Comparison of the Ellipsis-Based Theory of Non-Constituent Coordination with its Alternatives

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Abstract

In this paper, I compare the ellipsis-based theory of non-constituent coordination proposed in Yatabe (2001) with three of its alternatives, namely the theory that has been widely accepted within the context of Categorial Grammar, Mouret's HPSG-based theory, and the theory proposed by Bachrach and Katzir in the framework of the Minimalist Program. It is found (i) that the CG-based theory of non-constituent coordination cannot deal with medial RNR, i.e. a subset of right-node raising constructions in which either all or a part of the right-node-raised material is realized at a location other than the right edge of the final conjunct, (ii) that Mouret's theory encounters similar difficulties when applied to RNR, and (iii) that Bachrach and Katzir's theory cannot be applied to left-node raising in English, has difficulty capturing the semantic inertness of medial RNR, and overgenerates in several ways. The ellipsis-based theory, on the other hand, appears to be consistent with all the observations.

1 Introduction

In this paper, I compare the ellipsis-based theory of non-constituent coordination that has been proposed in Yatabe (2001), Crysmann (2003), Yatabe (2003), and Beavers and Sag (2004) with three of its alternatives, namely the theory that has been widely accepted within the context of Categorial Grammar (CG) (Steedman (2000)), the HPSG-based theory of Mouret (2006), and the theory proposed in Bachrach and Katzir (2007) and Bachrach and Katzir (2009) in the framework of the Minimalist Program (MP). I will examine, among other things, a subset of right-node raising (RNR) constructions in English and Japanese in which either all or a part of the right-node-raised material is realized at a location other than the right edge of the final conjunct, and argue that the properties of such constructions favor the ellipsis-based theory.

2 Levine's criticism of the ellipsis-based theory

Before embarking on the main discussion of this paper, I will make a few brief remarks concerning Levine's criticism of the ellipsis-based theory (Levine (2011)).

First, the ellipsis-based theory of non-constituent coordination that will be defended below is one in which a linearization-related operation such as RNR-inducing ellipsis is allowed to affect semantic interpretation, namely the type of theory proposed in Yatabe (2001) and Beavers and Sag (2004). This theory is compatible with the fact that the meaning of a sentence involving non-constituent coordination (e.g. sentence (1a), from Crysmann (2003)) can be different from

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that of its supposed counterpart involving no ellipsis (e.g. sentence (1b), also from Crysmann (2003)).

(1) a. I gave few men a book on Friday and a record on Saturday.

b. I gave few men a book on Friday and gave few men a record on Saturday.

As Levine notes, the question of under what circumstances the meaning of a sentence involving a right-node-raised or left-node-raised quantifier *must* be different from that of its counterpart involving no ellipsis is unresolved in the ellipsis-based theory. However, it is equally unresolved in other theories and thus should not be regarded as a reason to favor one theory over another.

Second, I concur with Levine (2011) that Beavers and Sag (2004) are wrong in claiming that the ellipsis-based theory of non-constituent coordination provides a solution for the problem of coordination of unlikes and the problem posed by an example like *every man and woman*. However, this observation does not constitute a reason to be skeptical of the theory, since there is no reason why a theory of non-constituent coordination has to provide a solution for these problems. (See Yatabe (2004) for an analysis of coordination of unlikes that does not rely on but is compatible with the ellipsis-based theory of non-constituent coordination.)

And third, it is possible to augment the ellipsis-based theory with a mechanism that makes it capable of delivering the correct truth conditions for sentences like (2) as well as sentences such as (3).

(2) Robin reviewed, and Leslie read, the same book.

(3) John gave Mary, and Joan presented to Fred, books which looked remarkably similar. (Abbott (1976))

In the theory to be presented in section 5 below, in which semantic interpretation is performed largely within order domains as suggested in Yatabe (2001), a sentence like (2), which is the result of right-node-raising the noun phrase *the same book* out of the two clauses whose order domains are depicted in (4) and (5) respectively, is optionally assigned an order domain like (6), where $\boxed{2{+}4}$ is an index whose interpretation is the sum of the interpretations of $\boxed{2}$ and $\boxed{4}$.

(4) $$\left\langle \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{5}\\ \textsc{reln} & \textit{name}\\ \textsc{name} & \textit{Robin}\\ \textsc{named} & \boxed{1}\end{bmatrix}\right\rangle\right], \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{5}\\ \textsc{reln} & \textit{reviewed}\\ \textsc{agent} & \boxed{1}\\ \textsc{theme} & \boxed{2}\end{bmatrix}\right\rangle\right], \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{7}\\ \textsc{reln} & \textit{the-same}\\ \textsc{inst} & \boxed{2}\end{bmatrix}, \begin{bmatrix}\textsc{hndl} & \boxed{7}\\ \textsc{reln} & \textit{book}\\ \textsc{inst} & \boxed{2}\end{bmatrix}\right\rangle\right]\right\rangle$$

(5) $$\left\langle \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{6}\\ \textsc{reln} & \textit{name}\\ \textsc{name} & \textit{Leslie}\\ \textsc{named} & \boxed{3}\end{bmatrix}\right\rangle\right], \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{6}\\ \textsc{reln} & \textit{read}\\ \textsc{agent} & \boxed{3}\\ \textsc{theme} & \boxed{4}\end{bmatrix}\right\rangle\right], \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{7}\\ \textsc{reln} & \textit{the-same}\\ \textsc{inst} & \boxed{4}\end{bmatrix}, \begin{bmatrix}\textsc{hndl} & \boxed{7}\\ \textsc{reln} & \textit{book}\\ \textsc{inst} & \boxed{4}\end{bmatrix}\right\rangle\right]\right\rangle$$

(6) $$\left\langle \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{7}\\ \textsc{reln} & \textit{and}\\ \textsc{conjuncts} & \left\langle\boxed{5},\boxed{6}\right\rangle\end{bmatrix}\right\rangle\right], \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{5}\\ \textsc{reln} & \textit{name}\\ \textsc{name} & \textit{Robin}\\ \textsc{named} & \boxed{1}\end{bmatrix}, \begin{bmatrix}\textsc{hndl} & \boxed{5}\\ \textsc{reln} & \textit{reviewed}\\ \textsc{agent} & \boxed{1}\\ \textsc{theme} & \boxed{2}\end{bmatrix}\right\rangle\right], \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{6}\\ \textsc{reln} & \textit{name}\\ \textsc{name} & \textit{Leslie}\\ \textsc{named} & \boxed{3}\end{bmatrix}, \begin{bmatrix}\textsc{hndl} & \boxed{6}\\ \textsc{reln} & \textit{read}\\ \textsc{agent} & \boxed{3}\\ \textsc{theme} & \boxed{4}\end{bmatrix}\right\rangle\right], \left[\textsc{ss}\mid\textsc{cn}\mid\textsc{ep}\ \left\langle\begin{bmatrix}\textsc{hndl} & \boxed{7}\\ \textsc{reln} & \textit{the-same}\\ \textsc{inst} & \boxed{2{+}4}\end{bmatrix}, \begin{bmatrix}\textsc{hndl} & \boxed{7}\\ \textsc{reln} & \textit{book}\\ \textsc{inst} & \boxed{2{+}4}\end{bmatrix}\right\rangle\right]\right\rangle$$

Assuming that the second last elementary predication inside (6) means that the denotation of $\boxed{2}$ and that of $\boxed{4}$ are the same, (6) can be seen to represent an appropriate truth condition. Thus Levine's criticism based on (2) is invalid.

