# At the Syntax Pragmatics Interface: Japanese Relative Clause Construal

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## 1. Introduction

Japanese relative clauses offer a unique opportunity to explore the way in which languages can be responsive both to what may be rigid ordering constraints imposed internally to the language system and yet to the opposing demand for flexibility to allow optimal accumulation of information in context. As demonstrated in the previous chapter of this book, Japanese has very great flexibility with respect to how individual terms are introduced in any Japanese discourse. Yet this is paired with rigidly positional unambiguous indication when some local chunk of information is complete, the particles in each case signalling clear transition points from one such chunk to the initiation of the next.[2] Case particles, end-placement of verbs and the morphologically transparent end-placed tense markers carried by the verb all contribute to this end. However, this gives rise to the apparent awkwardness that relative clauses will have to be positioned before the head noun to which the case particles are attached. This is essential, as otherwise relative clauses will not be able to play the adjunct role in building up complex restrictor specifications which is definitive of them. Indeed, relative clause modification invariably precedes the nominal head, if there is one:

(1) Hiroto-ga muita ringo-wa oisikatta
Hiroto$_{NOM}$ peeled apple$_{TOP}$ oisikatta
The apple Hiroto peeled was delicious.

[1] We are grateful to a number of people for input in the evolution of these ideas about relative clauses: Dov Gabbay, Eleni Gregoromichelaki, Jieun Kiaer, Wilfried Meyer-Viol, Masayuki Otsuka, Shinichiro Oyetade. The substance of this paper was presented at the Relative Clause conference Cambridge October 2008, and we are grateful for comments from participants there.

[2] There is some uncertainty as to whether case and tense marking particles should be classified as suffixes. In Japanese, case and tense particles alike are phonologically suffixed to the immediately preceding element. And, while they do not perform quite the same function as the inflectional suffixes in Romance languages, they have a systematic function in determining for the expression of which they are the final morphological element, the role of that phrase in the larger structure. Since, in the analysis, the particles are analysed in terms of the update they provide to the progressive projection of semantic structure, the use of the term `suffix' is purely informal. In particular, it should not be taken as indicating any commitment to a morphological component.

This imposes the challenge of how speakers resolve the apparently opposing tensions of linear order and head-finality. What we shall argue in this chapter is that sensitivity to the dynamics of language processing in context plays a central role in relative-clause construal in Japanese. In particular, we shall show that it is fundamental to two primary types of relative clause sequence displayed in head-final languages, so-called gapless and so-called head-internal relatives, (2) and (3), both of which lack the identifiable empty position characteristic of head-initial and head-final relative clauses:

(2) Keeki-ga yakeru nioi-wa subarasii
Cake$_{NOM}$ bake smell$_{TOP}$ lovely
The smell such that the cake is baking is lovely

(3) John-wa ringo-o muita-no-o tabeta
John$_{TOP}$ apple$_{ACC}$ peeled-*no*$_{ACC}$ ate
John ate the apple he had peeled

We shall also show how the full array of properties of these Japanese relative clauses emerges as a consequence of a perspective in which syntax is envisaged as mechanisms for building up structure in real time relative to context. We will predict the blurring of restrictive and nonrestrictive forms of construal for head-final relatives, and the availability of pragmatic inferencing for gapless relative clauses. As a final bonus, these relative clause types will form a subpart of an overall relative-clause typology.

## 2. Dynamic Syntax: a general dynamics for structural explanation

To summarise the general dynamics of Japanese structure-building in terms that Dynamic Syntax (DS) makes available, Japanese, like all other languages, involves mechanisms both for progressively inducing local representations of content and for inducing dependency relations between non-local elements in such structures. The structures that are built are predicate-argument structures, represented as trees, and developed across a sequence of partial trees in which content-representation, structural representation, and even the tree-relations themselves may all be in some way partial and needing later update. All syntactic processes are analysed in these terms, with concepts of structural underspecification and update totally replacing concepts of movement or permutation (see chapter 1 for details). For example, so-called short-scrambling is not analysed in terms of permutability of constituents, but via the assumption that argument terms projected from NPs can be constructed in arbitrary order, with the case marking on that NP used constructively to dictate the particular structural relation of the argument to some containing propositional node, viz logical-

subject, object or indirect object. Long-distance dependency is also not expressed as movement (``left dislocation'') but in terms of construction of a structurally unfixed relation, merely that of ``dominated by'' the node from which this relation is constructed, with the case or other suffix dictating later resolution within the emergent tree. In long-distance scrambling, case plays merely an ``output filter'' role, for example accusative-marked NPs impose the restriction that in the resultant tree, the mother of the node under construction must be a predicate node. Both general computational actions, such as the license to construct such ``unfixed'' nodes within an emergent structure, and lexical actions initiated by individual words or particles, are defined in terms of incremental growth of structural representation. The only difference is that the latter are lexically triggered, so there are natural feeding relations between the two.

All these mechanisms are defined to allow their implementation relative to information presented in the overall interpretation process, whether that is provided by the construction process itself, or from the context. The significance of this context-relativity is that the mechanisms are defined to take, as input, structures which may themselves be only partially developed, and to yield, as output, structures which equally may not be fully developed. The over-arching constraint is that for any successful sequence of actions, the process of tree-growth must be monotonic: there is no process of removing information already established. Furthermore, context is similarly defined as retaining a record of structure constructed and of actions used in its development; so the entire process both of construal and syntactic explanation is analysed in terms of incremental growth of information relative to context, with all aspects of that process structurally represented as monotonic growth of binary branching tree structures. The concept of wellformedness resides in there being at least one successful derivation from assigned input, using the words strictly in the sequence presented and general/lexical actions to yield at least one complete propositional structure representation along a strictly monotonic tree-growth process, with all requirements that have been imposed at intermediate steps having been satisfied (Cann et al 2007).

### 2.1. Logical Underpinnings - The Tree Logic LOFT

Two aspects of the methodology to which the Dynamic Syntax perspective is committed are central. On the one hand there is a commitment to being explicit about all aspects of structural growth. On the other hand, there is a commitment to defining a model which directly reflects the dynamics of on-line processing. The system is thus defined as a set of constraints licensing

incremental and monotonic growth of semantic representations, whose implementation in the explication of the data themselves is taken to match that dynamics. To give a DS-based account of relative clause construal in Japanese, we need to add an outline of quantifier construal to the DS assumptions set out in chapter 1.

The formal system underpinning the partial trees that are constructed is a logic of finite trees (LOFT: Blackburn and Meyer-Viol 1994). First we repeat here the central heart of the formal framework of Dynamic Syntax, the Logic of Finite Trees (Blackburn and Meyer-Viol 2004), as this and its defined modal operators are important for the characterisations of NP construal that follow. Being committed to explicitness about growth of tree-representations means being explicit about trees themselves. Trees are not simply presumed as primitives without further discussion as standardly in linguistic theorising: they are describable by a Logic of Finite Trees that determines what is and is not a well-formed tree. LOFT is a modal logic with simple up-down modalities, reflecting daughterhood and motherhood respective: from a node $n$, $\langle\downarrow\rangle X$ means `$X$ holds at the daughter of $n$'; $\langle\uparrow\rangle X$, conversely, means that `$X$ holds at the mother of $n$'. $\langle\downarrow_0\rangle$ and $\langle\downarrow_1\rangle$ are operators denoting argument-daughter and functor-daughter relations respectively. $\langle\downarrow^*\rangle$ and $\langle\uparrow_*\rangle$ define notions of `dominate' and `be dominated by' respectively, with more localised variants $\langle\downarrow_1^*\rangle$ and $\langle\uparrow_1^*\rangle$ respectively, to which we return. Dynamic Syntax uses this system to define nodes in a tree, and how any such tree may grow (see chapter 1).

### 2.2. Logical Underpinnings - The Epsilon calculus

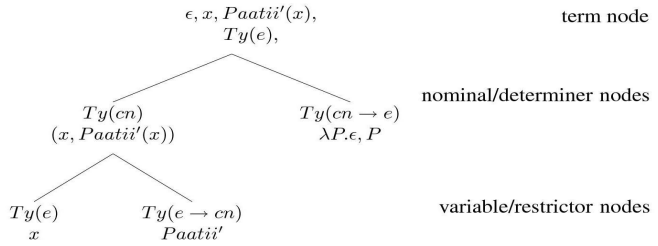
To express natural language quantification and its interaction with the tree-growth system, we need to look at the language of the *formula* values which express the content attributed to words. The language adopted is the *epsilon calculus*, a formal language defined by Hilbert (Hilbert and Bernays 1934) for study of arbitrary names as used in natural deduction systems of predicate logic.[3] In this, quantification is, as in natural language, defined

[3] Natural deduction systems are familiarly described in textbooks as being the closest to human reasoning of all the proof systems for predicate logic. Natural deduction systems have a number of properties redolent of human reasoning. They model valid inference in a step-by-step way that forces sensitivity to the build-up of information within a proof. They define quantificational reasoning in terms of eliminating each predicate-logic quantifier, replacing it with a name as an essential first step in establishing any validity that essentially involves quantificational reasoning (there are twinned introduction rules that re-introduce the quantifiers replacing such

over terms of individual type, with constructed names in which all (scope) dependencies are expressed as part of the restrictor of the name.

The parallelism between natural language and the epsilon calculus goes beyond merely defining quantifiers in terms of a special kind of name. First, names in the epsilon calculus have internal structure along lines similar to that displayed in natural language. Epsilon terms are term-binding operators made up of the triple of a binding-operator (the epsilon operator), a variable, and a restrictor. We give by way of illustration an epsilon term corresponding to *paatii*, the word in Japanese for *a party*:

(4)




Representing this triple as a binary tree, the term-internal structure echoes familiar linguists' vocabulary. The top type *e* term corresponds to DP; there is a binding operator provided by the term of type *cn*→*e* corresponding to DET (determiner); the type *cn* term corresponds to the NP or nominal node sister to the determiner head; there is a node for a variable also of type *e*; and finally a restrictor node of type *e*→*cn* corresponding to that of N (noun).

Secondly, the restrictor to any one such name grows over the course of establishing some possibly compound propositional inference: this is intrinsic to the way scope is defined as reflected in the restrictor for such names. Seeing that this is a further form of correspondence between natural language and the epsilon calculus, involves several steps. First, the underpinning to the process is the defined equivalence between an existentially quantified formula and its epsilon calculus congener:

(5) $\dfrac{\exists x.\varphi(x)}{\varphi(\varepsilon,x,\varphi(x))}$

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names, relative to defined constraints). Constraints on the proof-construction process are part of a set of metalevel annotations to the individual steps of reasoning, and these annotations detail how the inference steps are achieved, i.e. recording what rule was used, what assumptions the step depended on, and constraints specific to the form of quantification involved (see Gabbay 1996 for a general methodology for *labelled deductive systems*).

