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# Prosody and Recursion in Coordinate Structures and Beyond

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**Abstract** Generalizations about relative prosodic boundary strength are recursive. Initial evidence comes from the fragment of English consisting only of proper names and *and* and *or*. A systematic relation between the semantics, the syntactic combinatorics, and the prosodic phrasing of coordinate structures can be captured by recursively building up their prosody, in tandem with assembling their compositional meaning. Alternative edge-based approaches to prosodic phrasing fail to capture the recursive nature of the generalization, a result independent of whether or not prosodic representation itself is assumed to be recursive. The pattern generalizes beyond the grammar of coordination, despite two types of apparent counterexamples: Structures that are prosodically flat but syntactically articulated, and structures with an apparent outright mismatch between prosody and syntax. Closer inspection suggests that the syntax might actually be quite in tune with prosody. In both cases, natural language employs strategies to construe complex meaning with list-like structures rather than nested ones. The privileged status of lists may be due to processing factors.

**Keywords** Prosody, Recursion, Bracketing Paradoxes, Lists

## 1 Recursion and Prosodic Compositionality

A language can be called recursive if well-formed expressions can be used as compositional building blocks in even bigger expressions. In the case of formal languages, there are often recursive definitions of what counts as a well-formed expression, for example, the convention $if\ a,b \in L, then\ a \wedge b \in L$ allows for recursively constructing

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more and more nested coordinate structures. To recycle an output in this way in order to build more complex expressions is to take what can be called a *recursive step*.[1]

The grammar of English is recursive in this sense.[2] English coordinate structures provide a simple illustration of the recursiveness of grammar. Two or more constituents can be combined to form a new constituent by connective functors such as *and* and *or*. Each coordinate can itself consist of a coordinate structure:[3]

(1) a. Lysander or Demetrius.

b. Hermia and (Lysander or Demetrius).

c. Helena or (Hermia and (Lysander or Demetrius)).

Different bracketings of coordinate structures can affect truth-conditions. Consider the following two statements. While (2a) is a valid tautology, (2b) is false.[4]

(2) a. $p \wedge (q \vee r) \equiv (p \wedge q) \vee (p \wedge r)$

b. $p \wedge (q \vee r) \equiv ((p \wedge q) \vee p) \wedge r$

'p and q or r is equivalent to p and q or p and r.'

The difference in truth-value is a reflex of the structural difference and how it interacts with the composition of meaning. Along with a meaning, every expression is assigned a set of instructions specifying how to pronounce it. Just as the meaning reflects the internal structure, so does prosody. Prosody disambiguates spoken renditions of (2a) and (2b) and encodes the syntactic difference with boundaries of different strength. Boundary strength is encoded by various phonetic and phonological cues, such as pre-boundary lengthening, initial strengthening, pause, and the presence/absence of boundary tones (cf. Ladd, 2008, and references therein). Listeners have been shown to have clear percepts of relative boundary strength (de Pijper and Sanderman, 1994). I will indicate prosodic boundaries with the pipe symbol '|,' and the relative rank by the number of pipes ('|,' '||,' '|||'...). The intuitions about the prosody of the structures above can be represented as follows:

(3) a. $p \mid \wedge q \mid\mid \vee p \mid \wedge r$

b. $p \mid \wedge q \mid\mid \vee p \mid\mid\mid \wedge \ r$

The first part of this paper investigates the fragment of English that consists only of proper names and the connectors *and* and *or*. A close correspondence between

[1] An overview of definitions of recursion in the linguistic literature is given in Tomalin (2007).

[2] There are languages that seem to heavily restrict nesting, and prefer building complex meaning using iterative, paratactic expressions (e.g. many Amazonian languages, see Derbyshire and Pullum (1986). It is possible that the kind of nested structures discussed in this paper cannot be replicated in those languages. I will return to cross-linguistic differences of this kind in the conclusion of this paper.

[3] I will use the terminology employed in Huddleston and Pullum (2001), who refer to *and* and *or* as the 'connectors' of coordinate structures and the constituents they conjoin as the 'coordinates.'

[4] The expression *((p and q) or p)* seems redundant since logically it is equivalent to *p* alone. But in natural language, disjuncts can be interpreted exhaustively, so the expression can mean ((p and q) or just p), and hence is well-formed. The possibility of an exhaustive reading of disjunction is observed in Hurford (1974) who discusses inclusive and exclusive uses of *or*.

semantic, syntactic, and prosodic generalizations is found. Prosodic phrasing closely reflects interpretive properties of an expression, such that domains that are not *associative* are prosodically articulated and contain boundaries of different strengths, while domains that *are* associative separate constituents by boundaries *matching* in strength. The correct combinatorial power of possible bracketings can be achieved either by a purely representational syntactic theory with n-ary branching trees or a cyclic theory using only binary branching and recursive steps, or 'cycles.' Using both n-ary branching *and* cycles would provide more syntactic options than needed.

The distribution of boundary strength suggests that syntactic structure fixes the the *relative rank* of prosodic boundaries, but not the exact *type* (e.g., intonational phrase vs. intermediate phrase). This is compatible with categorical phonological differences between types of boundaries, as long as phonology has some leeway in how to *implement* relative ranks, using the phonological means of the language. However, at least in some cases, relative boundary strength might actually reflect a recursive organization of phonology itself, as originally argued in Ladd (1988, 1992).

The observations about relative boundary strength are at odds with 'edge-based' theories of the syntax-phonology mapping (Selkirk, 1986, 1995, Truckenbrodt, 1995, i.a.). Edge-alignment cannot capture the phrasing of recursively nested constituent of the same category, since it directly maps certain types of syntactic constituents of certain types to prosodic boundaries. It also fails to account for the observed flexibility in how relative ranks are implemented phonologically. This finding is independent of whether the implementation of differences in boundary rank is categorical—as assumed in the prosodic hierarchy theory—or gradient.

The second part of the paper addresses the question whether coordinate structures constitute a special case, or whether constraints observed here generalize to other types of structures. A close look at apparent mismatches—the original motivation for the edge-alignment approach—suggests that they do. The first type of mismatch involves structures that are prosodically 'flat' but their syntax seems to be articulated. The second type of mismatch involves a prosodic bracketing that seems to downright contradict the syntactic bracketing, a phenomenon epitomized by the famous *cat that caught the rat that stole the cheese* (Chomsky, 1965, Chomsky and Halle, 1968).

Rather than calling for a more complex mapping between syntax and prosody, it is in fact the syntactic analysis that has to be changed to account for these mismatches. In both types of cases, strategies are at play that permit to construct complex meaning with more list-like structures instead of nested ones. Lists enjoy a special status in grammar, possibly because they are easier to process. Cases in which prosodic boundaries seem to be optional might actually involve choices between a nested structure and a list structure. If correct, this line of argument provides more evidence against a more complicated mapping function, which effectively derives the right prosody from the wrong syntax.

