A Compositional Semantics for Complex Tenses in Japanese

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1 Introduction

The 'relative tense' theory in traditional grammar, an assumption that the tense interpretation of a subordinate clause depends on that of the matrix clause, has been accepted as intuitively capturing the tense meaning of complex sentences. Ogihara (1996) formalizes this idea in the framework of Montague Semantics and GB Syntax to analyze Japanese and English complex tenses. Seen from the perspective of the constraint-based formalism and Discourse Representation Theory (DRT; Kamp and Reyle 1993) we rely on, the theory can be paraphrased into the following two assumptions. First, each tense-related word is given a single lexical specification, irrespective of the environment in which it occurs. Second, compositional tense interpretation rules can be posited on the basis of the lexicon and syntactic constraints, keeping in line with the recent tendency to seek relationships between the tense meaning and the phrase structure (see e.g. Hornstein 1990 and Thompson 1999). Specifically, the process of tense interpretation is formulated as a monotonic specialization of the feature structure.

This paper proposes a formulation of these assumptions using an HPSG grammar with its semantics represented based on DRT. We argue that our proposal can be applied to elusive complex tense phenomena in Japanese.

2 Tense in Japanese

2.1 Tense Meaning and Interpretation

This paper discusses the central, tense-related part of the information provided by a predicate form obtained by attaching the auxiliary verb *ta* and a morphologically unmarked form, called '*ta* form' and 'non-*ta* form' hereafter. Although aspectual meanings are often concomitant with these forms, they are construed as essentially indicating past and non-past (i.e. present or future) tenses.

It has been pointed out that temporal information in Japanese complex sentences is determined by the following three factors:

 (i) the tense marking on the predicate,

 (ii) Aktionsarten of the predicate (i.e., stative vs. dynamic), and

 (iii) the three-level layered structure associated with the subordinate clause.

The three-level structure in (iii), an analysis of clause structure proposed by Minami (1974), is similar to the one argued for by Foley and Van Valin (1984). These levels are determined by co-occurrence restrictions between sentential constituents and provides a basis for the interpretation not only of tense, but also of focus, coreferentiality within a sentence with or without a topic, and so on, as explained in Subsection 3.4.

2.2 Three-Level Hierarchical Structure of Sentence

The three levels are called Levels 1, 2, and 3 in this paper. Clausal constituents of the three levels are summarized in Table 1.

Table 1: Three Level Hierarchical Structure of Sentence

level	clausal constituents	SC head
Level 1	direct & indirect objs; adverbs for state & grade; base verb; causative, passive, & donative AUXVs	*nagara, tsutsu*
Level 2	subject; adverbs for tense, place, assertion, & evaluation; past, polite, & negative AUXVs	*node, tame ni, nara*
Level 3	topic; tentative adverb; tentative & voluntative AUXVs	*kara, ga, keredo*

Following Minami, we extend the hypothesis of the layered structure to the general structure of the Japanese sentence not limited to subordinate clauses. As seen in Figure 1 depicting how sentence (1) is analyzed in terms of the three levels, a level of clause with a higher number is obtained by adding extra constituents to a level of clause with a lower number. A subordinate clause at a certain level is itself a constituent of the same level.

(1) Tarō   ga   [$_{L1}$ gitā wo *hiki*] **nagara**   *utat– ta*   *darō*.
    NAME SBJ guitar OBJ play SIMULTANEOUS sing PAST TENTATIVE

    'Tarō will probably have sung, playing the guitar.'

2.3 Examples of Complex Tenses

The following are examples of sentences with the three groups of subordinate clauses. [1] On the last line of each example, the temporal relationships between the matrix and subordinate event times and the utterance time are shown in a semi-formal manner. They are replaced by DRT-based formulations afterwards.

(2) Tarō   ga   [$_{L1}$ gitā wo *hiki*] **nagara**   uta   wo *utat– ta*.
    NAME SBJ guitar OBJ play SIMULTANEOUS song OBJ sing PAST

    'Tarō sang a song, playing the guitar.'
    ($E_s \supseteq E_m$)

(3) a. [$_{L2}$ Ōyuki   ga   *fut– ta*] **tame ni** yūbin ga   *okure–   ta*.
      heavy snow SBJ fall PAST CAUSAL post SBJ be delayed PAST

      'Because it snowed heavily, the mails were delayed.'
      ($E_s < E_m < n$)

---

[1]We hyphenate the main verb and *ta* to cope with a syntax-phonology mismatch: a consonant-ending verbal conjugational form such as *utat-* can never be pronounced separately. Nevertheless, the main verb and *ta* can be construed as independent syntactic units, i.e. words.
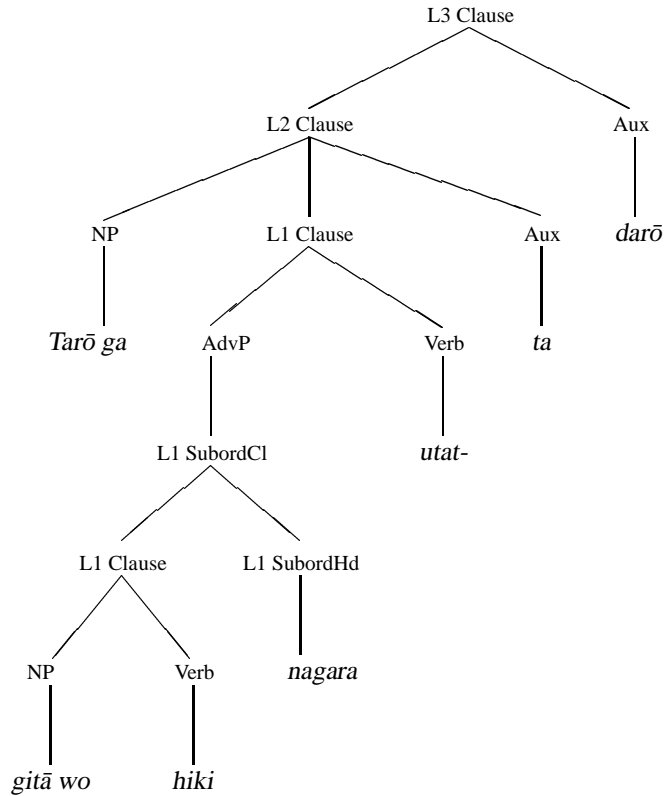
Figure 1: Hierarchical Syntactic Structure for Sentence (1)

b. [$_{L2}$ φ   *kekkon–suru*]   **node**   φ   ie   wo   *kau*.
   (SBJ)   get married-NONPST   CAUSAL   (SBJ)   house   OBJ   buy-NONPST

'Because I (etc.) am going to get married, I (etc.) will buy a house.'
(n < E$_s$, n < E$_m$)

(4) [$_{L3}$ Haruko   wa   Supein   e   *it– ta*]   **ga**   Akiko   wa   Itaria
    NAME   TOP   Spain   GOAL   go   PAST   ADVERS   NAME   TOP   Italy

e   *it– ta.*
GOAL   go   PAST

'Although Haruko went to Spain, Akiko went to Italy.'
(E$_s$ < n, E$_m$ < n)

    (2) is a sentence with a Level 1 subordinate clause. This kind of subordinate clause occurs without its own tense marking, and its tense interpretation depends exclusively on that of the matrix sentence. In (2), the time at which the subordinate event *hiki* ('play') occurs includes that of the matrix event *utat* ('sang').

