Linearization-based syntax and semantics: An overview

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Like many other theories developed within the framework of HPSG, what is now called Linearization Theory started out as a refinement of theories that had been developed in the context of other theoretical frameworks. Specifically, the original form of Linearization Theory (see Reape (1994)) can be regarded as an interesting reformulation of ideas put forth within transformational grammar (McCawley (1982)), GPSG (Zwicky (1986)), and categorial grammar (Dowty (1996)). In recent years, however, the theory has evolved in an unexpected direction. In this paper, I will attempt to describe the novel, and in my opinion quite compelling perspective that the theory now offers in regard to extraposition, right-node raising (RNR), and the syntax-phonology-semantics interface.

1 Some common properties of extraposition and RNR

Extraposition and RNR share the following six properties.[1] Theories like McCawley's (1982), Zwicky's (1986), and Dowty's (1996) provide a good explanation for some, but not all of these.

First, a string α can be extraposed or right-node-raised out of a phrase β only if α constitutes the right periphery of β, as shown by (1) and (2) respectively. (In this section, the words that have been extraposed or right-node-raised are shown in italics.)

(1)*It appears I have given the assignment to a fool after all(,) *complete and utter.* (from Stucky (1987))

(2)*I first offered apples and then sold peaches *the immigrant from Paraguay.* (from Postal (1998); see also Levine (2001))

Second, what is extraposed or right-node-raised from the right periphery of a phrase does not have to be a syntactic constituent; extraposition and RNR are both permitted to dislocate a string consisting of more than one constituent, as shown by (3) and (4).

(3) Can you give me the names of any newcomers as soon as possible *from Finland who may have programming experience*? (from Stucky (1987))

(4) a. Smith loaned, and his widow later donated, *a valuable collection of manuscripts to the library.* (from Abbott (1976))

b. a positively and a negatively *charged particle* (from Wilder (1997))

Third, when two or more constituents are extraposed or right-node-raised out of a phrase, the linear order between those constituents must be preserved, as shown by (5) and (6) respectively.

(5)*Can you give me the names of any newcomers as soon as possible *who may have programming experience from Finland*? (from Dowty (1996))
(cf. newcomers from Finland who may have programming experience/*newcomers who may have programming experience from Finland)

(6)*a positively and a negatively *particle charged*

Fourth, neither extraposition nor RNR affects binding relations, as shown by (7) and (8).

(7) They desired that pictures be painted *of each other.* (from Chomsky (1986, p. 41); attributed to J. R. Ross)
(cf. *They believed that the picture had been painted by each other.)

(8) (from Levine (1985))

a.*John wondered, and she$_i$ speculated, *about whether Mary$_i$ would win the fellowship.*

b. John wondered, and Mary$_i$ speculated,

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[1] So does long-distance scrambling in Japanese. See Yatabe (1996) and the references cited there.

about whether she$_i$ would win the fellowship.

Fifth, extraposition and RNR violate some of the island conditions that constrain leftward extractions such as topicalization. The sentence in (7) above violates the condition that bans extraction out of a grammatical subject. A sentence like (9) violates the Complex NP Condition, as pointed out in Wexler and Culicover (1980).[2]

(9) Mary owned, and John knew a man who wanted to buy, *a portrait of Elvis Presley.*

And sixth, although they both have all the earmarks of being 'stylistic rules,' extraposition and RNR sometimes have an effect on semantic scope relations, as shown by the contrast between (10a) and (10b)[3] and between (11a) and (11b). This is where theories like McCawley's and Dowty's falter.

(10) (from Guéron (1980))
  a. The owner of every car on the block will be fined.
  b. The owner will be fined *of every car on the block.*

(11) (from McCawley (1982))
  a. Karsh took photographs of many famous persons and Wyeth painted portraits of many famous persons.
  b. Karsh took photographs and Wyeth painted portraits *of many famous persons.*

(11b), but not (11a), is ambiguous between the following two interpretations: 'There are many famous persons such that Karsh took photographs of them and Wyeth painted portraits of them,' and 'There are many famous persons such that Karsh took photographs of them, and there is a possibly different set of many famous persons such that Wyeth painted portraits of them.' (See also Steedman (2000) and the references cited there.)

