Nonrestrictive Relatives and Growth of Logical Form

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1. Introduction

Though familiar, the relationship between restrictive and nonrestrictive relative clause construal remains poorly understood. On the one hand, relative clause sequences may be used to restrict the range of variables over which the determiner is presumed to quantify; on the other hand they may, nonrestrictively, solely add additional information about the entity picked out by the determiner-noun sequence alone:

(1) The linguists who were drunk spoiled the party.

Nonrestrictive relatives are a paradigm case of a construction-type in which syntactic and semantic properties appear not to correspond to each other. Semantically, nonrestrictives are like conjunction, occurring wherever clausal coordination is possible:[1]

(2) John, who is the smart one in the group, is coming with us.

(3) John, and he is the smart one in the group, is coming with us.

(4) John is coming with us, who is the smart one in the group.

They are said to be compatible only with existentially quantified heads:

(5) One student, who is studying Linguistics, is keen on Philosophy.

However, this common observation is not sustainable, as any form of non-negative quantifier-noun sequence can be nonrestrictively construed:[2]

* This paper is a linguistic application of ideas formulated jointly with Wilfried Meyer-Viol, without whose input the base formalism and account of quantification could not have taken this form. Thus a large part of this paper owes its substance to him. For comments on the linguistic content, I also thank Ronnie Cann, Eleni Gregoromichelaki, Akiko Kurosawa, Jieun Kiaer, Lutz Marten, Masayuki Otsuka, Chris Potts, Chris Barker, Noel Burton-Roberts, and the audiences at Amsterdam Colloquium December 2001 and WCCFL San Diego March 2003.

1. Safir (1986), Haegemann (1988), and Fabb (1990) characterize them in terms that reflect directly this quasi-external property with some additional discourse-level construct.

2. Data such as (8) are observed in passing without analysis by Safir (1986).

 WCCFL 22 Proceedings, ed. G. Garding and M. Tsujimura, pp. 301–314. Somerville, MA: Cascadilla Press.

(6) Every parachutist, to whom the pilot gave detailed instructions, was told not to pull the cord for 20 seconds.

(7) Each child, who the Head himself interviewed, said he was regularly bullied.

(8) John shouted at every student, who immediately snapped back.

(9) Before I left, I saw most students, who I gave something to read for discussion on my return.

Confirming the interaction of nonrestrictives and quantification, pronouns in nonrestrictives can take a quantified term as antecedent, with the scope of the quantifying expression extending across the nonrestrictive relative:[3]

(10) Every parrot sang a song, which it didn't understand.

(11) Every producer paid the lead actress, who hates his guts, a fortune.

Unlike restrictively construed relatives, nonrestrictives can modify all major constituents. Again, this is like conjunction, with the relative pronoun acting like a regular pronoun:

(12) John is sick, which upsets Mary.

(13) John is sick, and it upsets Mary.

(14) John sang the Brahms, which Mary did too.

(15) John is sick, which Mary is not.

There are, then, a number of restrictions which are syntactic insofar as they are not obviously related to any denotational, semantic property. In particular, nonrestrictives have to follow all restrictive construals (Jacobson 1984; Sag 1997) — (18) and (19) are not equivalent unless both relatives are construed either restrictively or nonrestrictively:[4]

(16) A friend of mine you dislike, who I met in Prague, is coming to stay.

(17) *A friend of mine, who I met in Prague, you dislike, is coming to stay.

3. (11) is taken from Kamp and Reyle 1993.
4. There are a number of putative restrictions, e.g. that only nonrestrictives license pied-piping (Fabb 1990, Borsley 1992), that they require adjacency (Fabb 1990), but both of them face counterexamples:
(i) Every sailor the tips of whose shoes were the slightest bit scuffed was not allowed ashore.
(ii) John is coming to stay, who we haven't seen for ages.

(18) The sole which I bought yesterday which was caught in Scotland was delicious.

(19) The sole which was caught in Scotland which I bought yesterday was delicious.