    A Level 2 subordinate clause undergoes tense marking by the addition of *ta* or its absence. If a sentence with this level of subordinate clause has a matrix predicate marked by *ta*, as in (3a), the *ta* and non-*ta* forms of the subordinate predicate are interpreted respectively as

temporally earlier and later than the event denoted by the matrix predicate. If the matrix event is not marked by *ta*, as in (3b), the subordinate predicate is interpreted in relation to the utterance time: the *ta* and non-*ta* forms each stand for the past and future.

In a complex sentence with a Level 3 subordinate clause, like (4), no temporal order is specified between the two events; each predicate is interpreted directly in relation to the utterance time.

The tense interpretation of a relative clause is complex and is not discussed in this paper.

3   The Semantic Representation of Complex Tenses

3.1   The Tense of Matrix Sentence

On the basis of Reichenbach (1947), Kamp and Reyle (1993), Abusch (1988), and Ogihara (1996), the temporal meanings of the *ta*-marked and non-*ta*-marked matrix predicates in Japanese are given as shown in Table 2. Throughout this paper, $<$, $=$, and $\circ$ stand for binary relations for temporal precedence, simultaneity, and overlap, respectively. e, t, and n indicate the eventuality time (ET) including both event and state, the location time (LT), and the utterance time (UT). The LT is the tense information of a temporal adverbial which is assigned even to a sentence without an explicit one. Following Kamp and Reyle (1993), the central meaning of a tense form is represented as a relationship between the UT and the LT. The ET is interpreted on the basis of this.

Table 2: Tense in Matrix Sentences

| e ∘ t		
Stative	*ta*	$t < n$
	non-*ta*	$t = n$
Dynamic	*ta*	$t < n$
	non-*ta*	$t = n \wedge t < t'$

In the table, the relationship between e and t, which is used further to relate e to n, is specified irrespective of the tense marking as 'e overlapping t.' When the verb is dynamic, this is tantamount to '$e \subseteq t$', since e is an instance.

The *ta* form of both stative and dynamic predicates has a tense meaning 't precedes n.' What correspond to the present and future tenses in English are conflated into the single tense semantic category 'non-*ta*'. The non-*ta* form of a stative predicate is interpreted as 't is simultaneous with n.' By contrast, the non-*ta* form of a dynamic predicate is given a slightly complex interpretation: it is analyzed as a modal auxiliary verb *woll* embedding a main predicate to cope with its typical usage to denote an event certain to happen in the future, often taking on connotations of prediction or promise. But in distinction from the original proposal by Abusch (1988) for the future in English, *woll* in Japanese occurs only in the non-*ta* form, not in combination with the past tense as in English. In the table, t stands for the LT of the whole phrasal predicate, e.g. *woll*(*kau*), and t' for the LT of the embedded main predicate e.g. *kau*. The LT of the whole phrasal predicate, which is simultaneous with the UT, precedes that of the embedded predicate.

3.2 Formalization by HPSG/DRT

Discourse Representation Structures (DRSs) are represented as a partial feature structure of HPSG as the value of the attribute path SYNSEM|LOCAL|CONTENT. The essential part of the temporal information also is specified as a CONTENT value, except the UT which is constrained in the CONTEXT. We adopt this approach, in distinction from Pollard and Sag (1994) and Van Eynde (2000) who constrain the tense information in the CONTEXT, since tense is a truth-conditional meaning and not a felicitous condition on an utterance. Although tense indeed shares some properties with anaphora (see Partee 1984) and this may be the reason for its inclusion in the CONTEXT by Pollard and Sag and their follower, it cannot be construed as forming a proper subset of anaphora. For example, Enç's (1987) account of embedded tenses by means of the Binding Theory is not tenable, as Ogihara (1996) has made clear. We admit one advantage of specifying the LT within the CONTEXT is that, given that the ET is a CONTENT value, it explains naturally the accessibility to the LT of a *woll*-embedded main verb and the inaccessibility to its ET from the outer DRS in non-*ta* marked dynamic predicates discussed in Subsections 3.5 and 4.1 (Van Eynde p.c.). We don't adopt this view, however, laying more emphasis on the non-anaphoric property of tense.

The element of the DRS conditions which corresponds to the predicate contains, when fully specified, the EVENT(UALITY)-T(IME), LOC(ATION)-T(IME), and TEMP(ORAL)-AX(IS) features (the last one will be explained shortly), whose values are further constrained by the binary temporal conditions 'overlap', 'precede', and 'be simultaneous with'. Below is a feature structure with a tense meaning 'e ∘ t < n.'
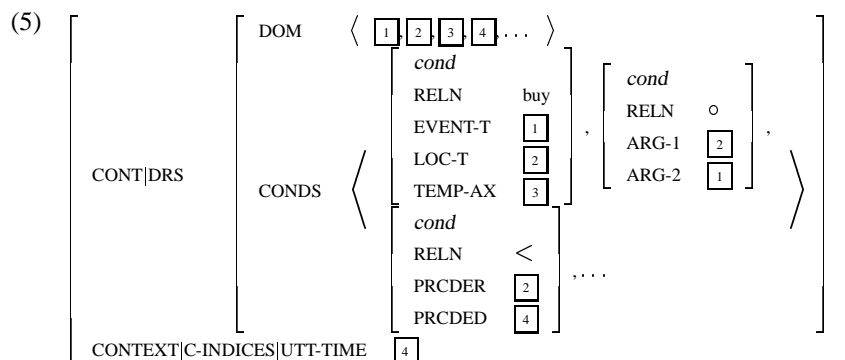
As is explained later, the semantics of complex tenses interacts with the syntax and lexicon in a complicated manner. The HPSG formalization we propose serves as a concise interface to cope with such interactions.

3.3 Building Up DRSs

DRSs are constructed using the L(A)MBD(A) feature adopted by Bos et al. (1994). The process consists of two basic operations, *merge* and *functional composition.*

(6) *Merge*

$$
\begin{bmatrix} cont \\ \text{DRS} \begin{bmatrix} \text{DOM} & \boxed{1} \\ \text{CONDS} & \boxed{2} \end{bmatrix} \end{bmatrix} \otimes \begin{bmatrix} cont \\ \text{DRS} \begin{bmatrix} \text{DOM} & \boxed{3} \\ \text{CONDS} & \boxed{4} \end{bmatrix} \end{bmatrix}
$$

$$
= \begin{bmatrix} cont \\ \text{DRS} \begin{bmatrix} \text{DOM} & \boxed{1} \oplus \boxed{3} \\ \text{CONDS} & \boxed{2} \oplus \boxed{4} \end{bmatrix} \end{bmatrix}
$$

The *merge* operation, indicated by '⊗', takes two DRSs and outputs a new one whose DOM(AIN) and COND(ITION)S values are each unions of those of the input DRSs. In the following, '⊕' stands for appending.

