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On the temporal interpretation of Japanese temporal clause

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Abstract The interpretation of Japanese temporal clauses depends on an intricate interplay between a number of factors including, in addition to the temporal connective, the tense and aspectual properties of the embedded clause as well as the matrix clause. This paper presents a detailed survey of these interactions and a model-theoretic compositional analysis which improves significantly over previous proposals in terms of attention to empirical detail and internal simplicity.

Keywords Semantics · Japanese · Tense · Aspect · Temporal clauses

1 Introduction

It is a common observation in many languages that formal analyses which capture the temporal interpretation of matrix clauses require considerable modifications in order to apply to embedding contexts as well. Japanese is no exception to this rule. One need not even consider the whole range of embedding contexts to see this. A detailed survey of episodic temporal clauses occurring in postpositional phrases (often called temporal adverbial clauses) is sufficient to see that the Japanese facts are intricate and far from well understood.

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In this paper we undertake such a survey and present a formal analysis which improves over previous attempts in precision and accuracy. We focus on postpositional phrases not only in order to limit the scope of the paper to a tractable set of phenomena but also because their temporal interpretation is particularly interesting in its intriguing interplay between tense, aspectual properties, and the lexical semantics of the embedding temporal expressions. Our goal is to give interpretations to all of these elements which jointly result in the right predictions for matrix and embedding contexts alike as well as for embeddings under a number of different temporal connectives.[1]

We begin with a brief introduction to the forms we are mainly concerned with in Sect. 2, followed by a detailed survey of the relevant data and previous analyses in Sect. 3. Sections 4 and 5 present our formal analysis and illustrate with a number of worked examples. We conclude with Sect. 6.

2 Preliminaries

To set the stage, we begin by introducing the basic lexical items we are concerned with and the way they combine into the complex expressions that are the topic of this paper.

2.1 Basic expressions

Japanese has two tenses, Nonpast and Past. There is generally no disagreement over this fact, unlike in the English case, where both the existence of a Future tense and its morphological manifestation have long been debated. In most of the examples used in this paper, the tense is expressed on verbs. In these cases, the morpheme expressing Nonpast and Past is some allomorph of *-ru* and *-ta*, respectively.[2] In addition to verbs, one class of Japanese adjectives[3] is also inflected for tense, and the Nonpast and Past in this case take the forms *-i* and *-katta*, respectively (the latter contains the form *-ta* also found in verbs). This adjectival paradigm is relevant here mainly because the morpheme expressing negation belongs to it. The four tense morphemes for verbs and adjectives are summarized in Table 1, and some examples are given in (1). In these and subsequent examples, the Nonpast and Past morphemes are glossed either NONPAST and PAST or, for brevity, NP and P, respectively.[4]

[1] The term ''connective'' is used here loosely, without implying any claims about the grammatical nature of the items in question. We discuss their grammatical properties briefly in Sect. 2.

[2] The actual form of the suffix depends on the verb stem; for instance, when the stem ends in a consonant, the Nonpast is expressed as *-u*. In this paper we gloss over the details of such morphophonemic processes.

[3] Kêyôsi (形容詞). All transliterations in this paper follow the Kunrei system.

[4] Other abbreviations used in the glosses are the following: ACC accusative; COM comitative; COND conditional; COP copula; GEN genitive; HAB habitual; IMP imperative; LOC locative; NEG negation; NOM nominative; PERF perfect; PROG progressive; QUOT quotative; TOP topic.

Table 1 Tense morphemes (underlying forms) for Past and Nonpast

[±past]	Category	
	Verbs	Adjectives
[+]	*-ta*	*-katta*
[−]	*-ru*	*-i*

(1) a. iru / ita // iku / itta
be-NP *be*-P *go*-NP *go*-P
'is/was (here) // will go/went'
b. atatakai / atatakakatta
warm-NP *warm*-P
'is/was warm'

Verbs and adjectives are negated with the suffix *-nai*, which, as mentioned above, is inflected for tense following an adjectival paradigm. Its forms are given in (2).

(2) **Negation:**
-nai / -nakatta
NEG-NP NEG-P

Some examples of negated verbs and adjectives follow in (3). As seen in (3b), adjectives like *atatakai* take on the inflected form *atataku-* under negation.

(3) a. inai / inakatta // ikanai / ikanakatta
be-NEG-NP *be*-NEG-P *go*-NEG-NP *go*-NEG-P
'isn't/wasn't (here) // isn't going/didn't go'
b. atatakakunai / atatakakunakatta
warm-NEG-NP *warm*-NEG-P
'isn't/wasn't warm'

As discussed in the introduction, the focus in this paper is on the interpretation of temporal clauses embedded under various temporal connectives. Specifically, we will deal with the following connectives, glossed here with their approximate English counterparts:

(4) **Temporal connectives:**
mae, ato, toki, uti
before *after* *when* *while*

The four items in (4) belong to the syntactic category of *formal nouns*,[5] so called because the phrases they head behave syntactically like noun phrases. The way they

[5] Kêsiki mêsi (形式名詞).

form temporal expressions is described and illustrated in the next subsection. The list in (4) is not exhaustive. There are a number of others that are interesting in their own right, but either similar in the relevant respects to ones discussed here (e.g., both *aida* 'while' and *mama* 'while' differ from *uti* mostly in non-temporal connotations) or beyond the scope of this paper (e.g., *to* is idiosyncratic in ways that we cannot do justice to here).

One more relevant morpheme is the postposition *ni*, which, roughly speaking, on its temporal use simply co-locates two eventualities in time. We say more on its semantics in the next subsection.

2.2 Composition

We have already seen in (1) and (3) above how tense morphology operates on verbs and the negative suffix *-nai*. More generally, tenses operate on *sentence radicals*, i.e., predicates with their arguments, that is, complete but untensed event descriptions that are headed by verbal or adjectival stems.

Temporal connectives take tensed clauses as their arguments as illustrated in (5a–c).[6] However, not all combinations with tenses are well formed. The details of these restrictions will be discussed below. Here we give only well-formed examples. As (5d) illustrates, the temporal connectives can also take event-denoting noun phrases as arguments. This use is irrelevant for the purposes of this paper, however, and we will not discuss it further.

(5) a. [[[Yuria-ga Nihon-ni i-] -ru] {uti / toki}]
Yuria-NOM *Japan*-LOC *be* NONPAST *while* *when*
'while/when Yuria is/was in Japan'

b. [[[Yuria-ga Nihon-ni ik] -u] {mae / toki}]
Yuria-NOM *Japan*-LOC *go* NONPAST *before* *when*
'before/when Yuria went/goes to Japan'

c. [[[Yuria-ga Nihon-ni it-] -ta] {ato / toki}]
Yuria-NOM *Japan*-LOC *go* PAST *after* *when*
'after/when Yuria had gone to Japan'

d. [[[sensô-] -no] {mae / toki / ato}]
war GEN *before* *when* *after*
'before/during/after the war'

As mentioned above, the phrases headed by the temporal connectives in (5) behave syntactically as noun phrases. For this reason, we will refer to them as

[6] Cross-linguistically, there may be cases in which temporal connectives combine with tensed clauses whose tense does not carry any semantic significance. See, for instance, Beaver and Condoravdi (2003) for the claim that in English *before*- and *after*-clauses, the tense of the embedded clause is semantically inert. It will become clear from the discussion below that the same assumption is not warranted for Japanese.

temporal noun phrases and reserve the term *temporal clauses* for the clauses embedded in them.

These temporal NPs optionally combine with postpositions such as *-ni* or *-de* to form adverbial modifiers. While these two postpositions result in subtly different connotations in some cases (especially in *mae-* and *ato*-clauses), we do not address those distinctions here because we believe that their proper analysis presupposes a full understanding of the expressions we are mainly concerned with. We use *-ni* in our examples throughout.

(6) a. [[[[Yuria-ga Nihon-ni i-] -ru] toki] ni]
Yuria-NOM *Japan*-LOC *be* NP *when* NI
'when Yuria is/was in Japan'

b. [[[[Yuria-ga Nihon-ni it-] -ta] ato] ni]
Yuria-NOM *Japan*-LOC *go* P *after* NI
'after Yuria goes/went to Japan'

Although the postposition is optional and in fact often omitted, especially in casual speech, we do assume that it does some semantic work.[7] Therefore we stipulate that it—or *some* appropriate postposition—is at least covertly present whenever a temporal NP is used as an adverbial modifier. Consequently, we call the temporal expressions we are concerned with *postpositional phrases* (PP).[8]

Finally, the resulting adverbial modifiers combine with the matrix clause.

(7) a. [[[[[Yuria-ga Nihon-ni i-] -ru] toki] ni] [[samukat-] -ta]]
Yuria-NOM *Japan*-LOC *be* NP *when* NI *cold* P
'when Yuria *is/was in Japan, it was cold'

b. [[[[[Yuria-ga Nihon-ni it-] -ta] ato] ni] [[kekkon-si-] -ta]]
Yuria-NOM *Japan*-LOC *go* P *after* NI *marry* P
'I got married after Yuria *goes/went to Japan'

Notice that, as the bracketing in (7) indicates, we do not assume that the temporal modifier is in the scope of the matrix tense. Nevertheless, the interpretive possibilities of the former clearly depend on the latter as the English glosses show: in each of (7a, b), the Nonpast reading for the temporal clause that was available up to (6) is now lost, presumably due to the Past tense in the matrix clause. Our analysis does capture these interactions, though not via scope relations, but rather by a kind of unification associated with the postposition. The details will become clear in Sects. 4.3 and 5 below.

[7] In general, matters are a bit more complicated. For instance, with the temporal connective *aida* 'during', which we do not deal with in this paper, the presence or absence of *-ni* makes a semantic difference (Nakau 1976).

[8] Ogihara (1996, p. 182) briefly concedes that they are really postpositional phrases but continues calling them ''temporal adverbial clauses'' for simplicity. Kusumoto (1999) adopts the latter term.

3 Data

The last section introduced the expressions that we are interested in. In the following two subsections, we discuss the interpretation of tensed clauses in two environments: as matrix clauses and as temporal clauses embedded under the connectives introduced above. As mentioned in the introduction, we focus here on episodic uses, setting aside habitual and quantificational ones.

While the temporal interpretation of Japanese matrix clauses is relatively straightforward, embedded clauses present us with a much more complicated picture. Both their well-formedness and their interpretive possibilities are determined by the interplay between (i) their tense, (ii) the temporal connective under which they are embedded, and (iii) their aspectual class. The details of this interaction have so far not been fully accounted for in the formal literature. The most comprehensive and detailed formal proposals to-date are those of Ogihara (1995b, 1996) and Kusumoto (1999). We return to them at the end of this section.

Regarding the role of aspectual properties, an important dividing line running through Japanese clauses locates statives, progressives, perfects, and negated clauses on one side, and activities, accomplishments, and achievements on the other. We refer to these two groups as ''stative'' and ''non-stative'' clauses, respectively.[9]

3.1 Matrix clauses

The temporal interpretation of Japanese matrix clauses with different tenses and aspectual classes is similar to the English case. We canvass them here in detail because the behavior of some of these combinations is quite different in embedded contexts. For the purposes of this exposition, the letters *s* and *r* refer to the Reichenbachian speech and reference time, respectively. In the examples we use the stative verb *iru* 'be' and the non-stative verb *iku* 'go'.

In matrix contexts, aspect has little influence on the interpretation of the tenses. Examples (8) and (9) show that when the reference time either precedes or follows the speech time (which is enforced here by the presence of the temporal frame adverbials), the interpretation is similar for both aspectual classes.[10]

[9] This choice of labels is, for the purposes of this subsection at least, somewhat arbitrary. Whether and in what sense statives, progressives, perfects, and negation form a natural class is an open question on which we do not presume to have a definitive answer. There is general agreement in the literature that progressives and perfects are ''derived statives,'' but less on whether negated clauses are stative (Bennett and Partee 1978; Dowty 1979, 1986; Link 1987; Verkuyl 1993; de Swart and Molendijk 1999) or not (Moltman 1991; Kamp and Reyle 1993; Condoravdi 2008; Csirmaz 2005).

[10] It is well known that the English gloss in (9) is felicitous only in certain special contexts and carries a connotation of ''scheduling'' or predetermination. The Japanese bare Nonpast, in contrast, is much less restricted. Kaufmann (2005) attributes the special constraints in English to the presence of a modal necessity operator as part of the lexical meaning of the tenses. Adopting this general strategy of separating the temporal and modal dimensions, we conjecture that the main difference between English and Japanese in this regard lies in the force of the modal operator involved: in contrast to the necessity operator Kaufmann postulates for English, Japanese tenses involve what Kratzer (1981) called *human necessity*, i.e., necessity mitigated by an ordering source (see also Arita 2007).

(8) Ken-wa kinô ohuisu-ni {*iru / ita // *iku / itta} $[r < s]$
Ken-TOP *yesterday* *office*-LOC *be*-NP *be*-P *go*-NP *go*-P
'Ken was in // went to the office yesterday'

(9) Ken-wa ashita ohuisu-ni {iru / *ita // iku / *itta} $[s < r]$
Ken-TOP *tomorrow* *office*-LOC *be*-NP *be*-P *go*-NP *go*-P
'Ken is in // goes to the office tomorrow'

The only difference between the aspectual classes arises with regard to co-temporal readings of the Nonpast: for Nonpast statives, the reference time may equal the speech time whereas Nonpast non-statives obligatorily receive a future interpretation. This is shown by the readings available with the frame adverbial *ima* 'now' in (10a, b). On the other hand, (10c) shows that the Past does not lend itself to a co-temporal interpretation in either case. All of these facts are quite common cross-linguistically.

(10) a. Hanako-wa ima ohuisu-ni iru $[s = r]$
Hanako-TOP *now* *office*-LOC *be*-NP
'Hanako is in the office now'
b. Hanako-wa ima ohuisu-ni iku $[s < r]$
Hanako-TOP *now* *office*-LOC *go*-NP
'Hanako goes / is about to go to the office now'
c. Hanako-wa ima ohuisu-ni {ita / itta} $[r < s]$
Hanako-TOP *now* *office*-LOC *be*-P *go*-P
'Hanako was in / went to the office (just) now'

Table 2 Speech and reference time in matrix clauses depending on tense and aspect

±past	±stat	$s \cdot r$
[+]	[+]	$s > r$
	[−]	$s > r$
[−]	[+]	$s \leq r$
	[−]	$s < r$

The above facts are summarized in Table 2. The four rows correspond to the four possible combinations of Past/Nonpast tense and stative/non-stative clauses. The pattern suggests that, for matrix contexts, the tenses can be given a unified interpretation that does not depend on the aspectual class, provided that the difference in availability of a co-temporal reading with the Nonpast can be explained independently.[11] The problem of whether such a unified interpretation

[11] One compelling proposal for the analogous English case has been made by Gennari (2003). The idea is that the Nonpast always locates the reference time in the (usually immediate) future of the speech time (i.e., $s < r$) and that the availability of the co-temporal reading with statives is due to a pragmatic

is possible and whether it should be $s < r$ or $s \leq r$ touches on deeper semantic and ontological questions which lie beyond the scope of this paper. We merely note that matrix contexts differ in this respect from embedded contexts, to which we now turn.