3 Problems with the CG-based theory and Mouret's theory

In this section, some problems with the CG-based theory and Mouret's HPSG-based theory will be pointed out. Mouret's HPSG-based theory of what the author calls argument-cluster coordination (Mouret (2006)) and the CG-based theory are both based on the view that there are cases where a string that is not considered to be a constituent in other theories nevertheless functions as a syntactic unit and that so-called non-constituent coordination is coordination of such unconventional syntactic units. For instance, the string *a book on Friday* and the string *a record on Saturday* in (1a) are regarded as such unconventional, conjoinable syntactic units in these theories.

I will begin by recapitulating Wilder's and Whitman's findings about RNR in English (Wilder (1999); Whitman (2009)), which are potentially problematic for the CG-based theory and Mouret's theory alike. It has been noted in their respective work that English sometimes allows right-node-raised material to be realized at a location other than the right edge of the final conjunct, as in (7)–(9), where the right-node-raised expressions are shown in italics.

(7) John should fetch and give *the book* to Mary. (from Wilder (1999))

(8) After using dishes, please wash, dry, and put *them* away in the proper place. (from Whitman (2009))

(9) . . . the whiskey drowns and the beer chases *my blues* away. (op. cit.)

Let us refer to the phenomenon illustrated by these examples as medial RNR. The existence of medial RNR will be problematic for any attempt to apply Mouret's theory to RNR in English, although that obviously should not be held against his theory as a theory of argument-cluster coordination. The CG-based theory, on the other hand, may not necessarily be contradicted by the existence of sentences like these. Whitman presents a CG-based theory of medial RNR in which the right-node-raised expression in each of these examples is in a sense located at the right edge of the final conjunct, but undergoes wrapping, i.e. a phonological process that inserts an expression into the phrase that it syntactically combines with. Whitman, however, goes on to point out some examples of medial RNR for which his analysis may not be applicable. Thus, it seems fair to say that it remains uncertain whether the CG-based theory can provide a comprehensive account of medial RNR in English or not.

RNR in Japanese poses related but more recalcitrant problems for these theories, especially for Mouret's theory. First of all, in Japanese, that part of a conjunct that does not undergo RNR in an RNR construction does not have to be a sequence of sister constituents, as shown by (10), where *Taroo wa* and *Sendai* are most probably not sisters. This fact makes it difficult to apply to RNR in Japanese Mouret's theory of argument-cluster coordination, which is designed to capture the more restricted nature of argument-cluster coordination in French.[1] Again, this does not necessarily mean that Mouret's theory is incorrect as a theory of argument-cluster coordination. However, since argument-cluster coordination in French and RNR in Japanese are mirror images of each other to a certain extent, a theory that treats the two in a uniform fashion seems preferable, other things being equal.

(10) [Hanako wa] Aizu, soshite [Taroo wa] [[Sendai no] sake o] nonda.
[Hanako TOP] Aizu and [Taroo TOP] [[Sendai GEN] sake ACC] drank
'Hanako drank sake from Aizu, and Taro drank sake from Sendai.'

(Here and elsewhere, when a Japanese example is used, words belonging only to the non-final conjunct are shown in purple, words belonging only to the final conjunct are shown in blue, and words shared by the two conjuncts are shown in red. The tense morpheme in an example like this may be outside the coordinate structure, but such details of Japanese morphosyntax will be ignored in this paper.)

More significantly, as the example in (11) shows, the phenomenon of medial RNR exists in Japanese as well, and here it does not seem possible to deal with the phenomenon using the mechanism of wrapping.[2] This is problematic both for the CG-based theory and for Mouret's theory.

(11) [Too-densha wa], [ichi-ryoo-me kara roku-ryoo-me made wa] [Ebina
[this train TOP] [Car No. 1 from Car No. 6 to TOP] [Ebina
de] Hon-atsugi-iki, [nana-ryoo-me kara saki wa]
at] train bound for Hon-atsugi [Car No. 7 from beyond TOP]
[Katase-enoshima-iki ni] [Shin-yurigaoka de], sorezore
[train bound for Katase-enoshima DAT] [Shin-yurigaoka at] respectively
setsuzoku itashimasu.
will connect
'Cars No. 1 to No. 6 of this train will connect with a train bound for Hon-atsugi at Ebina Station, and the rest of the cars will connect with a train bound for Katase-enoshima at Shin-yurigaoka Station.' <5, 7, 3, 0>

In this example, the expression *Shin-yurigaoka de* 'at Shin-yurigaoka Station', which semantically belongs only to the second conjunct, is sandwitched between two strings *ni* 'DAT' and *sorezore setsuzoku itashimasu* 'will connect respectively', which are both shared by the two conjuncts. There seems to be no natural way to apply Whitman's theory to sentences of this type.

[1] Abeillé and Mouret (2011) observe that the theory cannot be applied to RNR in French either.

[2] This example, which has the adverb *sorezore* 'respectively' inside the right-node-raised material, is another illustration of the fact noted in Section 2 that the type of ellipsis that yields non-constituent coordination is allowed to affect semantic interpretation.

To demonstrate that sentences like this are actually acceptable to native speakers, a questionnaire study has been conducted. The numbers following (11) and some other example sentences below show the result of that questionnaire study; the four figures indicate the number of respondents who stated ‘The sentence is completely natural (under the intended reading)’, ‘The sentence is slightly unnatural (under the intended reading)’, ‘The sentence is considerably unnatural (under the intended reading)’, and ‘The sentence is completely impossible (under the intended reading)’, respectively.[3] The figures above indicate that (11) is an acceptable, if slightly unnatural, sentence.

The fact that instances of medial RNR are generally judged to be less than perfect can be interpreted as a result of the degraded parallelism between the conjuncts in such sentences, and therefore does not necessarily justify the view that medial RNR is in fact not allowed by the grammar. If instances of medial RNR were to be analyzed as acceptable but ungrammatical sentences, then there would have to be an explanation as to why such sentences are felt to be more or less acceptable in English and Japanese (and in French as well according to Mouret and Abeillé (2011)), and it is at least not obvious how such an explanation could be obtained.

It might seem possible to reconcile the CG-based theory with the existence of medial RNR in Japanese by postulating a phonological rule that says that a particle such as *ni* can be optionally dropped when it occurs at the end of a conjunct, but such a move would be problematic for the following two reasons. First, such a phonological rule is arguably not a natural rule to have in the CG-based theory. In the ellipsis-based theory, such a phonological rule, if it existed, could be interpreted as saying that, when ellipsis takes place at the end of a conjunct, an extra word can be dropped as well as long as that extra word is merely a particle. In contrast, there is no way to make intuitive sense out of such a phonological rule in the CG-based theory. Second, such a phonological rule would make an empirically incorrect prediction. For example, a sentence like (13), which is the result of dropping *ni* at the end of the first conjunct in (12), would be incorrectly predicted to be acceptable.

(12) [Reijoo o] [okyakusama-gata ni], soshite [sono ato]
[thank-you note ACC] [guests DAT] and [after that]
[shoosetsu no tsuzuki o] kaita n desu. <4, 6, 1, 1>
[novel GEN continuation ACC] wrote
‘(I) wrote thank-you notes to the guests and then (wrote) the continuation of the novel.’

(13) ?*[Reijoo o] okyakusama-gata, soshite [sono ato] [shoosetsu no
[thank-you note ACC] guests and [after that] [novel GEN

[3] Let us define the *average rating* for a linguistic expression L as $(1a+2b+3c+4d)/(a+b+c+d)$, when the questionnaire result for L is $<a, b, c, d>$, and let us represent the average rating for L as $r(L)$. A linguistic expression L that is associated with a questionnaire result is shown in this paper with no diacritic if $1 \leq r(L) < 2$, with ‘?’ if $2 \leq r(L) < 2.5$, with ‘??’ if $2.5 \leq r(L) < 3$, with ‘?*’ if $3 \leq r(L) < 3.5$, and with ‘*’ if $3.5 \leq r(L) \leq 4$.

tsuzuki o] kaita n desu. <0, 2, 6, 4>
continuation ACC] wrote
'(I) wrote thank-you notes to the guests and then (wrote) the continuation of the novel.'