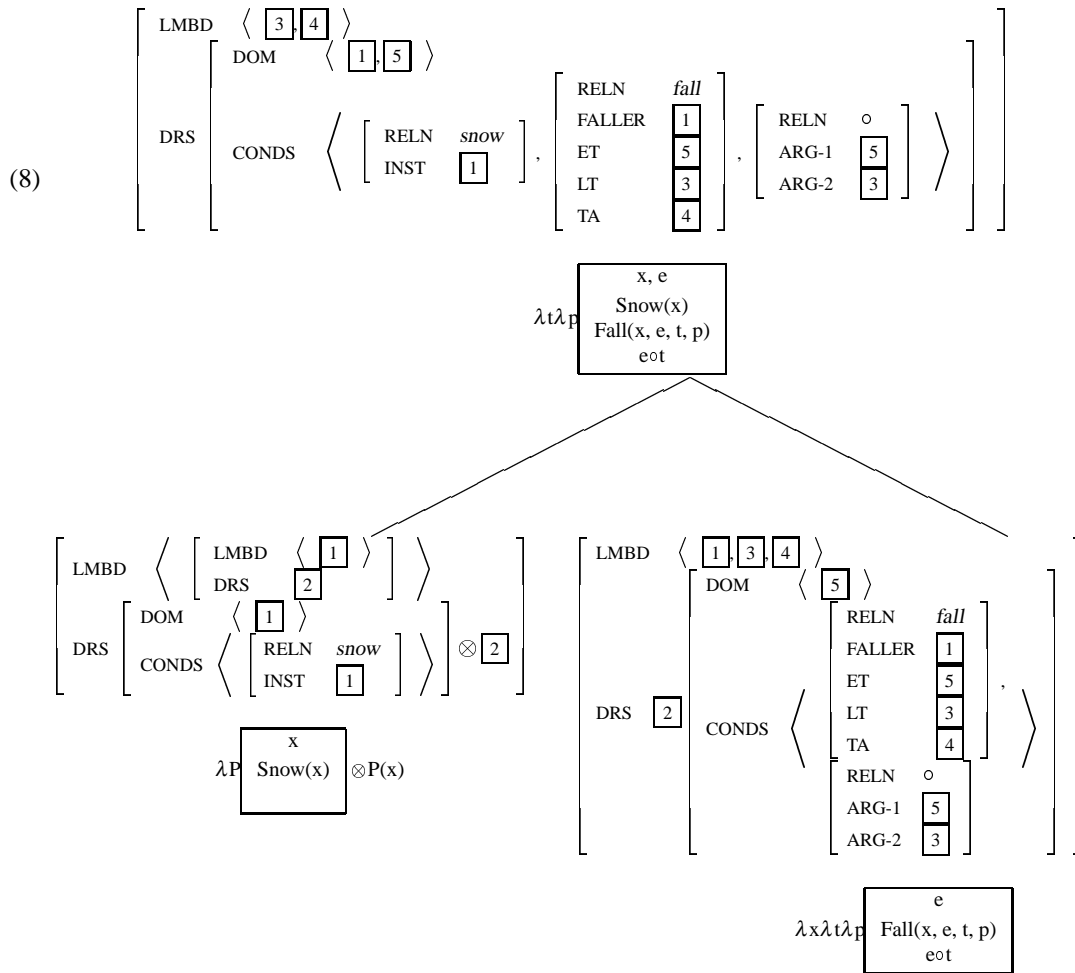(7) *Functional composition*

$$
\begin{bmatrix} cont \\ \text{LMBD} \left\langle \begin{bmatrix} cont \\ \text{LMBD} & \boxed{1}\,list(index) \\ \text{DRS} & \boxed{2} \end{bmatrix} \right\rangle \oplus \boxed{3} \\ \text{DRS} \quad \boxed{4} \end{bmatrix} \odot \begin{bmatrix} cont \\ \text{LMBD} & \boxed{1} \oplus \boxed{5} \\ \text{DRS} & \boxed{2} \end{bmatrix} = \begin{bmatrix} cont \\ \text{LMBD} & \boxed{3} \oplus \boxed{5} \\ \text{DRS} & \boxed{4} \end{bmatrix}
$$

Functional composition (indicated by '⊙') as defined here, which subsumes functional application as a special case, combines the semantic information by checking the LAMBDA value of the 'functor' DRS with that of the 'argument' DRS; the LAMBDA value of the first element in the functor's LAMBDA list is unified with the initial part of the argument's LAMBDA value, and 'popped off' from the resulting mother's LAMBDA list. The mother's LAMBDA value is the union of the remaining LAMBDA values of the functor and argument. By unifying the argument's DRS value with that of the first element in the functor's LAMBDA list, its information is percolated up to the mother. In applying functional composition, the syntactic head is usually the argument with which the non-head such as the complement, adjunct, or specifier combines as the functor. But in case a predicate is embedded by an auxiliary verb, the auxiliary verb takes the role of functor.

The definition in (7) diverges from Bos et al. (1994) in two important respects. First, the LAMBDA value of the first member in the functor's LAMBDA list to be popped off is not limited to a singleton list in order to cope with numerous temporal points. Second, the mother's LAMBDA list comprising the remaining LAMBDA elements of the functor and argument is ordered so that those of the functor take precedence; this is essential in maintaining semantic homogeneity when pairing a subordinate clause, which is the functor, with a matrix clause.

The official feature structure notation will be abridged hereafter to a linear notation as shown below the feature structure on each node of the tree in (8), which offers an instance of functional composition, so that the reader may make an analogy to the λ-calculus in Predicate Logic. The information about quantification is omitted, given that in Japanese it is provided only poorly by syntax and must be essentially compensated for by discourse and pragmatics.

(8)

$$
\begin{bmatrix}
\text{LMBD} & \langle\; \boxed{3}, \boxed{4}\; \rangle \\
\text{DRS} & \begin{bmatrix}
\text{DOM} & \langle\; \boxed{1}, \boxed{5}\; \rangle \\
\text{CONDS} & \left\langle\; \begin{bmatrix} \text{RELN} & snow \\ \text{INST} & \boxed{1} \end{bmatrix},\; \begin{bmatrix} \text{RELN} & fall \\ \text{FALLER} & \boxed{1} \\ \text{ET} & \boxed{5} \\ \text{LT} & \boxed{3} \\ \text{TA} & \boxed{4} \end{bmatrix},\; \begin{bmatrix} \text{RELN} & \circ \\ \text{ARG-1} & \boxed{5} \\ \text{ARG-2} & \boxed{3} \end{bmatrix}\; \right\rangle
\end{bmatrix}
\end{bmatrix}
$$

$$\lambda t \lambda p\; \boxed{\begin{array}{c} x,\, e \\ \text{Snow}(x) \\ \text{Fall}(x,\, e,\, t,\, p) \\ e \circ t \end{array}}$$

$$
\begin{bmatrix}
\text{LMBD} & \left\langle\; \begin{bmatrix} \text{LMBD} & \langle\; \boxed{1}\; \rangle \\ \text{DRS} & \boxed{2} \end{bmatrix}\; \right\rangle \\
\text{DRS} & \begin{bmatrix}
\text{DOM} & \langle\; \boxed{1}\; \rangle \\
\text{CONDS} & \left\langle\; \begin{bmatrix} \text{RELN} & snow \\ \text{INST} & \boxed{1} \end{bmatrix}\; \right\rangle
\end{bmatrix} \otimes \boxed{2}
\end{bmatrix}
$$

$$\lambda P\; \boxed{\begin{array}{c} x \\ \text{Snow}(x) \end{array}} \otimes P(x)$$

$$
\begin{bmatrix}
\text{LMBD} & \langle\; \boxed{1}, \boxed{3}, \boxed{4}\; \rangle \\
& \begin{bmatrix} \text{DOM} & \langle\; \boxed{5}\; \rangle \end{bmatrix} \\
\text{DRS} & \boxed{2}\quad \text{CONDS} \left\langle\; \begin{bmatrix} \text{RELN} & fall \\ \text{FALLER} & \boxed{1} \\ \text{ET} & \boxed{5} \\ \text{LT} & \boxed{3} \\ \text{TA} & \boxed{4} \\ \text{RELN} & \circ \\ \text{ARG-1} & \boxed{5} \\ \text{ARG-2} & \boxed{3} \end{bmatrix},\; \right\rangle
\end{bmatrix}
$$

$$\lambda x \lambda t \lambda p\; \boxed{\begin{array}{c} e \\ \text{Fall}(x,\, e,\, t,\, p) \\ e \circ t \end{array}}$$

3.4 HIERARCHY Feature

In order to cope with the hierarchical sentence structure in Japanese accounted for in Subsection 2.2, a new feature HIER(ARCHY) with a vaule *level1*, *level2*, or *level3* is introduced as a HEAD feature. Constituents of the same level share the same value. We propose the HIERARCHY Feature Principle to constrain the phrase structure in terms of the HIERARCHY value, and thus set up layered clause structures analogous to the analysis in Role and Reference Grammar by Foley and Van Valin (1984). It is also reminiscent of Kiparsky's (1982) level-ordered morphology which applies phonological rules as a word form is expanded from one level to another.