2 Extraposition

Let me now describe the linearization-based theory of extraposition advanced by Kathol and Pollard (1995), which successfully accounts for the first five of the six properties of extraposition that I have just described. In Kathol and Pollard's theory, the portion of syntactic structures that determines grammatical dependency relations is represented by means of unordered trees, that is, trees with no specifications as to the ordering of its constituents. The information as to the order of various constituents is contained in what are called *order domains* (or *domains* for short), each of which is associated with a node in an unordered tree. An order domain is a list of *domain objects*, and is given as the value of the DOM feature. A domain object is very much like a sign; unlike a sign, however, it does not carry any information as to its internal morphosyntactic structure.

Let me take a concrete example. Figure 1 shows part of the structure assigned to the English sentence *The man bought it.* What is shown in this figure is an unordered tree. There is actually no linear precedence relation between the VP node and the NP node; I placed the VP node to the left of the subject NP node in order to underscore the insignificance of the apparent linear order between the two. The order domain (i.e. the DOM value) of the VP node consists of two domain objects, one that is pronounced *bought*, and the other one that is pronounced *it.* The order between these two domain objects *is* significant; it indicates that this VP is to be pronounced *bought it*, rather than *it bought.* Likewise, the order domain of the NP node tells us that this NP is to be pronounced *the man*, and the order domain of the S node tells us that the S node is to be pronounced *The man bought it.*

Let us take a closer look and see how the order domain of the S node is related to the order domains of the NP node and the VP node in Figure 1. The two domain objects in the VP's order domain are both integrated, unaltered, into the order domain of the S node. Notice that the order between the two domain objects is the same in the VP's order domain and the S's order domain; the domain object that is pronounced *bought* precedes the domain object that is pronounced *it* in the S's order domain as well as in the VP's order domain. This is a consequence of the constraint given in (12) (Kathol (1995)).

(12) The Persistence Constraint:
  Any precedence relations holding of domain

[2] But see Steedman (2000, pp. 16–17).

[3] It has been brought to my attention that (10b) is a very awkward sentence, but Japanese sentences analogous to (10b) are only slightly awkward and serve to make the same point (Yatabe (2001)).

$$\begin{bmatrix} \text{S} \\ \text{DOM} \left\langle \begin{bmatrix} \textit{the man} \\ \text{NP[nom]} \end{bmatrix}, \begin{bmatrix} \textit{bought} \\ \text{V} \end{bmatrix}, \begin{bmatrix} \textit{it} \\ \text{NP[acc]} \end{bmatrix} \right\rangle \end{bmatrix}$$

$$\begin{bmatrix} \text{VP} \\ \text{DOM} \left\langle \begin{bmatrix} \textit{bought} \\ \text{V} \end{bmatrix}, \begin{bmatrix} \textit{it} \\ \text{NP[acc]} \end{bmatrix} \right\rangle \end{bmatrix} \quad \begin{bmatrix} \text{NP[nom]} \\ \text{DOM} \left\langle \begin{bmatrix} \textit{the} \\ \text{Det} \end{bmatrix}, \begin{bmatrix} \textit{man} \\ \text{N}' \end{bmatrix} \right\rangle \end{bmatrix}$$

Figure 1: Total compaction of an NP

objects in one order domain are also required to hold of those objects in all other order domains that they are members of.

Next, let us see how the NP's order domain is related to the S's order domain in Figure 1. The order domain of the NP node contains two domain objects, but this NP node contributes to the order domain of the S node only one domain object, which is pronounced *the man.* What is at work here is an operation called *total compaction.* (13) illustrates the way the total compaction operation takes a sign and turns it into a single domain object.