The fact is that a particle can be dropped at the end of a non-final conjunct only when the same particle appears somewhere inside the final conjunct, as in (14), which is another instance of medial RNR.

(14) [Reijoo o] okyakusama-gata, soshite [sono ato] [yuujin-tachi
[thank-you note ACC] guests and [after that] [friends
ni] [nengajoo o] kaita n desu. <3, 7, 2, 0>
DAT] [New Year's card ACC] wrote
'(I) wrote thank-you notes to the guests and then (wrote) New Year's cards to my friends.'

In order to account for the contrast between (13) and (14) while retaining the CG-based theory, it would be necessary to postulate a phonological rule that says that a particle such as *ni* can be optionally dropped at the end of a non-final conjunct if the same particle appears somewhere inside the final conjunct. In other words, it would be necessary to incorporate the ellipsis-based theory into the CG-based theory, if our goal were to capture the contrast in question without abandoning the CG-based theory. The resulting theory would arguably be less credible than the ellipsis-based theory, in that the latter can handle all cases of RNR in a uniform manner while the former cannot.

4 Problems with Bachrach and Katzir's theory

Let us turn our attention to the MP-based theory proposed in Bachrach and Katzir (2007) and Bachrach and Katzir (2009). This theory builds on the idea (expressed by McCawley and others) that an expression can have more than one mother, and uses that idea to deal with RNR as well as phenomena that are analyzed in terms of movement in MP-based theories. For example, in this theory, the phrase *the same book* in (2) is analyzed as having two mothers (the first VP node and the second VP node), and the phrase *which book* in *Which book did you like?* is similarly analyzed as having two mothers (the root CP node and the VP node).

This theory is disproved by the existence of examples like (15) below.

(15) Who do you think, and who don't you think, that John will see?

This sentence is incorrectly predicted to be impossible by Bachrach and Katzir's theory. In their theory, the first *who* in this sentence is taken to be multiply dominated and to exist at the beginning of the first conjunct and in the object position immediately following the verb *see* simultaneously, although it is pronounced only at the former location. The second *who* is likewise taken to be multiply dominated and to exist at the beginning of the second conjunct and in the object position immediately following the verb *see*. The problem here is that the first *who* and the second *who* are both taken to be in the object position immediately following *see*. On one hand, two different expressions are not allowed to be present at the same location in this theory (or in any other theory), and on the other hand, the verb *see* can take at most one object, not two, so there is no coherent structure that can be assigned to this sentence.

Rather than rejecting the theory outright for this reason, I will recast their theory as a theory of RNR alone (rather than a theory of all types of *wh*-movement as well as RNR) and compare that theory with the ellipsis-based theory of non-constituent coordination.

When recast as a theory of RNR alone, Bachrach and Katzir's theory turns out to bear considerable similarities to the theory proposed in Yatabe (2001) and Beavers and Sag (2004). The *D-list* in the former theory corresponds to the order domain in the latter theory, and SpellOut that is obligatorily triggered by a "phase node" in the former theory corresponds to total compaction in the latter theory.

One notable feature of Bachrach and Katzir's theory that sets it apart from the HPSG-based theories is that their theory contains no grammatical rule that is specifically responsible for generating RNR constructions or other types of non-constituent coordination. In their theory, the order of words is determined according to some general principles including (16), (17), and (19), and the existence of RNR constructions is a consequence of the way those principles interact.

(16) The D-list for a node X has all the terminals dominated by X as members, and only them.

(17) If y is completely dominated by X, then y appears on the D-list of X exactly once.

(18) **Complete Dominance:** A node X completely dominates a node Y iff (a) X is the only mother of Y, or (b) X completely dominates every mother of Y.

(19) In ordering $A = \langle a_1, \ldots, a_m \rangle$ to the left of $B = \langle b_1, \ldots, b_n \rangle$, written $A \bullet B$, the following must hold:

a. *Edge Alignment:* $a_1 \leq b_1$ and $a_m \leq b_n$

b. *Conservativity:* $a_1 \leq a_2 \leq \ldots \leq a_m$ and $b_1 \leq b_2 \leq \ldots \leq b_n$

When coupled with the operation of Parallel Merge, which allows an expression to be merged with multiple expressions simultaneously, these principles automatically give rise to RNR constructions while ruling out ungrammatical strings like (20), in which an expression has been right-node-raised from a medial position inside the first conjunct.

(20) *John should give the book and congratulate that girl.

Although the theory as it is presented in Bachrach and Katzir (2009) contains a stipulation that disallows medial RNR, it is possible to construct a variant of their theory that does away with that stipulation.

This ambitious and interesting theory, however, has the following three problems. First, the theory in question cannot be applied to left-node raising in a language like English. For instance, in their theory, it is not possible to analyze a sentence like *Mary went to London on Saturday and Paris on Sunday* as involving left-node raising of the string *went to*, because the presence of the word *and* at the beginning of the second conjunct prevents the string *went to* from being multiply dominated by the two VPs. This is a weakness of the theory, unless there turns out to be some fundamental difference between LNR and RNR.

Second, the theory fails to capture the semantic inertness of medial RNR noted in Sabbagh (2012). As noted above, it is easy to construct a variant of their theory that allows medial RNR. However, the resulting theory would most likely incorrectly entail that medial RNR could affect semantic interpretation just like non-medial RNR. In the theory proposed in Bachrach and Katzir (2007), interpretation of right-node-raised material is optionally delayed until the bottom-up interpretation procedure gets to the node that completely dominates the material, i.e. the node that dominates all the mothers of that material. There is nothing else in the theory that is specifically designed to affect the interpretation of sentences involving RNR. In such a theory, there is no reason to suppose that the semantic properties of medial RNR are any different from those of non-medial RNR; it must be possible to delay the interpretation of right-node-raised material irrespective of whether the RNR involved is medial or not. Thus the theory leads us to expect, incorrectly according to Sabbagh (2012), that the quantifier *every suspected arsonist* can take wide scope over the disjunction in (21), just as it can in (22).

(21) The lieutenant will either arrest or shoot every suspected arsonist with his rifle.

(22) The lieutenant will either arrest or shoot with his rifle, every suspected arsonist.

Third, the theory presented in Bachrach and Katzir (2009) overgenerates in several ways. To start with, the theory allows the right edge of a phrase and the left edge of the immediately following phrase to be fused. Thus the theory predicts that a sentence like (23), in which the expression *Mary* serves as the final word of the first conjunct and as the first word of the second conjunct at the same time, is grammatical. This prediction is made even by the original version of their theory, which disallows medial RNR.

(23) *John met Mary laughed and Bill was surprised. (as a sentence that means 'John met Mary, Mary laughed, and Bill was surprised')

Likewise, ill-formed sentences like (24), first noted by Paul Dekker and discussed in Steedman (2000, p. 269) among other places, are not ruled out in the theory

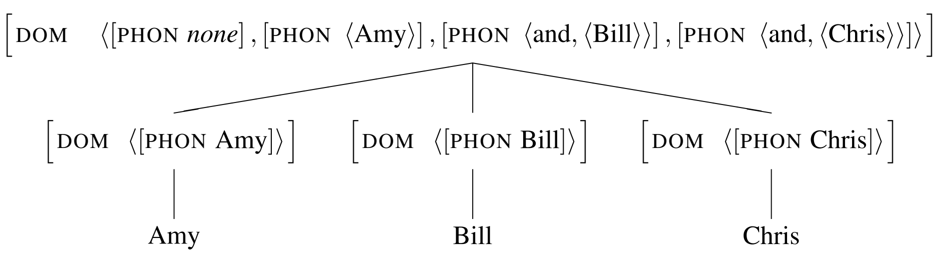

Figure 1: Part of the structure assigned to *Amy and Bill and Chris*

under discussion.