Of attempts to express a semantic concept of subordination for nonrestrictive construal, the most recent (Potts 2002a; 2002b) is that nonrestrictives project a conventional implicature form of content (see Grice 1989), a filter on the truth of the whole but not part of its resulting content.[5] This account, however, would not lead one to expect that quantified expressions could be modified nonrestrictively; it also makes no provision for the relative being able to provide antecedents for pronouns, since the relative is not part of the projected truth-theoretic content:

(20) I saw a friend, who I ran up to with a book. He didn't want it.

The task of this paper is to show how the apparent subordination and mismatch between syntactic and semantic properties emerge as a consequence of the steps by which interpretation is built up, buttressing grammar formalisms that are constructed to follow the dynamics of parsing (Phillips 1996; Phillips 2002; Kempson et al. 2001).

2. Dynamic Syntax

The model in which this account is set is the Dynamic Syntax framework (Kempson et al. 2001). In this model, the process of interpreting a string means building up a logical form in tree format as structure along a time-linear dimension, in which a propositional logical formula decorates the rootnode, its subterms each of the dominated nodes. The central idea is that the building up of such trees is goal-driven within a specific context, the goal being to establish the propositional structure the speaker has intended to express (reflecting Sperber and Wilson 1986; 1995). General and lexical actions jointly induce sequences of tree-update transitions, the goals and sub-goals as introduced by computational actions imposing a top-down aspect to the interpretation process, the words themselves inducing sub-structures to meet such goals providing the bottom-up aspect. Any one sequence of actions reflects a monotonic process of tree growth that yields a complete logical form representing the interpretation that has been progressively established. More

5. An alternative analysis of nonrestrictives in terms of presupposition (see Chierchia and McConnell-Ginet 1986 for discussion) fails to capture their use to modify quantifying expressions, or their use in narrative sequences:
(i) John ignored Mary, who was extremely offended, so she refused to speak to him, which annoyed him.

specifically, goals are represented in the form $?X$ for some decoration X: for example the overall goal is introduced first, $?Ty(t)$, as the first decoration on the first node introduced — the root.[6] The decorations at each node which are then progressively introduced are expressions of a typed lambda calculus — representations of content, each a value of the *Fo* predicate (*Fo* for 'formula'). Once all nodes are introduced as directed by the overall goal, additional subgoals (so-called 'requirements') and lexical actions (steps (1)–(5) in Figure 1),[7] the nonterminal nodes are decorated by a composite process of functional-application and type-deduction (step (6) in Figure 1). Notice that the formulae which are projected by the words are not themselves words; rather, they are representations of content as established in context.

There is no reflection of linear ordering on the tree itself, which solely reflects semantic relations. The effects of linear ordering (and the constraints imposed by it) are a consequence of how individual steps in the process of building up such trees interact.

Intrinsic to this construction process are different types of underspecification. Requirements, as already introduced, by definition provide constraints on the subsequent construction process, rather than fully determining the result — see $?Ty(t)$, $?Ty(e)$, $?Ty(e \rightarrow t)$, etc., in Figure 1. Also central to the framework is a concept of structural underspecification, introducing within a tree a node whose fixed position is initially not established, being characterized at that point only as dominated by the top node. This underspecification is subsequently to be resolved by unifying such a weakly specified node with some independently provided node. This is the analysis proposed for the core cases of long-distance dependency: the concept of "a dislocated expression" is replaced by the concept of "an initially unfixed node."[8]

Interacting with both these structural forms of underspecification is a third, in which the lexical specification provided by a word under-determines the denotational content assigned to it in any individual context. One prime example is anaphora, defined to project a metavariable as placeholder for some value to be provided by context. A second is quantification, defined, following a proof-theoretic methodology, to invariably project terms of type e as the basis of quantification.[9] Determiner noun sequences are taken to project

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6. See step (i) in Figure 1: $\Diamond$ is a pointer indicating which node in the partial tree is under development.

7. Transitive verbs in English, for example, expand the tree from a predicate-requiring node introducing the subtree containing a two-place-predicate Formula and an object-requiring node, leaving the pointer at the object node awaiting development. The tree displays given display only relevant decorations, for simplicity.

8. This process bears close formal resemblance to the concept of functional uncertainty of (Kaplan and Zaenen 1989), articulated within LFG, but that framework lacks the dynamics of updating such uncertainty as part of the structural characterisation.