To represent in the epsilon calculus the formula equivalent to existential quantification, we need a name which picks out the witness which makes that formula true. This is $\varepsilon,x,\varphi(x)$, a term that represents an arbitrary witness underpinning every true assertion of $\exists x.\varphi(x)$. To get the full flavour of the existentially quantified formula, we now have to express of this name the predicate attributed to the variable in the predicate-logic equivalent; and this is the very same predicate that constitutes the restrictor of the epsilon term. Hence:

$\varphi(\varepsilon,x, \varphi(x))$

This replication of the main predicate in the restrictor of the epsilon term is true however complex the formula. So for example, if we were to express the epsilon-calculus equivalent of $\exists x\varphi(x) \wedge \psi(x)$, this would be as follows:

$$\exists x\ \varphi(x) \wedge \psi(x) = \varphi(\varepsilon,x,\varphi(x)\wedge \psi(x)) \wedge \psi(\varepsilon,x,\varphi(x) \wedge \psi(x))$$

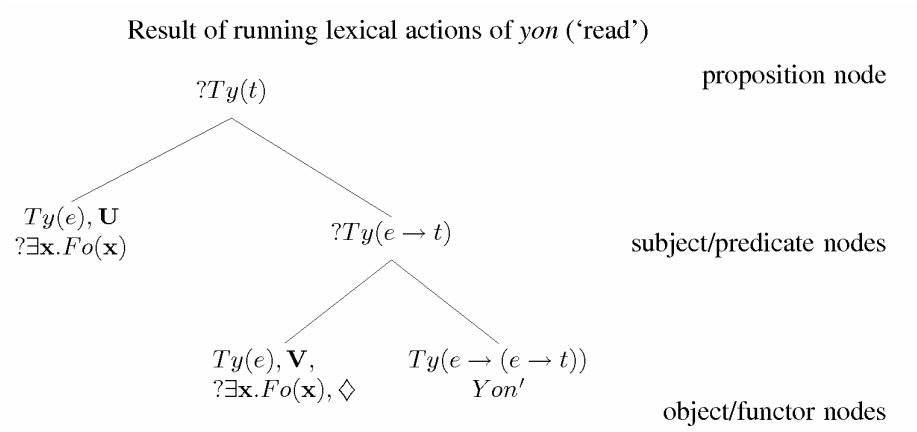
This equivalence in (5) expresses the heart of these epsilon terms as specifying an arbitrary witness for some formula within which they are contained. The bonus of this, for linguistic explication, is that despite their structural simplicity as naming devices, the restrictors of these epsilon terms will carry along with them, as they incrementally develop, all the information recording the way in which the term has been used, up to and including that point.

### 2.3. Lexical actions as processes for structure-constructing

To see this accumulating process applying in natural language construal, a further preliminary is to provide a means of constructing the requisite form of accumulating structure prior to the compilation of any such name, i.e. in the parsing of determiner plus nominal (and possibly also a relative clause).

Part of the shift in perspective in seeing syntax as inducing processes for structure building is that lexical items are not defined as a syntactic pair of word plus constraints as to the frame in which it is to fit, but as a pair of word plus a macro of procedures for pushing ahead the structure-building process. As we saw in chapter 1, verbs for example are taken to trigger a sequence of procedures that induce an entire propositional template, with not merely a predicate node, but also nodes bearing decorations that determine that their attendant arguments may either be further specified by the construction process or by substitution of information culled from context:

(6)



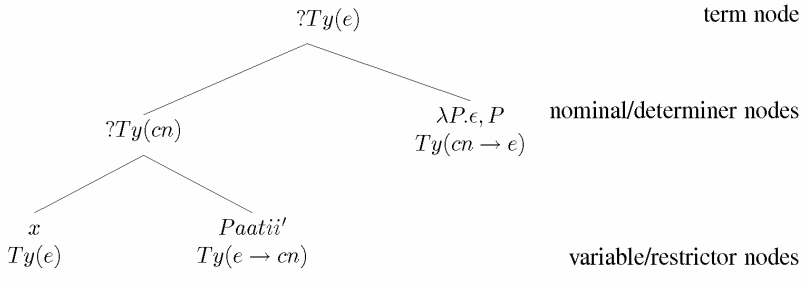

The tense particle phonologically suffixed to the verb is then defined to require that this entire complex of node-requirements be completed before its update-action can be carried out, with the effect that the tense particle drives the process of identifying argument values, either from context, or by unification with nodes already constructed.

This pattern carries over into the nominal domain. There is in Japanese one word that initiates a sequence of actions inducing a template of structure, the noun. Japanese is a language which characteristically lacks determiners. We take this lack of indefinite/definite as a signal not of radically different semantics from languages in which nouns require accompanying determiners but rather as an indication that the noun in those languages plays a role analogous to that of verbs in pro-drop structures, the noun itself economically bearing a larger share of responsibility for growth of the requisite semantic structure than in languages where a determiner is obligatory. That is, we take nouns, like verbs, to induce a set of actions that ensure the development of an entire sub-tree of individual type as in (7):

(7)

*paatii*
'party'

| | |
|---|---|
| IF | $?Ty(e)$ |
| THEN | $\texttt{make}(\langle\downarrow_1\rangle);\texttt{go}(\langle\downarrow_1\rangle);\texttt{put}(Ty(cn \rightarrow e), Fo(\lambda P.(\epsilon, P)), [\downarrow]\bot);$ |
| | $\texttt{go}(\langle\uparrow_1\rangle);\texttt{make}(\langle\downarrow_0\rangle);\texttt{go}(\langle\downarrow_0\rangle);\texttt{put}(?Ty(cn));$ |
| | $\texttt{make}(\langle\downarrow_1\rangle);\texttt{go}(\langle\downarrow_1\rangle);\texttt{put}(Ty(e \rightarrow cn), Fo(Paatii'), [\downarrow]\bot);$ |
| | $\texttt{go}(\langle\uparrow_1\rangle);\texttt{make}(\langle\downarrow_0\rangle);\texttt{go}(\langle\downarrow_0\rangle);\texttt{put}(x, Fo(x))$ |
| ELSE | Abort |



This partial tree will lead to the tree in (4) once nonterminal nodes are decorated, an update achieved by the set of case and topic-marking particles. These are phonologically suffixed to the noun or nominal sequence; and, by imposing the requirement that the node to which they are attached be a completed node of type *e*, these induce the complete decoration of that substructure. Their effect is analogous to tense: their constituent-final placement drives the compilation of these type *e* terms.

### 2.4. The Process of Incremental Growth

We can now put these verbal and nominal specifications of actions together with the general process of predicate-argument construction and the progressive accumulation of scope dependencies. As we saw in chapter 1, structures are assumed to be projected both by general actions enabling nodes to be introduced, and by lexical actions. The general actions may induce nodes with only a relatively weak structural relation to the containing tree, which lexical actions update.

Until such weak structural relations are resolved, decisions on scope dependency involving other terms in the emergent structure cannot be resolved. However once tree relations in any local sub-tree are fixed, relative scope dependencies can be accumulated at the local type-*t*-requiring node as a constraint on evaluation of the resulting propositional formula, so that once the interpretation of non-terminal nodes has been established by steps of functional application and type deduction applying to pairs of sister nodes in turn, the propositional tree will be compiled, and finally a full evaluation of the scope-relative terms will become possible.

The accumulation of scope dependencies is generally defined to follow linear order, with each new variable-binding term dependent on the one most recently added to the list; but lexical stipulations, e.g. for indefinites, may dictate otherwise. We illustrate with the simple example:

(8) Paatii-ga aru.
` A party is taking place'

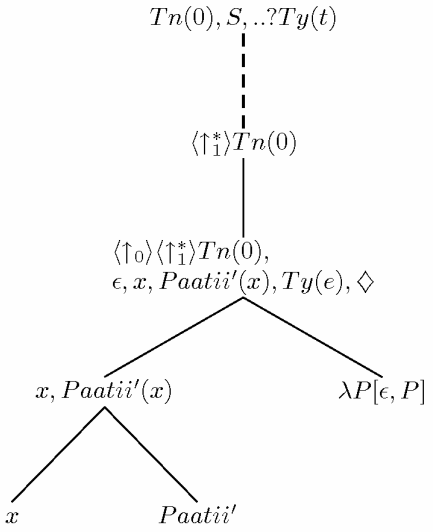
(8) has an interpretation that is expressible in predicate logic terms as:

(9) $\exists x.\ \text{Paatii}'(x) \wedge \text{Aru}'(x)$

General processes of tree construction license the introduction of some locally unfixed node (the specifics of the structure-building process are introduced in chapter 1). So as in (10), application of the process of *Local*Adjunction* building an unfixed node and the parsing of the word *paatii* jointly determine that the epsilon term with its internal structure

decorates a locally unfixed node:

(10)

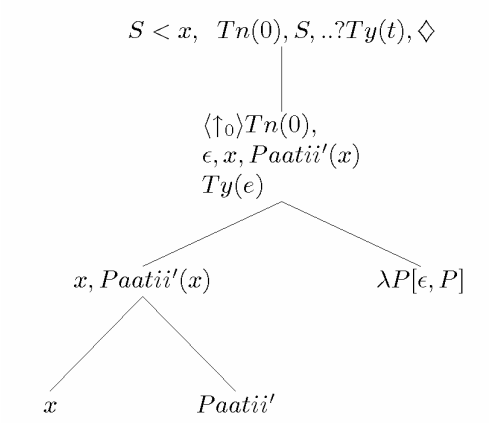



The relation $<\uparrow_0><\uparrow_1^*>$ *Tn(0)* indicated at the node decorated with the epsilon term means that the node being decorated is an argument as yet unfixed within the domain locally dominated by the root node ($<\uparrow_1^*>$ indicates the functor spine associated with some predicate-term yet to be provided). The case specification is then used constructively to enrich the structural relation to that of being immediately dominated by the local type-*t*-requiring node, here as the subject, and with this node fixed, the scope statement determining the scope dependency of the constructed term can be added to that immediately dominating node for the later evaluation of this term.[4] In this simple case, there is no option other than scope dependency of the indefinite on an event variable, and we assume that anticipation of such a variable is provided at the outset in the form of a metavariable specification, *S*, to be fleshed out by the subsequent construal process.[5] So `$S<x$' indicating that evaluation of the term binding the variable *x* is relative to the event variable *S* is added to the top node:

[4] Out of the class of quantified noun phrases, indefinites display greater freedom of scope dependency than any other quantified expression, with the possibility of very wide scope effects relative to other terms being constructed. We take this to involve the lexical encoding of an underspecified scope dependency, analogous to anaphora, with choice of dependency being made as part of the interpretation process (Kempson et al 2001).