(24) *The mother of and Bill thought John arrived. (as a sentence that means 'The mother of John arrived and Bill thought John arrived')

The problem of overgeneration will be exacerbated if the stipulation that blocks medial RNR is excised from the theory. For instance, the resulting theory will even generate sentences like the following.

(25) a. *I talked to and looked at the car that I persuaded the man to purchase. (as a sentence that means 'I talked to the man and looked at the car that I persuaded the man to purchase')

b. *I looked at and the owner of the car noticed. (as a sentence that means 'I looked at the car and the owner of the car noticed')

5 Details of the ellipsis-based theory

In this penultimate section, it will be shown that the ellipsis-based theory is in fact capable of capturing all the observations mentioned above, provided that some minor modifications are made to it. I will first describe the way conjunctions such as *and* and *or* are treated in the proposed theory, and then go on to present the details of the revised version of the ellipsis-based theory. I presuppose familiarity with Linearization-based HPSG (Reape (1994)), especially the version of the theory adopted in Yatabe (2001), whose basics are presented in Yatabe (2009, section 19.2.1) among other places.

In the theory proposed here, conjunctions such as *and* and *or* are introduced into syntactic structures not by phrase-structure rules or by constructional schemas but by linearization-related constraints. Thus the phrase *Amy and Bill and Chris* is assigned a syntactic structure like the one shown in Figure 1, where the word *and* does not appear even once as a node in the phrase-structure tree.

There are two partially interrelated motivations for dealing with conjunctions in terms of linearization-related constraints. Firstly, as noted in Hudson (1988) and Mouret (2006), the position of the first conjunction in a sentence like *John gave neither a book to Mary nor a record to Bill* is difficult to account for in a theory in which the traditional kind of constituent structure is assumed and the positions of conjunctions (such as *neither*) are dictated by phrase-structure rules. Second, while left-node raising can generally affect only strings at the left edge of a phrase, the presence of a conjunction at the left edge of a phrase does not prevent the words following it from being left-node-raised, as noted above in section 4. For instance, if the sentence above is to be analyzed as an instance of left-node raising, then the verb *gave* needs to be left-node-raised out of the two conjuncts despite the apparent presence of *neither* at the beginning of the first conjunct and of *nor* at the beginning of the second conjunct. This arguably means that there is a grammatical representation in which conjunctions like *neither* and *nor* are not part of the conjuncts.

This analysis can be implemented as follows. As part of the constraints that are applied to *coord-cx* (i.e. *coordinate-construction*), I propose to have (26).

(26) *coord-cx* $\Rightarrow$

$$\left[\begin{array}{ll} \textsc{mother} & \left[\begin{array}{ll} \textsc{ss} \mid \textsc{cont} \mid \textsc{semhead} & \boxed{h} \\ \textsc{dom} & \boxed{D_0} \end{array}\right] \\ \textsc{daughters} & \left\langle \boxed{1}\left[\textsc{ss} \mid \textsc{cont} \mid \textsc{ltop}\ \boxed{t_1}\right], \cdots, \boxed{n}\left[\textsc{ss} \mid \textsc{cont} \mid \textsc{ltop}\ \boxed{t_n}\right] \right\rangle \end{array}\right]$$

where the following condition holds:

$$\Big(\text{coord\_dom}\big(\langle\boxed{1}, \cdots, \boxed{n}\rangle, \boxed{D_0}, \boxed{f}\big) \vee \text{pnr\_dom}\big(\langle\boxed{1}, \cdots, \boxed{n}\rangle, \boxed{D_0}, \boxed{f}\big)\Big)$$

$$\wedge\ \boxed{f} : \left[\begin{array}{ll} \textsc{ss} \mid \textsc{cont} & \left[\begin{array}{ll} \textsc{ep} & \left\langle \left[\begin{array}{ll} \textsc{hndl} & \boxed{h} \\ \textsc{reln} & \boxed{c} \\ \textsc{conjuncts} & \langle\boxed{t_1}, \cdots, \boxed{t_n}\rangle \end{array}\right] \right\rangle \\ \textsc{h-cons} & \{\} \\ \textsc{h-store} & \{\} \end{array}\right] \\ \textsc{phon} & \textit{none} \end{array}\right] \wedge\ (\boxed{c} = \textit{and}\ \vee\ \boxed{c} = \textit{or}).$$

The *coord_dom* relation, employed in (26), is defined in (27), and the *pnr_dom* relation, which is used in (26) to allow left-node raising and right-node raising, will be defined in (29).

(27) $$\text{coord\_dom}\big(\langle\boxed{1}, \cdots, \boxed{n}\rangle, \boxed{D_0}, \boxed{f}\big) \equiv$$
$$\boxed{S} : \langle\boxed{1}\rangle \bigcirc \cdots \bigcirc \langle\boxed{n}\rangle \quad \wedge \quad \boxed{S} : \big\langle\boxed{s_1}, \cdots, \boxed{s_n}\big\rangle$$
$$\wedge\ \ \text{totally\_compact}\big(\boxed{s_1}, \boxed{d_1}\big) \quad \wedge \cdots \wedge \quad \text{totally\_compact}\big(\boxed{s_n}, \boxed{d_n}\big)$$
$$\wedge\ \ \text{add\_conjunction}\big(\big\langle\boxed{d_1}, \cdots, \boxed{d_n}\big\rangle, \boxed{D_0}, \boxed{f}\big)$$

The *add_conjunction* relation, used in (27), needs to be defined for each language, and the English-specific version of the relation is defined, albeit incompletely, in (28). The *totally_compact* relation, also used in (27), is a relation that holds between a sign and a domain object when the latter is the result of applying the total compaction operation defined in Yatabe (2001, (24)) to the former. The symbol "$\bigcirc$" is used here to represent the non-deterministic *shuffle* operation (Reape (1994)).

(28) $\text{add\_conjunction}\left(\boxed{L},\boxed{D},\boxed{f}\right) \equiv$

$$\left(\boxed{f} = \textit{none} \quad\wedge\quad \boxed{D}=\boxed{L}\right)$$
$$\vee \left(\boxed{f} : [\text{SS} \mid \text{CONT} \mid \text{EP} \mid \text{FIRST} \mid \text{RELN}\;\; \textit{and}] \quad\wedge\quad \boxed{L}:\boxed{L'}\oplus\left\langle\begin{bmatrix}\text{SS} & \boxed{s}\\ \text{PHON} & \boxed{p}\end{bmatrix}\right\rangle \right.$$
$$\left. \wedge\quad \boxed{D} : \left\langle\boxed{f}\right\rangle \oplus \boxed{L'} \oplus \left\langle\begin{bmatrix}\text{SS} & \boxed{s}\\ \text{PHON} & \left\langle\text{and},\boxed{p}\right\rangle\end{bmatrix}\right\rangle\right)$$
$$\vee \left(\boxed{f} : [\text{SS} \mid \text{CONT} \mid \text{EP} \mid \text{FIRST} \mid \text{RELN}\;\; \textit{and}] \quad\wedge\quad \boxed{L}:\left\langle\boxed{l}\right\rangle\oplus\left\langle\begin{bmatrix}\text{SS} & \boxed{s_1}\\ \text{PHON} & \boxed{p_1}\end{bmatrix},\dots,\begin{bmatrix}\text{SS} & \boxed{s_n}\\ \text{PHON} & \boxed{p_n}\end{bmatrix}\right\rangle \right.$$
$$\left. \wedge\quad \boxed{D} : \left\langle\boxed{f}\right\rangle \oplus \left\langle\boxed{l}\right\rangle \oplus \left\langle\begin{bmatrix}\text{SS} & \boxed{s_1}\\ \text{PHON} & \left\langle\text{and},\boxed{p_1}\right\rangle\end{bmatrix},\dots,\begin{bmatrix}\text{SS} & \boxed{s_n}\\ \text{PHON} & \left\langle\text{and},\boxed{p_n}\right\rangle\end{bmatrix}\right\rangle\right)$$
$$\vee \quad \cdots$$

In the proposed theory, peripheral-node raising, that is to say left-node raising and right-node raising, is a phenomenon that results when the relation between the daughter nodes and the order domain of the mother node conforms to the constraints specified by the *pnr_dom* relation, defined in (29), instead of constraints of the usual type, which give rise to a structure not involving peripheral-node raising. In (26) above, the relation between the daughter nodes and the order domain of the mother node is required to conform either to the constraints specified by the *coord_dom* relation or to those specified by the *pnr_dom* relation. When it conforms to the former constraints, the resulting structure is a coordinate structure involving no peripheral-node raising; when it conforms to the latter, the resulting structure is a coordinate structure involving left-node raising, right-node raising, or both.