## 2 Semantics: Prosody and Associativity

Utterances consisting only of proper names and connectors occur as fragment answers to questions:

(4) Who went to the forest?

a. Lysander and Hermia.

b. Lysander or Hermia.

Fragment answers can be analyzed as being complete sentences with elided IPs (Merchant, 2003), so (4a) can be derived from (5).[5]

(5) Lysander and Hermia went to the forest.

The precise bracketing in coordinate structures often does not seem to affect the truth conditions of an expression, e.g., the following expressions are truth-conditionally equivalent despite their different prosodic groupings:

(6) Who went to the forest?

a. Lysander | and Demetrius | and Hermia.

b. Lysander | and Demetrius || and Hermia.

c. Lysander || and Demetrius | and Hermia.

In the following, I will refer to the prosody in (6a) as 'prosodically flat.' It is 'flat' in that the coordinates are separated by boundaries of equal rank and are thus prosodically on par; structures involving elements that are separated by boundaries of different strength I will call 'prosodically articulated,' e.g. (6b,c). Constituents separated by relatively weaker boundaries are perceived as grouping together:

(7) a. A || or B | and C *Interpreted as: A or (B and C)*

b. A | or B || and C *Interpreted as: (A or B) and C*

What determines the choice of prosody in such coordinate structures? The generalization proposed here is that relative boundary strength reflects the compositional structure of expressions as follows:

(8) Recursive Generalization about Boundary Strength in Coordinate Structures

a. In an associative structure, elements are separated by boundaries of equal strength.

b. In a non-associative structure, constituents that are more deeply embedded are separated from each other by weaker boundaries than constituents that are less deeply embedded.

[5] Some theories even derive conjunction by ellipsis of identical material in the first coordinate. This type of coordination reduction was argued for, e.g., by Chomsky (1957, 36) and Harris (1957, 318ff). Predicates requiring plural subjects are one of many problems for this approach:

(i) a. Lysander and Hermia gathered in the forest.

b. * Lysander gathered in the forest and Hermia gathered in the forest.

But see Schein (1997) for a recent discussion of coordination reduction and related analyses.

This is a generalization of the observation in Taglicht (1998) that if in a structure with n $>$ 2 conjuncts, if two conjuncts are separated by an intonational phrase break, all have to be separated by an intonational phrase break.

Prosody reflects the attachment of constituents in the phrase marker. Based on observations from attachment ambiguities, Watson and Gibson (2004) hypothesize that "listeners prefer not to attach an incoming word to a lexical head that is immediately followed by an intonational boundary," (*Anti-Attachment*). The data discussed here suggests a more general pattern, in one way or other tacit in much research in prosody since early on (Lehiste, 1973, Cooper and Paccia-Cooper, 1980):

(9) Hypothesis about Attachment and Prosody:
In a sequence $A \prec B \prec C$, if the boundary separating A and B is weaker than the one separating B and C, then [[AB] C], if it is is stronger, then [A [BC]].

Prosodic boundary strength reflects syntactic bracketing. Let us consider now under what circumstances flat and articulated prosodies are used respectively.

## 2.1 The Associativity Hypothesis

Consider an analogy to the orthographic convention on placing parentheses in logic. Formulas (10a,b) are well-formed as they are, while formula (10c) is incomplete:

(10) a. $A \vee B \vee C$

b. $A \wedge B \wedge C$

c. $A \vee B \wedge C$

The parentheses are redundant in (10a,b) since disjunction and conjunction are associative operations; but in structures in which *and* and *or* are used alternately, such (10c), the parentheses are crucial. We can define a notion of associativity of expressions in natural language as follows: A constituent consisting of elements x, y, and z is associative if its denotation does not change under either order of composition:[6]

(11) ASSOCIATIVITY
Elements x, y and z are associative if the following holds:
$[[x(yz)]] = [[(xy)z]]$

Consider now the following hypothesis:

(12) ASSOCIATIVITY HYPOTHESIS

a. If a string of $n > 2$ elements are prosodically on par, then they are associative.

b. If a string of $n > 2$ is associative, they are prosodically a par.

[6] The parentheses '(...)' stand for functional application, as defined in Heim and Kratzer (1998). Sequences of more than two elements are associative if the denotation does not change under any bracketing.

In the following, I present evidence in favor of (12a). The second half of the hypothesis, (12B), is harder to test, and might not be correct, since factors other than associativity such as memory load or constituent length might induce additional prosodic boundaries. Associativity as a factor in the structure of multiple coordinations has also recently been discussed in Winter (2006). The general idea behind (12) is that prosodic boundaries are used parsimoniously and only distinguish boundaries of different strength when bracketing is crucial for interpretative reasons.

## 2.2 Flat Structures are Associative

The first part of the associativity hypothesis (12a) conjectures that prosodically flat structures have to be associative, i.e., whenever the bracketing affects the truth conditions of an utterance an articulated prosody is obligatory.

Adverbs such as *together*, *alone* and *respectively* interact with other elements in an expression in ways that affect truth conditions. Consider example (13). The context makes it clear that two apples were given out. The answer involves three people, so there must be a sub-grouping, depending on who had to share an apple. The answer in (13a) seems inappropriate, while (13b) and (13c) differ in their truth conditions:

(13) Two apples were given out, but I don't know to who. Who was given an apple?

a. # Lysander | and Demetrius | and Hermia respectively.

b. Lysander | and Demetrius || and Hermia respectively.

c. Lysander || and Demetrius | and Hermia respectively.

The bracketing is crucial and hence a flat prosody is infelicitous, as predicted. The use of *respectively* is crucial. *Respectively* indicates that the distribution of the apples will be specified. Without the adverb, it would be possible to use a flat prosody and leave the exact subgrouping unspecified. The resulting meaning would be much weaker, equivalent to the interpretation resulting from replacing the coordinate structure with a plural description referring to the entire group as a whole. As expected, a plural description would also be inappropriate in this context:

(14) Two apples were given out, but I don't know to who. Who was given an apple? # The three were given an apple respectively.

Consider also the case of *together*. The answer in the following dialogue is ambiguous: *Together* can take low scope, in which case Lysander went on his own, separate from Demetrius and Hermia; but it can also take wide scope, such that all went together as a group, and Demetrius and Hermia are furthermore marked as a sub-group, maybe because they are a couple:

(15) Who went to the forest?
Lysander || and Demetrius | and Hermia together.

Considering the low-scope meaning, we find that, as expected based on the Associativity Hypothesis, it is impossible to encode this meaning using the 'flat' prosody or the prosody that places a strong boundary between Demetrius and Hermia but a weak boundary between Lysander and Demetrius:

(16) Who went to the forest?

a. # Lysander | (and) Demetrius | and Hermia together.

b. # Lysander | and Demetrius || and Hermia together.

(if Lysander went on his own, and Demetrius and Hermia together)

Other types of sentential adverbs in also interact with prosodic grouping:

(17) Who went to the forest?

a. Lysander || and probably Demetrius || and Hermia.

b. Lysander || and probably Demetrius | and Hermia.