(9) HIERARCHY Feature Principle

M: [HIERARCHY /$\boxed{1}$]

C/A: [HIERARCHY $\boxed{1}$]   **H**

The HIERARCHY value of the mother unifies with that of the complement/adjunct daughter by default, i.e. unless contradicted by an overriding statement elsewhere.

To the auxiliary verbs and Level 2 subordinate clauses the default principle above does not apply. The following rule assigns to a Level 2 auxiliary verb a HIERARCHY value which is larger than that of the subcategorized-for main predicate by one.

(10)
$$\textit{l2-aux} \longrightarrow$$
$$\left[\ldots|\text{CAT} \left[\begin{array}{ll} \text{HEAD|HIER} & \textit{level2} \\ \text{SUBCAT} & \langle\ \textit{l1-clause}\ \rangle \end{array} \right] \right]$$

Level 2 subordinate clauses, not only disobeying the default principle (9), is also against our hypothesis that on the whole lower levels appear within higher ones. This issue is discussed shortly.

The HIERARCHY feature, while assumed as a well-formedness condition on the phrase structure, is a constraint much more general than the latter (see Foley and Van Valin 1984). In fact, it also works even if we ascribe a non-configurational, flat syntactic structure to Japanese. In any case, by restricting the application of the HPSG schemata in this manner, the construction of syntactic/semantic information is constrained to be appropriate not only in the tense interpretation, but also in the analysis of other phenomena.

First, ungrammatical co-occurrence of constituents is excluded. For example, the phrase,

(11) *[$_{L3}$ Tarō ga   kuru   deshō] [$_{L2}$ node]
     NAME   NOM come PRSM   CAUSAL

    ('Because Taro will probably come.')

is predicted to be inappropriate by assigning Level 3 to the presumptive auxiliary verb *deshō* and Level 2 to the subordinate clause head *node*, since an auxiliary verb cannot usually subcategorize for a clause hierarchically higher than itself.

Second, coreferentiality between the subjects of Level 2 clauses is explained. As has been often pointed out in the traditional grammar literature (e.g., Mikami 1970), the subject of a Level 2 subordinate clause is usually not identical with that of the matrix sentence.

(12) a. [$_{L2}$ *Tarō$_i$* **ga** uwagi wo nugu] to   [$_{L2}$ ϕ_j hangā ni kake-
           NAME   NOM jacket ACC undress SUCC (SBJ) hanger LOC hang

        ta]
        PAST

        'Tarō took off his jacket and then someone hung it on a hanger.'

In the sentence above, the omitted subject of *hangā ni kake-ta* ('hung on a hanger') is different from *Tarō*, the subject of the subordinate predicate *uwagi wo nugu* ('take off the jacket'). But when one of the subjects is marked by *wa* as a topic as below, the two subjects are coreferential.

(12) b. [_L3 *Tarō_i* **wa** [_L2 φ_i uwagi wo nugu] to [_L2 φ_i hangā ni

        NAME   TOP (SBJ) jacket ACC undress SUCC (SBJ) hanger LOC

    kake- ta]]

    hang PAST

    'Tarō took off his jacket and then hung it on a hanger.'

These phenomena are accounted for by assuming that the subject is introduced at Level 2, therefore subjects of different Level 2 clauses within the same sentence are not necessarily coreferential, and also by introducing the topic at Level 3 and positing a pragmatic rule which identifies the topic with omitted subjects. The interpretation of foci can also be formalized as incremental percolation of relevant information. Interested readers are referred to Yoshimoto (1998).

3.5 Incremental Construction of Tense Information

Figure 2 illustrates how a sentence acquires its tense meaning incrementally as it is expanded from one level to another.

A base verb, both dynamic and stative, possesses a semantic representation outlined as (13a), with which Level 1 is associated. A dynamic base verb may be embedded by *woll* as in (13b). In this DRS, the modal predicate *woll* embeds the meaning of the base verb to be combined and the relationship between the two LTs are posited.

(13) a. *base-verb-tense-sem* $\longrightarrow \lambda t \lambda p$

$$\begin{array}{|c|}\hline e \\ \mathrm{Pred}(e, t, p) \\ e \circ t \\ \hline\end{array}$$

    b. *woll-sem* $\longrightarrow \lambda P \lambda t \lambda p$

$$\begin{array}{|c|}\hline e, t' \\ \mathrm{woll}(P(t', p), e, t, p) \\ e \circ t \\ t < t' \\ \hline\end{array}$$

A Level 1 clause, both simplex and complex, undergoes the marking by *ta* or non-*ta*,[2] whose semantic contributions are given as (14a, b), resulting in a clause to which Level 2 is
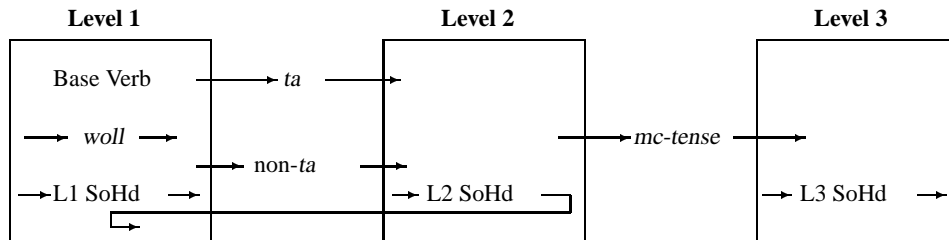

Figure 2: Level-Based Construction of Tense Meaning (Preliminary Ver.)

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[2]A feature must be still added to prevent *ta* from subcategorizing for the *woll*-headed phrasal predicate.

assigned. As these DRSs show, *ta* and non-*ta* markings add the information on the temporal relationship between the LT and TA.

(14) a. *ta-sem* $\longrightarrow \lambda P \lambda p$ $\boxed{\begin{array}{c} t \\ \hline t < p \end{array}}$ $\otimes P(t, p)$

 b. *non-ta-sem* $\longrightarrow \lambda P \lambda p$ $\boxed{\begin{array}{c} t \\ \hline t = p \end{array}}$ $\otimes P(t, p)$

A Level 2 clause marked by *ta* or non-*ta* is subject to the final process of sentence formation: as it is expanded into Level 3, it is given the tense information (15) intrinsic to the matrix clause:

(15)

$mc\text{-}tense\text{-}sem \longrightarrow \lambda P$ $\boxed{\begin{array}{c} p, n \\ \hline p = n \end{array}}$ $\otimes P(p)$
$\{\langle n, \text{utt-time}\rangle\}$

The DRS above identifies the TA with the UT. The parenthesized formula immediately below the body of the DRS shows that the discourse referent corresponding to n is unified with the UT within the CONTEXT feature, following the notation by Asher (1993).

