists, but is not specific. This also accounts for the pragmatic oddness of (29-b) since here the order is actually known, and it is odd to state the sentence as if the order wasn't known.

(29) a. Walking down Mass. Ave. from Arlington to Boston the sociologist found out: The residents on the eastern side of Mass. Ave. know each other.

b. #My mother and I procreated each other.

5 Conclusion

In this paper we have dealt with two problems having to do with how multiple plurals and plural anaphors in a sentence interact semantically. I have shown how this interaction can be described in a very restricted framework of how semantic interpretation takes place. Together with Sauerland (1995) this papers also supports the assumption of Heim *et al.* (1991) that the reciprocal *each other* has no properties or special grammatical rules referring to it, but all its properties arise from a complex lexical representation.

Section 2 established that codistributive interpretation is syntactically represented, because it obeys the same locality restrictions as quantifier raising. The explanation I give for codistributive interpretation explains this correlation, because it makes the application of quantifier raising a necessary part of the derivation of the correct logical form for codistributively interpreted sentences.

Once we acknowledge the existence of the codistributive interpretation these mechanism also are available for the interpretation of reciprocal sentences. In 3 I point out how this can be used. In section 4 we saw then that apart from the different readings of reciprocal sentences that are due to the possibility of codistributivity, there are no different readings. What have been called different readings of the reciprocals are in fact just differences of interpretation that arise in different contexts. This result is achieved by generalizing the process of *presupposition accomodation* of Lewis (1979) to a more general pragmatic accomodation process.

References

AVRUTIN, SERGEY, & ROSALIND THORNTON. 1994. Distributivity and binding in child grammar. *Linguistic Inquiry* 25.165–171.

CHOMSKY, NOAM. 1994. Bare phrase structure. Occasional Papers in Linguistics 5, Massachusetts Institute of Technology, Cambridge.

DALRYMPLE, MARY, MAKOTO KANAZAWA, SAM MCHOMBO, & STANLEY PETERS. 1994a. What do reciprocals mean? In *Proceedings of SALT IV, University of Rochester*, 61–78.

——, SAM MCHOMBO, & STANLEY PETERS. 1994b. Semantic contrasts and syntactic similarities between Chichewâ and English reciprocals. *Linguistic Inquiry* 25.145–163.

HEIM, IRENE, HOWARD LASNIK, & ROBERT MAY. 1991. Reciprocity and plurality. *Linguistic Inquiry* 22.63–101.

LANDMAN, FRED. 1989. Groups, I. *Linguistics and Philosophy* 12.559–605.

LEWIS, DAVID K. 1979. Scorekeeping in a language game. *Journal of Philosophical Logic* 8.339–359. Reprinted in ?.

—— 1983. *Philosophical Papers*, volume I. Oxford: Oxford UP.

LINK, GODEHARD. 1991. Plural (Plural). In *Semantik: Ein internationales Handuch der zeitgenössischen Forschung* (Semantics: An International Handbook of Contemporary Research), ed. by Arnim von Stechow & Dieter Wunderlich, number 6 in Handbücher zur Sprach- und Kommunikationsforschung, chapter 19, 418–440. Berlin: Walter de Gruyter.

MOLTMANN, FRIEDERIKE. 1992. Reciprocals and *same/different*: Towards a semantic analysis. *Linguistics and Philosophy* 15.411–462.

SAUERLAND, ULI. 1995. The representation of reciprocals in grammar. In *Proceedings of the Eleventh Eastern States Conference on Linguistics (ESCOL '94)*, ed. by Janet Fuller, Ho Han, & David Parkinson, p. ???, Ithaca. DMLL Publications. To Appear.

SCHA, REMKO. 1984. Distributive, collective, and cumulative quantification. In *Truth, Interpretation, and Information, GRASS 2*, ed. by Jeroen Groenendijk *et al.*, Dordrecht. Foris.

SCHWARZSCHILD, ROGER. 1991. *On the Meaning of Definite Plural Noun Phrases*. Amherst: University of Massachusetts dissertation.

——. 1992. Types of plural individuals. *Linguistics and Philosophy* 15.641–675.

STERNEFELD, WOLFGANG. 1993. Plurality, reciprocity, and scope. SfS-Report 13-93, Universität Tübingen, Tübingen.

Author's address: Uli Sauerland
Room 20C-231B
MIT, Cambridge MA 02139
`sauerlan@mit.edu`