When *probably* takes scope over a single coordinate, all coordinates can be separated by boundaries of equal rank, as in (17a); but when *probably* takes scope over the last two coordinates, they must be separated from the first coordinate with a stronger boundary (17b). Again, changing the bracketing is not innocuous and results in different truth conditions, and as expected prosodic articulation is required.

The adverb *both* has a similar effect (Lasersohn, 1995, 151). *Both* introduces the presupposition that the expression in its complement refers to a group with exactly two members. In a structure with three elements, two must group together:

(18) a. Both Lysander | and Demetrius || and Hermia.

b. Both Lysander || and Demetrius | and Hermia.

The flat prosody cannot be used with more than two coordinates:

(19) * Both Lysander, | [and] Demetrius, | and Hermia.

The interaction of *both* with prosodic bracketing can be made sense of if (18a,b) involve a coordination distributing over two propositions, one of which includes a plural subject consisting of the two coordinates that are grouped together more closely. The bracketing is crucial and has a truth-conditional effect.

More evidence comes from predicates which interact with collective readings of DPs. Consider the following example Winter (cf. 2001, 31). Similar examples are also discussed in Schein (1993) and Lasersohn (1995):

(20) a. Lysander and Demetrius weigh exactly 200 lbs.

b. Lysander weighs exactly 200 lbs and Demetrius weighs exactly 200 lbs.

Sentence (20a) has a collective reading that (20b) lacks, which is that Lysander and Demetrius together weigh 200 lbs. Both sentences have a distributive reading, in which Lysander and Demetrius each weigh 200 lbs. In cases that involve a coordination with a collective interpretation the bracketing can play a crucial role.

(21) Who weighs exactly 200 lbs.?

a. Lysander | [and] Demetrius | and Hermia.

b. Lysander | and Demetrius || and Hermia.

c. Lysander || and Demetrius | and Hermia.

Each sentence has a distributive reading in which each of the three weighs exactly 200 lbs. Example (21b) has an additional reading, in which Lysander and Demetrius together weigh exactly 200 lbs and Hermia does so alone. This collective reading that groups Lysander and Demetrius together is absent in (21a) and (21c). Example (21c) in turn has a reading in which Demetrius and Hermia together weigh exactly 200 lbs and Lysander weighs this much alone. Consider also the following example (prosodic annotation added), from Hoeksema (1983):

(22) Blücher | and Wellington || and Napoleon fought against each other near Waterloo.

It seems that it is not obligatory to mark the prosodic bracketing. The following sentences are compatible with what happened as well (22):

(23) a. The generals fought against each other near Waterloo.

b. Blücher, Wellington and Napoleon fought against each other near Waterloo (but I don't know who sided with whom).

However, these sentences express the weaker proposition that there was some fighting in which the three generals participated on at least two different sides. It is impossible to give the following sentence the reading of (22) (Lasersohn, 1995, 152):

(24) Blücher || and Wellington | and Napoleon fought against each other near Waterloo.

Finally, another way to induce truth-conditional effects by bracketing is to alternate *and* and *or*. With alternating functors it seems that usually a prosodically articulated bracketing is used. This observation was also made in Langendoen (1998):

(25) a. ? Lysander | and Helena | or Demetrius.

b. Lysander | and Helena || or Demetrius.

c. Lysander || and Helena | or Demetrius.

While in the earlier examples, adverbs or predicates interacted with the bracketing to yield truth-conditional effects, in the example in (25) it is the scope of *and* and *or* with respect to each other that is at stake. Again, as expected, an articulated prosody seems to be obligatory when it matters, lending further support to the first condition of the associativity hypothesis (12a).[7]

[7] The question of whether it is the interpretive property of associativity that directly induces prosodic boundaries, or unpronounced scope-taking operators such as quantifiers and collective/distributive operators lexically induce them is beyond the scope of this paper, but the former view seems more parsimonious.

## 2.3 Are all Associative Structures Prosodically Flat?

The other half of the Associativity Hypothesis (12b) states that all associative structures are prosodically flat. Consider again the following dialogue:

(6) Who went to the forest?

a. Lysander | and Demetrius | and Hermia.

b. Lysander | and Demetrius || and Hermia.

c. Lysander || and Demetrius | and Hermia.

The two answers in (6b,c) seem to justify the inference on the side of the listener that the speaker has some motivation for grouping two of the three individuals together—maybe because they went to the forest together, because they are a couple, or because they form a group for some other reason. This might reflect the presence of a collective operator, making the structure non-associative (Winter, 2001). For instance, in the following dialogue *Demetrius and Hermia* contrasts with *Helena* in the context, thus there is motivation for the subgrouping:[8]

(26) Lysander and Helena?
No. Lysander || and Demetrius| and Hermia.

If prosodic articulation always licenses an inference about grouping this would suggest that truly associative structures must be prosodically flat, and any apparently unlicensed prosodic boundary licenses some covert structure that results in additional grouping and hence non-associativity. However, there could be other factors involved. For example, introducing further sub-grouping might make processing a coordinate structure with many coordinates easier. Also, if the associative domains in question are also processing domains, then placing a particularly long constituent into a domain of its own might make it simpler to process the entire expression. Length was shown to be a factor in the placement of boundaries in Watson (2002).

An interesting question is whether each apparent optional prosodic break could involve a choice between two different syntactic expressions, with a closely similar but not identical meaning, or grammar simply allows for additional optional brackets. One problem in answering this question is the structure may be hard to establish in cases where additional boundaries do not make truth-conditional differences.

This section argued for a close relation between the prosody of coordinate structures and their interpretative properties. Prosodically flat structures are semantically associative, prosodically articulated structures are usually non-associative.[9]

[8] It is also possible in this context to use the flat prosody in the answer, and contrast *Lysander, Demetrius, and Helena* as a whole with *Lysander and Hermia*.

[9] This hypothesis is different from the claim that disambiguating prosodic boundaries are only used by a speaker when they are aware of an ambiguity (Snedeker and Trueswell, 2003): The prediction here is that non-associative structures will have an articulated prosody even if a speaker is not aware of the ambiguity, or if the context already provides sufficient information for disambiguation. I will argue that where prosody does not reflect the proper syntactic bracketing it must be that an associative list-structure was used instead of a nested one.

## 3 Syntax: The Combinatorics of Bracketing

An important step in understanding the syntax of coordinate structures is to establish how many different bracketings are possible. The number of bracketings syntax provides is by no means uncontroversial. Culicover and Jackendoff (2005), following Wells (1947, 103), recently argued that in the absence of evidence to the contrary, syntactic structures should be assumed to be n-ary branching for simplicity reasons. Positing an articulated binary-branching analysis of the VP structure, for example, necessitates positing sub-constituents which cannot be motivated based on the tests Culicover and Jackendoff (2005) apply. This goes against the view of much work in the minimalist literature (cf. Chomsky, 1995), which often assumes that syntax only creates binary-branching phrase markers, an assumption that is again based on a simplicity assumption, namely that the basic structure building operation 'Merge' always combines two elements. The problem with arguments based on simplicity is that different assumptions about what counts as 'simple' will lead to different conclusions. What are the empirical issues at stake in coordinate structures?