[5] Tense construal is only presented schematically in this paper.

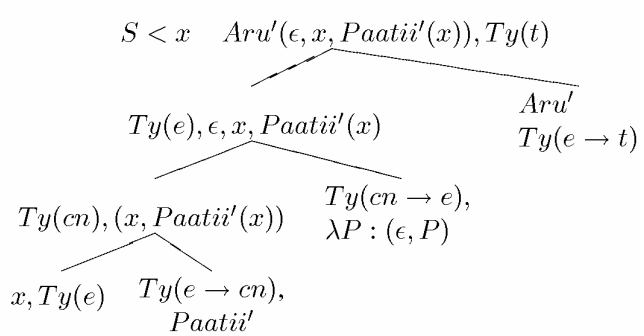
(11)




There is an important corollary of this epsilon-term construction-process: the term *ε,x, Paatii'(x)* constructible from the lexical specification of *paatii* is no more than a partial specification of what in the end result will be its full specification, since this will get enriched in the evaluation step to reflect the full content of the resulting propositional formula.

Prior to any such step, the parsing of the verb in (8) fleshes out a binary tree with the one-place predicate *Aru'(x)*, and the result is the tree:

(12)




With this tree constructed, the pair of scope statement and logical form can now be evaluated by a rule of scope evaluation, which follows the pattern dictated by the equivalence in (5). This involves constructing some suitable compound statement with constructed name which has to acquire a restrictor that reflects exactly that compound. The algorithm proceeds as follows. The restrictor of the quantifying term is taken to form a first conjunct with a name: that same name is taken as the basis for constructing the second conjunct with the name applied to the predicate given by the intransitive verb. What this yields as applied to the tree in (12) is:

(13) S: Paatii'(a) ∧ Aru'(a)

where:

a = (ε, x, S:(Paatii'(x) ∧ Aru '(x)))

Note the exact replication of the conjunction as part of the restrictor of the epsilon term. The algorithm defines the necessary connective for each constructed term-type. Here the connective is $\wedge$ in virtue of the expression being an indefinite, [6] with the compound term notably sustaining the predicate-logic epsilon-calculus equivalence. It is this pattern that we shall see repeating itself in the construal of Japanese relatives.

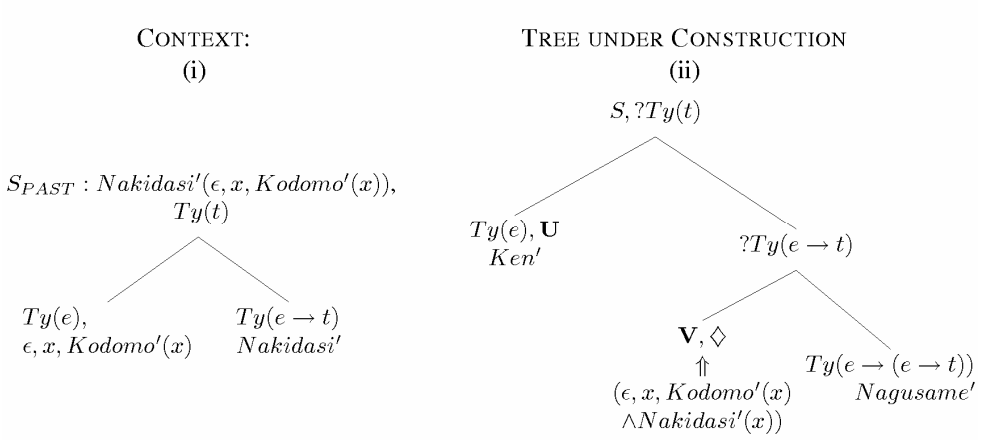
### 2.5. Anaphora Resolution

We can see the first effect of this changing epsilon-term specification in the interpretation of sentence sequences, where the interpretation of the first conjunct provides the context for interpreting the second.

| | | | | | | |
|---|---|---|---|---|---|---|
| (14) | (i) | Kodomo-ga | nakidasita | (ii) | Ken-ga | nagusameta |
| | | A child | began-to cry. | | Ken | comforted her. |

Parsing and compiling the tree for the parse of the first sentence involves building the tree given below as the context. The evaluation of this tree however yields as interpretation of the completed epsilon term, the name annotated below as ***a*** in the evaluation of (14)(i):

(15)




Evaluation of (i):

Nakidasi'(ε,x,Kodomo'(x)) = Kodomo'(**a**) ∧ Nakidasi'(**a**)

**a** = ε,x,(Kodomo'(x) ∧ Nakidasi'(x))

When this term is taken as the substituend for the formula decorating the object-argument node of *nagusameta* in (14)(ii), it will accordingly be the compiled term which becomes that object argument in the second conjunct. And when this is evaluated once the propositional formula is constructed from the second sentence, we have an accumulation of information recorded within that resulting term. This is because exactly the same procedure for

[6] If we had universal quantification, the connective would be →.

evaluating the term takes place in the evaluation of the second conjunct, this time with a composite term as input, hence an extended term as output:

(16) Nagusame'(ε,x,(Kodomo'(x) ∧ Nakidasi'(x))(Ken) =
Kodomo'(**a**) ∧ Nakidasi'(**a**) ∧ Nagusame'(**a**)(Ken)
**a** = ε,x,(Kodomo'(x) ∧ Nakidasi'(x) ∧ Nagusame'(x)(Ken))

What this mechanism for evaluating epsilon terms reflects is how information is incrementally built up throughout the interpretation process.

### 2.6. Building Paired Trees

The processes as so far sketched only induce the development of tree-structure presentations of single predicate-argument structures. What we now have to see is how such processes interact with the mechanisms of inducing paired structures as part of a single utterance process, as needed for relative clause formation. Relative clauses constitute one central case where clauses are recursively combined to yield composite forms of content. In English, these invariably involve placement of the so-called head initially in the sequence, followed by the modifying relative clause, normally identified by some relativizing element that signals that the following clause is to provide some ancillary identificatory property of the entity picked out by the head:

(17) John, who Sue upset, cried.

(18) A man who Sue upset cried

Following up on this dynamics, Kempson et al 2001 argued that the process of building up relative-clause construals involved an essentially anaphoric process, albeit algorithmically fixed, in which the head is in some sense carried over and used to induce the construction of a copy within that ancillary structure. Accordingly, an additional tree-logic operator, LINK, $<L>$ with its inverse $<L^{-1}>$, was defined to allow such linkage between predicate-argument structures; and the construction of a transition from one tree to another was said to involve construction of this LINK relation, in the case of relative clauses this involving also the algorithmic imposition of a requirement that the two structures so developed should share one argument term: the head. As we shall see shortly, this provides a basis for a range of relative clause construals displayed in English, but, in this paper, with focus on the Japanese dynamics, there is a consequence to the Dynamic-Syntax form of analysis which we should note as a point of departure. As with all other tree relations, there is nothing in the presumption of such pairings as to which tree should be constructed first,

and we duly expect there to be not only languages/structures in which the head is constructed first and the linked structure subsequently (the English type of case), but also languages/structures in which the linked structure is constructed first with some assumed term that is subsequently identified with the head that follows (the Japanese type of case). We would then anticipate that whatever distinctions there are between the different structures that emerge from this ordering difference should be a direct reflection of this ordering dynamics. And this is what we shall find.

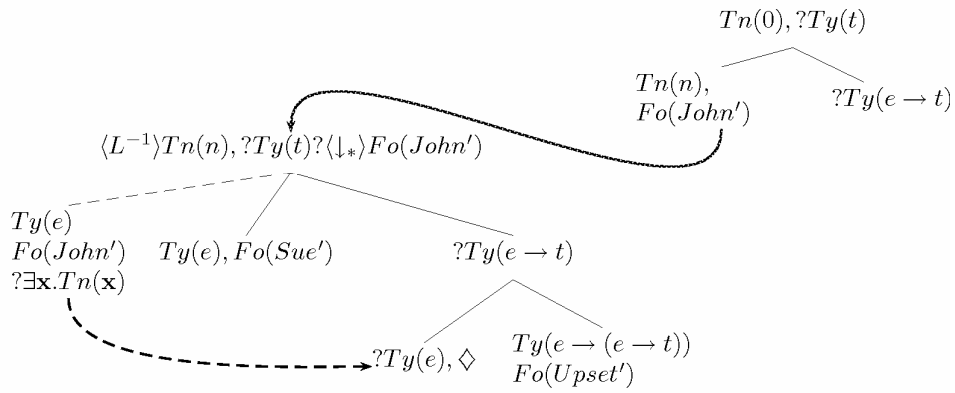
### 2.6.1. Head-initial Relatives

In languages such as English, with the head noun occurring first, we anticipate that properties of the head would determine the type of construal available for construal of the modifying relative clause, and hence for the construal of the whole. If a name provides the head, with no determiner, as in (17), the subsequent relative that occurs cannot be seen as providing any further restrictive specification, since the term under construction is already uniquely identifiable. If however, it is some determiner plus noun which provides the head, as in (18), then there are two options. On the one hand, there is the possibility of using the individual variable provided by the noun on which to build up such a structure. On the other hand, there is the possibility of using the intermediate interpretation got from the processing of the determiner plus noun sequence as a unit once the meanings of these two have been put together. The availability of these alternatives means that the subsequent relative may but need not be used to provide further restrictive specification for the associated quantifier. (18), that is, can be understood as either asserting of some entity that displays both the properties that he is a man and Sue upset him that he cried; or as asserting of some entity that is a man that he cried, and also, as an ancillary property, that Sue upset him. (17) has only the latter type of construal. This is the distinction traditionally recognised in English descriptive grammars as restrictive *vs*. nonrestrictive relative clause construal (Jespersen 1909).