(29) $\text{pnr\_dom}\left(\left\langle\boxed{1},\cdots,\boxed{n}\right\rangle,\boxed{D_0},\boxed{f}\right) \equiv$

$$\left(\boxed{A_L} \neq \langle\rangle \quad\vee\quad \boxed{A_R} \neq \langle\rangle \quad\vee\quad \boxed{B_L} \neq \langle\rangle \quad\vee\quad \boxed{B_R} \neq \langle\rangle\right)$$
$$\wedge\quad \text{syn\_pnr}\left(\left\langle\boxed{1}\right\rangle \bigcirc \cdots \bigcirc \left\langle\boxed{n}\right\rangle, \boxed{H}, \left\langle\boxed{l_1},\cdots,\boxed{l_n}\right\rangle, \left\langle\boxed{r_1},\cdots,\boxed{r_n}\right\rangle\right)$$
$$\wedge\quad \text{phon\_pnr}\left(\boxed{H},\boxed{G},\boxed{B_L},\boxed{B_R}\right)$$
$$\wedge\quad \text{totally\_compact\_each}\left(\boxed{G},\boxed{F}\right)$$
$$\wedge\quad \text{add\_conjunction}\left(\boxed{F},\boxed{E},\boxed{f}\right)$$
$$\wedge\quad \text{fuse\_each}\left(\left\langle\boxed{l_1},\cdots,\boxed{l_n}\right\rangle,\boxed{A_L},\boxed{f}\right)$$
$$\wedge\quad \text{fuse\_each}\left(\left\langle\boxed{r_1},\cdots,\boxed{r_n}\right\rangle,\boxed{A_R},\boxed{f}\right)$$
$$\wedge\quad \boxed{D_0} : \boxed{A_L} \oplus \boxed{E} \oplus \boxed{A_R}$$

When the structure involved is not a coordinate structure, the relation between the daughters $\boxed{1}\cdots\boxed{n}$ and the order domain $\boxed{D_0}$ of the mother is required to satisfy either constraints of the usual type or the following.

(30) $\text{pnr\_dom}\left(\left\langle\boxed{1},\cdots,\boxed{n}\right\rangle,\boxed{D_0},\textit{none}\right)$

The relations *syn_pnr*, *phon_pnr*, *totally_compact_each*, and *fuse_each*, which appear in (29), are defined in the Appendix.

$$
\left[\textsc{dom}\ \left\langle \begin{array}{l}
[\textsc{phon}\ \ \textit{none}], \\
[\textsc{phon}\ \ \langle\langle \text{Naomi}, \text{wa}\rangle, \langle \text{yama}\rangle\rangle], \\
[\textsc{phon}\ \ \langle \text{soshite}, \langle\langle \text{Ken}, \text{wa}\rangle, \langle \text{kawa}, \text{e}\rangle\rangle\rangle], \\
[\textsc{phon}\ \ \langle \text{sorezore}\rangle], \\
[\textsc{phon}\ \ \text{itta}]
\end{array}\right\rangle\right]
$$

$$
\left[\textsc{dom}\ \left\langle \begin{array}{l}
[\textsc{phon}\ \ \langle \text{Naomi}, \text{wa}\rangle], \\
[\textsc{phon}\ \ \langle \text{yama}, \text{e}\rangle], \\
[\textsc{phon}\ \ \langle \text{sorezore}\rangle], \\
[\textsc{phon}\ \ \text{itta}]
\end{array}\right\rangle\right]
\qquad
\left[\textsc{dom}\ \left\langle \begin{array}{l}
[\textsc{phon}\ \ \langle \text{Ken}, \text{wa}\rangle], \\
[\textsc{phon}\ \ \langle \text{kawa}, \text{e}\rangle], \\
[\textsc{phon}\ \ \langle \text{sorezore}\rangle], \\
[\textsc{phon}\ \ \text{itta}]
\end{array}\right\rangle\right]
$$

Figure 2: Part of the structure assigned to example (31)

I will illustrate the way the proposed theory works using the Japanese example in (31), whose structure is shown in a schematic format in Figure 2.

(31) [Naomi wa] yama, soshite [Ken wa] [kawa e] sorezore itta.
[Naomi TOP] mountain and [Ken TOP] [river to] respectively went
'Naomi went to the mountain and Ken went to the river.'

As in the theory proposed in Yatabe (2001), it is assumed here that there are two types of peripheral-node raising (PNR), namely syntactic PNR and phonological PNR. In (29) above, $\boxed{A_L}$, $\boxed{A_R}$, $\boxed{B_L}$, and $\boxed{B_R}$ denote syntactically left-node-raised material, syntactically right-node-raised material, phonologically left-node-raised material, and phonologically right-node-raised material, respectively. In the example in (31), the adverb *sorezore* and the verb *itta* are syntactically right-node-raised and the postposition *e* is phonologically right-node-raised.

Syntactic PNR deletes a list of domain objects at the right (or left, respectively) edge of each daughter (line 3 of (29)), fuses those domain objects item by item to create a possibly modified list of domain objects (lines 7 and 8 of (29)), and places the resulting list of domain objects at the right (or left, respectively) edge of the order domain of the mother (line 9 of (29)). In Figure 2, the two domain objects corresponding to the adverb *sorezore* and the verb *itta* are deleted at the right edge of each of the two conjuncts. Then the two domain objects deleted at the end of the first conjunct and the two deleted at the end of the second conjunct are fused pairwise to create two new domain objects whose semantic content (not shown in the figure) is altered, and the two new domain objects are placed at the right edge of the order domain of the mother. Generally, syntactically PNRed domain objects continue to exist as separate domain objects in the order domain of the mother, rather than becoming part of some larger domain objects.

Phonological PNR simply deletes some phonological material at the right (or left, respectively) edge of non-final (or non-initial, respectively) daughters, on condition that the same phonological material is contained in the final (or initial, respectively) daughter (line 4 of (29)). In Figure 2, the phonological material *e*, which represents a postposition, is allowed to be deleted at the end of the first daughter, because the same phonological material is contained in the second daughter. Phonologically RNRed (or LNRed respectively) material generally becomes part of the domain object corresponding to the final (or initial respectively) daughter. In Figure 2, *e* becomes part of the domain object that is to be pronounced *soshite Ken wa kawa e*, which corresponds to the second daughter.

The semantic inertness of medial RNR follows from this theory because phonological PNR is incapable of affecting semantic interpretation and syntactic PNR is incapable of yielding medial RNR or medial LNR. For example, (21), which involves medial RNR, cannot be generated by syntactic RNR, and hence must be an instance of phonological RNR, which cannot affect the scope of the quantifier.