9. The selected logical calculus is the epsilon calculus, developed by Hilbert (Hilbert and Bernays 1939) as the formal study of arbitrary names of predicate-logic

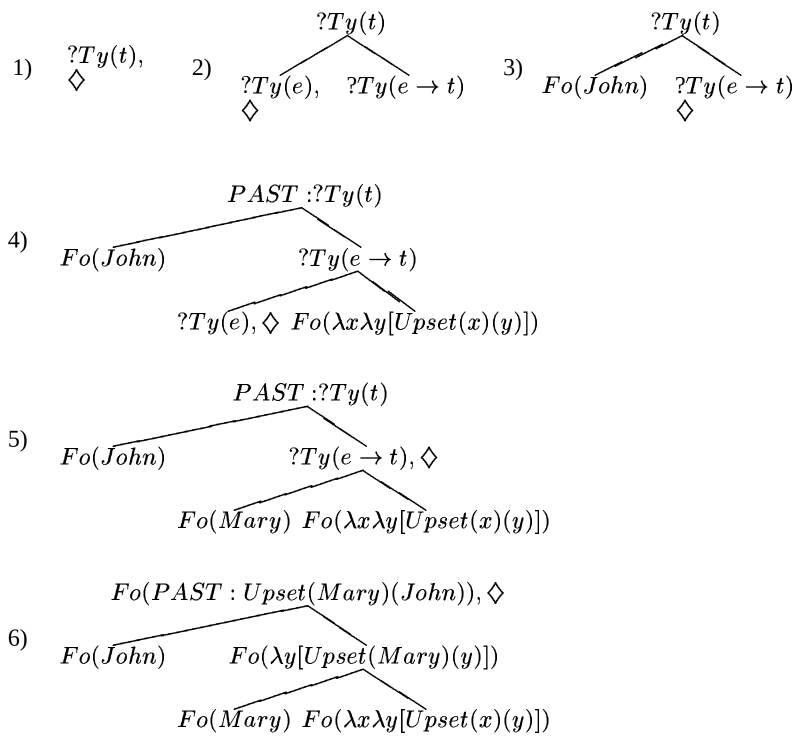


Figure 1: Parsing *John upset Mary*.

incomplete epsilon, tau, or iota terms.[10] Scope relations are not defined on the tree itself, but in the form of accompanying scope statements, which together with some completed logical form of type t are then interpreted by a scope evaluation algorithm, which determines the complex restrictor for each term that reflects its relative scope construal in the containing formula.[11] For example, parsing (21) induces a tree with rootnode formula (21′), which is

natural-deduction proofs.

10. This analysis is a structural variant of analyses of indefinites in terms of choice functions (von Heusinger 1997; von Heusinger 2000; Winter 1997).

11. This methodology for projection of scope is similar to Copestake, Flickinger and Sag (1999), but unlike them, scope statements are for relative scoping of terms alone, and not for all expressions as introduced.

evaluated as (21″), in which S represents the index of evaluation (see Appendix A for the general formal statement):[12]

(21) A man is leaving.

(21′) $S < x : Fo(Leave(\epsilon, x, Man(x)))$

(21″) $S : Man(a) \wedge Leave(a)$
where $a = (\epsilon, x, Man(x) \wedge Leave(x)))$

This pattern of term building is sustained in more complex examples also:[13]

(22) Every child ate an apple.

(22′) $S < x < y \quad Fo(Peel((\tau, x, Child(x)), (\epsilon, y, Apple(y)))), Ty(t).$