Given a Dynamic Syntax background, the distinction will be reflected as a choice as to which point in the overall process the LINK transition is induced. Formally, this involves the building of a LINK transition from one partial tree to initiate the construction of another. A LINK transition is defined from the head onto some newly introduced top-node specified for type-*t*-requiring tree imposing in addition a requirement that this new tree must contain a copy of the head, as in (19), where the requirement $?\langle\downarrow_*\rangle Fo(John')$ decorates the tree marked $\langle L^{-1}\rangle Tn(n)$:

(19)

Parsing *John, who Sue upset*:




What (19) also displays is how the ``relative pronoun'', aptly so termed by Jespersen 1909, has its construal fixed to agree with the head. To reflect the fact that such relative pronouns must occur at the very early position in the unfolding of the linked tree, they are lexically defined as decorating only an initially unfixed node in the structure. This node then unifies with some argument node for the constructed predicate (here the object node).

Because the LINK transition involves the construction of a propositional type, and there is no further rule licensing the compilation of this content at the type *e* node to which it is linked, no conjunction is derivable incrementally at the type *e* node, and so the parse of (17) proceeds to complete the construal of the matrix predicate, with the pair of linked trees overall yielding a conjunction (Cann et al 2005):

Upset'(John')(Sue') $\wedge$ Cry'(John')

### 2.6.2. Restrictive Relatives

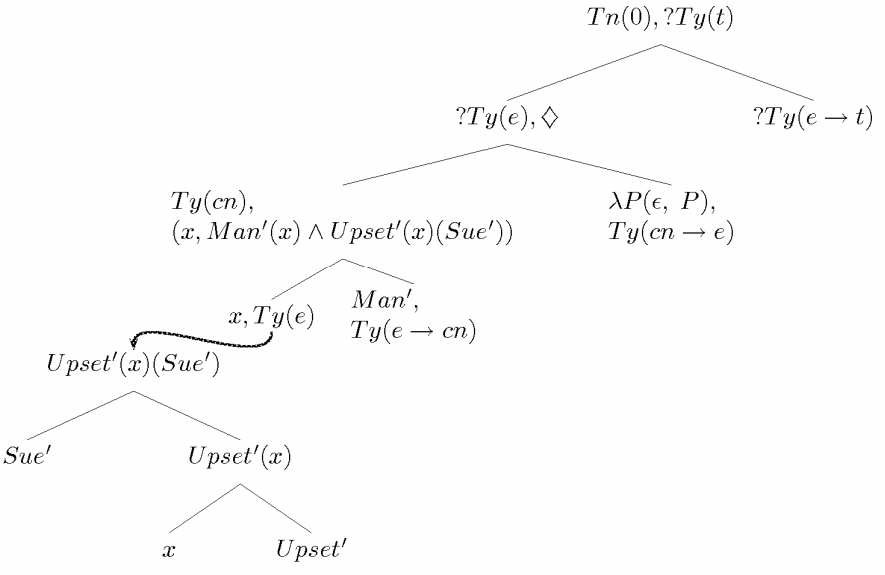
The construal of (17) is unavoidably nonrestrictive, as the head, being a name, in any case picks out a unique individual, and, by analysis, has no internal structure[7] However, there is also the restrictive form of construal; and it is at this point that we get the first bonus of adopting an epsilon-calculus-based system. An epsilon term, recall, is defined as containing two nodes of type *e*, the top-node corresponding to the epsilon term itself, and the node decorated by an individual-variable. Restrictive and nonrestrictive relative construals can be seen as differing as to the point in the tree construction process at which the LINK transition is constructed,

[7] Fleshing out this analysis would of course involve a formal analysis of linguistic names as both a device for constructing logical proper names and a device from which a predicate can be constructed enabling its combination, in English, with determiners; but we leave this on one side here.

either from the node decorated by the variable before any epsilon term can have been compiled, or from the higher node only after the determiner-provided formula and noun-provided formula have combined. From this, the different properties and in particular distinct semantic contents of the two types of relative emerge (see Cann et al 2005). The restrictive construal of (18) is set out in (20) showing how once the initially unfixed node decorated with the variable has unified with the argument node in the linked structure, the *cn* restrictor can be compiled:[8]

(20)

Parsing *a man who Sue upset ◊ cried*




Notice how, with the LINK transition being internal to the development of a restrictor predicate for the epsilon term under construction, the evaluation of that linked tree will give rise to a conjunction internal to the development of that restrictor, hence the conjunction at the *cn* node. This evaluation needs definition as a discrete rule; but, in reflecting orthodox model-theoretic characterisations of relative clause construal (see eg Morrill 1994), there is nothing controversial in its specification.

As we would expect, a nonrestrictive relative construal is also available for (18), as the sequence can also be construed as presenting the assertion that some man cried, with the ancillary assertion that Sue upset him; and in that case the epsilon term *ε, x, Man'(x)* will have been compiled from the determiner and noun sequence alone, before the requisite LINK transition is induced. On this latter construal, the process of building up

[8] The ◊ in the string informally indicates where in the parse sequence, the parsing process has reached.

interpretation would follow exactly that of (17).

## 3. Japanese Relative Clause Constructions

This modelling of restrictive vs. nonrestrictive relatives from a processing perspective provides the point of departure from which we can address the puzzle of relative clauses in head-final languages; and it might seem that because of this time-linear perspective, Japanese relatives can only be seen as very different indeed. At first blush, this seems to be confirmed. Japanese relatives constitute a distinct set of structures from head-initial patterns familiar in European languages, giving an impression of heterogeneity in the set of possible relative clause-structures that is not amenable to an integrated form of explanation. The primary type in Japanese are the head-final relatives, with no initial complementiser, indeed no morphological signal that the sequence is to be part of a relative structure. The only possible indication is the lack of any intonational signal of structural boundary as the verb is parsed (Kurosawa 2003):

(21) Hiroto-ga muita ringo-wa oisikatta
Hiroto$_{NOM}$ peeled apple$_{TOP}$ oisikatta
The apple Hiroto peeled was delicious.

The language is freely pro-drop, all arguments are optional, so the relative clause sequence, *Hiroto-ga muita* in (21) would be construed in isolation as either `Hiroto peeled it' or as `Hiroto peeled something'. And accordingly (21) can be construed as either `That apple already contextually identified which Hiroto peeled is delicious', which is at least superficially similar to the nonrestrictive construal available in English, or as `That thing that Hiroto peeled which is an apple is delicious', analogous to the restrictive form of construal.

Then there are the gapless relatives, which appear to lack even the possibility of any position in the relative sequence which could be construed as ``bound'' by the relative head (2) repeated as (22):

(22) Keeki-ga yakeru nioi-wa subarasii
Cake$_{NOM}$ bake smell$_{TOP}$ lovely
The smell such that the cake is baking is lovely

The puzzle about all these sequences, from the Euro-centric perspective of head-initial relatives, is that, much like the verb-final nature of individual clauses, it seems that the parser may have to wait until the head is reached before having any means of knowing that the sequence in question is a relative clause, let alone for deciding how to interpret that sequence in a

manner suitable for using it as a restrictor to some following head. The challenge, from a DS perspective, is as to how such different structures could be analysed in similar terms: the head after all is not processed until after the full relative sequence has been finished, so how could the head provide an antecedent for the interpretation of the preceding relative?

Exotic though these may seem, they are not, however, as puzzling as the so-called head-internal relatives (HIRC), which, at first glance, seem to contradict every assumption about relatives which the standard perspective would lead one to expect. Far from having a head noun in a suitable dominating position so that the noun and its restrictor can transparently combine together to determine the meaning of the whole, the apparent head is in the middle of the clause which constitutes its restrictor specification, with the nominalising particle *no* plus following case particle as the only indications that the sequence constitutes a relative clause structure:[9]

(23) John-wa ringo-o muita-no-o tabeta
John$_{TOP}$ apple$_{ACC}$ peeled-no$_{ACC}$ ate
John ate the apple he had peeled

If we are to make sense of these, it might seem that our assumptions of anaphoricity have to take a quite different form from that adopted for head-initial relatives. But, as we shall see, modelling the process of construal as a direct reflection of the sequence of words is all that is needed.

### 3.7. Head-Final Relatives: a first pass

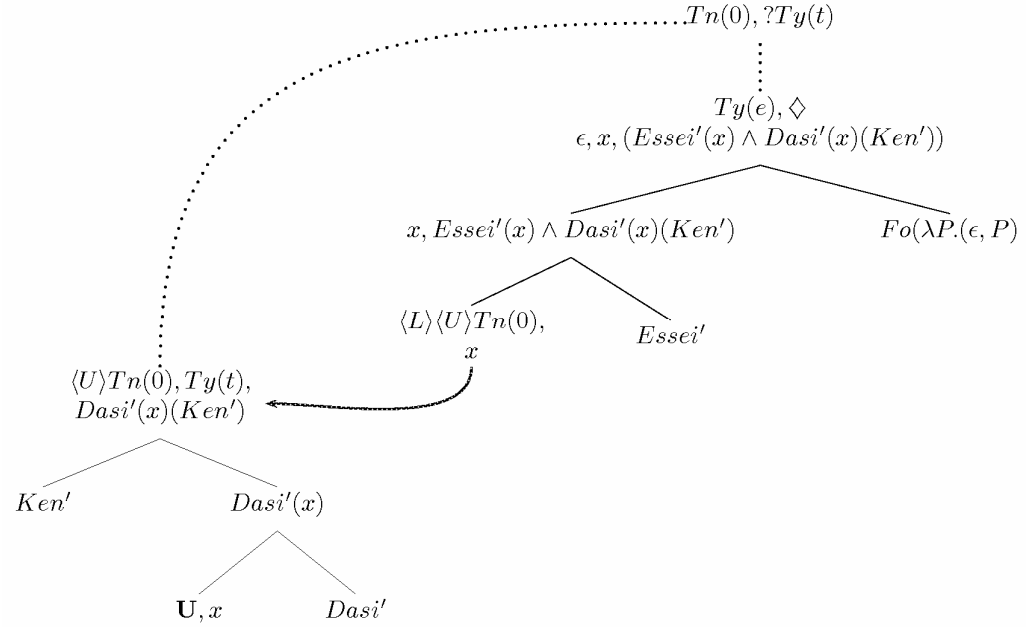
The first hypothesis about the difference between head-initial and head-final relatives is that, with the output logical structure reflecting interpretation, the only difference should be that the processing of head final relatives involves having to anticipate the structure that is induced by a copy mechanism in head-initial relatives. But we shall see that it is not quite this simple, as the dynamics of building up interpretation incrementally imposes a different ordering in the build up of information. Supposing first that head-final relatives do indeed follow the very same type of update, but with the linked structure constructed before the head. If this were to be so, the following structure might be expected to be induced, for a parse of the relative clause plus head in (24) - note the use of the variable *x* at the point of transition:

(24) Ken-ga dasita essei-wa omosiroi
Ken-$_{NOM}$ read essay interesting

[9] This particle -*no* has a range of uses, amongst them a genitive marker, and also a marker for these head-internal relatives.