3.2 Embedded clauses

3.2.1 Relative tense

Most Japanese temporal connectives impose selectional restrictions on both the aspectual class and the tense of their complement clause. *Mae* and *ato* only combine with non-stative clauses, *uti* only with stative ones, and *toki* with both non-statives and statives. Furthermore, while *mae* and *uti* require Nonpast tense, *ato* requires Past, and *toki* combines with both Nonpast and Past complements. Thus *toki* is the least restrictive connective of the four with regard to these properties; however, the interpretation of *toki*-clauses depends on both the aspectual class and the tense of the complement. The main facts are illustrated in (11) and the subsequent examples, again with stative *iru/ita* 'be-NONPAST/PAST' and non-stative *iku/itta* 'go-NONPAST/PAST'. In (11), the stars mark ill-formed expressions, and the glosses give an indication of which readings are available in each case.

(11) a. Tarô-ga Amerika-ni {*iru / *ita // iku / *itta} mae
Taro-NOM *America*-LOC *be*-NP *be*-P *go*-NP *go*-P *before*
'before Taro goes/went to America'

b. Tarô-ga Amerika-ni {*iru / *ita // *iku / itta } ato
Taro-NOM *America*-LOC *be*-NP *be*-P *go*-NP *go*-P *after*
'after Taro goes/went to America'

c. Tarô-ga Amerika-ni {iru / *ita // *iku / *itta} uti
Taro-NOM *America*-LOC *be*-NP *be*-P *go*-NP *go*-P *while*
'while Taro is/was (still) in America'

d. Tarô-ga Amerika-ni {iru / ita // iku / itta} toki
Taro-NOM *America*-LOC *be*-NP *be*-P *go*-NP *go*-P *when*
'when Taro is/was // goes/went to America'

Notice that the temporal relation with respect to the speech time in these clauses is not specified, as indicated in the English glosses. This information is independently supplied by the tense of the matrix clause. Thus the tenses in these embedded

footnote 11 continued
inference that is licensed by their *superinterval property*. Alternatively, one could say that Nonpast tense is literally interpreted as nonpast, allowing for speech and reference time to be co-temporal (i.e., $s \leq r$), and that the obligatory futurate interpretation of non-statives is due to some other factor. This is what Kaufmann (2005) assumes although he does not go into any detail as to what that other factor might be.

clauses receive a *relative* interpretation with regard to the reference time of the matrix clause.[12]

As we mentioned above, Japanese progressive, perfect, and negated sentences pattern with statives in their behavior with these temporal connectives. This is illustrated in (12).[13]

(12) a. Zyon-ga iru {*mae / *ato / uti / toki } [*stat.*]
John-NOM *be*-NP *before after while when*
'while/when John is/was here'

b. Zyon-ga aruite iru {*mae / *ato / uti / toki} [*prog.*]
John-NOM *walk*-PROG-NP *before after while when*
'while/when John is/was walking (for a while)'

c. Zyon-ga taorete iru {*mae / *ato / uti / toki} [*perf.*]
John-NOM *fall*-PERF-NP *before after while when*
'while/when John has/had fallen'

d. Zyon-ga inai {*mae / *ato / uti / toki} [*neg.*]
John-NOM *be*-NEG-NP *before after while when*
'while/when John is/was not here'

On the other hand, we observe the opposite pattern for all classes of non-statives, i.e., activities, accomplishments and achievements, as illustrated in (13) through (14).

(13) Activities:

a. Zyon-ga sanpo suru {mae / *ato / *uti / toki}
John-NOM *take a walk*-NP *before after while before*
'before John takes/took a walk'

b. Zyon-ga sanpo shita {*mae / ato / *uti / toki}
John-NOM *take a walk*-P *before after while after*
'after John takes/took a walk'

[12] An alternative view is that the forms serve as tenses in matrix contexts and as aspectual markers in the embedded contexts illustrated in (11) (Nakau 1976, and others). Ogihara (1999) offers a useful discussion of the issue and argues convincingly that the term *relative tense* is to be preferred. We adopt this view.

[13] Not all instances of the non-starred forms are uniformly well formed with *uti*. For instance, the meaning of a result-state denoting perfect may clash with the implicature, carried by *uti*, that the temporal clause will become false in the future. (i) is infelicitous on that reading.

(i) #Zyon-ga hon-o (zenbu) yonde iru uti
John-NOM *book*-ACC *completely read*-PROG-NP *within*
'while John had (still) read the whole book'

However, (i) may receive a marginally acceptable progressive reading.

(14) Accomplishments:[14]

a. Zyon-ga hon-o yomu {mae / *ato / *uti / toki}
John-NOM *book*-ACC *read*-NP *before* *after* *while* *before*
'before/while John reads/read the/a book'

b. Zyon-ga hon-o yonda {*mae / ato / *uti / toki}
John-NOM *book*-ACC *read*-P *before* *after* *while* *after*
'after John reads/read the/a book'

(15) Achievements:

a. Zyon-ga mezameru {mae / *ato / *uti / toki}
John-NOM *wake up*-NP *before* *after* *while* *before*
'before John woke/wakes up'

b. Zyon-ga mezameta {*mae /ato / *uti / toki}
John-NOM *wake up*-P *before* *after* *while* *after*
'after John woke/wakes up'

3.2.2 Absolute tense

Complicating matters, embedded tenses do not always receive a relative interpretation. This fact has been mentioned but never explored in detail in the formal semantic literature on Japanese (Ogihara 1999, see below for more details). Whether an absolute reading is available, either instead of or in addition to the relative one, depends on the temporal connective. Among the ones we are dealing with in this paper, only *toki* allows an absolute interpretation.[15]

[14] Nonpast accomplishment clauses like *Zyon-ga hon-o yomu* in (14a) are in some contexts ambiguous between a reading which locates the matrix clause eventuality before the *beginning* of the event in question (here, John's reading the book) and one which locates it before the *culmination* of the latter. This is the case with both *mae* and *toki*, both of which therefore sometimes appear to allow for a cotemporal reading with such complements. Beaver and Condoravdi (2003) address a similar phenomenon in English *before*-clauses, assuming that in the course of the composition of *before* with its complement, a ''selection function'' picks out a salient temporal instant from the denotation of the latter, typically either its beginning or its culmination. Alternatively, one could assume that the temporal clause itself can denote—by virtue of being ambiguous or as a result of coercion—either the whole event or only its culmination. This question is beyond the scope of the current paper.

[15] In general, *toki* is not the only such connective. For instance, Nakau (1976, p. 447) cites (i) with *koro* 'when', and Kudô (1995, p. 227) cites (ii) with *aida* 'while'.

(i) Kanozyo-wa, dokusin datta koro, utukusikatta
she-TOP *single* COP-PAST *when* *be beautiful*-PAST
'When she was single, she was beautiful.'

(ii) Kyôto-ni {taizaisitei-ru / taizaisitei-ta} aida, zutto ame datta
Kyoto-LOC *stay*-PROG-NP *stay*-PROG-P *while* *the whole time* *rain* COP-P
'When I was staying in Kyoto, it was raining the whole time.'

With stative clauses under *toki*, Nonpast and Past tense are interchangeable without a discernible difference in temporal interpretation, provided that the temporal reference lies in the past relative to the speech time.[16] This is illustrated in (16a). In (16b), in contrast, the temporal reference cannot lie in the past due to the Nonpast tense in the matrix clause and the fact that with statives, *toki* co-locates the two eventualities. Consequently, the use of Past tense in the temporal clause results in ill-formedness.

(16) a. Ken-wa, Kyôto-ni {iru /ita} toki-ni
Ken-TOP Kyoto-LOC *be*-NP *be*-P *when*-LOC
sensê-to atta
professor-COM *meet*-P
'When Ken was in Kyoto, he met with the professor.'

b. Ken-wa, Kyôto-ni {iru / *ita} toki-ni
Ken-TOP *Kyoto*-LOC *be*-NP *be*-P *when*-LOC
sensê-to au
professor-COM *meet*-NP
'When Ken is in Kyoto, he will meet with the professor.'

In (16a), the interpretations of Nonpast *iru* and Past *ita* are clearly relative and absolute, respectively. In (16b), however, it is harder to tell which interpretation is involved since with Nonpast *iru* both are equivalent. Thus the example does not settle the question as to whether an absolute reading under *toki* is available only for Past tense or also for Nonpast. We return to this question in a moment. First, notice also that the well-formedness of Past-tense statives under *toki* (though not *uti*) extends to derived statives as well:

[16] An anonymous reviewer points out that the absolute reading is not available in all contexts in which the relative reading is. Thus in (ia), the temporal clause can have a quantificational reading (*those times at which Mana was in Tokyo*) in a context in which the reference time of the matrix clause is an interval during which Mana was in Tokyo several times. This quantificational reading is not available with Past tense: (ib) must be evaluated relative to a reference time throughout which the temporal clause holds, hence relative to a single visit of Mana's to Tokyo.

(i) Mana-ga Tôkyô-ni { a. iru toki, / b. ita toki, } yoku tazunete-itta (mono-da)
Mana-NOM *Tokyo*-LOC { *be*-NP *time(s)* / *be*-P *time(*s)* } *often visit-go*-P HAB-COP
'When Mana was in Tokyo, I often visited her.'

This contrast is fascinating but not immediately relevant to our concerns because we are only concerned with episodic, non-quantificational readings. We reserve a detailed exploration of such sentences for future work.

(17) Zyon-ga {ita / aruite ita / taorete ita / inakatta}
John-NOM *be*-P *walk*-PROG-P *fall*-PERF-P *be*-NEG-P
{*uti /toki} denwa-ga kakatta
while *when* *phone* *ring*-P
'When John was here / was walking / had fallen / was not here, the phone rang.'

Non-statives, too, may receive an absolute interpretation under *toki*, and here it becomes evident that the absolute reading is available with Nonpast as well. The relevant data we cite here are due to Kudô (1995). Consider first (18).

(18) Sengetu, Rosia-ni {iku / itta } toki-wa, Siberia
last month *Russia*-LOC *go*-NP *go*-P *when*-TOP *Trans-Siberian*
tetudô-o *tukatta*
Railway-ACC *use*-P
'Last month, when I went to Russia, I took the Trans-Siberian Railway.'

Kudô notes that the Nonpast form *iku* in (18) is interpreted in the usual way, as precedence. (Although the use of the Trans-Siberian railway occurred during the trip, rather than strictly preceding it, it did precede the *culmination* of the trip. This is an instance of the ambiguity of accomplishment sentences mentioned in Footnote 14 above.) Past-tense *itta*, on the other hand, does not necessarily have a relative interpretation. Rather, it may refer somewhat vaguely to the entire trip and locate the train ride within or close to it. To show this, Kudô points out that the insertion of *ôfuku* 'both ways', placing train rides both at the beginning and at the end of the journey, renders the Nonpast tense inappropriate, as one would expect under a relative interpretation. However, it does not affect the felicity of the Past:

(19) Sengetu, Rosia-ni {*iku / itta} toki-wa, ôhuku
last month *Russia*-LOC *go*-NP *go*-P *when*-TOP *both*
tomo Siberia tetudô-o tukatta
ways *Trans-Siberian* *Railway*-ACC *use*-P
'Last month, when I went to Russia, I took the Trans-Siberian Railway both ways.'

In addition, it is worth pointing out that when the reference time of the matrix clause lies in the future, the Past can no longer be used in the embedded clause, as shown in (20). Thus the interpretation of the Past in (18) and (19) is indeed absolute.

(20) Raigetu, Rosia-ni {iku / *itta} toki-wa,
next month *Russia*-LOC *go*-NP *go*-P *when*-TOP
ôhuku tomo Siberia tetudô-o tukau
both *ways* *Trans-Siberian* *Railway*-ACC *use*-NP
'Next month, when I go to Russia, I will take the Trans-Siberian Railway both ways.'

Now, the felicity of Nonpast *iku* in (20) already indicates that it, too, can have an absolute reading: For otherwise it should be infelicitous for the same reason as in (19). Instead, we see that (20) is the mirror image of (19). Kudô also shows this with her second example (21). Here the adverb *kondo* 'next time' locates the time in question in the future from the perspective of the speech time.

(21) Kondo, uti-no daigaku-ga hakkututyôsa-ni
next time *our* *university*-NOM *archeological survey*-LOC
{iku / itta} toki, sono tetudai-ni ike
go-NP *go*-P *when* *that*-GEN *help*-LOC *go*-IMP
'Next time our university goes on an archeological survey, go help them.'

Here the Past form *itta* can only receive a relative interpretation whereas the Nonpast *iku* may be interpreted absolutely. Thus in (22), the insertion of *sôgê* 'see off and greet', analogously to *ôfuku* 'both ways' above, renders the Past tense infelicitous on the intended interpretation. The felicity of the Present, on the other hand, is not affected by this change since it can receive an absolute interpretation.

(22) Kondo, uti-no daigaku-ga hakkututyôsa-ni
next time *our* *university*-NOM *archeological survey*-LOC
{iku / *itta} toki, sono sôgê-no tetudai-ni ike
go-NP *go*-P *when* *that*-GEN *see off and greet*-GEN *help*-LOC *go*-IMP
'Next time our university goes on an archeological survey, go help see them off (when they leave) and greet them (when they come back).'

As expected, locating both events in the past as in (23) inverts the pattern: now the Present can no longer be interpreted absolutely, but the Past can.

(23) Kono mae, uti-no daigaku-ga hakkututyôsa-ni
last *time* *our* *university*-NOM *archeological survey*-LOC
{*iku / itta} toki, sono sôgê-no
go-NP *go*-P *when* *that*-GEN *see off and greet*-GEN
tetudai-ni itta
help-LOC *go*-P
'Recently, when our university went on an archeological survey, I went to help see them off and greet them.'