(22″) $Fo(S : Child(b) \rightarrow (Apple(a_b) \wedge Peel(b, a_b))), Ty(t)$

2.1. The Logic Of Finite Trees and tree growth

Each of these forms of underspecification interacts in the process of constructing interpretation. To define these and other forms of tree growth, a modal logic of finite trees is used (LOFT Blackburn and Meyer-Viol (1994)) with three basic operators (operators $\langle\downarrow\rangle, \langle\uparrow\rangle$ denoting daughter and mother relations respectively, and a "Link" relation between trees, $\langle L\rangle$, relating a node in one tree and the top node of another). As in Kaplan and Zaenen (1989), concepts such as domination are expressed using just the notion of daughter-relation: $\langle\downarrow_*\rangle$, the reflexive transitive closure of the daughter relation, is interpreted over the dominance relation – $\langle\downarrow_*\rangle Fo(\alpha)$ holds at some node n if within the tree of which n is the top, along some sequence of daughter relations there is a node m at which $Fo(\alpha)$ holds. The decorations that may hold at a node include not only specification of a value for the formula predicate Fo, a type specification, expressed as an argument of the predicate Ty, and a tree-node position — represented as an argument of the predicate Tn — but modal statements about decorations holding elsewhere on the tree, a flexibility which makes long-distance dependencies expressible without any concept of movement. For example, if $?\langle\downarrow_*\rangle Fo(John)$ holds at a node n, there must be in the resulting structure some node m that can be reached from n following daughter relations such that $Fo(John)$ holds at m, a form of requirement the analysis of relative clause construal will make use of.

12. The index of evaluation, S, is always first in the sequence of scope statements.
13. The evaluation is in two steps. In the first step, the indefinite, being the narrower scope term, is evaluated first, leaving the wider-scope term untreated. In the second step, the same process applies to the tau term, yielding (22″) in which:
$a_b = (\epsilon, y, (Apple(y) \wedge Peel((b, y)))$
$b = (\tau, x, Child(x) \rightarrow (Apple(a_x) \wedge Peel(x, a_x)))$
$a_x = (\epsilon, y, (Apple(y) \wedge Peel(x, y)))$.

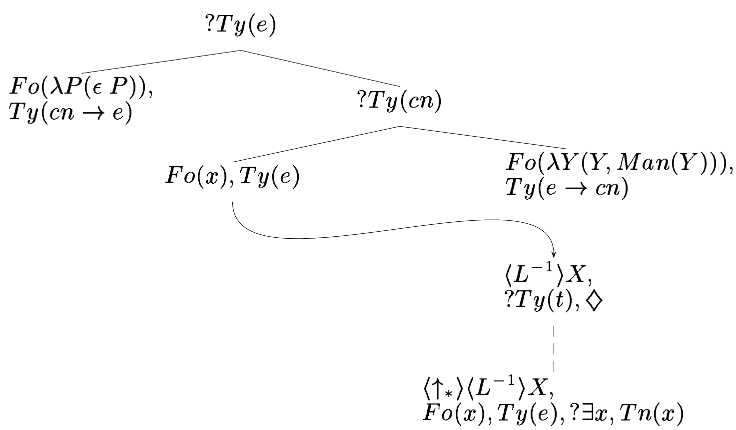
2.2. Relative clause construal: Linked structures

Interaction of underspecified tree relations, anaphoric processes, and quantification arises in the projection of pairs of trees. A pair of linked structures is by a definition a pair of independent trees which are constructed as sharing a term. The building of such trees involves the partial building of one tree, and a transition from some itemized node in that tree onto the topnode of a new tree, this new tree requiring both $?Ty(t)$ and also, somewhere within that tree, a copy of the formula decorating the itemized node. We use such processes to model relative clause construal:

(23) A man who Sue likes smokes.

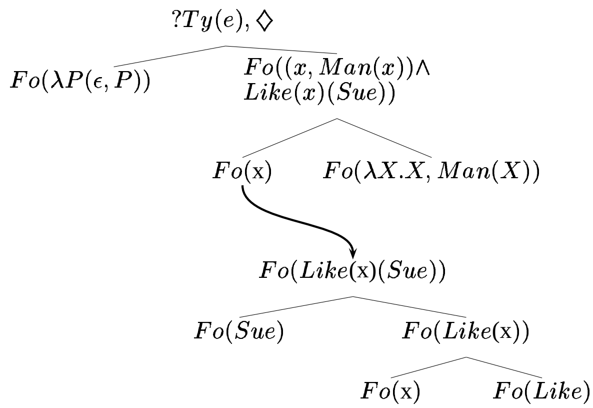
(24) John who Sue likes smokes.