`An essay Ken submitted is interesting'

(25) parsing the subject of (24):



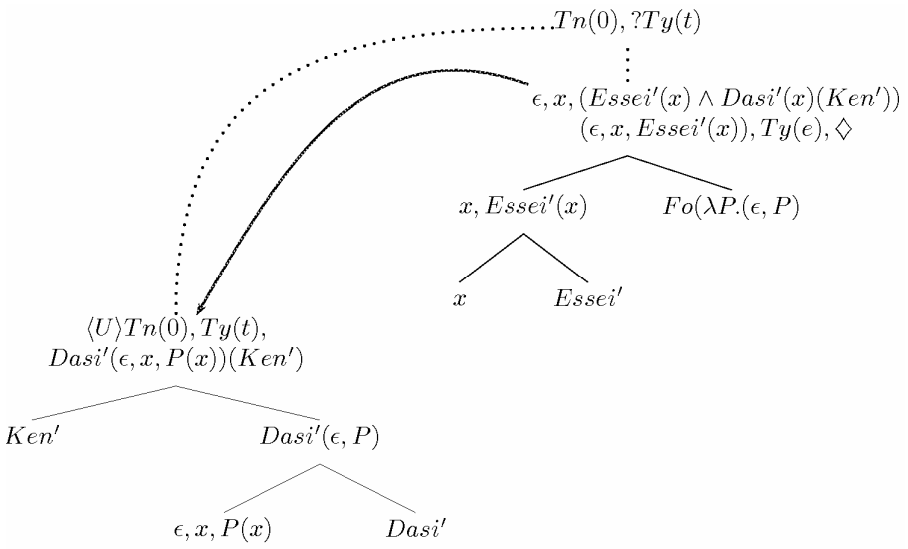

In this derivation step as depicted here, the lexically induced meta-variable decoration, ***U*** as object argument to the predicate *Dasi'* (`submit'), would be enriched to a variable, *x*; with no constructed term, the resulting propositional structure would not receive any scope evaluation (see section 2.4), so some definable LINK transition would induce a copy of that variable, from which node some containing term structure would have to be induced by the attendant noun *essei*. This is the mirror image of English.[10]

There are several complications to be faced in inducing the architectural structure for the head noun in subsequent steps, as given for (24), as the matrix structure is initiated with only a node for a variable. However, there is reason in any case to consider this not an optimal move. In head-initial relatives, to presume on a copy mechanism for an already provided variable is in principle unproblematic: if arbitrary decorated partial trees can serve as context and input to a LINK transition, then a partial pointed tree with a node decorated with a variable can serve as context. However the inverse does not hold. In the absence of any head, structure has to be constructed by assumption; but variables cannot be assumed, they have no life independent of the binder with which they are paired. Terms however precisely do play this role: constructed assumed

[10] This was the analysis of Japanese head-final relatives of Cann et al 2005 (chapter 6).

names are the life-blood of natural deduction systems. So if we are to anticipate structure and a type *e* term for subsequent provision of a head, then what should be assumed is some maximally weak unrestricted epsilon term, of the form of *ε,x,P(x)* for some predicate variable *P*. Upon this model of restrictive relative construal, the compilation of structure does indeed involve projection of a full propositional structure with a containing term, so in principle such a structure might be subject to scope evaluation.[11]

(26)




The LINK transition itself would merely construct a type *e* node across a created LINK transition:

(27)

| | |
|---|---|
| IF | $Ty(t), \downarrow_* Fo(\alpha)$ |
| THEN | $\texttt{make}(\langle L^{-1} \rangle); \texttt{go}(\langle L^{-1} \rangle);$ |
| | $\texttt{put}(?Ty(e), ?\exists x Fo(x[\alpha]))$ |
| ELSE | Abort |

This rule is defined as a general computational action as applying to a completed linked structure to create a copy of some term of type *e* contained within it, with no restriction as to whether such a formula is some completed term or not, or whether the propositional formula is evaluated or not. No copy is created in this transition, though there is a requirement for a resulting term to contain a copy of the selected term as a sub-term. The introduction of such a linked tree has to be paired with a subsequent step of evaluation combining the two constructed terms and binding them to create a new composite term. This step is essentially an apposition effect (see

[11] The construction step is here arguably simpler than if the node were of a variable formula, as the transition can be to the type -*e*-requiring node immediately to be developed by the subsequent noun.

Cann et al chapter 8 on *apposition*), where a created epsilon term can be extended, consistent with the general monotonicity constraint:

(28)

| | | |
|---|---|---|
| IF | $Ty(e), Fo(\epsilon, x, \phi(x))$ | |
| THEN | IF | $\langle L \rangle (Fo(\psi[\epsilon, x, P(x)]))$ |
| | THEN | $\mathtt{put}(Fo(\epsilon, z(\phi(z) \wedge \psi[z/(\epsilon, x, P(x))])))$ |
| | ELSE | Abort |
| ELSE | Abort | |

So the effect of this twinned pair of construction and evaluation steps is to bind in the constructed epsilon term to yield a compound term.[12] In the case of the provided derivation of (24), this is the term:

(29) ε,x, Essei'(x) ∧ Dasi'(x)(Ken)

Subsequent parsing steps are then as standard. The particle *wa* is taken here to be associated with fixed matrix subject construal,[13] the matrix verb providing the appropriate predicate-argument structure; and the resulting logical formula decorating the rootnode for (24) will be:

(30) Omosiroi'(ε, x, Essei'(x) ∧ Dasi'(x)(Ken))
`An entity such that it is an essay and submitted by Ken is interesting'.[14]

It is notable that the order in which the subparts of this term are built up is different from that of head-initial relatives. It comes as no surprise, then, that the restriction between restrictive and nonrestrictive construal, though

[12] Though the effect of the LINK-evaluation step is one of building linked type *e* terms, as though an apposition device, apposition cross-linguistically is a process which involves essentially independent terms, in English requiring full determiner-noun sequences as in *An old man, a long-term patient, was sitting by the window*. Yet it is essential that the operations for extending the binding of some head-final term should not be available to just any combination of epsilon terms decorating an emergent node, as this would allow the compatibility of the *no* nominaliser with any NP at all, contrary to fact. *No*- marked sequences with some following noun head cannot be interpreted as appositional, but involve specific relations such as numeral-head, possessor-head etc. Reflecting this, the binding operation of LINK Evaluation given here is defined as a mechanism for discharging some assumed term, and not as a general basis for appositional effects.

[13] There is a great deal more to be said about *wa*-marking in Japanese, but here, for simplicity, we simply assume it is associated with matrix subject construal.

[14] On this analysis, head-final relatives with their head noun invariably project an epsilon term. Head-final relatives in Japanese may occur with a following quantifying particle such as *hotondono*, but this, arguably, is a distributivity marker and not a direct binder of the term projected from the noun phrase sequence itself.

relatively easy to bring out in head-initial relative clauses, does not carry over at all easily to Japanese, since, in head-final relatives, neither the variable nor a term corresponding just to the term provided by the head is independently recoverable. So the assertion made by (24) does not correspond exactly either to that conveyed by *An essay which Ken submitted is interesting*, or to that conveyed by *An essay, which Ken submitted, is interesting*, though in the singular case these two and (24) may yield truth-conditional equivalents. Unlike these English analogues, the interpretation of (24) is built up as `The entity such that Ken submitted it, such that it is an essay, is interesting'. The only way in which a distinctive nonrestrictive construal becomes available at all for the relative clause sequence is if the object argument recovered in the relative clause sequence is taken to be anaphorically defined from the independent context. In such a case, the interpretation of (24) is `That essay, which Ken submitted, is interesting'; but this is distinct from the nonrestrictive interpretation of *An essay, which Ken submitted, is interesting*. In the latter, but not in the former (and not in (24)), there may be no independent identification of any such essay. So though the denotational content of the analogous expressions in Japanese and in English are sufficiently close to serve as translational equivalents, they nonetheless reflect different modes of combination.

### 3.8. Head-Internal Relatives

While the discussion about the optimal analysis for head-final relatives cannot be complete without detailed discussion of quantificational effects, one consequence of the DS-style account of quantification shines out: the account might have been tailor-made for head-internal relatives.

Head-internal relative structures (HIRC) are highly problematic for current syntactic theories, since binding and predicational operations are taken to be constrained by governance conditions on some (logical) tree inhabited by some sequence of words, with relations such as c-command defined over those trees, with the tree taken to reflect both the sequence of words (possibly with allowance of local permutation effects) and compositionality of the accruing content for that sequence of words. But, even setting aside local variation in word order as a supposedly independent problem, in the case of head-internal relatives, the head, despite retaining its function as the dictator of construal as in head-initial structures, turns out to be internal to the modifying relative sequence. This defies all expectations of how that relative might contribute to the restrictor delimiting the resulting term; and, to get around this anomaly, some accounts analyse the apparent relative-internal head as having a form in

which that head is not internal to the relative sequence despite appearances (Kitagawa 2005).

(31) Ken-ga san-satu-no hon-o mottekita-no-ga nusumareta
Ken$_{NOM}$ 3 books$_{ACC}$ brought-*no*$_{NOM}$ were-stolen
The three books Ken brought were stolen.

To make matters worse, the effect of the head-internal relative on the overall construal appears to vary according to the semantic type of the head. The type of head-internal relative made prominent in the literature by Kuroda 1992 and subsequently the focus of a considerable amount of attention was analysed by Hoshi 1995 as parallelling E-type pronouns (see Evans 1981 and many others thereafter), since they have a cumulative form of interpretation redolent of these. (31) has only the interpretation that all the three books which Hiroto brought were stolen.

But there are other head-internal relative sequences where this form of analysis doesn't appear to be appropriate:

(32) Ken-wa Naomi-ga nakidasita-no-o nagusameta
Ken$_{TOP}$ Naomi$_{NOM}$ crying-began$_{no\text{-}ACC}$ comforted
Ken comforted Naomi who had begun crying

And there are yet other head-internal relatives where there is a dependency of one of these relative-contained NPs on the other, as in:

(33) Sensei-wa dare-ga nani-o mottekita no-o toriagemasita-ka?
Teacher$_{TOP}$ who$_{NOM}$ what$_{ACC}$ brought-*no*$_{ACC}$ confiscated-Q
What, brought by who, did the teacher confiscate?