The tense meanings provided by *woll*, the non-*ta* marking, and the matrix clause, i.e. DRSs in (13b), (14b), and (15), are triggered by the syntactic rules below:

(16) a.
$$\begin{bmatrix} vp \\ \text{SYNSEM|LOC|CAT|HEAD|HIER} \quad level1 \end{bmatrix} \longrightarrow$$
$$\begin{bmatrix} \text{SYNSEM|LOC|CONT} \quad \boxed{1} \odot woll\text{-}sem \\ \text{DTRS} \begin{bmatrix} \text{COMP-DTRS} \quad \left\langle \begin{bmatrix} vp \\ \text{SYNSEM|LOC} \begin{bmatrix} \text{CAT|HEAD|HIER} \quad level1 \\ \text{CONT} \quad \boxed{1} \end{bmatrix} \end{bmatrix} \right\rangle \\ \text{HEAD-DTR} \quad \langle \quad \rangle \end{bmatrix} \end{bmatrix}$$

 b.
$$\begin{bmatrix} sentence \\ \text{SYNSEM|LOC|CAT|HEAD|HIER} \quad level2 \end{bmatrix} \longrightarrow$$
$$\begin{bmatrix} \text{SYNSEM|LOC|CONT} \quad \boxed{1} \odot non\text{-}ta\text{-}sem \\ \text{DTRS} \begin{bmatrix} \text{COMP-DTRS} \quad \left\langle \begin{bmatrix} sentence \\ \text{SYNSEM|LOC} \begin{bmatrix} \text{CAT|HEAD|HIER} \quad level1 \\ \text{CONT} \quad \boxed{1} \end{bmatrix} \end{bmatrix} \right\rangle \\ \text{HEAD-DTR} \quad \langle \quad \rangle \end{bmatrix} \end{bmatrix}$$

 c.
$$\begin{bmatrix} sentence \\ \text{SYNSEM|LOC|CAT|HEAD|HIER} \quad level3 \end{bmatrix} \longrightarrow$$
$$\begin{bmatrix} \text{SYNSEM|LOC|CONT} \quad \boxed{1} \odot mc\text{-}tense\text{-}sem \\ \text{DTRS} \begin{bmatrix} \text{COMP-DTRS} \quad \left\langle \begin{bmatrix} sentence \\ \text{SYNSEM|LOC} \begin{bmatrix} \text{CAT|HEAD|HIER} \quad level2 \\ \text{CONT} \quad \boxed{1} \end{bmatrix} \end{bmatrix} \right\rangle \\ \text{HEAD-DTR} \quad \langle \quad \rangle \end{bmatrix} \end{bmatrix}$$

Both tense-marked forms are derived syntactically, the *ta* form by the past auxiliary verb subcategorizing for the main predicate and the non-*ta* form by rule (16b), in distinction from the standard HPSG utilization of a lexical rule to obtain the latter, or Ackerman and Webelhuth's (1998) predicate-based lexical derivation of both. This is for the purpose of syntactically assigning a different HIERARCHY value to the tensed form from that for the embedded clause. The semantic operators *woll-sem*, *non-ta-sem*, and *mc-tense-sem*, introduced syntactically as illustrated above, are not encoded by independent lexical items. However, we occasionally give accounts in the following as if they had corresponding independent words denoting them for ease of explanation, where no confusion arises.

Clauses of Levels 1 to 3 are either simplex clauses or complex ones constructed by attaching subordinate clauses. With the subordinate clause embedding clauses of Levels 1 and 3 is associated the same level as the embedded clause by the default principle (9). But the subordinate clause embedding a Level 2 clause loops back to Level 1 to undergo a further tense marking by *ta* or non-*ta*, as Figure 2 illustrates.

It is straightforward how the semantic specifications (13a, b), (14a, b), and (15) are functionally composed, adding information on the ET, LT, TA, and UT, to produce a tense meaning in a simplex sentence.

4   Building Up Complex Tenses

4.1   Interpretation of Complex Tenses

The framework we have proposed accounts for the different complex tense meanings explained in Subsection 2.3. Figure 3 outlines the formation of the tense meaning of example (2) *Tarō ga gitā wo hiki nagara uta wo utat-ta* ('Tarō sang a song, playing the guitar').

In the abridged notation of DRSs in the following, e_s stands for the ET of the subordinate predicate, and t_s for its LT. e_m and t_m are their counterparts in the matrix clause. The subordinate clause head *nagara* is given the following semantic specification,

$$(17)\quad \lambda P\lambda Q\lambda t_m\lambda p\;\boxed{\begin{array}{c} t_s \\ \hline t_s = t_m \end{array}}\;\otimes P(t_s, p)\otimes Q(t_m, p)$$

which identifies the LT of the subordinate clause with that of the matrix clause. The part of the tree given the HIERARCHY value *level1* corresponds to *gitā wo hiki nagara uta wo utat-*. As it is further extended to Levels 2 and 3, it obtains additional information from the meaning of the auxiliary verb *ta* and *mc-tense-sem*, correctly producing the tense meaning: '$e_s \circ t_s$, $e_m \circ t_m$, $t_s = t_m$, $t_m < n$.'

The next tree in Figure 4 illustrates the formation of the essential part of the tense meaning of example (3a) *Ōyuki ga fut-ta tame ni yūbin ga okure-ta*. ('Because it snowed heavily, the mails were delayed; $e_s \circ t_s \wedge e_m \circ t_m \wedge t_s < t_m < n$) with a Level 2 subordinate clause.[3]

One of the central pieces of tense information, '$t_s < p_s$', derives from the lexical information of the auxiliary verb *ta* (see (14a)). The constraint '$p_s = t_m$' is specified by the subordinate clause head *tame ni*:

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[3]The relationships between the ETs and LTs (i.e., $e_s \circ t_s$ and $e_m \circ t_m$), which are derived from the lexical information of the main verbs, are omitted in the following trees.
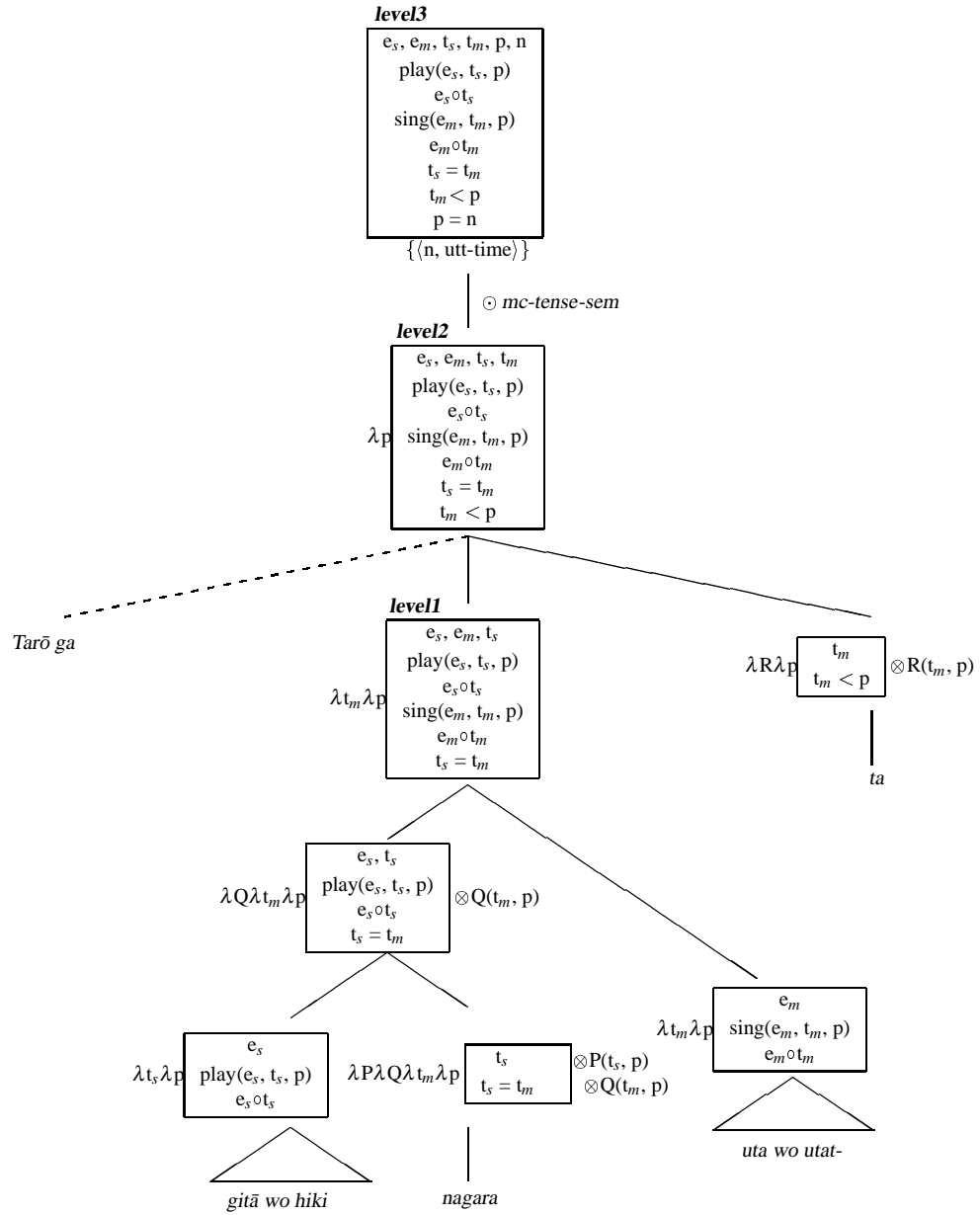
level3

$$e_s, e_m, t_s, t_m, p, n$$
$$play(e_s, t_s, p)$$
$$e_s \circ t_s$$
$$sing(e_m, t_m, p)$$
$$e_m \circ t_m$$
$$t_s = t_m$$
$$t_m < p$$
$$p = n$$

$$\{\langle n, \text{utt-time}\rangle\}$$

$\odot$ *mc-tense-sem*

level2

$$\lambda p \quad \begin{array}{c} e_s, e_m, t_s, t_m \\ play(e_s, t_s, p) \\ e_s \circ t_s \\ sing(e_m, t_m, p) \\ e_m \circ t_m \\ t_s = t_m \\ t_m < p \end{array}$$

Tarō ga

level1

$$\lambda t_m \lambda p \quad \begin{array}{c} e_s, e_m, t_s \\ play(e_s, t_s, p) \\ e_s \circ t_s \\ sing(e_m, t_m, p) \\ e_m \circ t_m \\ t_s = t_m \end{array}$$

$$\lambda R \lambda p \quad \begin{array}{c} t_m \\ t_m < p \end{array} \otimes R(t_m, p)$$

ta

$$\lambda Q \lambda t_m \lambda p \quad \begin{array}{c} e_s, t_s \\ play(e_s, t_s, p) \\ e_s \circ t_s \\ t_s = t_m \end{array} \otimes Q(t_m, p)$$

$$\lambda t_s \lambda p \quad \begin{array}{c} e_s \\ play(e_s, t_s, p) \\ e_s \circ t_s \end{array}$$

$$\lambda P \lambda Q \lambda t_m \lambda p \quad \begin{array}{c} t_s \\ t_s = t_m \end{array} \begin{array}{l} \otimes P(t_s, p) \\ \otimes Q(t_m, p) \end{array}$$

$$\lambda t_m \lambda p \quad \begin{array}{c} e_m \\ sing(e_m, t_m, p) \\ e_m \circ t_m \end{array}$$

gitā wo hiki

nagara

uta wo utat-

Figure 3: Tense Interpretation of Sentence (2)

level2

λp_m
$$
\begin{array}{c}
e_s, e_m, t_s, p_s \\
\text{fall}(e_s, t_s) \\
t_s < p_s \\
\text{be-delayed}(e_m, t_m, p_m) \\
p_s = t_m \\
t_m < p_m
\end{array}
$$
$[\odot$ *mc-tense-sem*$]$

level1

$\lambda t_m \lambda p_m$
$$
\begin{array}{c}
e_s, e_m, t_s, p_s \\
\text{fall}(e_s, t_s) \\
t_s < p_s \\
\text{be-delayed}(e_m, t_m, p_m) \\
p_s = t_m
\end{array}
$$

$\lambda R \lambda p_m$
$$
\begin{array}{c}
t_m \\
t_m < p_m
\end{array}
$$
$\otimes R(t_m, p_m)$

ta

$\lambda Q \lambda t_m$
$$
\begin{array}{c}
e_s, t_s, p_s \\
\text{fall}(e_s, t_s) \\
t_s < p_s \\
p_s = t_m
\end{array}
$$
$\otimes Q(t_m)$

$\lambda t_m \lambda p_m$
$$
\begin{array}{c}
e_m \\
\text{be-delayed}(e_m, t_m, p_m)
\end{array}
$$

λp_s
$$
\begin{array}{c}
e_s, t_s \\
\text{fall}(e_s, t_s) \\
t_s < p_s
\end{array}
$$

$\lambda P \lambda Q \lambda t_m$
$$
\begin{array}{c}
p_s \\
p_s = t_m
\end{array}
$$
$\otimes P(p_s)$
$\otimes Q(t_m)$

$\bar{O}yuki\ ga\ fut\text{-}ta$

$tame\ ni$

$y\bar{u}bin\ ga\ okure\text{-}$

Figure 4: Tense Interpretation of Sentence (3a)

312

(18) $\lambda P \lambda Q \lambda t_m$ $\boxed{\begin{array}{c} p_s \\ \hline p_s = t_m \end{array}}$ $\otimes P(p_s) \otimes Q(t_m)$

We posit for *ta* a syntactic position in which the auxiliary verb, as a syntactic head, is sister to the rest of the Level 2 clause, as shown in Figure 4. This is, for one thing, in order to cope with the scope of the negative auxiliary verb *nai* which occurs immediately before *ta*: if *ta* is first attached to the main predicate only, it will make a wrong prediction about the scopal behavior of the negation. The other reason is that this syntactic position eases the recursive formation of Level 2 DRSs which must be still marked by *ta* or non-*ta*.

The DRS for the part of the sentence shown in Figure 4 further combines with *mc-tense-sem*; the outcome is the semantic information '$t_s < t_m (= p_s) \land t_m < n$.'