Those parts of each daughter node that do not undergo syntactic or phonological PNR are totally compacted and become a single domain object (line 5 of (29)), and the newly created domain objects, each corresponding to one of the daughter nodes, are placed in the order domain of the mother (line 9 of (29)), after possibly having a conjunction word added to them (line 6 of (29)). In Figure 2, the second domain object in the order domain of the mother (to be pronounced *Naomi wa yama*) is that part of the first conjunct that does not undergo PNR, and the third domain object (to be pronounced *soshite Ken wa kawa e*) is that part of the second conjunct that does not undergo PNR, with the conjunction word *soshite* added to its left edge. The first domain object, which is phonologically empty, carries the meaning of conjunction.

Phonological PNR can delete a sequence of phonological constituents at the right (or left, respectively) edge of a non-final (or non-initial) daughter node if the same phonological sequence can be found at the right (or left) edge of the order domain of the final (or initial) daughter node. If that were all that the theory said about phonological PNR, the theory would licence non-medial PNR but not medial PNR. In the proposed theory, phonological PNR is licensed not only in the situation just described but also in a situation where the phonological sequence to be RNRed (or LNRed, respectively) can be made to line up at the right (or left) edge of the order domain of the final (or initial) daughter node by removing one or more of the domain objects from that order domain. That is the effect that the definition of the *contain_right* relation in (43) has concerning RNR, and the corresponding definition of the *contain_left* relation would have concerning LNR. These are relations that are required to hold between the final or initial daughter and the material to be phonologically PNRed (lines 4 and 6 of (38)). Let us see how this works in the case of (9). At the point where the two clauses are conjoined in (9), the order domain of the second, final daughter consists of four domain objects, as shown in (32).

(32) $\langle [\textsc{phon}\ \ \langle\langle \text{the}\rangle, \text{beer}\rangle], [\textsc{phon}\ \ \text{chases}], [\textsc{phon}\ \ \langle\langle \text{my}\rangle, \text{blues}\rangle], [\textsc{phon}\ \ \langle \text{away}\rangle]\rangle$

The phonological material to be RNRed, i.e. *my blues*, will come to be at the right edge of this order domain if the rightmost domain object (*away*) is set aside. Therefore the *contain_right* relation holds between this second daughter and the phonological material *my blues*, making deletion of *my blues* at the right edge of the first daughter licit.

In determining whether the *contain_right* relation (or the corresponding *contain_left* relation) holds between the final (or the initial, respectively) daughter and some phonological sequence, domain objects can be set aside, as we have just seen, but things that are smaller than domain objects cannot be set aside, according to (43). As a consequence, the sentence in (25a) above is correctly ruled out in the proposed account. In order for the *contain_right* relation to hold between the second conjunct in **talked to and looked at the car that I persuaded the man to purchase* and the phonological sequence *the man*, the phrase *to purchase*, which prevents *the man* from being at the right edge of the second conjunct, would have to be set aside. The phrase *to purchase*, however, does not constitute a domain object in itself at the point where the two VPs are conjoined, since the relative clause containing it has undergone compaction and the phrase has thus already become part of a larger domain object. Since this precludes phonological RNR of *the man* and syntactic RNR never gives rise to medial RNR, the impossibility of (25a) follows.

Phonological RNR (or LNR, respectively) is not allowed to elide a leftmost (or rightmost) phonologically non-empty branch or a part of such a branch in a prosodic structure. More specifically, and focusing on RNR rather than LNR, the leftmost phonologically non-empty domain object in a order domain cannot be elided by phonological RNR (due to line 8 of (41)), and it is not possible to elide even part of such a domain object (due to line 4 of (41)). Likewise, when the PHON value of a domain object is a possibly nested list, which can be construed as a representation of a tree, it is not possible to elide a leftmost branch inside it (due to line 8 of (42)) or even part of such a branch (due to line 4 of (42)). In addition, the phonological material to be elided at the right edge of non-final daughters cannot constitute a leftmost branch or part of such a branch in the prosodic structure representing the *final* daughter either (due to the way the *contain_right* relation is defined in (43)). This restriction on phonological RNR captures the ill-formedness of sentences like (24), **The mother of and Bill thought John arrived*, and (25b). Let us see here how (24) is ruled out. First of all, it is not possible to generate this sentence by right-node-raising a single phonological constituent of the form "$\langle\langle$John$\rangle$, arrived$\rangle$", because the first conjunct does not contain such a phonological constituent. At the same time, it is also not possible to generate this sentence through phonological RNR of a sequence made up of two phonological constituents, namely either "$\langle$John$\rangle$" or "John" followed by "arrived", because the first element in this sequence (i.e. "$\langle$John$\rangle$" or "John") constitutes a leftmost branch in the prosodic structure of the second conjunct and therefore is not deletable at the end of the first conjunct. At the point where the two clauses in this example are conjoined, the order domain of the second daughter will look like (33), although the precise predictions depend on the kinds of assumptions that are adopted concerning the construction of prosodic structures and the structure shown here is not the only possible one.

(33) $\langle$[PHON $\langle$Bill$\rangle$] , [PHON thought] , [PHON $\langle\langle$John$\rangle$, arrived$\rangle$]$\rangle$

In this representation, "$\langle$John$\rangle$" constitutes the leftmost branch of "$\langle\langle$John$\rangle$, arrived$\rangle$", and "John" is the leftmost branch of "$\langle$John$\rangle$".

When syntactic PNR fuses n domain objects of the form shown in (34) (each coming from a different daughter) to produce a single domain object of the form shown in (35) (to be placed in the order domain of the mother), one of the three conditions shown in (36) must be satisfied, due to (46).

(34) $\begin{bmatrix}\text{SS} \mid \text{CONT} & \begin{bmatrix}\text{INDEX} & \boxed{a_1} \\ \text{EP} & \boxed{b_1}\end{bmatrix}\end{bmatrix}, \cdots, \begin{bmatrix}\text{SS} \mid \text{CONT} & \begin{bmatrix}\text{INDEX} & \boxed{a_n} \\ \text{EP} & \boxed{b_n}\end{bmatrix}\end{bmatrix}$

(35) $\begin{bmatrix}\text{SS} \mid \text{CONT} & \begin{bmatrix}\text{INDEX} & \boxed{a_0} \\ \text{EP} & \boxed{b_0}\end{bmatrix}\end{bmatrix}$

(36) a. $\boxed{a_0} = \boxed{a_1} = \cdots = \boxed{a_n} \quad \wedge \quad \boxed{b_0} = \boxed{b_1} = \cdots = \boxed{b_n}$

b. $\boxed{b_0} = \boxed{b_1} \oplus \cdots \oplus \boxed{b_n}$

c. $\boxed{a_0}$ is $\boxed{a_1 + \cdots + a_n}$, and $\boxed{b_1} \cdots \boxed{b_n}$ all become $\boxed{b_0}$ when $\boxed{a_1} \cdots \boxed{a_n}$ that occur inside $\boxed{b_1} \cdots \boxed{b_n}$ respectively are all replaced by $\boxed{a_1 + \cdots + a_n}$.

The condition in (36a) can merge multiple quantifiers into one, producing an effect similar to that of Optional Quantifier Merger proposed in Beavers and Sag (2004). The condition in (36b) yields a representation whose semantics is not affected by PNR, as far as the EP value is concerned. And the condition in (36c) is the option that can give rise to a representation like (6).

6 Summary

The CG-based theory of non-constituent coordination cannot deal with all instances of medial RNR in English, French, and Japanese, Mouret's theory of argument-cluster coordination encounters similar difficulties when applied to RNR, and Bachrach and Katzir's theory cannot be applied to left-node raising in English, has difficulty capturing the semantic inertness of medial RNR, and overgenerates in several ways. The ellipsis-based theory, on the other hand, appears to be capable of capturing all the observations when modified appropriately.