(34) Sensei-wa dare-ga nani-o mottekitano-o bassimasita-ka?
Teacher$_{TOP}$ Who$_{NOM}$ what$_{ACC}$ brought-no$_{ACC}$ punish-Q
Who, bringing what, did the teacher punish?

Disparities such as these have led some to postulate ambiguity amongst the head-internal relative clause category with different assignment of structures (Kitagawa 2005). They certainly raise a number of important questions. How, without invocation of such ambiguity, can there be any hope of capturing the observed ambiguities in a single clausal sequence:

(35) Taroo-wa neko-ga nezumi-o oikaketeita-ta no-o
Taroo$_{TOP}$ cat$_{NOM}$ mouse$_{ACC}$ chased *no*$_{ACC}$
tukamaeta
caught
(a)Taroo caught the cat that was chasing the mouse
(b) Taroo caught the mouse that the cat was chasing

(36) Taroo-wa neko-ga nezumi-o oikaketeita-ta no-o
Taroo$_{TOP}$ cat$_{NOM}$ mouse$_{ACC}$ chased *no*$_{ACC}$
dotira-mo tukamaeta
both caught
Taroo caught both the cat and the mouse which the cat was chasing.

(37) Jiroo-wa kodomo-ga soba-o yudete-iru-no-o mita
Jiroo$_{TOP}$ child$_{NOM}$ noodle$_{ACC}$ boil$_{be\text{-}no\text{-}ACC}$ saw
A child is boiling noodles and Jiroo saw him/it$_{noodles}$/it$_{event}$

In (37) for example, either the expression *kodomo*, or the expression *soba* or some reflection of the clause as a whole can in some sense constitute the head. But, despite this variability in possible interpretation, in no case is the expression itself sufficient to capture the necessary interpretation. Each of the available interpretations has to include some composite form of construal involving the clause as a whole.

These head-internal relatives, so puzzling for current theoretical assumptions, are a characteristic feature of head-final languages. An immediate further question has to be: Why might this be so? If grammars merely define configurational dependencies between expressions on a hierarchical basis, there are no grounds, even if these structures can receive satisfactory explanation, for explaining why they are a canonical structure only in verb-final languages. There is also the problem of their correspondence with another apparent ``gap''-less relative construction, what have been called gap-less relatives, which do have a head. All HIRC-deploying languages also display such relatives. These, like the head-internal relatives, display a relative-clause sequence which provides no indication of having any missing element in the structure for the provided head to bind:

(38) Keeki-ga yakeru nioi-wa subarasii
Cake$_{NOM}$ bake smell$_{TOP}$ lovely
The smell such that the cake is baking is lovely

These two types of structure thus look wholly unlike the more familiar head-initial relative clause. Such gapless relative structures have been taken as indicative of the need for a non-movement analysis in these languages; but this raises as many questions as it solves. Why is it that some languages have relative clause sequences which require a movement-based analysis, others one that must not involve any such mechanism? More puzzlingly yet (given that movement-style analyses are posited only if a gap position can be motivated in the relative clause), the head-internal relatives, which, like

the gapless relatives, signally lack any such position, nevertheless display the very type of locality constraint taken to be criterial of a movement analysis, sensitivity to island constraints (Hoshi 2005):

(39) *John-ga Mary-ga subarasii ronbun-o kaita toyuu
John$_{NOM}$ Mary$_{NOM}$ excellent paper$_{ACC}$ wrote COMP
uwasa-o kiita-no-ga syuppan-sareta
rumour$_{ACC}$ heard$_{no\text{-}NOM}$ was-published (intended)
*An excellent paper which John heard a rumour that Mary had written was published.

In fact, they display a much tighter restriction than this in that they have to be construed as the restrictor of an argument associated with the immediately following predicate. The tightness of this restriction is problematic for other more anaphoric bases of explanations such as Hoshi 1995. Ishizuka 2006 argues that this is contra-indicative of a straightforward anaphoric dependency, as anaphoric dependencies are generally associated with a pragmatic concept of salience, not simply a recency effect. Nevertheless, the relation between relative clause and subsequent structure has to be construed as in some way anaphoric; for, just like anaphor-antecedent relationships, the relation between relative as construed and the structure in which one of its NPs has to be construed as head can apparently be established by intermediate steps of pragmatic reasoning. In some cases, this may be directly derivable from the lexical content of the words themselves, but not by any means in all:

(40) Jiroo-wa zubon-ga yogore-ta -no-o hukitotta
Jiroo$_{TOP}$ trouser$_{NOM}$ got-dirty *no*$_{ACC}$ wiped-out
`Jiroo's trousers got dirty and Jiroo wiped the dirt from his trousers'

The characterisation of all such relations would seem to fall outside the remit of standard grammars, pragmatics being the study of how general principles of cognition determine the interpretation of utterances in context, given some priorly defined grammar-specified concept of intrinsic content. On these grounds alone, HIRC appear to require entirely exceptional mechanisms even to express the facts. And part of the challenge which these structures is to be able to explain why such gapless relatives and head-internal relatives invariably co-exist.

There is then the problem that head-internal relatives notably license what on standard analyses might be expected, quite wrongly, to be highly marked structures:

(41) Ama-naru nun$_{COP\text{-}AND}$ katai-no beggar$_{NOM}$ ateyaka-naru-ga elegant$_{COP\text{-}ADN\text{-}NOM}$ ideki-taru-o came$_{NM\text{-}ACC}$ yobiide-te.... summoned-

I summoned a beggar who was a nun, very elegant, whocame. [Pillow Book of Sei Shonagon. Section 87]

This composite of problematic head-modifier relation, and syntax-pragmatics inter-relatedness might reasonably lead one to rate these structures as amongst the most marked structures of all. Yet, as (41) illustrates of Classical Japanese, such structures may constitute a perfectly natural narrative sequence (see Kurosawa 2003 for further details).

Overall, then, such head internal structures pose a number of major problems for current hypotheses, and, despite a considerable bulk of literature, their formulation remains stipulatory (see Kitagawa 2005 and Hoshi 2004 for parameter specifications for a relative-clause typology).

### 3.9. The dynamic perspective

Shifting into the dynamic perspective imposed by the Dynamic Syntax framework, one might ask what is it that the commitment to modelling syntax as the relentlessly incremental process of structure-building would lead one to expect? The shift leads to a number of observations, all inexorably leading to a broadly anaphoric form of explanation.

#### 3.9.3. Tree-theoretic configurationality

By way of preliminary, the first observation is negative. Nothing in the LOFT system underpinning the tree-growth mechanism defined dictates whether head or relative clause sequence should precede. Tree-defined relations are defined of trees themselves, and the linearity of the natural-language processing-based explanations is a by-product only of the correspondence taken to hold between on-line processing and monotonic tree growth. More specifically, for any directional tree-relation, there is an inverse, so not only are there mother-daughter pair of relations, dominate and be-dominated-by pairs, but also there are pairs of $<L><L^{-1}>$ relations. And, given that the LINK transitions defined for head-initial relatives involve a transition from head-node of type *e* onto a type-*t*-requiring node, given the independent projectability of propositional structures, we would accordingly expect such propositional structures to be constructable before the construction of some head with which they are to be paired.

### 3.9.4. Context-shifting in natural-language processing

The heart of the explanation turns however not on the neutrality of LOFT with respect to directionality, but on the specific expectations as to directional dependency which the presumed monotonicity of tree growth imposes. A number of predictions follow.

#### 3.9.4.a. HIRC and setting up the discourse context

First, in all substructures decorated with an epsilon term whose restrictor is constructed from a linked structure, there will be a formula as head and an associated restrictor containing a second token of that head in the emergent semantic structure. Whichever of head or restrictor is introduced first into the emergent structure in a given relative-clause strategy, it is this that will serve as context for the process that follows. In head-initial relatives, with head preceding, it is indeed the head that uniquely determines the value of the shared term and in this sense provides the context relative to which that propositional structure is linked; all that is left open for later resolution is the contribution of this term within the linked structure. Conversely, with the relative clause sequence coming first in the sequence of relative clause and head, we would expect that any one of the terms constructed as a subterm within the constructed propositional formula could serve as the input to identifying the correspondence with the head, as it is precisely which node in the linked structure that is to serve as the point of correspondence with the head which is not dictated by the propositional structure itself. This is exactly analogous to the phenomenon that nothing in some antecedent sentence determines antecedenthood for some following anaphoric expression. It is rather the processing of the overall structure which constitutes the context out of which the anaphoric expressions select an antecedent: such selection is simply part of the ongoing dynamics of utterance interpretation. The ambiguities available for the construal of head-internal relative clauses confirm this. We correctly expect ambiguity in structures such as (42) as to which subterm is to be the substance of the correspondence with whatever it is that serves as head:

(42) Taroo-wa neko-ga nezumi-o oikaketeita-ta no-o tukamaeta
Taroo$_{\text{TOP}}$ cat$_{\text{NOM}}$ mouse$_{\text{ACC}}$ chased *no*$_{\text{ACC}}$ caught
(a)Taroo caught the cat that was chasing the mouse
(b) Taroo caught the mouse that the cat was chasing

#### 3.9.4.b. HIRC and the occurrence of the internal head

Second, nothing dictates that such preceding relative clause sequence should

lack one such argument expression. To the contrary, given that it is the relative sequence which, on this perspective is the context for whatever subsequent construal has to be built up, we expect that it might be the relative clause sequence that is built up from explicit morphologically provided expressions and the head that be elliptical, reconstructed by some algorithmically fixed copy device (the exact inverse of the English relative pronoun).[15] So indeed, in principle, given the ability to construct linked structures before the node to which they stand in correspondence, we expect the existence of head-internal relatives, with some particle dictating the value for some selected shared term as head. This is the anaphoric analysis of *-no* of Hoshi 1995, Kitagawa 2005 and others. So in (32) for example, the expression *Naomi* occurs within the relative sequence *Naomi-ga makidasita*, in so doing providing the antecedent for the term to be constructed subsequently as the argument for the matrix predicate *nagusameta*. And it is the immediately following particle *-no* which induces the transition from the structure induced from the relative sequence onto the new argument node which will subsequently become argument of the matrix verb, for which it provides the `anaphoric' copy. The procedure provided by *no*, that is, can be straightforwardly defined as simultaneously inducing a tree-transition and providing some selected value as its head:

(43)

| *-no* | | |
|---|---|---|
| | IF | $Ty(t), Fo(\psi[\alpha])$, |
| | THEN | $\mathtt{make}(\langle L^{-1}\rangle); \mathtt{go}(\langle L^{-1}\rangle);$ |
| | | $\mathtt{put}(Fo(\alpha), Ty(e))$ |
| | ELSE | Abort |

Given the Dynamic Syntax perspective, with lexical items inducing tree-growth actions that induce subtrees and their decorations, nothing exceptional in kind has to be attributed to *-no*. This is, for sure, a lexical stipulation, but it is just an algorithmically determining anaphoric expression much like its congener in head-initial relatives, though, in the head-final case, determining a transition from the structure resulting from the relative sequence onto the emergent head node, rather than the other way round (see section 2.6.1 and Cann et al chapter 2005, chapter 3).