An important aspect of this account is the assumption that all quantified expressions project terms of type e. Accordingly, noun phrase construal will involve the projection of a local sub-structure in which a top node of type e, immediately dominating the variable-binding term-operator projected by the determiner, dominates a second node of type e, which is decorated by the variable which the operator binds. (It is the lexical actions of nouns which introduces these variables.) The transition from one tree to another to which it is linked is from one of these type e nodes. The relative complementizer, or “relative pronoun” as Jespersen (1927) aptly called it, introduces the requisite copy of the formula at an unfixed node within that new emergent tree:



As in ‘left-dislocation’ cases, this initially unfixed node in the linked tree has its position in that tree established in due course through the process of Merge. It is this anaphoric pattern of copying information from one structure to another,[14] which we take to be the heart of relative-clause construal.[15]

Looked at from this time-linear perspective, a natural distinction between restrictive and nonrestrictive relatives emerges, depending on the stage at which the linked structure is constucted.[16] If the transition is introduced immediately after the variable is projected by the noun, we establish a restrictive relative construal (the figure displays just the type e sub-tree at the point at which the restrictor predicate is completed). In this case, the variable is copied over onto an unfixed node in the emergent structure, subsequently unified with the object node projected by the relative clause verb, and the interpretation for the whole clause is compiled as part of the restrictor for the variable:



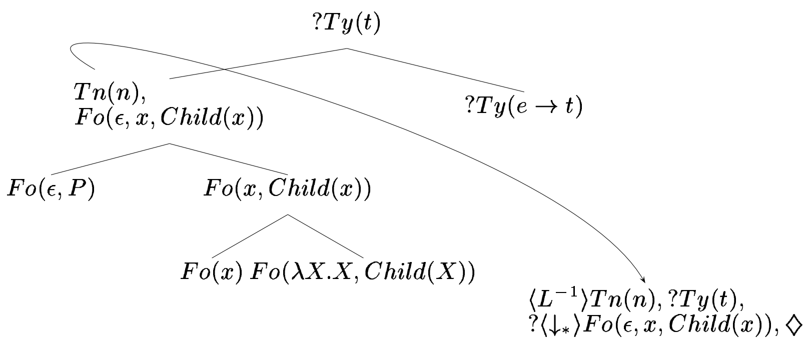
If, on the other hand, the transition is induced only once the determiner, variable and restrictor are compiled, with the LINK transition defined from the higher of the two type e nodes, then we define a nonrestrictive relative construal:

(25) A child, who John had upset, cried.

14. The only case where such a relativizer is unnecessary is where from a pointer position at the variable itself, a free lexical transition is available which induces a LINK relation directly, plus the introduction within that newly introduced structure of an unfi xed node immediately decorated with a copy of that variable.

15. Notice how in this analysis, the equivalent of co-indexing is determined *ab initio*, and not, as in other frameworks, via a bottom-up mechanism of operator-binding and predication.

16. This is unlike orthodox perspectives, in which syntactic and semantic analyses can only make reference to a static form of hierarchical structure.



The LINK transition in (2.2) induces a requirement for a copy of the incomplete term, $(\epsilon, x, Child(x))$, as a constraint on building up the linked structure. Since the restrictor is already compiled, the linked structure cannot form part of the restrictor, and the pair of trees together will yield a compound formula:[17]

$Fo(Cried(\epsilon, x, Child(x)) \ \wedge S' : Upset(John, (\epsilon, x, Child(x))))$

Once this compound formula is taken to decorate the topnode of the primary structure, the algorithm for evaluating the terms then applies to the pair of this compound formula and the scope statement $S < x$ associated with that node. The result is a compound assertion in which all occurrences of the term containing x are replaced by an appropriate arbitrary name to yield the compound existential assertion:

$$Fo(S : (Child(a) \wedge (Cried(a) \wedge S'(Upset(John, a)))))$$

where

$$a \ = \ (\epsilon, x, Child(x) \wedge (Cried(x) \wedge S' : (Upset(John, x))))$$

2.3. Nonrestrictive relatives, anaphora, and semantic subordination?

With this account, we have a direct reflection of the coordinate nature of the nonrestrictive relative clause construal, and its truth-conditional equivalence with a corresponding separate sentence in which the pronoun replaces the relative pronoun:

17. This step involves a general LINK evaluation process which applies to a pair of linked trees decorated with $Fo(\phi)$ and $Fo(\psi)$ respectively as long as they are of the same type to yield a compound formula $Fo(\phi \wedge \psi)$ decorating the node of the primary structure.