Next, let us investigate how a complex sentence with a non-*ta* marked predicate is interpreted by means of the meanings of *woll* and the non-*ta* marking we hypothesized as (13b) and (14b). Figure 5 accounts for how sentence (19), another example with a Level 2 subordinate clause but with a non-*ta* marked main predicate, is given a semantic representation.
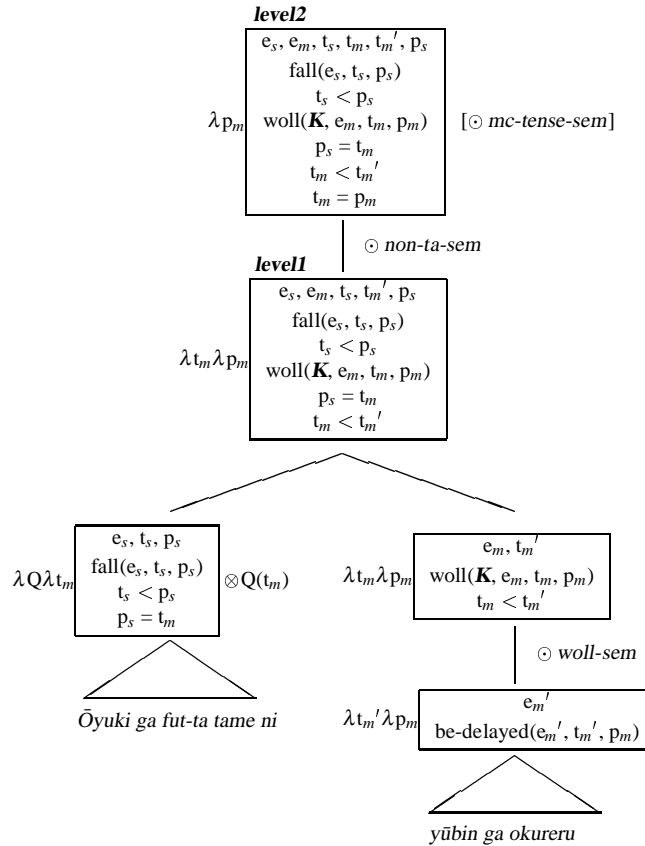
Figure 5: Tense Interpretation of Sentence (19)

313

(19) [$_{L2}$ Ōyuki   ga *fut– ta*] **tame ni** yūbin ga *okureru*.
   heavy snow SBJ fall PAST CAUSAL post   SBJ be delayed-NPST

   'Because it snowed heavily, the mails will be delayed.'

   $(e_s \circ t_s \wedge e_m \circ t_m \wedge t_s < n < t_m' \; [\wedge e_m' \circ t_m'])$

First, *woll* is triggered by the non-*ta* marked predicate *okureru* ('be delayed'), embedding a DRS corresponding to the meaning of the main predicate. This DRS is abbreviated as **K** within the upper DRSs, where **K** is equal to the following subDRS:

(20) **K** =

e_m'
be-delayed(e_m', t_m', p_m)

In Figure 5, the ET of the embedded predicate, e_m', is not accessible from the main DRS; this reflects the modal meaning of *woll* which does not guarantee that the event comes true, while the LT t_m' is accessible so that its relationship to the phrasal predicate's LT, t_m, can be specified.

Second, the present-tense information of the non-*ta* marking, *non-ta-sem*, is applied by the rule (16b) to produce a representation at Level 2. The result gained by the combination of *mc-tense-sem* with this is '$t_s < n \; (= p_s = t_m = p_m) \wedge n < t_m'$'.

There are 16 possible combinations of different types of predicates within a complex sentence with a Level 2 subordinate clause in terms of the tense marking and the dynamic/stative distinction. The proposed approach produces correct interpretations for all of them. We will leave the reader to verify this.

To a Level 3 subordinate clause, e.g. the *ga*-clause *Haruko wa Supein e it-ta ga* ('although Haruko went to Italy') in (4), is applied *mc-tense-sem* which unifies the TA with the UT, as in the case of a simplex sentence.

4.2   Simplification of Complex Tense Interpretation

The Japanese complex tenses behave in a manner which seems to resist an easy generalization at first sight. The tenses in matrix clauses are illustrated in Table 2. The interpretation of subordinate clause tenses depends on the tense marking on the predicate, as is outlined in Tables 3 and 4.

We have captured the regularity in the tense behavior by introducing a new hypothetical temporal point, temporal axis (TA), which, by being equated with the LT of the matrix predicate or the UT, relates the LT of the relevant clause to them. Thus, as summarized below, the

Table 3: Subordinate Clause Tense with Non-*Ta*-Marked Matrix Predicate

	Dynamic	Stative
non-*ta*	$n < t_s$	$t_s = n$
ta	$t_s < n$	$t_s < n$

Table 4: Subordinate Clause Tense with *Ta*-Marked Matrix Predicate

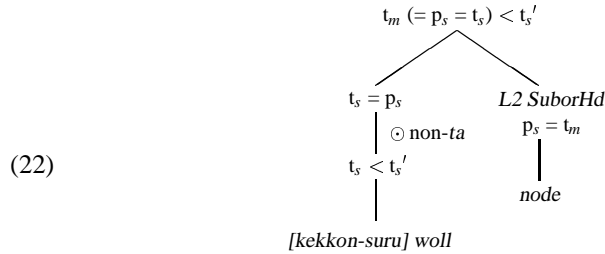|	Dynamic	Stative
non-*ta*	$t_m < t_s$	$t_s = t_m$
ta	$t_s < t_m$	$t_s < t_m$

semantic contribution of a non-*ta* marked predicate, irrespective of whether it is dynamic or stative, lies in identifying the LT (t) with the TA (p). On the other hand, a *ta*-marked predicate sets the LT in a temporal position earlier than that of the TA:

(21) non-*ta* $t = p$
  ta $t < p$

The TA is further identified with the LT of the matrix clause (i.e., $p_s = t_m$) by the subordinate clause head if the clause's HIERARCHY value is *level2*, as is p_s in Figures 4 and 5. The non-*ta*/*ta* meanings in (21) work as well in a matrix clause or a simplex sentence: the TA is unified by (15) with the UT (i.e., $p_m = n$) if it is *level3*.

  Even the meaning of a non-*ta* marked dynamic predicate squares with the proposed formalization. For this purpose, we have introduced in Subsection 3.5 a modal auxiliary verb *woll*, which relates the LT of the hypothetical phrasal predicate, not that of the embedded main predicate, with the temporal point provided outside (this is done by the λ-prefixed LT, λt, in (13b)). So, the Level 2 subordinate clause ϕ *kekkon-suru node* ('Because I (etc.) am going to get married') in (3b) is given the following interpretation:

(22)

$$t_m \; (= p_s = t_s) < t_s{}'$$

$$t_s = p_s \qquad\qquad L2\ SuborHd$$
$$\odot \text{ non-}ta \qquad p_s = t_m$$
$$t_s < t_s{}'$$
$$node$$
$$[kekkon\text{-}suru]\ woll$$

It is t_s, the LT of the phrasal predicate *[kekkon-suru] woll*, not that of the embedded predicate, $t_s{}'$, that is identified with the matrix clause LT, t_m, through the mediation by p_s; $t_s{}'$ is interpreted indirectly by way of t_s. Thus it is sufficient to give each of the non-*ta* and *ta* forms a single lexical specification in terms of temporal meanings, as proposed in (14a, b) and summarized in (21).

4.3   Counterevidence against Relative Tense Theory?

Counterevidence against the accounts on the Japanese complex tenses based on the relative tense theory and the hierarchical sentence structure, an approach adopted in this paper and Yoshimoto (1998), is given by Igarashi (1999).