(13) Total compaction:

$$\begin{bmatrix} \alpha_0 \\ \text{DOM} \left\langle \begin{bmatrix} \beta_1 \\ \alpha_1 \end{bmatrix}, \ldots, \begin{bmatrix} \beta_n \\ \alpha_n \end{bmatrix} \right\rangle \end{bmatrix} \Rightarrow$$
$$\begin{bmatrix} \beta_1 \circ \cdots \circ \beta_n \\ \alpha_0 \end{bmatrix}$$

What's shown on the left of the arrow is the input to the operation; the input is a sign. The first line of a sign (namely "α_0" in this case) indicates its syntactic category; the second line (namely "DOM ...") shows what its order domain looks like. On the right of the arrow is shown the output of the operation; the output is a domain object. The first line of a domain object (namely "$\beta_1 \circ \cdots \circ \beta_n$" in this case) is a string that shows how it is pronounced. (The small circle is an operator that concatenates strings.) The second line of a domain object (namely "α_0" in this case) indicates its syntactic category.

In Figure 1, the subject NP is totally compacted and produces a single domain object, which is pronounced *the man.* This resultant domain object is then placed in the S's order domain.

The order between the domain object that comes from the subject NP and the domain objects that come from the VP is determined by a linear precedence statement that states that a subject NP should precede a V in English.

So far, we have seen two ways in which a given node's domain objects can be integrated into that of its mother. Now, there is a third way in which a given node's DOM value can be integrated into that of its mother: *partial compaction.* Partial compaction takes a sign and turns it into one or more domain objects, as opposed to total compaction, which always produces a single domain object. (As will become clear shortly, total compaction can be seen as a special case of partial compaction.) (14) illustrates the way the partial compaction operation takes a sign and turns it into one or more domain objects, which are to be placed in the order domain of the mother of that sign; again, the first line is the input and the second line is the output.

(14) Partial compaction:

$$\begin{bmatrix} \alpha_0 \\ \text{DOM} \left\langle \begin{bmatrix} \beta_1 \\ \alpha_1 \end{bmatrix}, \ldots, \begin{bmatrix} \beta_n \\ \alpha_n \end{bmatrix} \right\rangle \end{bmatrix} \Rightarrow$$
$$\begin{bmatrix} \beta_1 \circ \cdots \circ \beta_i \\ \alpha_0 \end{bmatrix}, \begin{bmatrix} \beta_{i+1} \\ \alpha_{i+1} \end{bmatrix}, \ldots, \begin{bmatrix} \beta_n \\ \alpha_n \end{bmatrix}$$
$$(1 \leq i \leq n)$$

In (14), the DOM value of the sign that is fed to the operation as the input has n domain objects in it. Of those domain objects, the first (i.e. leftmost) i domain objects are bundled together and turned into a single domain object, while the remaining domain objects, if any, are left out of the bundle and continue to be separate domain objects.

When an expression is partially compacted, part of that expression can appear detached from the main portion of that expression, giving rise

$$\begin{bmatrix} \text{S} \\ \text{DOM} \left\langle \begin{bmatrix} \textit{a man} \\ \text{NP[nom]} \end{bmatrix}, \begin{bmatrix} \textit{entered} \\ \text{V} \end{bmatrix}, \begin{bmatrix} \textit{who was wearing a black cloak} \\ \text{S}' \end{bmatrix} \right\rangle \end{bmatrix}$$

$$\begin{bmatrix} \text{VP} \\ \text{DOM} \left\langle \begin{bmatrix} \textit{entered} \\ \text{V} \end{bmatrix} \right\rangle \end{bmatrix} \quad \begin{bmatrix} \text{NP[nom]} \\ \text{DOM} \left\langle \begin{bmatrix} \textit{a} \\ \text{Det} \end{bmatrix}, \begin{bmatrix} \textit{man} \\ \text{N}' \end{bmatrix}, \begin{bmatrix} \textit{who was wearing a black cloak} \\ \text{S}' \end{bmatrix} \right\rangle \end{bmatrix}$$

Figure 2: Partial compaction of an NP

to various types of extraposition constructions. Figure 2 shows how the English extraposition construction can be generated via partial compaction. Here, the subject NP has been partially compacted. The relative clause has been left out of the bundle and appears in the sentence-final position. Again, what puts the relative clause in this particular position is an English-particular linear precedence statement, which I will not formulate in this paper.