(26) A child cried. John had upset her.

As a bonus, we can express the distinction between such sequences of sentences involving pronouns on the one hand, and the restrictive relative construal of the same sentence on the other, hence resolving the problem of capturing the notion of semantic subordination expressed by a nonrestrictive relative clause. The nonrestrictive construal of (25) involves the copying of the epsilon term $(\epsilon, x, Child(x))$. In its cross-sentence near-equivalent, (26), the term that provides the value for the pronoun *her* is the epsilon term that can be constructed once the logical form for the first sentence is not only constructed but also evaluated; and this is the richer term

$$(\epsilon, x, (Child(x) \wedge Cry(x)))$$

In the restrictive construal of (25), on the other hand, the conjunction derived from the linked structure is compiled as part of the restrictor for the epsilon term under construction, which is:

$$(\epsilon, x, (Child(x) \wedge Upset(John, x)))$$

Hence the resulting construal of the different forms, though truth-conditionally equivalent (at least in the singular indefinite case), differs according to the ways in which the resulting content is built up.

Contrary to a conventional implicature analysis, on the present analysis, we expect that nonrestrictively construed relative clauses can contain antecedents for subsequent pronominals:

(27) I saw a man, who ignored a friend of mine. When she hit him, he continued to ignore her.

The data present no more of a problem than regular cross-sentential identification of a pronoun with some epsilon term as antecedent, leading to the construction of a new extended epsilon term in the logical form constructed for the sentence containing the pronoun.

Nonrestrictive relative modification is also expected to be freely available to all noun phrases, not merely indefinites or names:

(28) Every referee, who I had personally selected, turned down my research application.

(29) Every parachutist, who was instructed by the pilot, was warned not to open his parachute too early.

In these cases, it is the term under construction — in (29) $(\tau, x, Parachutist(x))$ — that is imposed as a requirement on the linked structure. It is then the combination of the LINK evaluation rule and a subsequent single process of scope evaluation which ensures that the construal of the linked structure forms a conjunction in the consequent of the conditional associated with the evaluation of the tau term. The resulting logical form is:[18]

$$S < x : \ (Warned(\tau, x, Parachutist(x)) \ \wedge \ (Instructed(\tau, x, Parachutist(x))$$

with its fully evaluated form:

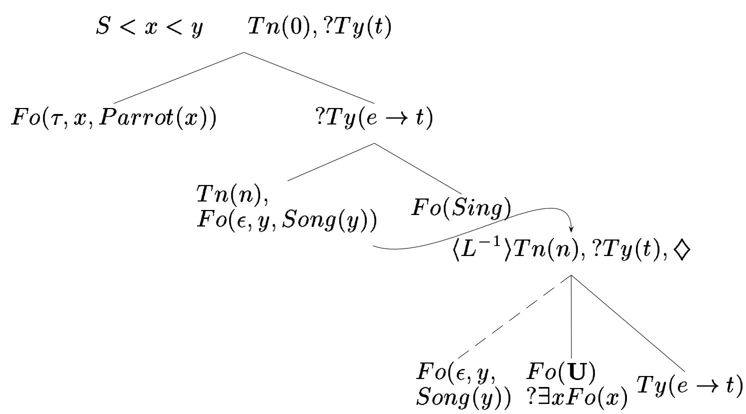
$$S : Parachutist(a) \rightarrow (Warned(a) \wedge Instructed(a))$$

$$a = \tau, x, Parachutist(x) \rightarrow (Warned(x) \wedge Instructed(x))$$

There are a number of further consequences. For example, quantifiers in the main clause may bind pronouns in the relative (Safir 1986):[19]

(30) Every nurse alerted the sister, who congratulated her on her prompt reaction.