### 3.1 The Combinatorics of Coordination

Taking prosody into account, it seems that we have to distinguish at least three different bracketings for the case of n = 3 coordinates:

(27) a. Lysander | and Helena | and Demetrius.

b. Lysander | and Helena || and Demetrius.

c. Lysander || and Helena | and Demetrius.

The bracketing of the functors themselves is not syntactically significant. There might be a contrast between cliticizing to the right or to the left, but this, it seems, does not correspond to a syntactic/semantic distinction:

(i.) Lysander 'n/and Hermia.

I will henceforth assume that the connectors group syntactically with the following coordinates. Ross (1967, 90–91) supporting this with the following contrast (see Munn, 1993, 15 for more evidence):

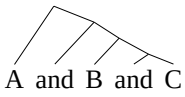
(ii.) a. John left. And he didn't even say good-bye.

b. * John left and. He didn't even say good-bye.

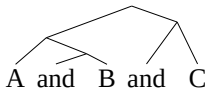
If all coordinate structures were binary and there are only binary branching trees, then it would be unexpected that there are *three* different structures with 3 coordinates. There are only two binary branching trees that one can construct for three elements under these assumptions:

(28) Two Binary Branching Trees, Assuming Binary Functors

a. Right-Branching



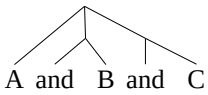

b. Left-Branching



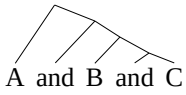

The number of binary branching trees over n linearly ordered items is called the Catalan number of (n-1). The Catalan number for n = 3 is 2.[10] One way to get to the right number of structures is to abandon the assumption of binary branching:

(29) Trees with Unbounded Branching

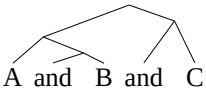
a. Flat




b. Right-Branching




c. Left-Branching




This is combinatorically equivalent to positing phrase structure rules that allow any number of arguments (Chomsky and Schützenberger, 1963):[11]

(30) $A \rightarrow A\ Co\ A\ (CoA)*$,
where $(Co\ A)*$ stands in for zero or more occurrences of *Co A*

The number of bracketings for n coordinates is then the number of trees over linear strings allowing arbitrary branching, also called the 'Super-Catalan number of n'.[12] The Super-Catalan number for n = 4 is 11. The possible bracketings of coordinations with n = 3 and n = 4 are summarized schematically below:

(31) a. n = 3: xxx, x(xx), (xx)x

b. n = 4: xxxx, xx(xx), x(xx)x, (xx)xx, x(xxx), (xxx)x, (xx)(xx), x(x(xx)), x((xx)x), ((xx)x)x, (x(xx))x

The simplest coordinate structure involving four elements is the 'flat' one, with each coordinate separated by boundaries of equal strength. Then there are three structures with three alternatives, one of which is complex:

(32) a. Lysander || or Demetrius or || Hermia | and Helena.

b. Lysander || or Demetrius | and Hermia || or Helena.

c. Lysander | and Demetrius || or Hermia || or Helena.

Three structures involve two alternatives, one or two of which are complex:

(33) a. Lysander || or Demetrius | and Hermia | and Helena.

[10] See Langendoen (1987) for a first discussion of the number of prosodic bracketings.

[11] See also Gazdar et al. (1985).

[12] See (Stanley, 1997) for an interesting overview of the history of these 'Plutarch numbers' and recurrence functions for both Catalan and Super-Catalan sequences.

b. Lysander | and Demetrius | and Hermia || or Helena.

c. Lysander | and Demetrius || or Hermia | and Helena.

Finally, there are four structures which involve two alternatives. Just as in (33a,b), one of the two is internally complex, but they involve another level of embedding:

(34) a. Lysander ||| or Demetrius || and Hermia | or Helena.

b. Lysander ||| or Demetrius | or Hermia || and Helena.

c. Lysander || and Demetrius | or Hermia ||| or Helena.

d. Lysander | or Demetrius || and Hermia ||| or Helena.

Langendoen (1987, 193) and Langendoen (1998, 243) argue that these doubly nested structures are not grammatical, and that the actual number of bracketings in English is only $2^{(n-1)} - 1$. However, in a production experiment reported in Wagner (2005) people were able to produce structures like (34) which were prosodically distinct from (33). At least for cases up to n=4, natural language coordinate structures have Super-Catalan-many bracketings, and I will assume in the following that grammar provides *exactly* Super-Catalan many bracketings. It is possible that the distinction between lower boundaries gets prosodically washed out, and it's certainly hard to introduce yet another level of embedding, so with higher numbers of constituents the full number of possibilities will not be used—but that may have processing reasons.

The combinatorics seem to favor a theory of syntax that allows for n-ary branching, and n-ary braching has often been taken as the null hypothesis for coordinate structures. Miller and Chomsky (1963, 196) state: "Clearly, in the case of true coordination, by the very meaning of this term, no internal structure should be assigned at all within the sequence of coordinate items." N-ary branching trees were assumed in many subsequent generative approaches, e.g. Gleitman (1965).

However, there are alternative ways to distinguish nodes. We could simply mark certain nodes as special, by introducing some additional representational or derivational distinction between nodes. Marking certain nodes in the tree as special has a history. $\bar{X}$-theory distinguishes '*XP*-nodes' and intermediate $\bar{X}$ nodes (Jackendoff, 1977); alternatively, we might use the notion of 'shell'-structures from Larson (1988), or assume the notion of 'extended projections,' and try to distinguish the newly introduced right-branching nodes by looking at their categorical lexical labels (as opposed to their functional labels) following Grimshaw (2005); finally, another alternative is to treat the special nodes as points of 'spell-out' (Chomsky, 1995, 2001). If we adopt any of these additional distinctions, the postulation of n-ary branching nodes may become unnecessary or even unwanted, since it introduces further combinatorial options. Ultimately, the reasons for choosing binary branching over n-ary branching are largely theory-internal, and rely on assumptions about how binding and other dependency relations work. But suppose that we want to go with the set of assumptions favoring binary branching—how can we best capture the facts about prosody and associativity?

## 3.2 A Cyclic Theory

As we saw, for combinatoric reasons, a purely representational grammar assuming only binary-branching trees is simply not sufficient. One way to increase the combinatorial power is to postulate special recursive steps at which a substructure is interpreted both semantically and phonologically, a 'cycle.' The idea that syntactic and phonological composition are interleaved and phonological structure is assigned at each cyclic node originates in Bresnan (1971). Recent approaches to syntax have returned to this view and invoke 'multiple spell-outs' (Uriagereka, 1999) or 'phases' (Chomsky, 2001), and this section explores how prosodic such a derivational theory could account for the presented generalizations.