### 3.9.4.c. The E-type Effect

Defining the E-type flavour to the interpretation required for head-internal relatives is also expected. These always make reference to the containing structure as a whole in which the head is contained as (31), repeated below

[15] Kim (2004) notably observes that ``the discourse context is set up by the content of the relative clause'' but she doesn't take this up in her analysis.

as (44), illustrates, with its interpretation of the relative sequence as `the three books that Ken brought':

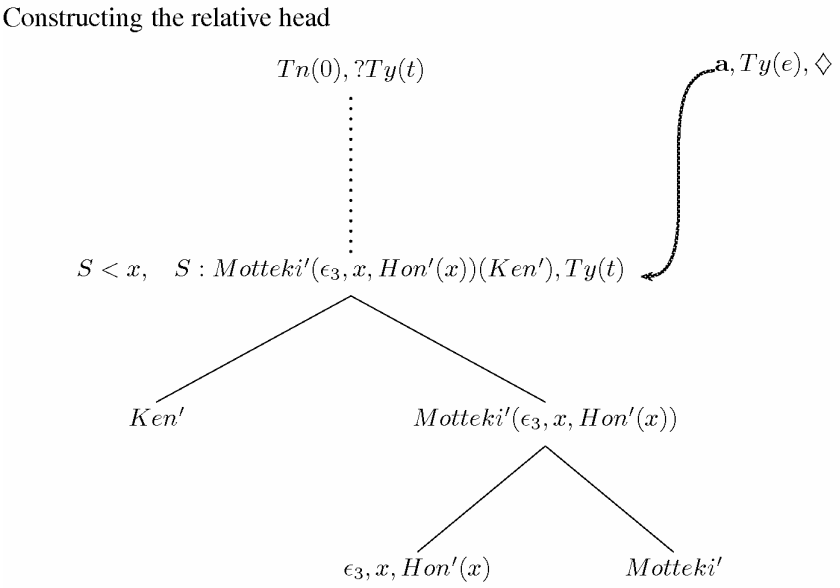
(44) Ken-ga san-satu-no hon-o mottekita-no-ga nusumareta
Ken$_{NOM}$ 3 books$_{ACC}$ brought-*no*$_{NOM}$ were-stolen$_{PASS}$
The three books Ken brought were stolen.

This construal follows immediately from the overall DS dynamics, the account of quantification, and its application to Japanese. Given the nature of phrase-final particles in this head-final language, we expect in head-internal relatives, with their final *–no* particle, that all aspects of the propositional structure to serve as input to the LINK transition would be complete at the point of the transition. That is, the nominalizer *-no*, like *-ta* and the case particles, is defined as closing off the structure it completes and inducing the building of structure from that completed substructure. Indeed, as this dynamics would now lead one to expect, head-internal relatives are full clausal sequences: *Ken-ga san-satu-no hon-o mottekita-no-ga nusumareta* is a complete sentence. Head-internal relatives indeed lack nothing; they need no item in context to provide them with input from which to build up interpretation; they can contain a full array of noun phrases to provide the requisite number of argument expressions for the predicate which the verb provides. Moreover, they invariably precede the head to which they provide input, in so far as they can be said to have a head at all. But, with this being so, given the account of quantification, we expect that such head-internal relatives would be subject to an E-type interpretation. All indefinite expressions constitute epsilon terms, and these by assumption on the output of the interpretation process take the form of a name that contains a restrictor that carries a full record of the dependencies that may have been set up during the course of constructing that propositional content. Thus we expect that the correspondence between head and antecedent in the relative clause sequence is not between the words themselves, nor between the construal of the word itself and the head to be established. It is by definition a carrying over of the composite term that results from the resulting clause-level specification of restrictor for any quantifying terms, so that one of these becomes the argument term in the subsequently constructed propositional structure. And because the process of determining quantificational force is taken to be one of name construction rather than any covert quantifying-operator movement, the requisite terms are an automatic consequence of that interpretation process, and the prediction of E-type effects follows immediately.

We now turn to seeing how these consequences emerge so directly

with a detailed derivation for (31)/(44). (45) provides the partial structure at which the transition induced by *-no* takes place:

(45) Constructing the relative head




The relative sequence of (31)/(44), once evaluated as in (45) is:

Hon'(**a**) ∧ Motteki(**a**)(Ken)

**a** = ($\varepsilon_3$, x, (S: Hon '(x) ∧ Motteki'(x)(Ken')))

`the set of three books such that Ken brought them'.

As (45) shows, with the head-internal relative providing all that is needed to establish a complete propositional formula, nothing will prevent that formula being subject to the scope evaluation algorithm to yield a complete interpretation. And the output of that scope evaluation process will yield composite epsilon terms that duly reflect their containing propositional formula. These can then serve as antecedents for anaphoric processes, and this matches many other pronominal accounts of this use of *-no*, analyzing it as ensuring that some term from the linked structure be constructed as copy in the new structure introduced by the actions of *-no*. Once the transition from linked structure onto a decorated argument node is provided by the actions associated with *-no*, the interpretation proceeds thereafter exactly like other construction of containing structure. There is a process of building a locally unfixed but dominating node (the inverse of Local*Adjunction: Cann et al 2005), which the case-specification can be used to constructively enrich. The final verb will provide the appropriate predicate, and the containing propositional formula then be duly evaluated to yield (46) as the overall interpretation of (31)/(44)

(46) Nusumare'($\varepsilon_3$,x,Hon'(x) ∧ Motteki'(x)(Ken'))
= Hon'(**a**) ∧ Motteki(**a**)(Ken') ∧ Nusumare'(**a**)

$$\mathbf{a} = (\varepsilon_3,x,(\text{Hon}'(x) \wedge \text{Motteki}'(x)(\text{Ken}') \wedge \text{Nusumare}'(x))$$

This is exactly the event-emphasising flavour of head-internal relative clauses taken to be characteristic of these structures, the construal of the head itself apparently needing compilation of the containing proposition. The semantic and syntactic properties of head-internal relatives directly follow. We expect the local contiguity between the complementiser *-no* and the structure within which it has to serve as argument. These are by definition inseparable since *-no* by analysis provides both the transition and the value of the head to be constructed. The varying dependency when the head-initial relative contains more than one existentially quantified expression is also predicted, as in (47)-(48), as there will be more than one putative antecedent for the matrix argument, both of them quantified:

(47) Sensei-wa dare-ga nani-o mottekita no-o toriagemasita-ka?
Teacher$_{TOP}$ who$_{NOM}$ what$_{ACC}$ brought$_{no\text{-}ACC}$ confiscated-Q
What, brought by who, did the teacher confiscate?

(48) Sensei-wa dare-ga nani-o mottekita no-o bassimasita-ka?
Teacher$_{TOP}$ who$_{NOM}$ what$_{ACC}$ brought$_{no\text{-}ACC}$ punish-Q
Who, bringing what, did the teacher punish?

Moreover, given the weakly existential quantifying nature of *dare* and *nani*, we expect full compilation of content as part of the restrictor of each, once the scope constraints on the propositional structure are evaluated. Whichever of the two terms is selected as antecedent will carry a record of the way in which dependency had been established in the construal of the containing clause, with varying suitability for serving as argument of the subsequent predicate. So the supposedly distinct quantification type of head-internal relative posited by Kitagawa is covered by the same analysis. On the other hand, we predict lack of E-type effects if it is a name that is copied over into the emergent structure, as names are not scoping terms and so will not be subject to any such process of evaluation:

(49) Ken-wa Naomi-ga nakidasita-no-o nagusameta
Ken$_{TOP}$ Naomi$_{NOM}$ crying-began$_{no\text{-}ACC}$ comforted
Ken comforted Naomi who had begun crying\end{itemize}

The one analysis in terms of using constructed epsilon terms and their process of evaluation therefore covers the types of construal that Kitagawa took to warrant three distinct types of analysis. The dynamic account thus succeeds in establishing a generalisation for which the more static account, with its presumed correspondence between resulting syntactic structure and semantic interpretation, has to impose a non-unitary analysis.

We also expect the ease with which the structures constructed from head-internal relatives can apparently be nested one within another, as upon the analysis provided a succession of these can play the role of a narrative: one linked structure is constructed from another as its immediate context, with due progressive growth in the accumulating epsilon term:

(50) [[[Ama-naru ]katai-no ateyaka-naru]-ga ideki-taru]-o yobiide-te....
nun$_{COP\text{-}AND}$ beggar$_{NOM}$ elegant$_{COP\text{-}ADN\text{-}NOM}$ came$_{ADN\text{-}ACC}$ summoned-
I summoned again a nun, a beggar,very elegant, who came (to beg).
[Pillow Book of Sei Shonagon. Section 87]

Indeed the successive building of composite epsilon terms matches the cumulative effect:

(i) *ama-naru katai-no* restrictive relative on *katai*
('a beggar who's a nun') :
ε,x, Ama'(x) ∧ Katai(x)

(ii) epsilon term to be constructed from *ama-naru katai-no ateyaka-naru*
('a beggar who's a nun that's elegant'):
Ama'(**a**) ∧ Katai' (**a**) ∧ Ateyaka' (**a**)
**a** = (ε,x, Ama'(x) ∧ Katai'(x) ∧ Ateyaka'(x))

(iii) epsilon term from *ama-naru katai-no ateyaka-naru-ga ideki-taru*
('a beggar who's a nun that's elegant who came (to beg)'):
Ama'(**a**) ∧ Katai'(**a**) ∧ Ateyaka'(**a**) ∧ Ideki'(**a**)
**a** = ε,x, Ama'(x) ∧ Katai'(x) ∧ Ateyaka'(x) ∧ Ideki'(x)

We can go further than this, however. Pursuing this style of analysis into the domain of temporal construal yields further results. Gregoromichelaki 2006 argued that the closing steps in the construal of every propositional formula involve the construction of a term denoting the witness for the event depicted by the propositional formula.[16] Adopting such an account provides the basis for anticipating the purely eventive construals of head-internal relatives, the third type of construal for example of (37) repeated below:

(51) Jiroo-wa kodomo-ga soba-o yudete-iru-no-o mita
Jiroo$_{TOP}$ child$_{NOM}$ noodle$_{ACC}$ boil$_{be\text{-}no\text{-}ACC}$ saw
A child is boiling noodles and Jiroo saw him/it$_{noodles}$/it$_{event}$

We thus have strong grounds for an account of head-internal relatives in

[16] This is part of a series of arguments that the antecedent in conditional sentences constitutes the specification of the event term relative to which the propositional structure induced from the consequent has to be evaluated, with an event term having to be postulated as an additional argument for every predicate (Gregoromichelaki 2006).

terms of a process of anaphoric substitution with the head-internal relative sequence providing the putative antecedent.