It is not entirely clear to us at this point what constraints, if any, govern the availability of the absolute interpretation of tense under *toki*. It seems that it is harder to come by with achievements than with accomplishments and activities. Furthermore, it seems to be the more readily available, the farther both eventualities lie in the past. Thus (24), for which only the absolute reading is available, is much more acceptable with *kyonen* 'last year' than with *kinô* 'yesterday'. As (24) also shows, the temporal relation between the temporal and matrix clauses is less strictly constrained than under the relative interpretation.

(24) {#Kinô / Kyonen} Sikago-ni itta toki, maemotte
yesterday *last year* *Chicago-loc* *go*-P *when* *beforehand*
gaidobukku-o katta
guidebook-ACC *buy*-P
'When I went to Chicago {yesterday / last year}, I bought a guidebook beforehand.'

The details await further investigation. What we can say with some confidence is the following:

(25) a. If both the matrix clause and the embedded clause are stative, their temporal reference must coincide.
b. If one is stative and the other non-stative, the reference time of the former must include that of the latter.
c. If both are non-stative, both must refer to times that are ''close'' to each other in some vague and context-dependent sense.

More empirical work may reveal additional constraints. Meanwhile, our formal analysis below accounts for (25a, b) and requires for (25c) that the two eventualities merely have to be co-located within the reference time of the matrix clause; the exact temporal relation is underspecified. In line with this treatment, *toki* in these cases is glossed as English 'when' below.

Table 3 Temporal interpretation of embedded clauses depending on tense, aspect and connective

[±past]	[±stat]	*mae*	*ato*	*uti*	$toki_{rel}$	$toki_{abs}$
[+]	[+]	*	*	*	*	'when'
	[−]	*	'after'	*	'after'	'when'
[−]	[+]	*	*	'while'	'while'	'when'
	[−]	'before'	*	*	'before'	'when'

The facts about embedded contexts are summarized in Table 3. The presence of two entries for *toki* reflects our contention that the temporal connective is responsible for the availability (or not) of an absolute reading. We will see below that the lexical entries for the two variants are closely related, however.

3.2.3 Some aspectual complications

The judgments and generalizations we discussed in this section are generally clear and uncontroversial, but certain kinds of examples behave in ways that do not seem to fit the pattern neatly. In this subsection we mention a few such problematic cases, in part pointed out by anonymous reviewers, all of which concern the interpretation of embedded stative clauses. While these data certainly need to be taken seriously, it is not clear that they pose a challenge to our account. Pending further investigation, what we take them to show is that statives can easily be reinterpreted in ways which suit the contexts they occur in but which also change their aspectual properties.

One question is whether statives are indeed unable to occur embedded under connectives such as *ato*. Kusumoto (1999) notes that ''a stative predicate in *after*-clauses does not always result in ungrammaticality'' (p. 232):

(26) Watasi-wa san-zikan niwa-ni ita ato-de
I-TOP *three hours* *garden*-LOC *be*-PAST *after*-LOC
heya-ni haitta
room-LOC *enter*-PAST
'I entered the room after I was in the garden for three hours.'

Kusumoto does not offer an explanation for the well-formedness of such sentences and leaves the problem open. An anonymous reviewer points out a similar example:

(27) Hanako-wa tosyokan-ni sibaraku ita ato-de ie-ni
Hanako-TOP *library*-LOC *for a while* *be*-P *after*-LOC *home*-LOC
kaetta
return-P
'Hanako returned home after she was at the library for a while.'

It seems to us that the well-formedness of such examples may well be due to a kind of aspect shift or coercion which would not fall under the purview of the present proposal (Smith 1991; de Swart 1998; Verkuyl 1993, 1999). There are several indications in favor of this view. One is that all such examples that we are aware of involve adverbs of duration like *san-zikan* 'for three hours' or *sibaraku* 'for a while'. Without such adverbs, their acceptability would be markedly lower.

(28) ?Watasi-wa niwa-ni ita ato-de heya-ni haitta
I-TOP *garden*-LOC *be*-PAST *after*-LOC *room*-LOC *enter*-PAST
'I entered the room after I was in the garden for three hours.'

(29) ?Hanako-wa tosyokan-ni ita ato-de ie-ni kaetta
Hanako-TOP *library*-LOC *be*-P *after*-LOC *home*-LOC *return*-P
'Hanako returned home after she was at the library for a while.'

But even examples like (28) and (29) are not entirely unacceptable. It is merely harder to interpret them without extra contextual information. Generally what is required is a context in which the eventuality referred to by the embedded clause is somehow bounded or quantized.[17]

[17] The most well-known examples of a similar phenomenon in English involve activity verbs with *in*-adverbials, as in *John ran in an hour*, which is perfectly acceptable if the relevant eventuality involved John's running of a contextually more or less determinate distance, such as his usual five miles.

This is related to the second piece of evidence for a coercion analysis: Not all statives can be embedded under *ato* with equal ease, and the verb *iru* 'be' is rather exceptional in this regard. Prototypical statives such as *atui* 'be hot' or *byôki-da* 'be ill' do not occur with *ato*, despite their stage-level nature:

(30) *Kinô atukatta ato, kyû-ni ame-ga futta
*yesterday be-hot-*P *after suddenly rain-*NOM *fall-*P
'After it was hot yesterday, it suddenly rained.'

(31) *Hanako-wa byôki-datta ato-de ronbun-o kakioeta
*Hanako-*TOP *be-ill-*P *after-*LOC *paper-*ACC *write-finish-*P
'Hanako finished writing the paper after she was ill.'

Thirdly, the intended reading as 'after' only arises with *ato*, never with *toki*, even though, as we saw above, *toki* can in fact mean 'after' with Past non-statives:

(32) ??Watasi-wa sibaraku niwa-ni ita toki-ni ie-ni kaetta
*I-*TOP *for a while garden-*LOC *be-*PAST *when-*LOC *home-*LOC *return-*P
'When I was in the garden for a while, I went home.'

(33) ??Hanako-wa tosyokan-ni sibaraku ita toki-ni
*Hanako-*TOP *library-*LOC *for a while be-*P *when-*LOC
ie-ni kaetta
*home-*LOC *return-*P
'Hanako returned home after she was at the library for a while.'

The unacceptability of (32) and (33) suggests that when the temporal connective allows for a cotemporal reading (i.e., the reading one would expect if the temporal clause were to behave like a true stative), then this cotemporal reading is the only one available. *Toki* does and *ato* does not allow for such a reading.

Related to this problem, an anonymous reviewer notes that in B's reply in (34), Past tense occurs under *toki* in (what looks like) a stative clause.

(34) A: Mosi Hanako-ga itara...?
*if Hanako-*NOM *be-*COND
'What if Hanako is there?'
B: Hanako-ga ita toki-ni-wa, kinô-no koto-o
*Hanako-*NOM *be-*P *if/when-*LOC-TOP *yesterday-*GEN *matter-*ACC
ayamarimasu
*apologize-*NP
'If/when Hanako is there, I will apologize for what happened yesterday.'

The connective *toki* has a somewhat special use here, close in meaning to the conditional *tara* in A's question. The reviewer takes this example to show that Past tense can occur with statives under *toki* in a relative use of the connective. We agree that the Past is relative but are not convinced that the clause is truly stative. Rather, we believe that despite appearances, the embedded clause has a non-stative use meaning, in effect *If it turns out / if I find that Hanako is there*, which is responsible for the availability of a relative reading with *toki*. This claim is not easy to test, but one piece of evidence is that such clauses can also contain adverbs like *ikinari* or *kyû-ni* 'suddenly'. Those adverbs normally accompany only change-of-state predicates but can also occur with statives, provided that those complements are reinterpreted as referring to the change of *mental state* involved in finding that the state in question holds.

In sum, it seems to us that the examples discussed in this section are acceptable because they are ''rescued'' by a coercion-like strategy that remains to be investigated in detail. On this view, our analysis explains why they are in need of rescue but stops short of explaining the rescue itself. The latter task is reserved for future work.

3.2.4 Interim summary

The picture that emerges once we take embedded clauses into account is considerably more complicated than the case of matrix clauses alone. Our goal is to assign interpretations to the aspectual classes, tenses, and temporal connectives in such a way that the constraints on co-occurrence and interpretation follow. Doing so in a uniform and compositional way poses some challenges.

First, recall that the selectional restrictions of temporal connectives and the constraints on the interpretation of the whole temporal phrase (in the case of *toki*) make reference to both the aspectual class and the tense of the embedded clause. If we adopt the common assumption that tense and aspect enter the composition separately, with tense scoping over aspect, in the interest of compositionality we cannot allow the temporal connective to ''see past'' the tense and have direct access to the aspectual properties of the embedded radical. Rather, the relevant aspectual properties must be recoverable from the denotation of the tensed clause.

Second, we saw above that the interpretation of Nonpast statives depends on whether they occur in matrix or embedded contexts: They have either a co-temporal or a future interpretation in the former whereas only the co-temporal reading is available in the latter. This poses another challenge to compositionality. In principle, the interpretation of a clause should not depend on its place in a larger structure. Our data suggest, however, that the meaning we assign to temporal clauses must somehow be sensitive to the depth of embedding.

In addition, the availability of an absolute reading under some, though not all, connectives must be accounted for and properly constrained.

Before we turn to our own account, the next subsection discusses the major results and open problems of previous research on the topic, with special emphasis on the challenges mentioned above.

3.3 Previous work

The most comprehensive formal analyses of Japanese temporal PPs thus far are due to Ogihara (1989, 1994, 1995b, 1996, 1999) and Kusumoto (1999, see also Arregui and Kusumoto 1998). Compared with the present paper, both cover a wider variety of embedding contexts, such as attitude descriptions and relative clauses. Without diminishing the considerable value of these contributions, it is fair to say that their sweeping breadth of coverage comes at the cost of rigor and exactitude in detail, at least with regard to the phenomena here under consideration.

Ogihara's main contribution consists in the formalization of a relative theory of Japanese tense (see Ôta 1973; Soga 1983; Matsumoto 1985, for precursors). He uses this framework to explain the restrictions imposed by *mae* and *ato* on the tenses of their complement clauses (Nonpast and Past, respectively) in terms of constraints on the relation between the reference time of the embedding context and that of the temporal clause. These constraints are imposed independently by the tense and the temporal connective and lead to contradiction and hence semantic ill-formedness in case of a mismatch (Ogihara 1996, Sect. 5.5). As will become clear below, our proposal derives these restrictions in similar ways.

Ogihara (1999) later recognized that some Past-tensed clauses under *toki* are interpreted absolutely. One of Ogihara's examples is (35)[18]:

(35) Tarô-wa Tôkyô-ni i-ta toki, apâto-ni sundeita
Taro-TOP *Tokyo*-LOC *be*-P *when* *apartment*-LOC *live*-P
'When Taro was in Tokyo, he lived in an apartment.'

Ogihara speculates about sentences like (35) that due to the presence of *toki*, the entire temporal phrase may be ''somehow moved in the syntax and ... interpreted independently of the matrix clause tense,'' citing the factivity of *toki*-phrases as a possible trigger of this operation. As appealing as the idea may appear, it is not clear whether factivity would be the correct criterion for singling out all and only those connectives with which the absolute reading is available. *Uti*, for one, is no less factive than *toki* but does not allow Past-tensed complements.

One might conceivably look for an explanation in terms of other idiosyncratic properties of *toki*, perhaps along the lines Ogihara suggests. Kusumoto (1999, pp. 234–235) rejects Ogihara's idea on the grounds that *mae* and *ato*, like *toki*, are syntactically nouns and project noun phrases, which presumably would somehow have to be prevented from undergoing the same movement.[19] A defender might point out in response that while all of *toki*, *mae*, *ato*, and *uti* are nouns (or rather grammaticalized descendants of nouns), only *toki* has a separate existence as a non-relational noun meaning 'time'. It would still be incumbent upon the defender, though, to clarify whether and why this fact would lend support to Ogihara's proposal.

[18] The glosses of cited examples are adjusted to the usage in this paper.

[19] Incidentally, Kusumoto takes the proposal to address a different problem from the one intended by Ogihara, namely the fact that *toki* with Past non-statives does not have a simultaneous reading; see below.

But even if these issues could be resolved, Ogihara's analysis is limited in other respects as well. For instance, although he cites Kudô (1995) as the source of (35), he glosses over the fact that Kudô gives examples with *aida* 'while' in the course of the same discussion (see Fn. 15 above). Nor does he discuss the restriction of *mae* and *ato* to non-statives or that of *uti* to statives. In sum, while the formalization of the idea of relative tense is an important contribution, it is not applicable across the board, and Ogihara's account as it stands does not scale up to the full range of data.

Kusumoto (1999, esp. Chap. 3) discusses some of the above limitations of Ogihara's analysis. Granting that the relative-tense approach is successful in explaining the restriction of *mae* and *ato* to Nonpast and Past, respectively, she lists a number of real and purported problems with it. She rightfully points out Ogihara's failure to account for the restriction of *mae* and *ato* to non-statives but makes no attempt to address this issue herself, leaving the entire topic of aspectual classes to future work. In fact, her own account does not even capture the selection of tenses by *mae* and *ato* which Ogihara's does (see Sect. 3.3.4.1).

Kusumoto's analysis of *toki* is problematic as well. She models her account on extant analyses of English *when*. Those proposals generally assume that the temporal relation between the embedded clause and the matrix clause is uniform with *when* and broadly fall into two classes according as this relation is taken to be simultaneity or (immediate) subsequence. Kusumoto's attempt to apply this analysis to the Japanese data predictably runs into problems because the temporal relation between *toki*-clauses and their matrix clauses varies according to tense and aspectual class. Kusumoto considers the interpretation of the various combinations of tense and aspect under *toki* as contradictory evidence that this relation is precedence, simultaneity, and subsequence, concluding that an Ogihara-style account of *toki*-clauses must lead to a dead end: ''... *when* has to mean 'before' [with Nonpast non-statives – SK] and 'after' [with Past non-statives – SK], which is unrealistic.''[20]

Kusumoto's alternative (Sect. 3.3.4.2), however, raises more questions than it resolves. She first observes that *toki* may take two kinds of complements, relative clauses and tensed verb phrases.[21] That *toki* can combine with relative clauses is shown by examples like (36).

(36) Watasi-wa Zyunko-ga Satosi-ga tuku to itta
I-TOP *Junko*-NOM *Satoshi*-NOM arrive-NP QUOT *say*-PAST
toki-ni eki-de kare-o matteita
when-LOC *station*-LOC *he*-ACC *wait*-PROG-P
'I was waiting for Satoshi at the station when Junko said that he would arrive.'
a. at the time of Junko's utterance
b. at the time of Satoshi's arrival according to Junko

[20] Somewhat incongruously, Kusumoto speaks of Japanese ''*when*-clauses,'' ''*before*-clauses,'' and ''*after*-clauses,'' a terminological choice which may inspire unrealistic expectations of cross-linguistic uniformity.