I trust that it is obvious how the theory accounts for the first five of the six properties of extraposition mentioned in section 1. The sixth property mentioned there will be discussed in section 4 below.

3 RNR

Let us now turn our attention to RNR. The first five of the six properties that I claimed were shared by extraposition and RNR in section 1 strongly suggest that RNR should also be given a linearization-based analysis. However, we cannot simply model our theory of RNR after Kathol and Pollard's (1995) theory of extraposition. RNR is allowed to affect a wider range of things than extraposition; there are things that cannot be extraposed but can nevertheless be right-node-raised (see for example (4b) above). Our theory needs to be able to capture this discrepancy between the two, as well as the properties shared by them.

One natural way to capture this difference between RNR and extraposition is (i) to represent prosodic constituency within order domains along the lines suggested by Donohue and Sag (1999) and (ii) to allow prosodic constituents (which are contained in but do not constitute domain objects) as well as domain objects to be right-node-raised. In such a theory, what is extraposed is always a whole domain object or a sequence of whole domain objects, whereas what is right-node-raised does not have to be a whole domain object or a sequence of whole domain objects and could be a portion of a domain object, as long as that portion constitutes a prosodic constituent or a sequence of prosodic constituents. Yatabe (2001) shows how such a theory could be formulated. Figure 3 shows a structure that is claimed to result from RNR of a domain object, and Figure 4 shows a structure that is claimed to result from RNR of a prosodic constituent. Here it is assumed that the morphological words *subhuman* and *superhuman* each consist of two prosodic words, as indicated by use of spacing between the prefixes and the stems.[4]

Because it is linearization-based, this analysis captures in a straightforward manner the first five of the six common properties of extraposition and RNR. At the same time, the proposed analysis captures the fact that RNR can affect a wider range of things than extraposition, by allowing the former but not the latter to to alter the internal structure of domain objects.

This theory of RNR allows two prosodic constituents to be right-node raised as long as they have identical prosodic internal structure, even if they have distinct morphosyntactic internal structure. This aspect of the theory is confirmed

[4]Some people might be inclined to analyze the phrase *sub- and superhuman* as involving coordination of two prefixes (*sub-* and *super-*), not as involving RNR out of two APs. Examples like *We must distinguish psycho- from sociolinguistic claims* and *the in- and the output of this machine* (both discussed in Wilder (1997)) show more clearly that part of a morphological word can be affected by RNR. See also Booij (1984).