But introducing cycles will actually provide too many structures, so we need to introduce a restriction on which kinds of structures can be built in one cycle. Consider the following strong right-branching conjecture, a stronger version of a conjecture made in Haider (1993):

(35) Strong Right-Branching Conjecture
In a given work-space, grammar only generates right-branching structures.

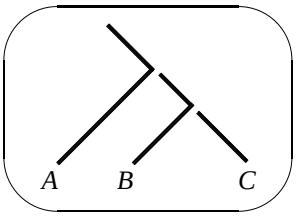
Every current theory of syntax assumes that an output of grammar can be reused in order to build an even larger expression. So even assuming (35), it is still possible to assemble a seemingly left-branching structure—just not within a single work-space.

(36) The Recursive Step
Each output can re-enter a new work-space to build a bigger expression.

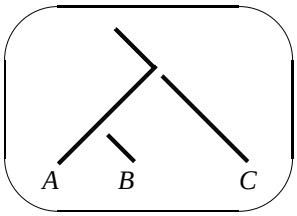
*Within* any workspace, only (37a) can be generated, (37b) is impossible:

(37) Structure within a Cycle

a. Possible:




b. Impossible:




The idea is that 'flat' structures are really right-branching structures that are formed within a single cycle. 'Flat' structures indeed show the c-command asymmetries expected from right-branching structures (cf. Munn, 1993, 16):

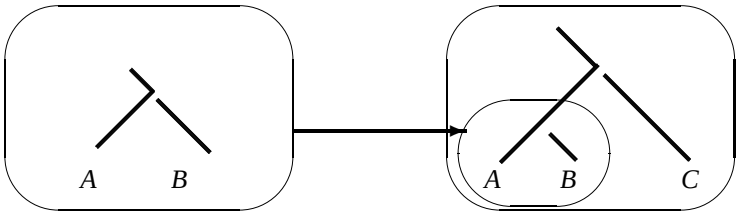
(38) The foreign exchange program must assign students to host families by a method that ensures that no student$_i$, or his$_i$/her$_i$ athletic interests or abilities were a component of the placement process.
www.whsaa.org/handbook/

Right-branching structures seem to be privileged: Larson (1988) and much work since then discuss evidence that complex VPs have right-branching 'shell' structures; Haider (1993, 2000) conjectures that right-branchingness is a systematic property of all extended projections; Kayne (1994)'s anti-symmetric theory of syntax translates c-command into linear precedence privileges right-branching structures; and Phillips (1996) proposes that structures are parsed by default into right-branching structures, unless their semantic forces a different bracketing;Pesetsky (1995) proposes a default right-branching 'cascade' structure for syntactic expressions, in addition to the more standard layered structure.

In the cyclic approach here, the privileged status of right-branching structures is implemented in a way first proposed in Uriagereka (1999): Deriving a left-branching structure requires the combination of more than one work-space, while right-branching structures can be created in one go.

(39) Creating a Left-Branching Structure

a. First Cycle b. Second Cycle:




There are thus three ways of assembling structures with three elements, and for n elements, there are exactly Super-Catalan of (n-1)-many structures. If we had allowed both left- and right-branching structures within a cycle, there would be more derivations than needed, in the case of n = 3 we would predict 4 instead of 3 different structures.

The interpretive properties of 'flat' vs. 'articulated' coordinate structures can now be explained with the simple hypothesis that the output of every cycle must be associative. This can be thought of as an interface condition on the interpretability of linguistic expressions.

(40) Interface condition on cycles
The elements combined in a single cycle must be semantically associative.

While the proposal here shares important characteristics with the one in Uriagereka (1999), a fundamental difference is that the causal relation between right-branchingness and being assembled in a single cycle is reversed. Uriagereka (1999) characterizes cycles as domains that are linearizable according to the LCA, and material that is not linearizable in this way has to go through multiple spell-outs.[13] Whether or not a cycle occurs is thus derived from the geometry of the tree structure. According to the proposal here, in the absence of a motivation to impose multiple

[13] A similar line of reasoning is given in Guimarães (2004).

cycles, an expression will be assembled in one cycle and receive a right-branching binary structure simply because this is the default structure. The motivation for multiple spell-outs does not lie in the geometry of the tree structure but is semantic: The output of a single cycle must be associative.

As a reviewer points out, the idea that the condition on what constituents form cycles is semantic diverges from the standard assumption in current Minimalism in which spell-out is triggered by certain syntactic heads that are stipulated to be phases (Chomsky, 2001). Semantic criteria to define the size of a spell-out domain are not unheard of, however. Chomsky (2001) claims that phases are 'proposition'-sized, and Svenonius (2001, e.g.), argues that a spell-out occurs as soon as all uninterpretable features have been checked and only interpretable ones remain.

The effect of the right-branching assumption and the associativity condition on cycles is similar to the principle 'Branch Right' proposed in Phillips (1996), which favors right-branching structures unless they are not compatible with the semantic interpretation of an expression. If the meaning of the elements combined in one cycle is associative, the bracketing of the material within a cycle is immaterial from a semantic point of view. This architecture of the grammar chunks elements into one cycle for which the bracketing does not matter. In fact, the meaning could be computed bottom-up (as is conventionally assumed) or top-down/left-to-right, as proposed in Phillips (1996, 2003).

There are alternative possibilities. First, the representational theory involving flat trees and the derivational theory with special cyclic nodes are notational variants of each other, at least with respect to the number of structures they provide for a tree with *n* terminal nodes. Also, one could view the tree structures that are composed in one single cycle as 'elementary trees,' as they are proposed in Tree Adjoining Grammar, and the insertion into a new cycle as the operation of 'substitution' (Frank, 2002). There is nothing in the approach here that would decide between these different interpretations. Note, however, that in order to obtain the right combinatoric power it would be necessary to restrict elementary trees to be right-branching.

An important lesson to learn from the combinatorics of coordination is that we should pick the cyclic theory, a TAG theory, or any other theory that distinguishes types of nodes, *or* allow for n-ary branching, but one should not combine any of these options, since otherwise the number of combinatorial possibilities is too high. Suppose we assume that n-ary branching nodes are possible *and* there are cycles. Then we would predict a choice at each non-terminal, non-root node of whether or not to spell out. This would increase the number of structures that can be built from 3 elements from 3 to 5, and the number of structures that can be built from 4 elements rises from 11 to 31. In other words, the number of possible phrase markers becomes implausibly high given what we know about language.