[21] In Kusumoto's analysis, the relative clauses in question are TPs with a variable over times bound by a lambda operator. The internal structure of the tense-bearing VPs is not specified in detail. Both are assumed to denote properties of times.

This sentence, like its English translation, is ambiguous between the two readings shown: one according to which the relevant time of the speaker's waiting coincided with Junko's utterance and one according to which the speaker waited at what was to be Satoshi's time of arrival according to what Junko had said. On the latter reading (36b), it is indeed reasonable to treat *Junko-ga Satoshi-ga tuku to itta toki* as a relative clause headed by *toki*. Kusumoto expands this analysis and claims that *all toki*-phrases with Past-tensed temporal clauses, including (36a) and (37), are relative clauses.

(37) Satosi-ga kita toki, Zyunko-wa heya-ni ita
Satoshi-NOM *come*-P *when* *Junko*-TOP *room*-LOC *be*-P
'Junko was in her room when Satoshi came.'

Under Kusumoto's analysis, the Past tenses of both the temporal clause and the matrix clause in these examples receive an absolute interpretation relative to the speech time, and *toki* asserts that the respective reference times are equal.

One immediate problem with this idea is that a Past-tense *toki*-clause can refer to the future if the matrix clause does, as shown in (38).

(38) Satosi-ga kita toki, eki-ni iku
Satoshi-NOM *come*-PAST *when* *station*-LOC *go*-NP
'When Satoshi has come, I'll go to the station.'

Here, not only can the time of Satoshi's coming lie in the future, it actually has to in order for the sentence to make sense pragmatically. A typical scenario would be one in which Satoshi is expected to get in touch by phone once he has arrived or one in which the speaker will first meet Satoshi at the airport and then take him to the station. Under Kusumoto's analysis, the future reference should be inconsistent with the Past marking on the temporal clause. Such examples are perfectly well formed, but as far as we can see, the only way to account for them within her analysis would be to give different interpretations to Past-tensed *toki*-clauses depending on whether they are used with past or future reference. There seems to us to be no good argument for such a move.

Sentence (38) also illustrates another problem with Kusumoto's account, viz. the fact that the temporal relation between the two clauses is not simultaneity as she would have it. The sentence is not true if the trip to the station occurs during Satoshi's arrival: it has to follow the arrival. The use of the Perfect in the gloss, though not obligatory in English, brings this out.

Although Kusumoto does not discuss how Past *toki*-clauses with future reference are interpreted, she does recognize that the above account would make the wrong predictions about the converse, i.e., Nonpast *toki*-clauses with past reference, such as (39).

(39) Heya-de neteiru toki-ni Zyunko-ga tazunete-kita
room-LOC *sleep*-PROG-NP *when*-LOC *Junko*-NOM *come visit*-P
'Junko visited me when I was sleeping in my room.'

About this example, Kusumoto's syntactic claim is that the complement of *toki* is a tensed verb phrase. Semantically, it simply refers to a property of times, independently of either the speech time or the matrix reference time. This leads to the right predictions for (39), where the complement of *toki* is a (derived) stative. Kusumoto also notes that these predictions are not correct for non-statives since here the temporal relation must be (immediate) subsequence:

(40) Genkan-o deru toki-ni denwa-ga natta
entrance-ACC *leave*-NP *when*-LOC *phone*-NOM *ring*-P
'The phone rang right before I went out the front door.'

Kusumoto proposes to address this by stipulating ''a silent element that corresponds to *will* that cooccurs with a present tensed eventive predicate'' (p. 280). Thus with non-statives like (40), the temporal property in question is not the set of times at which the speaker leaves but those times at which she is *going to* leave. At first glance, this idea is not unreasonable: we saw above that Nonpast non-stative clauses cannot have a co-temporal interpretation either in matrix or in embedded clauses, and a stipulation along these lines could take care of this fact. Moreover, as Kusumoto notes and we showed above, stative clauses have a co-temporal interpretation in both contexts. What is not explained by Kusumoto's stipulation, however, is the fact that statives in matrix clauses (but *not* in embedded clauses) can also have futurate interpretation; see our example (9) above. Kusumoto acknowledges this fact in a footnote (p. 231, Fn. 9) but does not account for it in her formal analysis. If the availability of a futurate reading with statives is due to the same silent element she stipulates for non-statives, one would have to conclude that this element is optionally available for statives as well, albeit only in matrix clauses. If the futurate reading for statives is due to some other mechanism, one would have to explain why the same mechanism is not also responsible for the futurate reading of non-statives. Either way, Kusumoto's proposal is too sketchy to see how it is supposed to account for all the facts.

Overall, we conclude that at least with regard to this particular set of phenomena, Kusumoto's proposal does not improve significantly over the relative tense hypothesis in terms of either descriptive accuracy or internal coherence and simplicity. The distinction between relative clauses headed by the ''full noun'' *toki* and temporal NPs headed by the ''formal noun'' *toki* seems orthogonal to the difference between Past and Nonpast complement clauses, and the line Kusumoto uses it to draw creates an artificial division between the clauses in the two tenses, leaving her unable to account for the felicity of Past temporal clauses with future reference. Moreover, her insistence on giving *toki* a uniform interpretation of simultaneity compels her to stipulate a silent future-like operator in Nonpast non-statives with past reference, but it does not address the parallel problem with Past non-statives with future reference. To be sure, Kusumoto notes repeatedly that her discussion does not prove that a relative tense account is inferior. Nor, we find, does she make a compelling case for her alternative.[22]

[22] On a more peripheral note, in her criticism of Ogihara's relative tense theory, Kusumoto points out that two Japanese temporal connectives, *to* and *ya ina ya*, uniformly select for Present-tense complements but require a temporal relation of subsequence. Kusumoto does not return to these connectives in her own analysis. Nor do we discuss them in this paper.

We emphasize again that the shortcomings of the proposals discussed above with regard to the data at hand must be weighed against their broad coverage. Given this perspective, our criticism must not be taken as a wholesale rejection. We merely note that neither fully accounts for the facts. We now proceed to present our own analysis.

4 Analysis

This section presents our formal analysis of the data presented above. In order to ensure that the main ideas do not get lost in the technicalities, we first introduce them in informal terms.

4.1 Informal preview

The interpretation of the tenses under our account is essentially relational. This means that tensed clauses do not denote properties of times (represented formally as sets of intervals) but relations between times (sets of sequences of intervals). This approach has several advantages. First, it provides for a straightforward formal distinction between the denotations of Nonpast and Past temporal clauses, which is needed to account for the incompatibility of *ato* with the former and *mae* with the latter. As we mentioned above in Sect. 3.3, this was already Ogihara's argument for choosing a relational analysis. Secondly, the relational account allows us to distinguish formally between different aspectual classes, needed to account for the fact that *mae* and *ato* occur only with non-statives while *uti* occurs only with statives. Thirdly, the relational account gives us a handle on the difference between matrix and embedded contexts, which as we saw corresponds to differences in the temporal interpretion of statives.

The view we take here is basically Reichenbachian, but we do not distinguish formally between reference time and event time. Rather, tensed clauses are interpreted relative to sequences consisting of the speech time followed by one or more reference times, growing with the depth of embedding, the last one of which is the analog of Reichenbach's event time. Thus in matrix contexts we are just dealing with speech and reference time, the latter doubling as event time. Embedded contexts involve one or more intervening reference times. Temporal connectives add new references times, as do aspectual operators such as Perfect and Progressive. The latter are beyond the scope of this paper, however.[23]

[23] The decision not to represent event times as a separate entity is a design choice which is not forced upon us by the data. The alternative would be an option, which however would not necessarily yield a leaner formal account. The general challenge that either account must face is the fact that the relations imposed by tense and aspect hold between reference and event time in embedded contexts and between speech and reference time in matrix contexts.

Table 4 Interpretation of tensed clauses in matrix and embedded contexts illustrated

			Matrix	Embedded				
				mae	*ato*	*uti*	$toki_{rel}$	$toki_{abs}$
		ita	$s > r$	*	*	*	*	$s > r'$
		be-P						
		kita	$s > r$	*	$r > r'$	*	$r > r'$	$s > r'$
Tarô-ga	Nihon-ni	*come*-P						
Taro-NOM	*Japan*-LOC	iru	$s \leq r$	*	*	$r \subseteq r'$	$r \subseteq r'$	$s \leq r'$
		be-NP						
		kuru	$s < r$	$r < r'$	*	*	$r < r'$	$s < r'$
		come-NP						

Table 4 gives a concrete linguistic example along with the relevant generalizations in a simplified version of our formalism. The letters s, r, and r' are meant to stand for the speech time, the reference time of the matrix clause, and the reference time of the embedded clause, respectively. The relevant facts were already summarized in Table 2 for matrix contexts and in Table 3 for embedded contexts. Each cell in Table 4 displays either an asterisk (in case the corresponding combination of expressions is ill formed, as for instance in the case of *Tarô-ga Nihon-ni ita mae*), or a constraint on the relation between two of the times in question which is imposed by the corresponding combination of aspectual class, tense, and, where applicable, embedding temporal connective. Thus for instance, *Tarô-ga Nihon-ni kita ato* and *Tarô-ga Nihon-ni kita toki* both require that the matrix-clause eventuality be located after Taro's coming to Japan, which is expressed by the condition that $r > r'$. The non-starred entries for embedded contexts correspond to the paraphrases in Table 3 above: $r < r'$ corresponds to 'before', $r > r'$ to 'after', and $r \subseteq r'$ to 'while'. Table 3 glossed $toki_{abs}$ as 'when', alluding to the loose relation between r and r'. The entries in Table 4, in contrast, are meant to capture the dependence of the well-formedness of $toki_{abs}$ on the reference of the temporal clause relative to the speech time.

The goal of the analysis is to assign denotations to the various expressions in such a way that the patterns in Table 4 are derived.

Consider first embedded contexts. As mentioned above, we may think of r as the reference time inherited from the matrix clause and r' as the local reference time of the embedded clause. Tense, aspect, and temporal connectives all contribute constraints on the relation between r and r'. Collectively, these constraints will stand in one of three logical relations: (i) *contradictory* constraints result in ill-formedness of the sentence; (ii) *identical constraints* amount to a test for consistency; (iii) non-identical but jointly *consistent* constraints are effectively conjoined, resulting in a unification of sorts.

Three of the temporal connectives impose constraints on the relation between r and r': precedence with *mae*, subsequence with *ato*, and inclusion with *uti*. $Toki_{rel}$ does not impose any condition of its own. We can state these contributions as in (41). (The relation symbols have their usual interpretation; the formal definitions are in Sect. 4 below.)

(41) *mae* *ato* *uti* $toki_{rel}$
$r < r'$ $r > r'$ $r \subseteq r'$ $\cdots$

Further constraints are imposed by the temporal clauses themselves. First, the aspectual class plays an important role: statives occur only under *uti* and *toki* whereas non-statives occur only under *mae*, *ato*, and *toki*. In our analysis, these restrictions result from the interaction of aspectual information (contributed by a covert operator in our system) with the constraints from the temporal connective. The relevant aspectual information is quite simple: r must contain r' for statives,[24] and the two must be disjoint for non-statives. Formally, this is spelled out in (42). (The symbol '$\varnothing$' means that the two temporal intervals in question are disjoint.)

(42) [+stat] [−stat]
$r \subseteq r'$ $r \varnothing r'$

A number of restrictions on co-occurrence and interpretive possibilities follow from (41) and (42). For instance, *mae* cannot combine with stative complements because the conditions that $r < r'$ and that $r \subseteq r'$ cannot be met simultaneously. On the other hand, *mae* does combine with non-statives because the conditions that $r < r'$ and that $r \varnothing r'$ are compatible. Furthermore, when *uti* combines with a stative complement, both add the condition that $r \subseteq r'$.

The aspectual information restricts the relation between r and r' but determines it only for statives. With non-statives, aspect alone does not specify in what order the two disjoint intervals must stand. This information is supplied by the tenses, as shown in (43).

(43) [+past] [−past]
$r > r'$ $r \leq r'$

The result is that Past statives cannot occur in embedded contexts because the Past is inconsistent with the inclusion relation. With non-statives, one of two things happens: *Mae* and *ato* each have a fully specified temporal meaning and thus ''select'' Nonpast and Past, respectively. With *toki*, the tenses add to the underspecified information supplied by aspect and the connective a further constraint on the relative location of the two disjoint intervals.[25]

Turning to matrix clauses, instead of r and r', we are dealing with s and r, the speech time and reference time of the matrix clause. It turns out that with one exception, the constraints discussed so far for embedded contexts yield the right predictions in matrix clauses as well. The one exception is the condition imposed by stative aspect in embedded contexts that r be included in r'. Clearly the analog of this condition, that s be included in r, cannot be operative in matrix contexts, where Past statives are well formed and Nonpast statives may refer to the future. In order

[24] In embedded contexts, that is. In matrix contexts, the constraint is a bit weaker, as we discussed above.

[25] We see now that Kusumoto's (1999) dismissal of this outcome as ''unrealistic'' (see Sect. 3.3 above) was overly pessimistic. The facts follow naturally from the assumption that $toki_{rel}$ is underspecified.

to restrict the condition to embedded contexts, however, the difference between matrix and embedded contexts must somehow be represented formally. How exactly this is done will become clear in Sect. 4.3 below. For now, suffice it to say that the stative aspectual operator is sensitive to the level of embedding and imposes the inclusion relation only when it does not find itself in a matrix clause.

The absolute reading of embedded tenses with $toki_{abs}$ comes about through a special interpretation of r' relative to the speech time, rather than r. In order for this to work in a compositional framework, the speech time must be accessible in both matrix and embedded contexts in a uniform way. The mechanism by which this is achieved in the formal system is the same as the one that distinguishes between matrix and embedded environments in the interpretation of statives. Again, we postpone the discussion of the details until the formal definitions are in place.