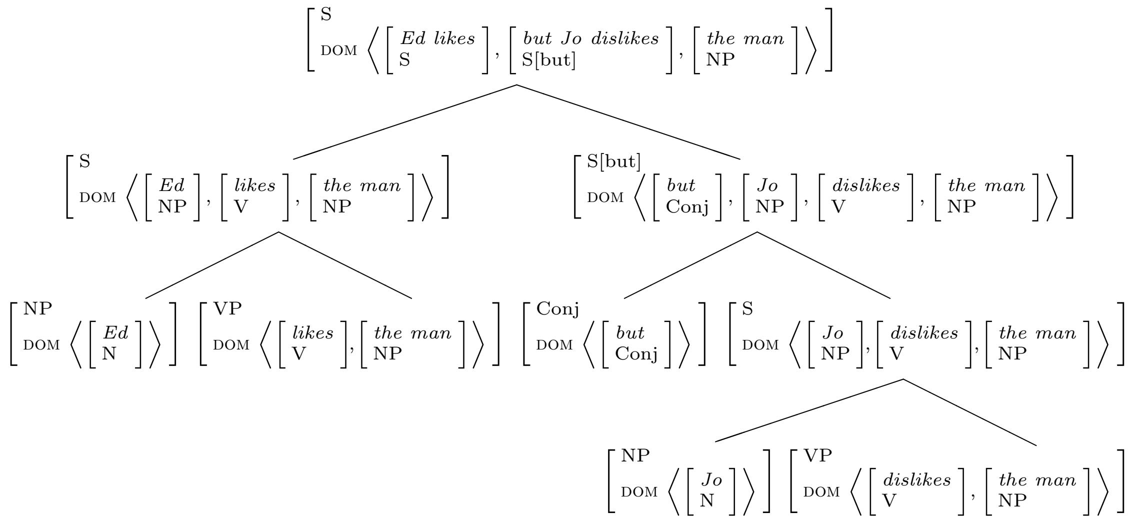

Figure 3: Right-node raising of a domain object

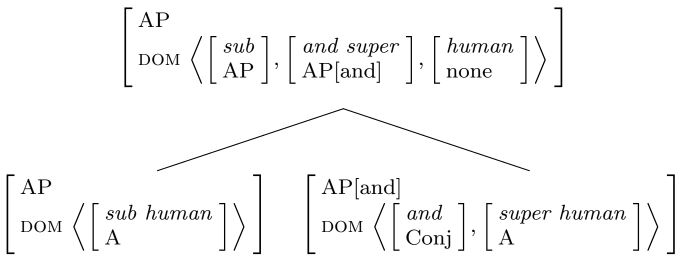

Figure 4: Right-node raising of a prosodic constituent

by the following type of example.

(15) Peter beschreibt den, und Martin beschreibt das Quark.
(from Hartmann (2000))
'Peter describes the fresh cheese and Martin describes the quark.'

The word *Quark* has two senses: with the masculine article, it refers to fresh cheese, while with the neuter article, it refers to an elementary particle. This sentence clearly demonstrates that two phonologically identical expressions can indeed sometimes be right-node raised together even if they are syntactically and semantically distinct from each other.

4 Semantic composition

Finally, let me consider how we could come to grips with the fact that extraposition and RNR sometimes have semantic effects. The solution I propose for this problem in Yatabe (2001) involves a rather major reorganization of the way semantic composition is carried out in HPSG. The basic idea behind the proposal is that domain objects, and not signs, are the principal carriers of semantic information and that semantic composition (including 'quantifier retrieval') takes place not when some signs are syntactically combined to produce a new, larger sign but when some domain objects are (either totally or partially) compacted to produce a new domain object. The theory is implemented in the framework of Minimal Recursion Semantics (Copestake et al. (1997)).

The theory under discussion implies (roughly) that a quantifier α is obligatorily retrieved from quantifier storage when the domain object that represents α is merged with some other domain object(s) by the total or partial compaction operation. In other words, the theory is making the following claim (roughly speaking): when a domain object representing a quantifier α and some other domain object(s) are compacted to produce a new domain object β, either what is signified by β or a part of it becomes the semantic scope of α.

The theory thus correctly predicts that extraposition and RNR of domain objects can alter scope relations (while RNR of prosodic constituents cannot). For instance, in (10a) the subject NP is totally compacted, and therefore the quantificational expression *of every car on the block* contained in the subject NP is predicted to take scope within that NP, whereas in (10b) the domain object corresponding to the quantificational expression is not merged with other domain objects until the entire sentence undergoes total compaction, with the result that the expression is expected to take scope over the entire sentence. Likewise, the quantifiers (*of many famous persons*) in (11a) must take scope inside the first and the second conjunct respectively, because each conjunct is totally compacted in this case. On the other hand, the following two scenarios are both possible in the case of (11b). What is involved here can be RNR of a domain object; in that situation, the right-node-raised expression is expected to take scope over the entire sentence. What is involved can be RNR of a prosodic constituent as well; in that situation, the right-node-raised expression is expected to be interpreted just as in the case of (11a).

Furthermore, in conjunction with the assumption that a tensed sentence is always required to undergo total compaction in English (Kathol and Pollard (1995); Dowty (1996)), the proposed theory provides an explanation for the putative fact that a tensed sentence is always a scope island in English (see Partee (1999) for a recent discussion).

5 Conclusion

Mainly on the basis of some properties of extraposition and RNR, we have proposed a theory of grammatical architecture in which (i) syntactic structure and linear order are mediated not via encodings of hierarchical relations but instead via order domains and (ii) semantic composition is carried out on the basis of prosodic, rather than syntactic structure. The theory already has some compelling stories to offer, and future work will allow us to either confirm or disconfirm those aspects of the theory that remain speculative at the moment.

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