(23) a. [$_{L2}$Kodomo ga   kuruma wo *arat– ta*] **nara** ϕ kozukai
      child   SBJ car   OBJ wash PAST COND (SBJ) pocket money

    wo   *ageru.*
    OBJ give

    'If my child has washed my car, I will give him pocket money.'
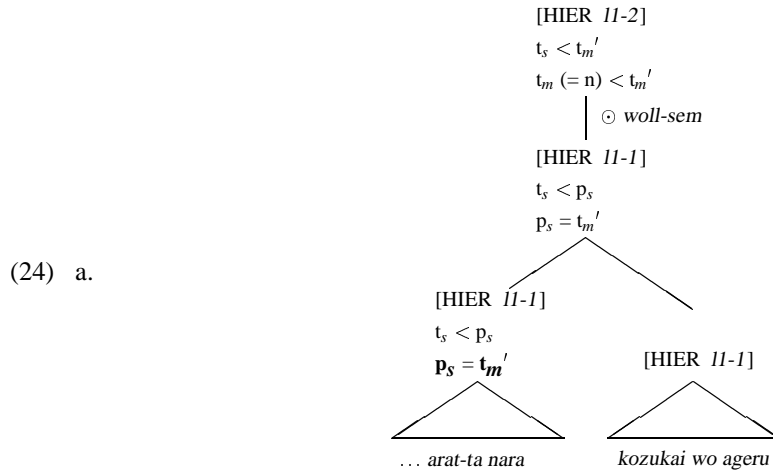
In the sentence above, the LT of the subordinate predicate *arat-ta* embedded by a Level 2 subordinate clause head *nara* (CONDITIONAL) is interpreted as only preceding the LT of the

matrix predicate *ageru* (i.e., $t_s < t_m'$), without any explicit relationship established between the former and the UT: the event denoted by the subordinate clause can occur either in the past or in the future, in other words, $t_s < n$ or $n < t_s$. By contrast, sentences such as (23b) with a parallel construction with Level 2 subordinate clause heads other than *nara* mean that the LT of the subordinate clause is prior to the UT ($t_s < n$).

(23) b. [$_{L2}$ Kodomo ga kuruma wo *arat–* *ta*] **node** ϕ kozukai
         child   SBJ car   OBJ wash PAST CAUSAL (SBJ) pocket money

       wo *ageru.*
       OBJ give

       'Because my child has washed my car, I will give him pocket money.'

However, the semantic difference between the two sentences with the syntactically same construction in fact poses merely a minor difficulty which can be resolved by splitting Level 1 into two levels and assigning them to the two types of subordinate clauses. A HIERARCHY value *level1-1*, the lower level within the former Level 1, is given to a subordinate clause headed by *nara*. *Woll* embeds a clause of Level 1-1, and the outcoming phrasal predicate is lifted to Level 1-2. Thus the subordinate clause in (23a) is included within the clause embedded by *woll*. Subordinate clause heads such as *node* form a clause of Level 1-2, the higher level, and cannot be embedded by *woll*. (24a, b) depicts the syntactic difference between (23a) and (23b).
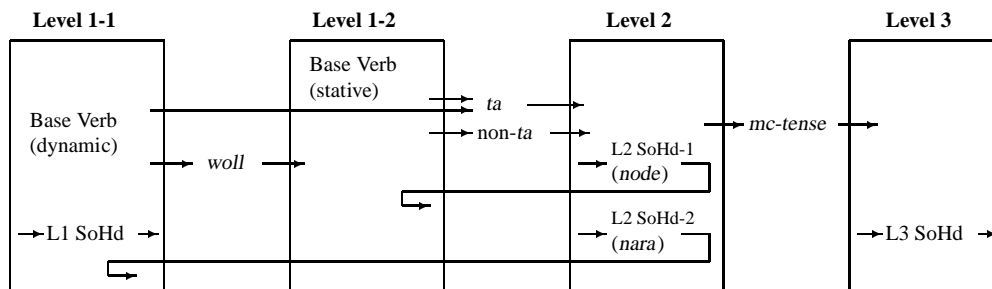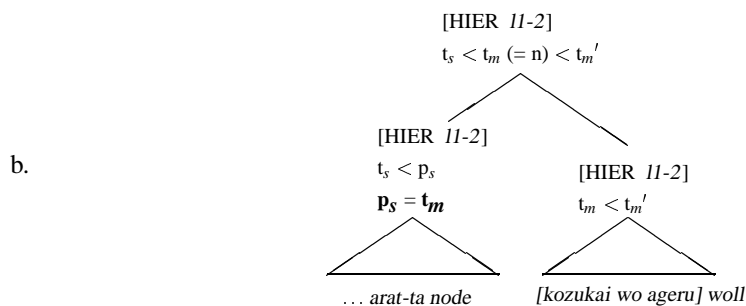

(24) a.

Figure 6: Level-Based Construction of Tense Meaning (Final Ver.)

b.

[HIER *l1-2*]
$t_s < t_m (= n) < t_m'$

[HIER *l1-2*]
$t_s < p_s$
$\mathbf{p_s = t_m}$

[HIER *l1-2*]
$t_m < t_m'$

$\dots$ *arat-ta node*   *[kozukai wo ageru] woll*

In (24b) which has a Level 1-2 subordinate clause, the subordinate clause head *node* identifies the TA of the subordinate clause, p_s, with t_m, the LT of the matrix phrasal predicate headed by *woll*, i.e. *[kozukai wo ageru] woll*, since the subordinate clause is directly adjoined to the matrix phrasal predicate. Therefore, the sentence is interpreted as '$t_s < t_m (= n)$'. In (24a) with a Level 1-1 subordinate clause, *woll* semantically embeds the rest of the sentence, and the subordinate clause head *nara* equates the TA, p_s, with t_m', the LT of the embedded predicate. Accordingly, the sentence is interpreted as '$t_s < t_m'$', and the relationship between t_s and n is unknown.'

Thus the hypothetical semantic operator *woll*, while it simplifies the interpretation of non-*ta*-marked dynamic predicates in both subordinate and matrix clauses, also allows for the solution to the difficulty by refining the hierarchical distinctions.

Figure 6 is a revised version of Figure 2, which diagrams the relationship between the tense-related constituents and semantic operators in terms of the hierarchical levels. As has been just discussed, the meaning of a non-*ta*-marked dynamic verb is split into three components within our framework: the first, shown as (13a) and given a HIERARCHY value *level1-1*, corresponds to the tense meaning of the body of a main verb. The second is that of *woll* (see (13b)), which bears a modal meaning, embeds a Level 1-1 clause, and derives a clause with a HIERARCHY value *level1-2*. The last one is the meaning of the non-*ta* marking, shared by a non-*ta*-marked stative verb. It embeds a Level 1-2 clause and produces a Level 2 clause. The syntactic rules (16a, b) for *woll* and non-*ta* need revision in the HIERARCHY values. Note that both Level 1-1 and 1-2 clauses can be fed into the auxiliary verb *ta*.

As discussed in Subsection 3.5, the temporal meanings of *woll*, non-*ta*, and the matrix clause are introduced by the syntactic rules (16a, b, c). Given the layered syntactic structure,

confusion over the application of these rules is avoided despite the absence of their morphological forms.

5 Conclusions

The approach we have proposed can provide a foundation for contrastive studies with other languages. To take an example, it is applicable to a group of subordinate clauses in English parallel to the Level 2 subordinate clauses in Japanese. Likewise, one of the usages of the English infinitive and gerund is comparable to the Level 1 subordinate clause in Japanese. In addition to our 'relative' interpretation, however, a module of constraints is needed for English to cope with the 'sequence of tenses', i.e., the dependency of the subordinate clause tense morph on that of the matrix clause in case the latter is in the past (see Ogihara 1996).

To sum up the major points of our investigation: we have proposed a mechanism of tense interpretation which consecutively combines DRSs in parallel with an otherwise motivated hierarchical syntactic structure. The framework provides a concise and comprehensive account of the Japanese simplex and complex tenses, specifically made possible by the introduction of the hypothetical temporal point TA and the semantic operator *woll*.

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