Table 5 Interpretation of tensed clauses in matrix and embedded contexts formalized

[±past]		[±stat]		Matrix	Embedded				
					mae	*ato*	*uti*	$toki_{rel}$	$toki_{abs}$
				$s \cdot r$	$r < r'$	$r > r'$	$r \subseteq r'$	$r \cdot r'$	$s \cdot r'$
[+]	$\cdot > \cdot$	[+]	$r \subseteq r'$	$s > r$	*	*	*	*	$s > r'$
		[−]	$\cdot\varnothing\cdot$	$s > r$	*	$r > r'$	*	$r > r'$	$s > r'$
[−]	$\cdot \leq \cdot$	[+]	$r \subseteq r'$	$s \leq r$	*	*	$r \subseteq r'$	$r \subseteq r'$	$s \leq r'$
		[−]	$\cdot\varnothing\cdot$	$s < r$	$r < r'$	*	*	$r < r'$	$s < r'$

Table 5 summarizes the main points of the discussion in this section. As before, the contributions of tense, aspect, and temporal connective (where applicable) are given separately. The table is meant to be read as follows: the inequalities along the top row (e.g., '$r < r'$') indicate on which two times the constraints in question are imposed, namely speech time and reference time in matrix clauses, the two most local reference times in embedded clauses, and speech time and the most local reference time with $toki_{abs}$. A dot in these expressions is a generic placeholder indicating that no constraint is imposed by the particular expression in question (e.g., $toki_{rel}$). The entries in the two columns on the left contain relation symbols with two dots, (e.g., '$\cdot > \cdot$'), representing the semantic contributions of the respective elements. These contributions ultimately are relations which are asserted to hold between s and r, r and r', or s and r', as the case may be. The deviating expression '$r \subseteq r'$' for '[+stat]' is owed to the fact that this inclusion relation is not imposed on s and r in matrix clauses but only in embedded contexts. This way of encoding it may seem stipulative, but it reflects the fact that the inclusion relation is imposed only on reference and event time (or multiple reference times), not on speech and reference time.

The semantic contributions of aspect, tense, level of embedding, and (where applicable) temporal connective are conjoined to yield the interpretation in particular cases. The results are shown in the cells in the center of the table. Stars indicate contradictoriness, hence semantic ill-formedness.

4.2 Model theory

As a first step towards a precise implementation of the ideas laid out above, we fix the definitions of the model-theoretic apparatus. We adopt the notion of a *convex period structure* from van Benthem (1983, see also Landman 1991).

Definition 1 (*Convex period structure*) Let $\langle T, \prec \rangle$ be a non-empty set of temporal instants ordered by the transitive, irreflexive, and connected relation $\prec$. The *convex period structure* induced by $\langle T, \prec \rangle$ is a triple $\langle I, \subseteq, < \rangle$, where I is the set of non-empty convex subsets of T, $\subseteq$ is set-theoretic inclusion, and $<$ is the relation of strict precedence on $I \times I$.[26]

A few more notational conventions will be useful later. Definition 2 provides shorthand notations for relations defined in terms of the *earlier-than* relation $<$: the *later-than* relation $>$; the relation $\leq$ of *beginning no later than*; and the relation $\varnothing$ of being *disjoint*.

Definition 2 (*Relations between intervals*) Given a convex period structure $\langle I, \subseteq, < \rangle$, the relations $>, \leq, \varnothing$ on I are defined as follows: For all $i, j, k \in I$,

$$\begin{array}{lcl} i > j & \Leftrightarrow & j < i \\ i \leq j & \Leftrightarrow & \forall k[k < i \rightarrow k < j] \\ i \varnothing j & \Leftrightarrow & i < j \vee j < i \end{array}$$

As discussed earlier, there is a fundamental distinction in temporal interpretation between (basic and derived) statives, on the one hand, and non-statives, on the other. In the formal setup, this aspectual difference corresponds to a difference in denotation at the radical level: stative radicals denote *temporal properties* (i.e., sets of intervals) whereas non-stative ones denote *event properties* (sets of events). Similar distinctions, albeit with differences in detail, have been made in analyses of English and other languages that are sensitive to the stative/non-stative difference (Katz 1995, 2000; see Jackson 2005 for an overview of this and related proposals). Some researchers have invested much work towards the goal of deriving the differences in aspectual behavior from deeper truths about the underlying ontological properties of the eventualities in question. Such motivation would go beyond the scope of this paper; however, we do give temporal intervals and events distinct representations in the model.

Definition 3 (*Event structure*) An *event structure* is a join-semilattice $\langle E, \sqsubseteq \rangle$, where E is a non-empty set of events, and $\sqsubseteq$ is a partial order interpreted as the mereological ''sub-event'' relation.[27]

[26] Transitivity: for all t, t', t'', if $t \prec t'$ and $t' \prec t''$, then $t \prec t''$. Irreflexivity: for all t, $t \not\prec t$. Connectedness: for all t, t', either $t \prec t'$ or $t' \prec t$ or $t = t'$. Transitivity and irreflexivity jointly imply asymmetry: for all t, t', if $t \prec t'$, then $t' \not\prec t$. A set $i \subseteq T$ is convex in $\langle T, \prec \rangle$ iff for all $t, t' \in i$ and $t'' \in T$, if $t \prec t'' \prec t'$, then $t'' \in i$. Strict precedence: $i < i'$ iff for all t in i and t' in i', $t \prec t'$.

[27] The relation $\sqsubseteq$ is a partial order iff it is transitive, reflexive, and antisymmetric. Transitivity: see Fn. 26. Reflexivity: for all $e, e \sqsubseteq e$. Antisymmetry: for all e, e', if $e \sqsubseteq e'$ and $e' \sqsubseteq e$, then $e = e'$. For all $E' \subseteq E$, f $\in E$, f is an *upper bound* on E' iff $e \sqsubseteq f$ for all $e \in E'$; f is a *least upper bound* on E' iff $f \sqsubseteq f'$ for all upper bounds f' on E'. $\langle E, \sqsubseteq \rangle$ is a join-semilattice iff all finite non-empty $E' \subseteq E$ have a least upper bound in E.

The two structures are related by a mapping from events to their runtimes or temporal traces.

Definition 4 (*Temporal event structure*) A *temporal event structure* is a sextuple $\langle I, \subseteq, <, E, \sqsubseteq, \tau \rangle$, where $\langle I, \subseteq, < \rangle$ is a convex period structure, $\langle E, \sqsubseteq \rangle$ is an event structure, and $\tau : E \mapsto I$ maps events to *temporal traces*, subject to the condition that for all $e, e' \in E$, if $e \sqsubseteq e'$, then $\tau(e) \subseteq \tau(e')$.

Our interpretation of the Japanese expressions does not proceed directly in terms of the model but by mapping them to expressions of a first-order language. For simplicity, we do not define its syntax explicitly; it will become clear as we go along. The language is assumed to have predicates for the crucial ingredients of the model (relations between intervals, the temporal trace function, etc.); for these we reuse the same symbols as in the definitions above as there is no danger of confusion. In addition, the language has a symbol R' for each Japanese sentence radical R.

The model includes an interpretation function for the non-logical constants which interprets the symbols for set-theoretic properties and relations as expected and which maps the translations of sentence radicals to properties of the appropriate sort.

Definition 5 (*Temporal model*) A *temporal model* is a septuple $\langle I, \subseteq, <, E, \sqsubseteq, \tau, V \rangle$, where $\langle I, \subseteq, <, E, \sqsubseteq, \tau \rangle$ is a temporal event structure and V is an interpretation function for non-logical constants such that for non-stative and stative sentence radicals R, V maps R' to characteristic functions of subsets of E and I, respectively.

Given a model as defined above and the mapping $\cdot'$ from sentence radicals to the corresponding predicates of the formal language, we define an interpretation function $[\![\cdot]\!]$ which extends the translation to entire Japanese sentences. An important role in the logical representation of Japanese sentences will be played by *interval sequences* (as distinct from single intervals). As we will see below, these sequences carry information about the local depth of embedding, required for the interpretation of stative sentences in both tenses, and they make the speech time accessible in the interpretation of *toki*$_{abs}$-phrases. Formally, an interval sequence is a (possibly empty) finite list $\langle i_1, \ldots i_n \rangle$, where $i_k \in I$ for $1 \leq k \leq n$.

Definition 6 (*Types*) The set of basic types is $\{t, ə, \imath\}$. A function D maps types to their domains: $D_t = \{0, 1\}$ (truth values); $D_{ə} = E$ (events); $D_\imath = I$ (intervals). Furthermore, let σ be a type with $D_\sigma = \bigcup_{0 \leq n} I^n$ (finite sequences of intervals). If α, β are types, then $\langle \alpha, \beta \rangle$ is the type of partial functions with domain D_α and range D_β. Nothing else is a type.

The inclusion of partial functions in Definition 6 is needed below because some denotations of type $\langle \sigma, t \rangle$ require that their argument have at least some non-zero number of elements and are undefined if their argument is too short. More on this below.

For readability, in the definitions below we use the variable 'ρ' to range over $D_{\langle ə, t \rangle}$ and 'φ' for $D_{\langle \sigma, t \rangle}$. Thus ρ is restricted to the denotations of non-stative

sentence radicals whereas φ covers the denotations of both basic and derived statives.

Our formal language has variables ranging over events, intervals, and interval sequences. As a notational convention, we use the variables $e, e', \ldots$ and $i, i', j, \ldots$ to range over events and intervals, respectively. The variables $\ell, \ell', \ldots$ are used to range over interval sequences. The empty interval sequence is denoted by the constant 'ε'. A feature of the logical language that requires special mention is the use of *complex variables*, built out of interval and sequence variables by concatenation and interpreted in effect much like regular expressions. Definition 7 fixes their syntax and semantics.

Definition 7 (*Variables over interval sequences*) Let $VAR_\iota = \{i, i', j, \ldots\}$ and $VAR^0_\sigma = \{\ell, \ell', \ldots\}$ be disjoint sets of variables ranging over intervals in D_ι and sequences in D_σ, respectively. VAR_σ is the smallest set containing VAR_ι and VAR^0_σ, and closed under concatenation. For all $\mathbf{u}, \mathbf{v} \in VAR_\sigma$, if $\mathbf{u}$ ranges over D_α and $\mathbf{v}$ ranges over D_β, then $\mathbf{uv}$ ranges over $D_\alpha \times D_\beta$.

Thus for instance, 'ℓij' ranges over all sequences containing two or more intervals, i.e., beginning with some possibly empty sequence ℓ and ending in two intervals ij. The variable '$i\ell j$' ranges over the same set of sequences. The difference lies in how parts of the sequence assigned to the complex variable can be referred to in logical expressions in which the variable occurs. For example, $\lambda \ell ij[i = j]$ is not equivalent to $\lambda i \ell j[i = j]$. While both are characteristic functions of sets of sequences with two or more members, the former requires that the last two elements be identical whereas the latter imposes that requirement on the first and last member. Only for sequences with two members do the two coincide.

Where needed to avoid confusion, the complex variables are enclosed in angle brackets (e.g., '$\langle \ell ij \rangle$') in the formulas below. Generally, the intention is that the first member of the sequence is the speech time, and its last member is the local reference time, with zero or more reference times in between.

4.3 Denotations

We are finally ready to spell out the function $[\![\cdot]\!]$ mapping Japanese expressions to expressions of the logical language. The semantic theory is presented here without a theory of syntax. The main purpose of this is to keep things simple and to avoid a commitment to any particular syntactic framework. However, we do make some implicit syntactic assumptions which would have to be spelled out in order to avoid overgeneration. For instance, the semantic account does not impose restrictions on the order in which the various elements combine. Although negation always scopes under tense, this constraint is not imposed by the semantic types. For the purposes of this paper, we assume that facts of this sort are accounted for in the syntax.

Table 6 Denotations of basic expressions

Radicals	$[\![\mathrm{R}]\!] = \begin{cases} \mathrm{R}' & \text{if R is non-stative} \\ \lambda\langle\ell j\rangle[\mathrm{R}'(j)] & \text{if R is stative} \end{cases}$
Negation	$[\![\mathrm{na}]\!] = \lambda\rho\lambda\langle\ell j\rangle\neg\exists e[\rho(e) \wedge \tau(e) \subseteq j] \cup \lambda\varphi\lambda\langle\ell j\rangle[\neg\varphi(\ell j)]$
Aspect	$[\![\textsc{asp}]\!] = \lambda\rho\lambda\langle\ell ij\rangle[i \varnothing j \wedge \exists e[\rho(e) \wedge \tau(e) \subseteq j]] \cup \lambda\varphi\lambda\langle\ell ij\rangle[(\ell \neq \varepsilon \rightarrow i \subseteq j)] \wedge \varphi(ij)]$
Tenses	$[\![\mathrm{ru}]\!] = \lambda\varphi\lambda\langle\ell ij\rangle[i \leq j \wedge \varphi(\ell ij)]$
	$[\![\mathrm{ta}]\!] = \lambda\varphi\lambda\langle\ell ij\rangle[j < i \wedge \varphi(\ell ij)]$
Connectives	$[\![\mathrm{mae}]\!] = \lambda\varphi\lambda\langle\ell i\rangle\exists j[i<j \wedge \varphi(\ell ij)]$
	$[\![\mathrm{ato}]\!] = \lambda\varphi\lambda\langle\ell i\rangle\exists j[j < i \wedge \varphi(\ell ij)]$
	$[\![\mathrm{uti}]\!] = \lambda\varphi\lambda\langle\ell i\rangle\exists j[i \subseteq j \wedge \varphi(\ell ij)]$
	$[\![\mathrm{toki}_{\mathrm{rel}}]\!] = \lambda\varphi\lambda\langle\ell i\rangle\exists j[\varphi(\ell ij)]$
	$[\![\mathrm{toki}_{\mathrm{abs}}]\!] = \lambda\varphi\lambda\langle a\ell j\rangle[\varphi(aj)]$
Postposition	$[\![\mathrm{ni}]\!] = \lambda\varphi\lambda\psi\lambda\ell[\varphi(\ell) \wedge \psi(\ell)]$

The denotations of basic expressions are listed in Table 6. Some comments may help in reading the formulas. The right-hand side in the top entry reflects the sortal distinction between non-stative and stative sentence radicals. As stated above, we use the variables ρ and φ to range over properties of events and of interval sequences, respectively. In the subsequent rows in the table, expressions of the form '$\lambda\rho\lambda\langle\ldots\rangle[\ldots]$' or '$\lambda\varphi\lambda\langle\ldots\rangle[\ldots]$' refer to functions mapping such properties to properties of interval sequences, which then in turn may become the arguments of further function applications.