## 4 Phonology: Relative Boundary Ranks and Prosodic Matching

The prosodic boundaries reported so far were not labeled with respect to the intonational categories (intonational phrase, phonological phrase, etc.) as they are standardly assumed in prosodic phonology (Selkirk, 1986, Nespor and Vogel, 1986,

Truckenbrodt, 1995) and in the ToBI labeling convention (Silverman et al., 1992). And the generalization proposed in (8), repeated below, does not make reference to the precise nature of phonological representation:

(8) Recursive Generalization about Boundary Strength in Coordinate Structures

a. In an associative structure, elements are separated by boundaries of equal strength.

b. In a non-associative structure, constituents that are more deeply embedded are separated from each other by weaker boundaries than constituents that are less deeply embedded.

What kinds of boundaries are used in coordinate structures? More generally, what kinds of syntactic objects are separated by what kinds of prosodic junctures?

## 4.1 Compositionality and the Metrical Grid

The relational view of syntax-phonology mapping makes it possible to think of the building up of prosodic structure in a compositional way. The prosodies of bigger constituents are composed of and properly contain the prosodies of their parts, e.g., the prosodic representation of (41a) is a proper subpart of (41b):

(41) a. (p and q) or p

b. ((p and q) or p) and r

This is not to say that the substring underlined in (41b) is *phonetically* identical to (41a). The two structures are identical at a more abstract level, just as the [k]s in spoken renditions of *cup* and *cat* are not phonetically identical, but are usually assumed to share an identical piece of information in their representation, the featural representation of /k/. Surface phonetic differences in the realization come about as a result of how phonological structure is implemented. But how can this abstract notion of prosody be represented?

Although prosodic phrasing closely reflects syntax, it is not transparently encoded in the syntactic tree structures usually employed in generative syntax. Chomsky and Halle (1968) therefore propose a phonological notation of syntactic structure that is more palatable to phonology. The syntactic representation is 'transcribed' by employing boundary symbols that are built up cyclially:

(42) Syntactic Transcription (ignoring connectors)

a. ### *A* ## $\vee$ *B* # $\wedge$*C* ### A or (B and C)

b. ### *A* # $\vee$ *B* ## $\wedge$*C* ### (A or B) and C

Where are these boundary symbols placed exactly? Chomsky and Halle (1968, 13) argue as follows: "As a first approximattion to the problem of analysis into words, let us assume that each lexical category (e.g., noun, verb, adjective) and each category

that dominates a lexical category (e.g., sentence, noun phrase, verb phrase) automatically carries a boundary symbol # to the left and to the right of the string that belongs to it (i.e., that it dominates [...])."

Could we simply replace 'certain places' by the current notion of cycles/phases? We could then simply add boundary marks enclosing the elements of each cyclic domain. But this will not quite derive the right boundary strength. Consider what happens if we simply enclose 'cycles' with boundary marks in a more elaborate structure:

(43) (A or B) and C and D $\rightarrow$ ### *A* # $\vee$ *B* ## $\wedge$ *C* # $\wedge$ *D* ###

The boundary separating C and D is too weak. The information that is not reflected in the boundary symbols is that the three items (A or B), C and D are prosodically on par. The problem is reminiscent of a problem in the assignment of nuclear stress, discussed in Halle and Vergnaud (1987), Arregi (2002), which was resolved using the 'stress equalization principle,' which brought the metrical representations of two sister constituents to the same level before applying the Nuclear Stress Rule. The solution to the equalization problem in the domain of prominence proposed in Halle and Vergnaud (1987) is to employ a metrical grid to represent stress, and add a convention that brings elements on par before other rules apply.

The metrical grid does not only reflect prominence, it also reflects the timing structure of an utterance. It was originally proposed in analogy to musical notation in Liberman (1975) and further developed in Liberman and Prince (1977), Prince (1983), Selkirk (1984) and subsequent research. According to Prince (1983) the metrical grid encodes both prominence and prosodic grouping simply by virtue of prominence relations: "A time signature, such as 2/4, imposes a kind of implicit metric on the pulse train, distinguishing certain pulses as intrinsically stronger than others." This is illustrated in Prince (1983) as follows:

(44) Metrical Grid

| | ♩ | ♩ | | ♩ | ♩ | | ♩ | ♩ | |
|---|---|---|---|---|---|---|---|---|---|
| | × | | | × | | | × | | |
| | × | × | | × | × | | × | × | |

In this theory, higher prominence in the grid representation corresponds to a separation into different rhythmic intervals, and perceptually the beats chunk up the stream of sounds into smaller units. Each level of grouping adds a level to the grid. The grid marks do double duty: They encode prominence and prosodic grouping.

It seems. however, that grouping, or 'prosodic phrasing,' and prominence must be separated—although they interact, and intuitions about prominence are often affected by phrasing. But often prominence is shifted around due to information structure, and yet phrasing remains intact. In the following dialogue, the break between the two coordinates remains perceptible in the answer, despite the fact that the material after *Demetrius* is pitch-suppressed:

(45) Who will get married?

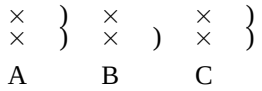
a. (Egeus and Helena) | and (Lysander and Hermia)?

b. No! (Demetrius and Helena) | and (Lysander and Hermia).

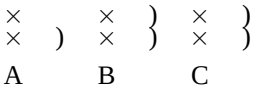
It is therefore necessary to distinguish prosodic phrasing from metrical prominence, and this is why the notation purely relying on grid marks in Prince (1983) is not sufficient. The particular notation employed in the following is one where the grid is furthermore annotated for 'foot' boundaries. I will adopt a version of the bracketed metrical grid introduced in Idsardi (1992) and Halle and Idsardi (1995):

(46) Bracketed Metrical Grid

a. A or (B and C)




b. (A or B) and C




The notation is to be read as follows: The right parentheses demarcate feet at each level in the grid. All material to their left up to another foot parenthesis counts as a foot (Idsardi, 1992, Halle and Idsardi, 1995). Foot boundaries at higher levels necessarily correlate with foot boundaries at lower levels. This representation encodes boundary strength in a straightforward way: The higher the grid line the stronger the boundary. The boundary rank can be read off as the height of the column of brackets.

(47) BOUNDARY RANK
The rank of a prosodic boundary at a certain point is the rank of the highest grid line with a foot boundary at that point.

The feet of the abstract metrical grid are implemented using the means the phonology of the language provides. The version of the grid I employ here departs from earlier work (Prince, 1983, Halle and Vergnaud, 1987, Idsardi, 1992) in an important way. It does not single out a grid mark within each foot as its head by projecting only that one to a higher line, and hence it does not directly encode the syllable that is perceived by native speakers as the most prominent.

However, the representation in (46) still singles out some beats by virtue of them being *final within their foot*. Newman (1946) and Truckenbrodt (1995) observe that, in English, main prominence is perceived on the last accented element within a constituent, and I adapt the idea in the following form:[14]

(48) NUCLEAR STRESS GENERALIZATION
Within each foot on any grid line, main prominence is perceived on the last of those grid marks that project highest.