There is one idiosyncrasy of head-internal relatives which Kim took to be evidence that the process was not anaphoric: this is that in virtue of there being an obligatory particle whose encoded property is to ensure the transition from completed propositional structure onto the construction and decoration of some head node, the locality between relative clause and interpreted head has to be one of adjacency of structure. Such a locality is not a normal corollary of anaphoric processes that depend on pragmatic provision of antecedent; but, nonetheless, this pattern is exactly like relative pronouns in head-initial relatives except in reverse. In both cases, an algorithmically fixed anaphoric device ensures two token-identical copies in paired structures.

### 3.9.5. Head-Internal and Gapless Relatives Compared

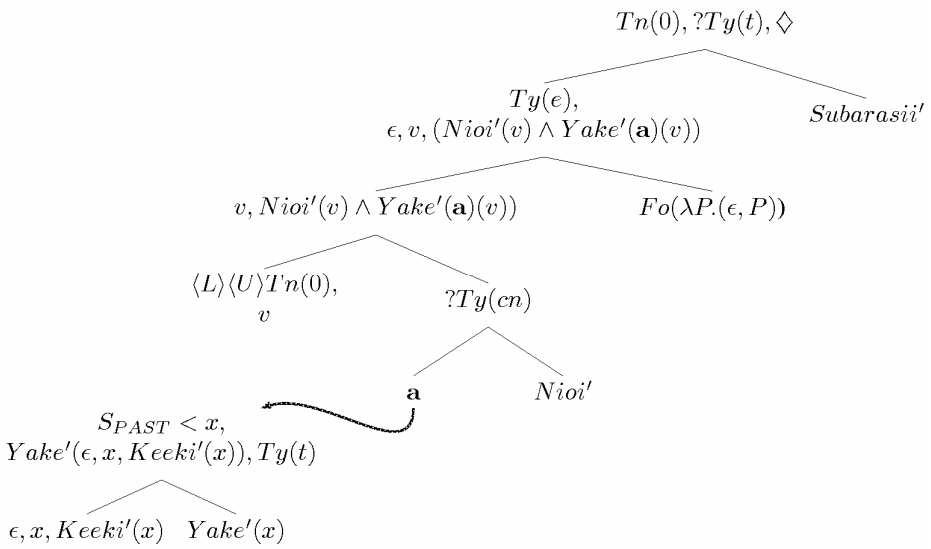
This analysis has the bonus of extending seamlessly to gapless relatives. These like head-internal relatives involve a sentential sequence capable of being fully independent before the head. Unlike head-internal relatives, however, gapless relatives have a head; and the challenge posed by these structures is that the gapless relative would seem to involve some kind of pragmatic processing in order to establish the link between relative and its head (copied from (2) above):

(52) Keeki-ga yakeru nioi-wa subarasii
Cake$_{NOM}$ bake smell$_{TOP}$ lovely
The smell such that the cake is baking is lovely

While some examples may indeed involve pragmatic reasoning, this is not essential for all structures. Indeed the strategy that can be implemented is precisely that of the head-internal relative: the only difference is that the compiled term carried over is required to function as an argument to the predicate provided by the nominal. Thus following the construal of (52) as `The smell of the cake baking is lovely', all that we need to assume is that the constructed witness of the event denoted by the entire propositional formula expressed be *Keeki-ga yakeru* is taken as the input to the LINK transition, and from the output initiation of the head structure with the provision of one argument, a skeletal nominal structure is first established and then rounded out with the parsing of *nioi*:[17]

[17] The details of this would involve an inverse step of Local*Adjunction within the nominal domain (see Cann et al 2005). This is not uncontentious, but such a process can be independently motivated.

(53)




**a** = ε,x, ($S_{PAST}$ : Keeki'(x) ∧ Yake(x))

The construal as projected here involves construing the predicate projected by the nominal as a two-place relation between that entity (the smell), and the cake baking which is being talked about. Indeed Marten 2002 argues that verbs are underspecified with respect to the number of arguments to be attributed to them; and this type of analysis merely extends such an account to nominals so that expressions such as *keeki* are taken to project predicates with varying numbers of arguments. On this assumption, the construction process involves a process of enrichment.[18]

### 3.9.6. The Syntax Pragmatics interface

Since Hoshi 1995, a lot of attention has been given to the fact that the relation between head-internal relative and its subsequent contribution to the overall structure in which it is contained can be mediated by pragmatic reasoning:

(54) John-wa goko-no koori-ga sara-no ue –de tokete-simatta
John$_{TOP}$ five-GEN ice cube$_{NOM}$ dish$_{GEN}$ top$_{LOC}$ melt have
-no-o gokugoku nonda.
*no*$_{ACC}$ gulped down
'John gulped down (the water resulting from) the five ice cubes having melted on the dish'

[18] Confirmation of this assumption might of course be expected by its commensurability with what is independently known about the baking of cakes, but there need not be an inference step as part of the construction process itself.

Unlike their head-final equivalents, such sequences are acceptable; and some intermediate step of inference seems inescapable, given that the predicate expressed by *gokugoku nonda* is incompatible with that expressed by *koori*, with no means of side-stepping this by assuming a process of enrichment of the predicates as is available in (52). This raises the puzzle as to how such broad-based, arguably common-sense reasoning, can be modelled as though an intermediary step in a construal process which is otherwise driven by purely grammar-internal mechanisms. What has to be construed as an immediate step in the processing of this form of head-internal relative is the inference, as driven by the words presented, that the five ice cubes melted. The question is how to explain this possible intermingling of syntax, semantics and pragmatics.

Given Dynamic Syntax assumptions, the answer isn't hard to find, though the details of how the transitions needed should be defined remains to be given (see Kurosawa 2003 for a preliminary study). The requisite inference in such cases is an inference from the constructed proposition of five ice cubes having melted to there being water as a result. Such an inference clearly is not made available as part of the structure directly induced from the words themselves: any move to the contrary would weaken the DS claim of syntactic explanations residing solely in the construction process of semantic tree structure representations. So it might seem that these data provide as much of a challenge to DS assumptions as they do to all others. However, all that is required is to formulate the general phenomenon of lexically grounded inferences (the familiar technical term being *meaning postulates*) in terms of optional procedures for building transitions onto accompanying linked structures. The formal mechanisms for such construction are in place. Moreover, given the constraint-based nature of the DS model, all operations are optional, so no controversial assumptions about the overall language architecture need to be stipulated in addition. There is, that is, a basis for modelling lexically driven inferences not otherwise explicitly reflected in the linguistic string. Furthermore, given the full independence of head-internal relatives, and the identical role they play in both independent clauses and as input to a transition identifying them as contributing to a relative-clause structure, it is not surprising that these optional inference steps should be legitimate. The apparent intermingling of pragmatic and structural processing is, in any case, not a problem for the DS framework of assumptions. The grammar is taken to be a formal set of constraints on monotonic tree growth, with free interaction between pragmatically driven and structural processes. Indeed this is intrinsic to the account of pronominal and other forms of anaphora. So the

apparent break down of encapsulation of structural processes in the face of such structures does not threaten the DS account, to the contrary it is in principle directly compatible with it.

## 4. Conclusion: towards a relative-clause typology

In this chapter, we have set out an account of Japanese relative clause construal in terms of encoded anaphoric devices linking one structure to another. Head-final relatives involved a computational action inducing the transition from linked structure onto some head node: head-internal relatives involved a lexically defined action associated with the particle *–no,* which induced this transition. This creates the potential for seeing relative clause construal in a newly integrated way. According to more traditional perspectives, the best that can be hoped for is a parametrised typology. Some relative clause structures, such as the head-internal relatives of Japanese might be anaphorically based, but such an explanation is not normally envisaged for head-initial relatives, since these standardly involve a complementiser and associated abstraction operation discharging a posited variable. However, to the contrary, the DS account of relative clauses is uniformly an anaphoric account: in all types of relatives, there is a grammar-induced sharing of terms. So, as it turns out, the overall picture of relative-clause variation in Japanese can be seen as a mere sub-part of a general typology of anaphoric effects in language. Natural language systems need ways of creating recursively more complex contents, but, to be robust, the means of doing this needs to be optimally simple. The solution is to use fixed anaphoric mechanisms whose effect is to chain together locally discrete sub-structures. Sensitive as such devices are to what the immediate context contains, we would not, on this view, expect symmetry between head-initial and head-final relatives, and this prediction is confirmed. Head-initial relatives allow a restrictive construal as the initial parse of the head noun will introduce a variable and this variable will be a possible input to the LINK transitions. In head-final relatives, this precise basis for construal will not be available. Nevertheless, because it is the relative which may initiate the narrative sequence in head-final relatives, these will contribute essentially to the overall content to be established by the sequence of relative-clause plus subsequent head. All that is required to achieve similar effect is to license the assumption of an epsilon term, a possibility in any case needed for a possible construal of the string making the relative. This similar but distinct basis for head-final relatives has the immediate advantage of reflecting the lack of any obvious distinction between restrictive and nonrestrictive construals for these head-final

relatives. This style of analysis also suggests an answer as to why head-initial relatives never give rise to the E-type interpretation that head-internal relatives do. it is simply because the head precedes - because, that is, there is something external to the structure to be built up which dictates the value of one argument node in that emergent structure, whether as variable or as an epsilon term. Whichever of these it is, it cannot be the completed term after some requisite scope evaluation process which constitutes the head, as in head-internal relatives, as the structure is only at this juncture being initiated as under construction.

Overall, then, though this typology of relative clauses cannot be substantiated without a much broader illustrative base, the family of relative-clause types is now firmly grounded in the prediction that all variants will be subject to explanation as grammar-internal procedures that fix construal relative to their immediate context. If this typological perspective is confirmed against the full set of relative clause types, we shall have a remarkable confirmation of the fruitfulness of adopting a perspective in which natural language grammars reflect the dynamics of incremental processing of language input in real time.

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