Negation and the aspectual operator ASP combine with sentence radicals directly, hence their denotations need to be able to combine with objects of both sorts. In the table, their denotations are specified for both sorts of arguments.[28] Notice that their values are invariably properties of interval sequences. Thus negation, in addition to its usual semantic role, acts as an aspectual operator mapping sentence radicals of both aspectual classes to derived statives. (In general, of course, negation takes not only radicals but also derived statives as its complement.) A similar role is played by ASP, which we assume always applies directly before tense. Its role is to mediate between the uniform interpretation of the tenses on the one hand and the particular manifestations of that interpretation as a function of aspectual class and level of embedding on the other. Formally, it adds constraints on the last two intervals in its argument sequence, i and j in the definitions. For non-stative sentence radicals, the constraint is that i and j be disjoint, thus ruling out co-temporal interpretations of Nonpast tense in both matrix and embedded clauses. For basic and derived statives, no constraints are added if the argument sequence consists only of ij (i.e., in matrix contexts), whereas if the sequence ℓ preceding ij is not empty (i.e., in embedded

[28] Since functions are sets of pairs, and the two sub-domains are disjoint, the denotation in each case is the union of the two sub-functions, hence the symbol '$\cup$' in the definitions.

contexts) *i* must be included in *j*. Notice that this latter condition also precludes the Past from occurring with statives in embedded contexts. The one exception, the absolute reading under $toki_{abs}$, is allowed by evaluating the Past tense relative to a sequence consisting of only two intervals.

This treatment of the role of aspect in the interpretation of the tenses is admittedly stipulative as there is no technical reason for not encoding the above constraints directly in the interpretation of the tenses themselves. However, there is at least a conceptual advantage to doing it this way since the tenses themselves now receive a simple and uniform interpretation as denoting exactly what they should intuitively denote: nonpast and past. The tenses are not sensitive to the sortal distinction between statives and non-statives because they never combine with sentence radicals directly.

The definitions for the temporal connectives encode the conditions discussed in the earlier sections. *Mae*, *ato*, and *uti* impose their own constraints on the location of the local reference time relative to that of the embedding context, leading to contradictory truth conditions whenever they are combined with anything other than Nonpast non-statives, Past non-statives, and Nonpast statives, respectively. Illustrations of such clashes are given in the next subsection. In contrast, $toki_{rel}$ does not add any constraints and is therefore both combinatorially promiscuous and semantically versatile. On the other hand, $toki_{abs}$ does not introduce a new interval variable and evaluates its complement relative to a pair of intervals holding only the speech time and the most local reference time. Consequently, the temporal clause receives the same interpretation as it does in matrix contexts, thus allowing Past statives as well as future reference with Nonpast statives.

The postposition *-ni* merely conjoins two constraints on interval sequences, corresponding to the denotations of the temporal NP and the matrix clause, respectively. As we mentioned above, we do not assume that the matrix tense scopes over the temporal clause.

Some further remarks are in order regarding these definitions. First, the interpretations of all connectives except $toki_{abs}$ add a new ''local'' reference interval *j*, with *mae*, *ato*, and *uti* imposing constraints on the temporal location of *j* relative to *i*. In our definitions, *j* is bound by an existential quantifier. For at least some of the connectives, this is a simplistic treatment. Although all of the connectives imply the existence of an eventuality with the relevant properties, they differ among each other in respects which our definitions do not capture. Nor, however, do we aim to capture this variation in this paper as it cannot be dealt with adequately without extensive discussion of the modal dimension. For instance, similarly to English *before* and *after*, *mae* can be used non-veridically whereas *ato* cannot. In general, we believe with Beaver and Condoravdi (2003, henceforth BC) that the non-veridical use can be accounted for by allowing eventualities at possible worlds other than the world of evaluation to satisfy the existence claim inherent in the temporal PP. But we do not deal with modality in this paper, and our formal model does not include multiple possible worlds. Likewise, BC argue that for the truth of English *before*- and *after*-sentences it is not sufficient that there be *some* eventuality with the right properties in the right temporal location; rather, the truth of the sentence is determined relative to the *earliest* such eventuality. In BC's implementation, *earliest* implies existence but not vice versa. If BC's analysis

is also applicable in Japanese—an open question which future work will have to settle—our definitions in terms of mere existence are too weak. Finally, and related to the previous points, there is some evidence that Japanese *mae* and *ato*, again similarly to their English counterparts, differ in that the former licenses negative polarity items (NPIs) while the latter does not (Ogihara 1995 has some discussion). But things are not so clear-cut even in the English case. NPIs do occur in *after*-sentences, and Condoravdi (2009) argues that they are licensed there in much the same way as in *before*-sentences. Although an account of NPI licensing in Japanese temporal clauses at a comparable level of detail is desirable, no such account is available at this point, and providing one would go beyond the scope of this paper.

While the above questions remain open, we merely note that we expect that our analysis in terms of existential quantification can be extended to incorporate an adequate account of non-veridicality and NPI licensing, for instance by replacing our existential quantification with the *earliest* operator of BC and Condoravdi, along with appropriate adjustments to account for the modal dimension.

The joint effect of the above definitions will become clear only by working through some concrete examples. The next subsection discusses several sample derivations in detail.

5 Sample derivations

The development of the formal analysis is now complete; in this section we illustrate its workings by stepping through a number of examples.

5.1 Tensed clauses

Before turning to the interpretation of complex structures involving embedded clauses, we show how simple clauses are interpreted. The derivation is the same inside and outside of embedding contexts although, as we mentioned above, the resulting truth conditions of Nonpast statives depend on to the level of embedding. For a first simple example, consider the non-stative clauses in (44).

(44) Kare-ga {kuru / kita}
he-NOM *come*-NP *come*-P
'He {is coming / came}.'

We abbreviate the sentence radical as ''kgk'' (for *kare-ga ku-*). Regardless of the tense, the radical combines first with the aspectual operator ASP. In the above definitions, the entry for ASP had two lines corresponding to the two sorts of arguments it can take, one for non-statives and one for statives. In these examples we write only the one that is relevant.

(45) $[\![\,[\mathrm{kgk}]_{\mathrm{ASP}}]\!] = [\![\mathrm{ASP}]\!]\big([\![\mathrm{kgk}]\!]\big)$
$= \lambda\rho\lambda\langle \ell ij\rangle[i\varnothing j \wedge \exists e[\rho(e) \wedge \tau(e) \subseteq j]]\big(\mathrm{kgk}'\big)$
$= \lambda\langle \ell ij\rangle[\underline{i\varnothing j} \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq j]]$

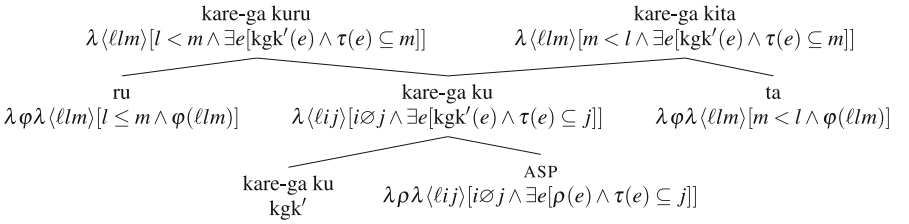

Fig. 1 Tensed non-stative clauses, Example (44)

Thus ASP imposes on the final intervals i, j in the input sequence the condition that they not overlap. The corresponding expression in the formula is underlined. Nonpast tense further specifies that j must not precede i while Past requires that j precede i. In (46a, b), these constraints are underlined on the penultimate line and the expression can be simplified to the doubly underlined one.

(46) a. $[\![[\mathrm{kgk}]_{\mathrm{ASP}}\mathrm{ru}]\!] = [\![\mathrm{ru}]\!]\big([\![[\mathrm{kgk}]_{\mathrm{ASP}}]\!]\big)$
$= \lambda\varphi\lambda\langle\ell lm\rangle[l \leq m \wedge \varphi(\ell lm)]\big(\lambda\langle\ell' ij\rangle[i \varnothing j \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq j]]\big)$
$= \lambda\langle\ell lm\rangle[\underline{l \leq m} \wedge [\underline{l \varnothing m} \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq m]]]$
$= \lambda\langle\ell lm\rangle[\underline{\underline{l < m}} \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq m]]$

b. $[\![[\mathrm{kgk}]_{\mathrm{ASP}}\mathrm{ta}]\!] = [\![\mathrm{ta}]\!]\big([\![[\mathrm{kgk}]_{\mathrm{ASP}}]\!]\big)$
$= \lambda\varphi\lambda\langle\ell lm\rangle[m < l \wedge \varphi(\ell lm)]\big(\lambda\langle\ell' ij\rangle[i \varnothing j \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq j]]\big)$
$= \lambda\langle\ell lm\rangle[\underline{m < l} \wedge [\underline{l \varnothing m} \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq m]]]$
$= \lambda\langle\ell lm\rangle[\underline{\underline{m < l}} \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq m]]$

These derivations are summarized in Fig. 1. When the sentences are used in a matrix context, their denotations are applied to pairs $\langle sr\rangle$ of intervals corresponding to speech and reference time, respectively. The result is given in (47a, b).

(47) a. $[\![\text{kare-ga kuru}]\!](sr) \Longleftrightarrow s < r \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq r]$
b. $[\![\text{kare-ga kita}]\!](sr) \Longleftrightarrow r < s \wedge \exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq r]$

In words, the sentences are true if and only if the speech time strictly precedes (47a) or follows (47b) the reference time and the reference time contains the temporal trace of an occurrence of ''his'' coming.

The outcome is somewhat different with stative clauses such as the ones in (48).

(48) Kare-ga {iru /ita}
he-NOM *be*-NP *be*-P
'He {is / was} [here].'

For statives, the definition of the aspectual operator ASP has two sub-clauses, one for sequences of exactly two intervals and one for longer sequences. As before, the sentence radical first combines with ASP:

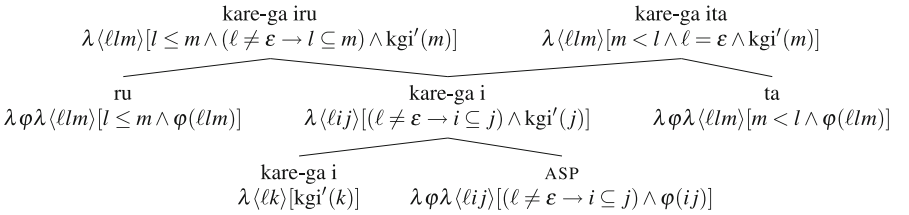

Fig. 2 Tensed stative clauses, Example (48)

(49) $$\begin{aligned}[\![[\text{kgi}]_{\text{ASP}}]\!] &= [\![\text{ASP}]\!]\big([\![\text{kgi}]\!]\big)\\ &= \lambda\varphi\lambda\langle\ell ij\rangle[(\ell \neq \varepsilon \rightarrow i \subseteq j) \wedge \varphi(ij)]\big(\lambda\langle\ell' k\rangle[\text{kgi}'(k)]\big)\\ &= \lambda\langle\ell ij\rangle[\underline{(\ell \neq \varepsilon \rightarrow i \subseteq j)} \wedge \text{kgi}'(j)]\end{aligned}$$

The resulting denotation does not impose any constraints on sequences of exactly two intervals (i.e., where ℓ is empty). For longer sequences, the penultimate member must be contained in the last one. This latter requirement interacts with the contributions of the tenses: Nonpast is effectively strengthened from non-subsequence to inclusion while Past is incompatible with the inclusion requirement. As a result, Past statives are defined only for sequences of exactly two intervals, meaning they can be used only in matrix contexts (or with *toki*$_{abs}$; see below). This is reflected in the last lines of (50a) and (50b), respectively.[29]

(50) a. $$\begin{aligned}[\![[[\text{kgi}]_{\text{ASP}}\text{ru}]\!] &= [\![\text{ru}]\!]\big([\![[\text{kgi}]_{\text{ASP}}]\!]\big)\\ &= \lambda\varphi\lambda\langle\ell lm\rangle[l \leq m \wedge \varphi(\ell lm)]\big(\lambda\langle\ell' ij\rangle[(\ell' \neq \varepsilon \rightarrow i \subseteq j) \wedge \text{kgi}'(j)]\big)\\ &= \lambda\langle\ell lm\rangle[\underline{\underline{l \leq m \wedge (\ell \neq \varepsilon \rightarrow l \subseteq m)}} \wedge \text{kgi}'(m)]\end{aligned}$$

b. $$\begin{aligned}[\![[[\text{kgi}]_{\text{ASP}}\text{ta}]\!] &= [\![\text{ta}]\!]\big([\![[\text{kgi}]_{\text{ASP}}]\!]\big)\\ &= \lambda\varphi\lambda\langle\ell lm\rangle[m < l \wedge \varphi(\ell lm)]\ \big(\lambda\langle\ell' ij\rangle[(\ell' \neq \varepsilon \rightarrow i \subseteq j) \wedge \text{kgi}'(j)]\big)\\ &= \lambda\langle\ell lm\rangle[\underline{m < l} \wedge \underline{(\ell \neq \varepsilon \rightarrow l \subseteq m)} \wedge \text{kgi}'(m)]\\ &= \lambda\langle\ell lm\rangle[\underline{\underline{m < l \wedge \ell = \varepsilon}} \wedge \text{kgi}'(m)]\end{aligned}$$

The derivations are summarized in Fig. 2. When used in a matrix context, the truth conditions relative to speech and reference time $\langle sr\rangle$ are as in (51).

(51) a. $\lambda\langle\ell lm\rangle[l \leq m \wedge (\ell \neq \varepsilon \rightarrow l \subseteq m) \wedge \text{kgi}'(m)](sr) \Longleftrightarrow s \leq r \wedge \text{kgi}'(r)$

b. $\lambda\langle\ell lm\rangle[m < l \wedge \ell = \varepsilon \wedge \text{kgi}'(m)](sr) \Longleftrightarrow r < s \wedge \text{kgi}'(r)$

Comparing these truth conditions to the ones for non-statives in (47) above, we see that the temporal constraints are almost the same, except for the fact that Nonpast imposes strict precedence with non-statives but allows for overlap with statives. This is what we observed in Sect. 3.1.

[29] We omit the parentheses around Boolean compounds where no ambiguity results.

5.2 Non-stative temporal clauses

Turning to embedded clauses, we first consider the simple well-formed sentence in (52) to show how the pieces come together.

(52) Kare-ga kuru mae-ni denwa-o sita
he-NOM *come*-NP *before*-LOC *call*-P
'I called him on the phone before he came.'