(31) Every parrot sang a song, which it ruined.



In the processing of (31), there are two terms under construction, $(\tau, x, Parrot(x))$, and $(\epsilon, y, Song(y))$. With the object having a relative clause as modification, it is $\epsilon, y, Song(y)$ that is imposed as the requirement on the newly introduced linked structure and projected onto the unfixed node in that structure. Nothing precludes the first term, $(\tau, x, Parrot(x))$,

18. The internal structure of the two verb-phrases *was instructed by the pilot* and *was warned not to open his parachute too early* are simplifi ed to '*Instructed*' and '*Warned*,' respectively.
19. By convention, **U**, **V**, . . . indicate metavariables.

from being identified as the antecedent to the pronoun in that relative. The LINK evaluation statement will be essential to the interpretation, creating the necessary conjunctive formula; the result may be a logical form which with selection of the epsilon term as taking narrower scope than the tau term:

$$S < x < y \quad Sing((\tau, x, Parrot(x)), (\epsilon, y, Song(y))) \wedge$$
$$S' : Ruin((\tau, x, Parrot(x)), (\epsilon, y, Song(y)))$$

Its subsequent evaluation yields:

$$S : (Parrot(a) \rightarrow (Song(b_a) \wedge Sing(a, b_a) \wedge S' : Ruin(a, b_a)))$$

Notice how the content of the nonrestrictive emerges to the right of the major connective. The LINK evaluation rule, as before, acts as a scope extending device so that terms in any linked structure may be interpreted as within the scope of a term introduced in the primary structure, a result that in other frameworks would require an itemised rule of accommodation (Roberts, 1989) to license the binding across the clausal boundary.[20]

2.4. Relative ordering restrictions

Like the semantic properties, the syntactic properties of nonrestrictive relatives also emerge as a consequence of this analysis — in particular, the fact that nonrestrictive relative construal has to follow all restrictive relative construals:

(32) An interviewer you disliked who I was on good terms with is now in Beijing.

(33) *An interviewer, who I was on good terms with, you disliked, is now in Beijing.

This simply follows from the fact that in order to license the transition to induce a nonrestrictive relative, a type e term must be compiled, and this in its turn necessitates the compilation of a cn value. If the two forms of relative clause construal are to occur together, it follows that the restrictive relative, which is a construction strategy for expanding a formula at a cn node, must occur before the nonrestrictively construed sequence, and not after it. As we would expect, this result does not differentiate between different types of quantifying expression, so it extends to universally quantified expressions:

20. Also licensed are nonrestrictively modified quantified expressions taking narrow scope with respect to some following quantified expression:
(i) A referee, who I had personally recommended, rejected each project application.

(34) Every interviewer you disliked, who I was on good terms with, liked our CVs.

As further expected, the nonrestrictive in (34) has to be interpreted as modifying *every interviewer you disliked* and not *every interviewer*.

3. Summary — The general perspective

One striking property of the present analysis is how the two forms of relative clause construal and their attendant structural properties have been explained in terms of how the various mechanisms for building up structure interact, variation in construal emerging as a consequence of the different points in the interpretation process at which such structures can be introduced. The analysis turned on the account of quantification as invariably projecting terms of type e, for it was this that provided the discrete points at which the process of LINK Introduction could apply. More generally, semantic properties are defined over a structured representation, which is built up through the progressive update process which constitutes natural language parsing. Both semantic and syntactic properties have been explained by the form of that output representation and the process of incrementally establishing it. The mismatch between syntactic and semantic properties promises to dissolve.[21] The syntactic properties of nonrestrictive forms of construal are displayed in nothing more than the progressive projection of their required semantic structure. With quantification analysed in terms of type e terms, subject to a process of growth, nonrestrictive relative clause construal provides one piece of evidence in favor of the dynamic time-linear nature of natural-language syntax.

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21. The post-posing of nonrestrictive relatives involves a characterisation in terms of a form of correlative construction, which we omit for reasons of space. The ability to modify other constituents than type e have been left on one side pending a full account of temporal specification, but, in principle, given the anaphoric nature of the explanation, these are not unexpected.

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