The underlying assumption is that prominence is not a primitive of the theory. Still, intuitions about relative prominence can give important cues to phrasing. Consider the difference between the following two coordinate structures:

[14] Newman (1946, 174) singles out a heavy stress as 'nuclear' if it 'acts as the nucleus of an intonational unit.' Within any intonational unit it is always the last heavy stress that counts as the nuclear stress. Newman (1946, 176) suggests that in coordinate structures ('enumerations') each coordinate receives a nuclear accent. The intuition that each coordinate is on par is attributed here to the fact that the boundaries that separate them are identical.

(49) a. (A or B or C) an D

b. (A or B) or (C and D)

One way to tell the two phrasings apart is to probe for intuitions about prominence. In (49a), C is more prominent than B, while in (49b), B is more prominent than C, as predicted by (48). We can thus use intuitions about relative prominence as a cue to detect phrasing, as long as we control other factors affecting prominence which can constitute possible confounds, e.g., information structure or rhythmic readjustments. How does the grid encode the location of pitch accents in a structure? I will assume that the following generalization holds:

(50) ACCENT PLACEMENT
All and only top-line grid marks receive pitch accents. All other material is either unaccented or realized with a sharply reduced pitch range.

We can now return to the observation that phrasing and prominence can be dissociated. Each coordinate in coordinate structures normally receives an accent, which will be represented in the notation here by projecting top line grid marks within each coordinate to the top line of the entire structure. But under certain circumstances some coordinates do not receive an accent, e.g., if there is a contrast as in (51):

(51) Was it Demetrius and Hermia?
No, Lysander and Hermia!

In a natural rendition of (51) the material following the first coordinate is deaccented or at least heavily pitch reduced. It is *prosodically subordinated*. It is this type of prosodic subordination which is responsible for cases in which nuclear stress does not fall on the final element in a phrase (see Wagner, 2005). We can present prosodic subordination in the grid as follows:

(52) Subordination

```
×   )
×   )   ×   )
Lysander    Hermia
```

The 'nuclear' stress now falls on the syllable with main stress in *Lysander*, since it is the last unsubordinated element, i.e., the last element that projects to the top line. An important property of subordination is that the phrasing in the subordinated domain is maintained. Consider the grid notation of the response in (45):

(53) Phrasing in Post-nuclear domain

```
×   )
×   )   ×   )   ×       ×   )
×   )   ×   )   ×   )   ×   )
Demetrius   Helena   Lysander   Hermia
```

Nuclear stress of the entire answer is perceived on the main stress of *Demetrius*, since this syllable is the last (and only) one that projects a grid mark to the top line. For the same reason, main prominence within the first coordinate (*Demetrius and Helena*) is perceived on that syllable. The prosodic phrasing *within* the subordinated material, however, is maintained; the break after *Helena* is intuitively stronger than that after *Lysander*. That post-nuclear phrasing still reflects differences in boundary rank was experimentally tested in Jaeger and Norcliffe (2005).[15]

## 4.2 Putting things together: Deriving a Relational Grid

A metrical grid for an expression can be derived from syntax if, whenever an associative domain is completed, the cycle is 'spelled out.' Part of 'spelling-out' involves mapping the content of a cycle to a single prosodic unit. I will call this creation of a prosodic unit out of two or more parts *Prosodic Matching*, since the elements of the cycle are prosodically on par:[16]

(54) PROSODIC MATCHING

a. Concatenate
Concatenate the prosodic representation of the elements in the domain aligning their top lines and filling the columns where necessary.

b. Project
Create a new top-line grid line n by projecting all grid marks on line n-1, and mapping them into a single foot on line n.

This principle simply maps the output of the cycle to a single foot in a new top-line in the metrical structure. 'Concatenate' plays a role similar to the 'stress equalization principle' in Halle and Vergnaud (1987) and Arregi (2002). It assures that constituents within a cycle start out on an equal footing in their prosodic representation. In the following, I will use a black dot to indicate a spelled out domain.

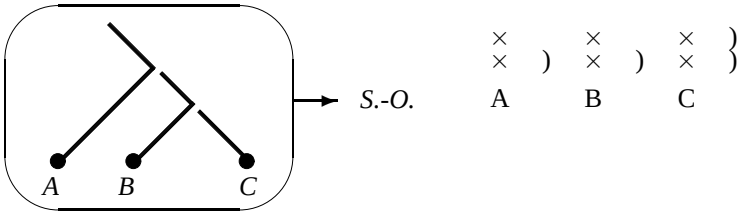
(55) Building a Right-Branching structure in one single cycle:

A | and B | and C

Spell-Out of the Cycle:

[15] Apart from information structure, there are other factor that can induce prosodic subordination, e.g., Wagner (2005) argues that the functor-argument relation plays a crucial role and functors are subordinated when they are preceded by an argument in complement position. I will not discuss the determinants of prosodic subordination in this paper.

[16] Each coordinate in a coordination structure, I assume, has already undergone a cycle. Every element thus comes in with some metrical structure associated with it. I will not discuss the cyclic foot structure below the word in this paper, but see Arad (2005), Marantz (2001), Marvin (2002).

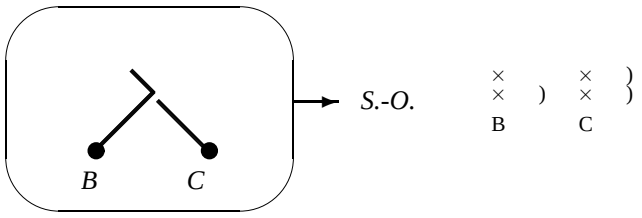



A right-branching structure may also the result of two separate cycles. This is the case when the associative law does not hold, as in the following expression:

(56) A and (B or C)

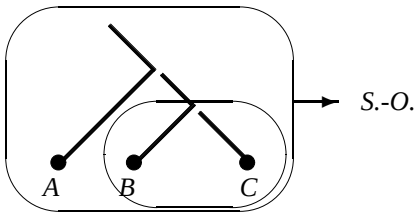
A first cycle assembles the constituent *(B and C)*.

(57) First Cycle, Spelled-Out:



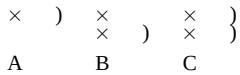

The output of the first cycle is inserted into a second cycle:

(58) Spell-Out of the Second Cycle



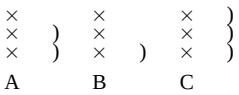

When the second cycle is spelled out, the metrical elements corresponding to the constituents within are concatenated:

(59) Concatenating the Grids



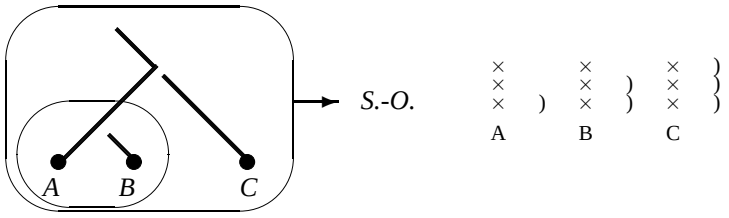

Then, a new grid line is projected. I will also ‘fill up’ the grid column that is unfilled, simply for notational reasons—the relations in the grid are relative, and constituents of different complexity can be matched to the same grid level.