The derivation of the temporal clause was already given in (44–46). For the matrix clause, the details are similar. The combination with *mae* adds the condition that the last member of the input interval sequence be followed by one of which the temporal clause is true. The expressions corresponding to both constraints are underlined in (53). As they are identical, the expression can be simplified. As we discussed above in Sect. 4.1, in other combinations the corresponding constraints are not necessarily identical, and their logical relationship plays an important role in determining well-formedness. Examples of non-identical (contradictory or consistent) constraints are given in (53′) through (53‴) below.

(53) $[\![[[[\text{kgk}]_{\text{ASP}}\text{ru}]\text{mae}]\!] = [\![\text{mae}]\!]\big([\![[[[\text{kgk}]_{\text{ASP}}\text{ru}]]\!]\big)$
$= \lambda\varphi\lambda\langle\ell j\rangle\exists k[j < k \wedge \varphi(\ell jk)]\big(\lambda\langle\ell' lm\rangle[l < m \wedge \exists e[\text{kgk}'(e) \wedge \tau(e) \subseteq m]]\big)$
$= \lambda\langle\ell j\rangle\exists k[\underline{j < k} \wedge [\underline{j < k} \wedge \exists e[\text{kgk}'(e) \wedge \tau(e) \subseteq k]]]$
$= \lambda\langle\ell j\rangle\exists k[\underline{\underline{j < k}} \wedge \exists e[\text{kgk}'(e) \wedge \tau(e) \subseteq k]]$

Next, the postposition *-ni* combines with the output of (53) to form a modifier for the main clause. To facilitate the exposition later on, we do not simplify the expression resulting in (54) as far as would be possible.

(54) $[\![[[[[\text{kgk}]_{\text{ASP}}\text{ru}]\text{mae}]\text{ni}]\!] = [\![\text{ni}]\!]\big([\![[[[[\text{kgk}]_{\text{ASP}}\text{ru}]\text{mae}]]\!]\big)$
$= \lambda\varphi\lambda\psi\lambda\ell[\varphi(\ell) \wedge \psi(\ell)]\big(\lambda\langle\ell' j\rangle\exists k[j < k \wedge \exists e[\text{kgk}'(e) \wedge \tau(e) \subseteq k]]\big)$
$= \lambda\psi\lambda\ell[\lambda\langle\ell' j\rangle\exists k[j < k \wedge \exists e[\text{kgk}'(e) \wedge \tau(e) \subseteq k]](\ell) \wedge \psi(\ell)]$

In the final step, the output of (54) combines with its matrix clause. Recall that on the present account, the latter is tensed independently of the temporal clause.

(55) $[\![[[[[[\text{kgk}]_{\text{ASP}}\text{ru}]\text{mae}]\text{ni}][\text{ds}]\text{ta}]\!] = [\![[[[[\text{kgk}]_{\text{ASP}}\text{ru}]\text{mae}]\text{ni}]\!]\big([\![\text{ds}]\text{ta}]\!]\big)$
$= \lambda\psi\lambda\ell[\lambda\langle\ell' j\rangle\exists k[j < k \wedge \exists e[\text{kgk}'(e) \wedge \tau(e) \subseteq k]](\ell) \wedge \psi(\ell)]$
$\big(\lambda\langle\ell' ij\rangle[j < i \wedge \exists e[\text{ds}'(e) \wedge \tau(e) \subseteq j]]\big)$
$= \lambda\ell\begin{bmatrix}\lambda\langle\ell' j\rangle\exists k[j < k \wedge \exists e[\text{kgk}'(e) \wedge \tau(e) \subseteq k]](\ell) \wedge \\ \lambda\langle\ell' ij\rangle[j < i \wedge \exists e[\text{ds}'(e) \wedge \tau(e) \subseteq j]](\ell)\end{bmatrix}$

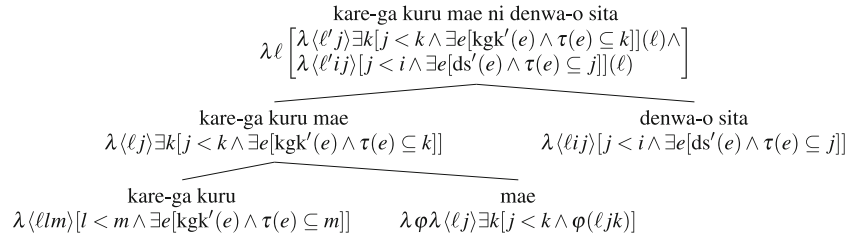

Fig. 3 Non-statives under *mae*, Example (52)

Notice that the interval sequences ℓ of which (55) is true must have at least two members, for otherwise the second conjunct would be undefined.[30] Furthermore, once ℓ is instantiated, both occurrences of j are matched with its last member, thus in effect with each other.

The entire derivation is summarized in Fig. 3. In this and the following figures, we skip the application of the postposition *-ni* in the interest of brevity. The truth conditions that result when the output is applied to a pair $\langle sr\rangle$ of intervals corresponding to speech and reference time are as follows:

(56) $[\![$kare-ga kuru mae ni denwa-o sita$]\!](sr) \Longleftrightarrow$
$\exists k[r<k\wedge\exists e[\mathrm{kgk}'(e)\wedge\tau(e)\subseteq k]]\wedge r<s\wedge\exists e[\mathrm{ds}'(e)\wedge\tau(e)\subseteq r]$

In words, the sentence is true if and only if the reference time precedes the temporal trace of an event of ''his'' arriving and the reference time precedes the speech time and contains the temporal trace of an event of the speaker's calling. No constraints on the temporal relation between ''his'' coming and the speech time are imposed. This is as it should be, for the Japanese sentence is indeed true as long as the mentioned constraints are met, regardless of whether ''his'' coming has already occurred or still lies ahead at speech time.

Unlike the above well-formed sentence, combining a Past-tensed temporal clause with *mae*, a Nonpast clause with *ato*, or a stative in either tense with either *mae* or *ato* would result in contradictory constraints, hence semantic ill-formedness. The relevant parts of the formulas are underlined in (53′ a–c).

(53′) a. *Kare-ga kuru ato
he-NOM *come*-NP *after*
$\lambda\langle\ell j\rangle\exists k[\underline{k<j}\wedge[\underline{j<k}\wedge\exists e[\mathrm{kgk}'(e)\wedge\tau(e)\subseteq k]]]$

b. *Kare-ga kita mae
he-NOM *come*-P *before*
$\lambda\langle\ell j\rangle\exists k[\underline{j<k}\wedge[\underline{k<j}\wedge\exists e[\mathrm{kgk}'(e)\wedge\tau(e)\subseteq k]]]$

[30] Thus such requirements on the length of the argument sequence are treated as presuppositions, hence the need for partial functions in the formal model. An alternative would be to write such minimum-length requirements into the lexical entries and treat them as entailments. Which approach is ultimately most appropriate is open for debate.

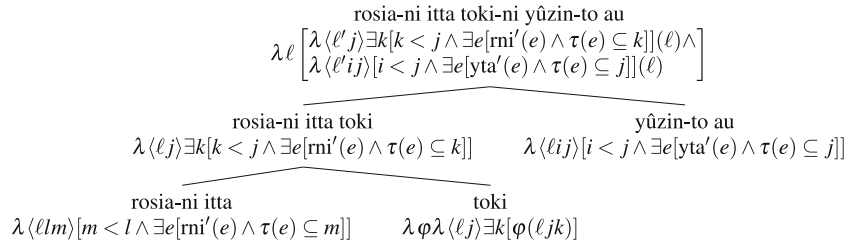

Fig. 4 Future reference with Past non-statives under *toki*, Example (57)

c. *Kare-ga kuru uti
he-NOM *come*-NP *while*
$\lambda\langle\ell j\rangle\exists k[\underline{j\subseteq k}\wedge[\underline{j<k}\wedge\exists e[\text{kgk}'(e)\wedge\tau(e)\subseteq k]]]$

On the other hand, *toki* does not contribute any constraints of its own, hence the temporal interpretation of the *toki*-phrase is fully determined by the complement clause. The outcome for non-statives is shown in (53″).

(53″) a. Kare-ga kuru toki
he-NOM *come*-NP *when*
$\lambda\langle\ell j\rangle\exists k[\underline{\underline{j<k}}\wedge\exists e[\text{kgk}'(e)\wedge\tau(e)\subseteq k]]$
b. Kare-ga kita toki
he-NOM *come*-P *when*
$\lambda\langle\ell j\rangle\exists k[\underline{\underline{k<j}}\wedge\exists e[\text{kgk}'(e)\wedge\tau(e)\subseteq k]]$

As mentioned earlier, *toki* with Past complements can result in a ''past-in-the-future'' interpretation.[31] Sentence (57) is such a case. It features a Past clause embedded under *toki* modifying a Nonpast matrix clause.

(57) Rosia-ni itta toki-ni yûzin-to au
Russia-LOC *gl*-P *when*-LOC *friend*-COM *meet*-NP
'When I've gone to Russia, I will meet a friend.'

The derivation is given in Fig. 4. According to (58), the sentence is true of a pair of intervals $\langle sr\rangle$ if and only if r is preceded by both an occurrence of the speaker's

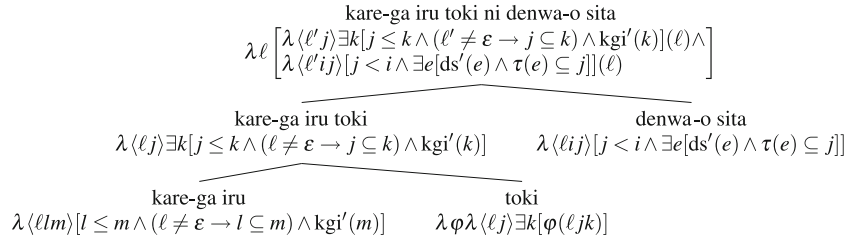

Fig. 5 Statives under *toki*, Example (59)

[31] We thank an anonymous reviewer for suggesting that we discuss this example.

going to Russia and by s and r contains an occurrence of the speaker's meeting with his or her friend.

(58) $[\![$Rosia-ni itta toki-ni yûzin-to au$]\!](sr)$
$\iff \exists k[k < r \wedge \exists e[\mathrm{rni}'(e) \wedge \tau(e) \subseteq r]] \wedge s < r \wedge \exists e[\mathrm{yta}'(e) \wedge \tau(e) \subseteq r]$

Notice that these truth conditions do not impose any particular order between the speech time and the speaker's going to Russia. Accordingly, the sentence may be true if the speaker is already in Russia. It is arguably not felicitous in that situation, but we take that to be a pragmatic fact and do not write it into the truth conditions.

5.3 Stative temporal clauses

Stative temporal clauses differ from the above examples due to the difference in the effect of ASP. Consider (59) and the derivation of its temporal PP, given in (60).

(59) Kare-ga iru toki ni denwa-o sita
he-NOM *be*-NP *when*-LOC *call*-P
'I called him on the phone when he was here/there.'

(60) $[\![[[[\mathrm{kgi}]_{\mathrm{ASP}}]\mathrm{ru}]\mathrm{toki}]\!] = [\![\mathrm{toki}]\!]\big([\![[[\mathrm{kgi}]_{\mathrm{ASP}}]\mathrm{ru}]\!]\big)$
$= \lambda\varphi\lambda\langle\ell j\rangle\exists k[\varphi(\ell jk)]\big(\lambda\langle\ell' lm\rangle[l \leq m \wedge (\ell' \neq \varepsilon \rightarrow l \subseteq m) \wedge \mathrm{kgi}'(m)]\big)$
$= \lambda\langle\ell j\rangle\exists k[j \leq k \wedge (\ell \neq \varepsilon \rightarrow j \subseteq k) \wedge \mathrm{kgi}'(k)]$

The result is still sensitive to the length of the input sequence $\langle\ell j\rangle$: if ℓ is non-empty, i.e., j is preceded by one or more intervals, then j must be contained in k. This is always the case in embedded contexts. Consider for instance the truth conditions relative to $\langle sr\rangle$ in (61). As is most obvious in the second line, the variable $\langle\ell' j\rangle$ is set to $\langle sr\rangle$, thus ℓ' contains $\langle s\rangle$ and is therefore non-empty.

(61) $[\![$kare-ga iru toki ni denwa-o sita$]\!](sr)$

$$= \lambda\ell\begin{bmatrix}\lambda\langle\ell' j\rangle\exists k[j \leq k \wedge (\ell' \neq \varepsilon \rightarrow j \subseteq k) \wedge \mathrm{kgi}'(k)](\ell)\wedge \\ \lambda\langle\ell' ij\rangle[j < i \wedge \exists e[\mathrm{ds}'(e) \wedge \tau(e) \subseteq j]](\ell)\end{bmatrix}(sr)$$

$$\iff \lambda\langle\ell' j\rangle\exists k[j \leq k \wedge (\ell' \neq \varepsilon \rightarrow j \subseteq k) \wedge \mathrm{kgi}'(k)](sr)\wedge$$
$$\lambda\langle\ell' ij\rangle[j < i \wedge \exists e[\mathrm{ds}'(e) \wedge \tau(e) \subseteq j]](sr)$$
$$\iff \exists k[r \subseteq k \wedge \mathrm{kgi}'(k)] \wedge r < s \wedge \exists e[\mathrm{ds}'(e) \wedge \tau(e) \subseteq r]$$

In words, ''his'' being in the (contextually given) location must hold throughout an interval containing the reference time, which in turn must precede the speech time and contain the temporal trace of a calling event. Notice that these truth conditions do not rule out the possibility that the state of ''his'' being in the location in question continues to hold at speech time. This is as it should be since the Japanese sentence is true in this case. Figure 5 shows the derivation of this example.

The result of applying the temporal PP to an input sequence $\langle sr\rangle$ is repeated in (53‴a). As in (53″) above, although *toki* does not constrain the temporal relation,

the interplay between ASP and Nonpast results in a tight constraint, here that the reference time of the embedded clause be contained in that of the embedding context. The same interplay between ASP and tense results in contradictory truth conditions with *mae* and *ato* in (53‴b, c).