Appendix

(37) $\text{syn\_pnr}\left(\boxed{A}, \boxed{B}, \boxed{L}, \boxed{R}\right) \equiv$

$\boxed{A} : \left\langle \begin{bmatrix}\text{SS} & \boxed{s_1} \\ \text{DOM} & \boxed{l_1} \oplus \boxed{d_1} \oplus \boxed{r_1}\end{bmatrix}, \cdots, \begin{bmatrix}\text{SS} & \boxed{s_n} \\ \text{DOM} & \boxed{l_n} \oplus \boxed{d_n} \oplus \boxed{r_n}\end{bmatrix} \right\rangle$

$\wedge \quad \boxed{L} : \left\langle \boxed{l_1}, \cdots, \boxed{l_n} \right\rangle$

$\wedge \quad \boxed{R} : \left\langle \boxed{r_1}, \cdots, \boxed{r_n} \right\rangle$

$$\land \quad \boxed{B} : \left\langle \begin{bmatrix} \textsc{ss} & \boxed{s_1} \\ \textsc{dom} & \boxed{d_1} \end{bmatrix}, \ldots, \begin{bmatrix} \textsc{ss} & \boxed{s_n} \\ \textsc{dom} & \boxed{d_n} \end{bmatrix} \right\rangle$$
$$\land \quad \boxed{d_1} \neq \langle\rangle \quad \land \quad \cdots \quad \land \quad \boxed{d_n} \neq \langle\rangle$$

(38) $$\text{phon\_pnr}\left(\boxed{H}, \boxed{G}, \boxed{B_L}, \boxed{B_R}\right) \equiv$$
$$\boxed{H} : \left\langle \boxed{h_1} \right\rangle \oplus \boxed{H'} \oplus \left\langle \boxed{h_n} \right\rangle$$
$$\land \quad \boxed{G} : \left\langle \boxed{g_1} \right\rangle \oplus \boxed{G'} \oplus \left\langle \boxed{g_n} \right\rangle$$
$$\land \quad \text{phon\_del}\left(\boxed{h_1}, \boxed{g_1}, \langle\rangle, \boxed{B_R}\right) \;\land\; \text{contain\_left}\left(\boxed{g_1}, \boxed{B_L}\right)$$
$$\land \quad \text{phon\_del\_each}\left(\boxed{H'}, \boxed{G'}, \boxed{B_L}, \boxed{B_R}\right)$$
$$\land \quad \text{phon\_del}\left(\boxed{h_n}, \boxed{g_n}, \boxed{B_L}, \langle\rangle\right) \;\land\; \text{contain\_right}\left(\boxed{g_n}, \boxed{B_R}\right)$$

(39) $$\text{phon\_del\_each}\left(\boxed{C}, \boxed{D}, \boxed{B_L}, \boxed{B_R}\right) \equiv$$
$$\boxed{C} = \boxed{D} = \langle\rangle$$
$$\lor \quad \left(\boxed{C} : \left\langle \boxed{c} \mid \boxed{C'} \right\rangle \quad \land \quad \boxed{D} : \left\langle \boxed{d} \mid \boxed{D'} \right\rangle\right.$$
$$\left. \land \;\; \text{phon\_del}\left(\boxed{c}, \boxed{d}, \boxed{B_L}, \boxed{B_R}\right) \;\land\; \text{phon\_del\_each}\left(\boxed{C'}, \boxed{D'}, \boxed{B_L}, \boxed{B_R}\right)\right)$$

(40) $$\text{phon\_del}\left(\boxed{c}, \boxed{d}, \boxed{L}, \boxed{R}\right) \equiv$$
$$\boxed{c} : \begin{bmatrix} \textsc{ss} & \boxed{s} \\ \textsc{dom} & \boxed{D} \end{bmatrix} \quad \land \quad \boxed{d} : \begin{bmatrix} \textsc{ss} & \boxed{s} \\ \textsc{dom} & \boxed{F} \end{bmatrix}$$
$$\land \quad \text{elide\_left}\left(\boxed{D}, \boxed{E}, \boxed{L}\right) \quad \land \quad \text{elide\_right}\left(\boxed{E}, \boxed{F}, \boxed{R}\right)$$

(41) $$\text{elide\_right}\left(\boxed{E}, \boxed{F}, \boxed{R}\right) \equiv$$
$$\left(\boxed{R} = \langle\rangle \quad \land \quad \boxed{F} = \boxed{E}\right)$$
$$\lor \quad \left(\boxed{E} : \boxed{E'} \oplus \left\langle \begin{bmatrix} \textsc{ss} & \boxed{s} \\ \textsc{phon} & \boxed{p} \end{bmatrix} \right\rangle\right.$$
$$\land \;\; \neg\left(\boxed{E'} : \text{list}\left(\begin{bmatrix}\textsc{phon} & \textit{none}\end{bmatrix}\right)\right)$$
$$\land \quad \text{phon\_elide\_right}\left(\boxed{p}, \boxed{q}, \boxed{R}\right)$$
$$\left.\land \quad \boxed{F} : \boxed{E'} \oplus \left\langle \begin{bmatrix} \textsc{ss} & \boxed{s} \\ \textsc{phon} & \boxed{q} \end{bmatrix} \right\rangle\right)$$
$$\lor \quad \left(\boxed{E} : \boxed{E'} \oplus \left\langle \begin{bmatrix} \textsc{ss} & \boxed{s} \\ \textsc{phon} & \boxed{r} \end{bmatrix} \right\rangle\right.$$
$$\land \;\; \neg\left(\boxed{E'} : \text{list}\left(\begin{bmatrix}\textsc{phon} & \textit{none}\end{bmatrix}\right)\right)$$
$$\land \quad \boxed{R} : \boxed{R'} \oplus \left\langle \boxed{r} \right\rangle$$
$$\land \quad \text{elide\_right}\left(\boxed{E'}, \boxed{F'}, \boxed{R'}\right)$$
$$\left.\land \quad \boxed{F} : \boxed{F'} \oplus \left\langle \begin{bmatrix} \textsc{ss} & \boxed{s} \\ \textsc{phon} & \textit{none} \end{bmatrix} \right\rangle\right)$$

(42) $\text{phon\_elide\_right}\left(\boxed{P}, \boxed{Q}, \boxed{R}\right) \equiv$

$$\left(\boxed{R} = \langle\rangle \quad \wedge \quad \boxed{Q} = \boxed{P}\right)$$
$$\vee \quad \left(\boxed{P} : \boxed{P'} \oplus \left\langle \boxed{p} \right\rangle \right.$$
$$\wedge \quad \boxed{P'} \neq \langle\rangle$$
$$\wedge \quad \text{phon\_elide\_right}\left(\boxed{p}, \boxed{q}, \boxed{R}\right)$$
$$\left.\wedge \quad \boxed{Q} : \boxed{P'} \oplus \left\langle \boxed{q} \right\rangle\right)$$
$$\vee \quad \left(\boxed{P} : \boxed{P'} \oplus \langle \boxed{r} \rangle \right.$$
$$\wedge \quad \boxed{P'} \neq \langle\rangle$$
$$\wedge \quad \boxed{R} : \boxed{R'} \oplus \langle \boxed{r} \rangle$$
$$\left.\wedge \quad \text{phon\_elide\_right}\left(\boxed{P'}, \boxed{Q}, \boxed{R'}\right)\right)$$

(43) $\text{contain\_right}\left(\boxed{A}, \boxed{R}\right) \equiv$

$$\boxed{A} : \left[\text{DOM} \quad \boxed{D}\right] \quad \wedge \quad \boxed{D} : \boxed{D_1} \bigcirc \boxed{D_2} \quad \wedge \quad \text{elide\_right}\left(\boxed{D_1}, \boxed{E}, \boxed{R}\right)$$

(44) $\text{totally\_compact\_each}\left(\boxed{C}, \boxed{D}\right) \equiv$

$$\boxed{C} = \boxed{D} = \langle\rangle$$
$$\vee \quad \left(\boxed{C} : \left\langle \boxed{c} \mid \boxed{C'} \right\rangle \quad \wedge \quad \boxed{D} : \left\langle \boxed{d} \mid \boxed{D'} \right\rangle \right.$$
$$\left.\wedge \quad \text{totally\_compact}\left(\boxed{c}, \boxed{d}\right) \wedge \text{totally\_compact\_each}\left(\boxed{C'}, \boxed{D'}\right)\right)$$

(45) $\text{fuse\_each}\left(\left\langle \boxed{K_1}, \cdots, \boxed{K_n} \right\rangle, \boxed{K_0}, \boxed{f}\right) \equiv$

$$\boxed{K_0} = \boxed{K_1} = \cdots = \boxed{K_n} = \langle\rangle$$
$$\vee \left(\boxed{K_1} : \left\langle \boxed{1} \mid \boxed{L_1} \right\rangle \wedge \cdots \wedge \boxed{K_n} : \left\langle \boxed{n} \mid \boxed{L_n} \right\rangle \wedge \boxed{K_0} : \left\langle \boxed{0} \mid \boxed{L_0} \right\rangle\right.$$
$$\wedge \left(\boxed{f} : \left[\text{SS} \mid \text{CONT} \mid \text{EP} \mid \text{FIRST} \mid \text{RELN} \quad \boxed{\text{Conj}}\right] \quad \vee \quad \boxed{f} = \boxed{\text{Conj}} = \textit{none}\right)$$
$$\wedge\ \text{fuse}\left(\langle \boxed{1}, \cdots, \boxed{n} \rangle, \boxed{0}, \boxed{\text{Conj}}\right)$$
$$\left.\wedge\ \text{fuse\_each}\left(\left\langle \boxed{L_1}, \cdots, \boxed{L_n} \right\rangle, \boxed{L_0}, \boxed{f}\right)\ \right)$$

(46) $\text{fuse}\left(\langle \boxed{1}, \cdots, \boxed{n} \rangle, \boxed{0}, \boxed{\text{Conj}}\right) \equiv$

$$\boxed{0} = \boxed{1} = \cdots = \boxed{n}$$
$$\vee \Big(\neg\left(\boxed{1} = \cdots = \boxed{n}\right)$$
$$\wedge \boxed{1} : \begin{bmatrix} \text{SS} & \boxed{S_1} \\ \text{PHON} & \boxed{P} \end{bmatrix} \wedge \cdots \wedge \boxed{n} : \begin{bmatrix} \text{SS} & \boxed{S_n} \\ \text{PHON} & \boxed{P} \end{bmatrix} \wedge \boxed{0} : \begin{bmatrix} \text{SS} & \boxed{S_0} \\ \text{PHON} & \boxed{P} \end{bmatrix}$$
$$\wedge\ \text{fuse\_synsem}\left(\left\langle \boxed{S_1}, \cdots, \boxed{S_n} \right\rangle, \boxed{S_0}, \boxed{\text{Conj}}\right)\Big)$$
$$\vee \Big(\neg\left(\boxed{1} = \cdots = \boxed{n}\right)$$
$$\wedge \boxed{1} : \begin{bmatrix} \text{SS} & \boxed{S_1} \\ \text{PHON} & \boxed{P} \end{bmatrix} \wedge \cdots \wedge \boxed{n} : \begin{bmatrix} \text{SS} & \boxed{S_n} \\ \text{PHON} & \boxed{P} \end{bmatrix} \wedge \boxed{0} : \begin{bmatrix} \text{SS} & \boxed{S_0} \\ \text{PHON} & \boxed{P} \end{bmatrix}$$
$$\wedge\ \text{cumulate\_synsem}\left(\left\langle \boxed{S_1}, \cdots, \boxed{S_n} \right\rangle, \boxed{S_0}, \boxed{\text{Conj}}\right)\Big)$$

The *fuse_synsem* relation, used in (46), and the *fuse_valence* relation, used in (47), are defined in Yatabe (2003). The *contain_left* relation and the *elide_left* relation are intended to be the mirror images of the *contain_right* relation and the *elide_right* relation respectively, and are not defined here.

(47) $$\text{cumulate\_synsem}\Big(\big\langle \boxed{1}, \cdots, \boxed{n} \big\rangle, \boxed{0}, \boxed{\text{Conj}}\Big) \equiv$$

$$\boxed{\text{Conj}} = \textit{and}$$

$$\wedge \boxed{1} : \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \boxed{a} \\ \text{VAL} & \begin{bmatrix} \text{SUBJ} & \boxed{b_1} \\ \text{COMPS} & \boxed{c_1} \\ \text{MOD} & \boxed{d_1} \end{bmatrix} \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{LTOP} & \boxed{e_1} \\ \text{INDEX} & \boxed{f_1} \\ \text{SEMHEAD} & \boxed{g_1} \\ \text{EP} & \boxed{h_1} \\ \text{H-CONS} & \boxed{i_1} \\ \text{H-STORE} & \boxed{j} \end{bmatrix} \end{bmatrix} \wedge$$

$$\cdots \wedge \boxed{n} : \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \boxed{a} \\ \text{VAL} & \begin{bmatrix} \text{SUBJ} & \boxed{b_n} \\ \text{COMPS} & \boxed{c_n} \\ \text{MOD} & \boxed{d_n} \end{bmatrix} \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{LTOP} & \boxed{e_n} \\ \text{INDEX} & \boxed{f_n} \\ \text{SEMHEAD} & \boxed{g_n} \\ \text{EP} & \boxed{h_n} \\ \text{H-CONS} & \boxed{i_n} \\ \text{H-STORE} & \boxed{j} \end{bmatrix} \end{bmatrix}$$

$$\wedge \boxed{0} : \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \boxed{a} \\ \text{VAL} & \begin{bmatrix} \text{SUBJ} & \boxed{b_0} \\ \text{COMPS} & \boxed{c_0} \\ \text{MOD} & \boxed{d_0} \end{bmatrix} \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{LTOP} & \textit{none} \\ \text{INDEX} & \boxed{f_1 + \cdots + f_n} \\ \text{SEMHEAD} & \textit{none} \\ \text{EP} & \boxed{h_0} \\ \text{H-CONS} & \boxed{i_1} \cup \cdots \cup \boxed{i_n} \\ \text{H-STORE} & \boxed{j} \end{bmatrix} \end{bmatrix}$$

$$\wedge \text{ substitute}\Big(\boxed{h_1}, \boxed{h_0}, \boxed{f_1}, \boxed{f_1 + \cdots + f_n}\Big) \wedge$$

$$\cdots \wedge \text{substitute}\left(\boxed{h_n}, \boxed{h_0}, \boxed{f_n}, \boxed{f_1 + \cdots + f_n}\right)$$
$$\wedge \text{ fuse\_valence}\left(\left\langle \boxed{b_1}, \cdots, \boxed{b_n} \right\rangle, \boxed{b_0}, \boxed{\text{Conj}}\right)$$
$$\wedge \text{ fuse\_valence}\left(\left\langle \boxed{c_1}, \cdots, \boxed{c_n} \right\rangle, \boxed{c_0}, \boxed{\text{Conj}}\right)$$
$$\wedge \text{ fuse\_valence}\left(\left\langle \boxed{d_1}, \cdots, \boxed{d_n} \right\rangle, \boxed{d_0}, \boxed{\text{Conj}}\right)$$

(48) substitute $\left(\boxed{A}, \boxed{B}, x, y\right)$ holds if and only if the feature structure denoted by $\boxed{A}$ becomes the feature structure denoted by $\boxed{B}$ when all the occurences of x in the denotation of $\boxed{A}$ are replaced by y.

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