(53‴) a. Kare-ga iru toki
he-NOM *come*-NP *when*
$\lambda\langle\ell j\rangle\exists k[j \leq k \wedge (\ell \neq \varepsilon \rightarrow j \subseteq k) \wedge \mathrm{kgi}'](sr)$
$\Longleftrightarrow \exists k[\underline{r \leq k} \wedge \underline{r \subseteq k} \wedge \mathrm{kgi}'(k)]$
$\Longleftrightarrow \exists k[\underline{\underline{r \subseteq k}} \wedge \mathrm{kgi}'(k)]$

b. *Kare-ga iru mae
he-NOM *come*-NP *before*
$\lambda\langle\ell j\rangle\exists k[j < k \wedge [j \leq k \wedge (\ell \neq \varepsilon \rightarrow j \subseteq k) \wedge \mathrm{kgi}']](sr)$
$\Longleftrightarrow \exists k[\underline{r < k} \wedge \underline{r \subseteq k} \wedge \mathrm{kgi}'(k)]$

c. *Kare-ga iru ato
he-NOM *come*-NP *after*
$\lambda\langle\ell j\rangle\exists k[k < j \wedge [j \leq k \wedge (\ell \neq \varepsilon \rightarrow j \subseteq k) \wedge \mathrm{kgi}']](sr)$
$\Longleftrightarrow \exists k[\underline{k < r} \wedge \underline{r \subseteq k} \wedge \mathrm{kgi}'(k)]$

Recall from (50b) that the denotation of Past-tense *kare-ga ita* is true of a sequence $\langle\ell lm\rangle$ only if ℓ is empyt, and from (60) and (61) that in an embedded context the input sequence consists at least of three intervals *srk*. Therefore the Past-tense analog of (53‴b, c) is already ruled out (but see the discussion of $toki_{abs}\ below$).

Unlike *toki*, which does not contribute any temporal constraints, *uti* does require that the reference time of the temporal clause include that of its embedding context. With stative temporal clauses, this is the same condition as the one contributed by

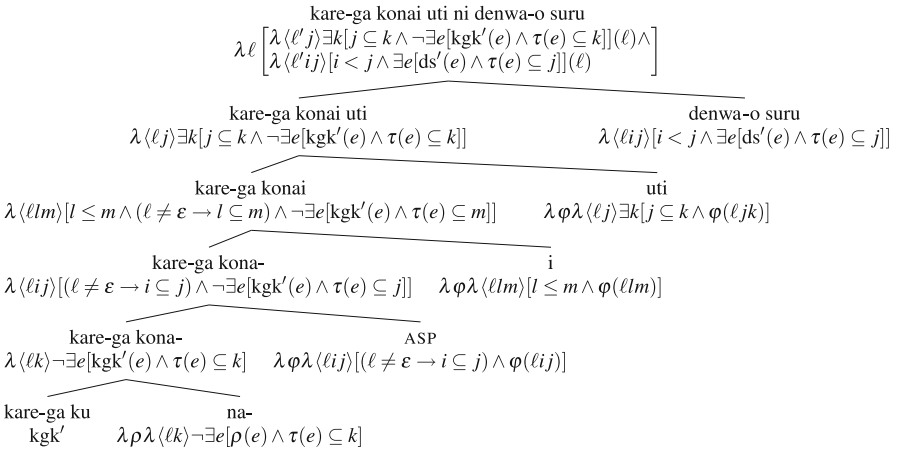

Fig. 6 Negation under *uti*, Example (62)

ASP in combination with Nonpast tense, thus *uti* is well formed with such complements. An example is (62).

(62) Kare-ga konai uti-ni denwa-o suru
he-NOM *come*-NEG-NP *while*-LOC *call*-NP
'I will call him on the phone while he was not (yet) here.'

The derivation of this example is shown in Fig. 6. (Recall that the Nonpast tense of the negative suffix *na-* is expressed by the morpheme *-i*.) Notice that the constraint $j \subseteq k$ contributed by *uti* entails the weaker conditions carried by *kare-ga konai*, hence the result is expressed in a simpler formula.

As shown in (63), the sentence is true of $\langle sr \rangle$ just in case (i) r is included in an interval k which does not also contain the temporal trace of an event of ''his'' coming; (ii) r follows s; and (iii) r contains the temporal trace of a calling event.

(63) $[\![$kare-ga konai uti (ni) denwa-o suru$]\!]$ (sr)
$\iff \exists k[r \subseteq k \wedge \neg\exists e[\mathrm{kgk}'(e) \wedge \tau(e) \subseteq k]] \wedge s < r \wedge \exists e[\mathrm{ds}'(e) \wedge \tau(e) \subseteq r]]$

To be sure, these conditions do not fully do justice to the meaning of the sentence. In particular, they do not account for the presupposition, carried by *uti*, that the state referred to by the temporal clause is expected to come to an end. It is because of this presupposition that *uti*, when combined with a negated complement, results in a phrase that closely corresponds to English *before*.[32] However, this presupposition is essentially modal rather than temporal, therefore beyond the scope of this paper (see Kaufmann and Takubo 2007, for some discussion).

5.4 Absolute *toki*

Recall that $toki_{abs}$ occurs with both statives and non-statives. The former is illustrated by (64a), the latter by (64b) and (65) (from Kudô 1995, repeated here from (19) above).

(64) a. Kare-ga ita toki-ni denwa-o sita
he-NOM *be*-PAST *time*-LOC *call*-PAST
'I called him on the phone when he was here/there.'
b. Denwa-o sita toki-ni kare-ga ita
call-PAST *time*-LOC *he*-NOM *be*-PAST
'He was here/there when I called on the phone.'

(65) Sengetu, Rosia-ni itta toki, ôhuku tomo
last month *Russia*-LOC *go*-P *when*-TOP *both* *ways*
Siberia tetudô-o tukatta

[32] The use of *uti* with negation in this sense is so prevalent that *uti* has at times been described as ambiguous between 'while' and 'before' (e.g., Nakau 1976, p. 451). This is clearly a mistake, however: The temporal clause in (62) does not mean *before he did not come*; its actual meaning *before he came* is exactly what one would expect from its semantic meaning *while he did not come* together with the presupposition that the state of his not coming is expected to end.

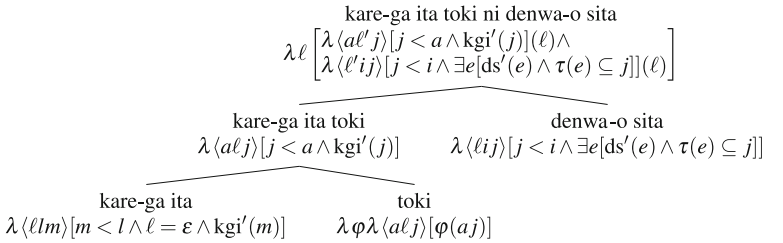

Fig. 7 Statives under absolute *toki*, Example (64a)

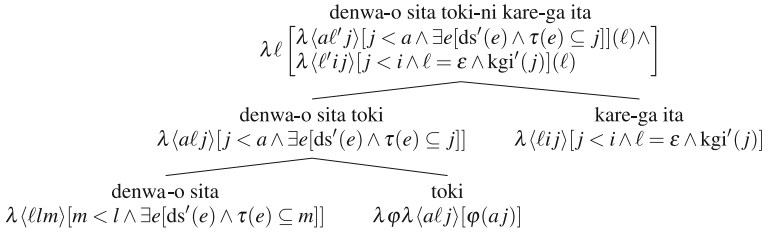

Fig. 8 Non-statives under absolute *toki*, Example (64b)

Trans-Siberian Railway-ACC *use*-P
'Last month, when I went to Russia, I took the Trans-Siberian Railway both ways.'

These examples illustrate some of the effects of the aspectual class of matrix and embedded clauses that we mentioned in Sect. 3.2: If one is stative and the other one is non-stative, then the reference time of the stative must contain the temporal trace of the eventuality referred to by the non-stative one. This is the case in both of (64a, b), thus as far as the relevant temporal relations are concerned, they are equivalent. To see how our analysis predicts this, consider the derivations in Fig. 7 and 8 and the truth conditions in (66a, b).[33]

(66) a. $[\![\text{kare-ga ita toki ni denwa-o sita}]\!](sr)$
$\iff r<s\wedge \mathrm{kgi}'(r)\wedge r<s\wedge\exists e[\mathrm{ds}'(e)\wedge\tau(e)\subseteq r]$
$\iff r<s\wedge \mathrm{kgi}'(r)\wedge\exists e[\mathrm{ds}'(e)\wedge\tau(e)\subseteq r]$

[33] The result of applying absolute *toki* to stative *kare-ga ita* can be simplified immediately by dropping the constraint carried by statives that the argument sequence have only two members (i.e., that the sequence ℓ' preceding it must be empty), hence the transition in the second line in (i), which is presupposed in Fig. 7.

(i) $\lambda\varphi\lambda\langle a\ell j\rangle[\varphi(aj)]\big(\lambda\langle\ell' lm\rangle[m<l\wedge\ell'=\varepsilon\wedge \mathrm{kgi}'(m)]\big)$
$=\lambda\langle a\ell j\rangle[\lambda\langle\ell' lm\rangle[m<l\wedge\ell'=\varepsilon\wedge \mathrm{kgi}'(m)](aj)]=\lambda\langle a\ell j\rangle[j<a\wedge \mathrm{kgi}'(j)]$

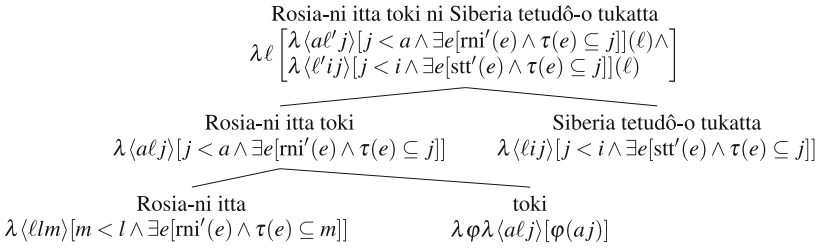

Fig. 9 Non-statives under absolute *toki*, Example (65)

b. $[\![\text{denwa-o sita toki ni kare-ga ita}]\!](sr)$
$\iff r<s\wedge\exists e[\mathrm{ds}'(e)\wedge\tau(e)\subseteq r]\wedge r<s\wedge\mathrm{kgi}'(r)$
$\iff r<s\wedge\exists e[\mathrm{ds}'(e)\wedge\tau(e)\subseteq r]\wedge\mathrm{kgi}'(r)$

If both the matrix clause and the temporal clause are non-stative, as in (65), the temporal relation between the two events is less tightly constrained. All that is required is that both events—in this case, the trip to Russia and the ride on the Trans-Siberian Railroad—be ''close'' in some sense. The derivation is given in Fig. 9, and the corresponding truth conditions are as in (67).

(67) $[\![\text{Rosia-ni itta toki ni Siberia tetudô-o tukatta}]\!](sr)$
$\iff r<s\wedge\exists e[\mathrm{rni}'(e)\wedge\tau(e)\subseteq r]\wedge r<s\wedge\exists e[\mathrm{stt}'(e)\wedge\tau(e)\subseteq r]$
$\iff r<s\wedge\exists e[\mathrm{rni}'(e)\wedge\tau(e)\subseteq r]\wedge\exists e[\mathrm{stt}'(e)\wedge\tau(e)\subseteq r]$

While the stative temporal clause in (66a,b) is asserted to hold over the entire reference time and thus to contain the temporal trace of an occurrence of the matrix event, in (67) the two events are merely required to both be located within the reference time. How strict a requirement this is depends on the reference interval, a purely pragmatic parameter.

The definitions also allow for an absolute reading of two Nonpast tenses, one in the matrix clause and one under *toki*, illustrated by (22), repeated here as (68):

(68) Kondo, uti-no daigaku-ga hakkututyôsa-ni
next time *our* *university*-NOM *archeological survey*-LOC
{iku / #itta} toki,
go-NP *go*-P *when*
sono sôgê-no tetudai-ni ike
that-GEN *see off and greet*-GEN *help*-LOC *go*-IMP
'Next time our university goes on an archeological survey, go help see them off and greet them (when they come back).'

In all of these examples, the fact that the absolute reading is available only when the tense of the embedded clause matches that of the matrix clause is explained here by its interpretation relative to the speech time. It is for this reason that ''mismatched'' sentences like (69) are ill formed:

(69) #Kare-ga ita toki-ni denwa-o suru
he-NOM *be*-P *time*-LOC *call*-NP
(*intended:*) 'I'll call him on the phone when he was here/there.'

As shown in (70), this sentence receives contradictory truth conditions asserting that the reference time both precedes and follows the speech time.

(70) $[\![\text{kare-ga ita toki ni denwa-o suru}]\!](sr)$
$\Longleftrightarrow r < s \wedge \text{kgi}'(r) \wedge s < r \wedge \exists e[\text{ds}'(\text{e}) \wedge \tau(\text{e}) \subseteq \text{r}]$

For the same reason, the absolute reading is also unavailable with combinations of a Past temporal clause with a Nonpast matrix clause.

6 Conclusions

We conclude with a few general remarks on what our analysis did and did not accomplish and some suggestions regarding wider implications and applications of the framework we presented.

The main methodological innovation consists in the use of interval sequences in the compositional semantics. These sequences offer a way to account for dependencies of local tenses on global parameters such as the speech time while maintaining a simple bottom-up compositional framework. At each point in the derivation, the sequence provides access to the speech time and all intervening reference times. Embedded temporal expressions such as tenses and frame adverbials may vary with respect to the position in the sequence relative to which they are interpreted, accounting for differences between absolute (deictic) and relative (anaphoric) interpretations. Such variation may be due to idiosyncratic properties of tenses or embedding operators as well as to parametric variation across languages.

In this connection, the present framework extends that of Kaufmann (2005), which it resembles in some respects. In his analysis of conditional sentences and their parts, Kaufmann introduces a time variable which is ultimately set to the speech time of the matrix clause and passed around down to the level of sentence radicals. This additional variable, which in the paper serves no other purpose than to provide the deictic anchor for adverbs like *tomorrow*, is superfluous in the present framework. The flexibility of interval sequences ensures that the speech time can generally be accessed at any depth of embedding as the first member of the input sequence.

The Japanese data discussed in Sect. 3 are intricate but not intractable. The formal analysis proposed in Sect. 4 captures the patterns better than previous formal accounts. At the same time, it leaves a number of questions open which should be addressed in future work. Among all ingredients of the theory, the aspectual

operator ASP comes closest to being merely a formal restatement of the observations about aspectual classes. One would like to derive the fact that non-stative radicals require non-overlap between reference and event time whereas statives require inclusion (but in embedding contexts only) from some deeper generalization about the nature of (non)stativity. At this time, we cannot offer such an explanatory account.

Another open question concerns the modal connotations of the temporal connectives we discussed. For instance, above we mentioned that *uti* presupposes that the state referred to by its complement clause is expected to terminate in the future. This is not an entailment, however. *Uti*, like *mae*, has non-veridical uses similar to English *before*. There are differences in details, however, which remain to be explored (Kaufmann and Takubo 2007). The integration of the present temporal framework with the modal dimension is the ultimate goal of this work.

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