(60) Spell-Out of Second Cycle



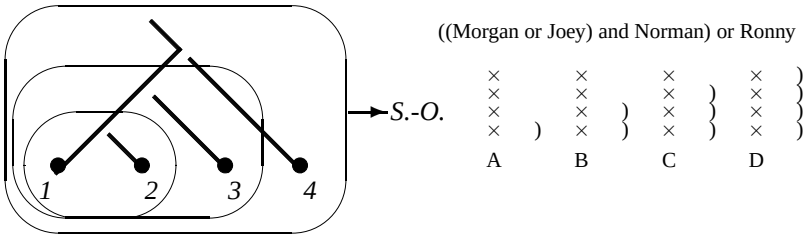

Two different grids are derived, although representationally the same right-branching binary tree is involved. The grid keeps track of the derivational difference. A left-branching structure necessarily is created via two cycles:

(61) Left-Branching Structure




Three different grid structures are derived for the three different derivations. Similarly for the case of n=4, the metrical grid distinguishes 11 different derivations for the 5 different binary trees. Consider first a fully left-branching tree, which necessarily goes through three cycles:

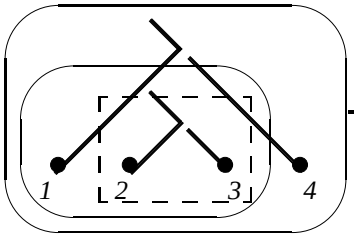
(62) Left-Branching: 1 Derivation




There are three binary branching tree involving four elements that have one right-branching node and one left-branching node. The elements on the right branch of a right-branching node can either be a separate cycle or be assembled together with the other material in the tree—which one is the right output depends on whether or not the associative law holds; the elements under the left branch on a left-branching node necessarily form a cycle together.

In the tree below, it is the first three elements that are on the left branch, and they always form a separate cycle. Elements 2 and 3 may or may not form an additional separate cycle (a node that could be a separate cycle or be part of a bigger cycle, i.e. a right-branching node, is marked by the dotted rectangle, which reflects the fact there could be an extra cycle—depending on the content of the terminal nodes and whether or not the associative law holds within the cycle that contains it):

(63) One Right-Branching node: 2 Derivations




*S.-O.*

i. (Morgan and Joey and Norman) or Ronny

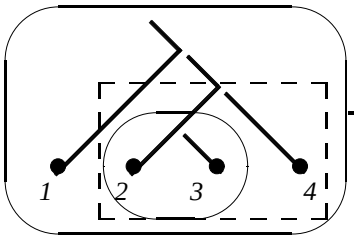
A B C D

ii. (Morgan and (Joey or Norman)) or Ronny

A B C D

In the second structure, the middle two elements are on the left branch of the left-branching node and hence they must form a cycle. The last three structures may or may not form another separate cycle:

(64) One Right-Branching node: 2 Derivations




*S.-O.*

i. Morgan or (Joey and Norman) or Ronny

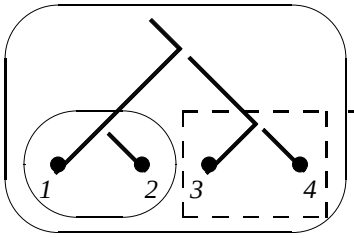
A B C D

ii. Morgan or ((Joey or Norman) and Ronny)

A B C D

In the following tree structure, the first two elements are on the left branch of a left-branching node, and the last two elements can form an additional cycle:

(65) One Right-Branching node: 2 Derivations




*S.-O.*

i. (Morgan and Joey) or Norman or Ronny

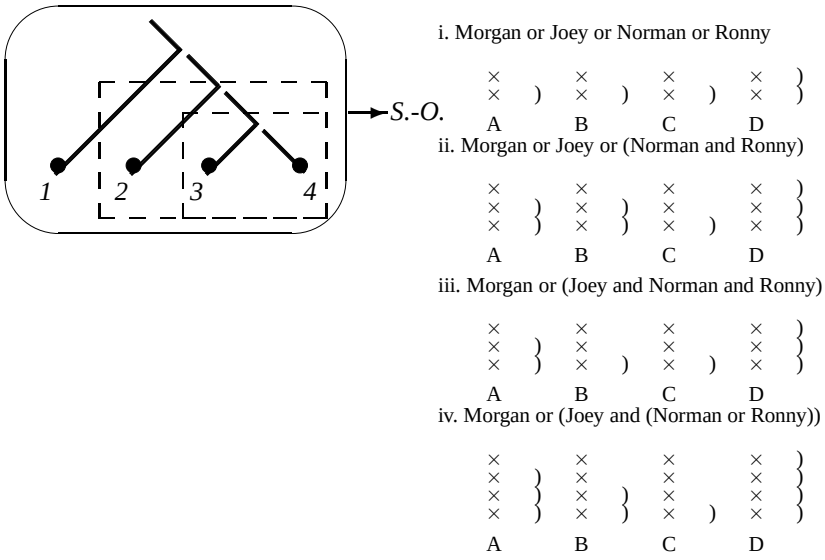
A B C D

ii. (Morgan and Joey) or (Norman and Ronny)

A B C D

Finally, the fully right-branching tree corresponds to four derivations, since each right branching node may or may not contain a separate cycle.

(66) Two right-branching nodes, 2 x 2 = 4 derivations




In the cyclic approach, there are 11 different derivations, and correspondingly there are 11 different metrical grids. The only mapping principle necessary is the one that the domain of a spell-out is mapped to a foot on a new top-line in the grid (54). The grid comes about as a result of the way syntactic derivations interact with this mapping principle. The metrical representation reflects not just the tree structure, but also how it was assembled. The close relation to semantics is a result of the associativity condition on cycles.

A cyclic mapping in syntax is interleaved with the building up of phonological structure was first proposed in Bresnan (1971), and has recently gained more currency in the context of 'multiple spell-out' (Uriagereka, 1999) and 'phases' (Chomsky, 2001), e.g., in Arregi (2002), Adger (2007), Dobashi (2003), Ishihara (2003), Kahnemuyipour (2004), Legate (2001), Marvin (2002) and Kratzer and Selkirk (2007). Most of these approaches are mostly concerned with prominence, with the exception of Dobashi (2003), whose also relates phrasing and cycles.

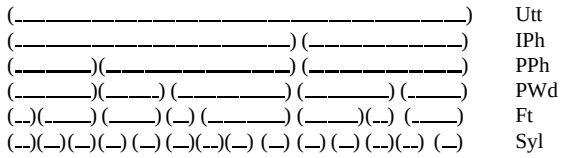
Note that so far we have not seen any evidence in favor of the derivational, cyclic view and against a purely representation view with n-ary branching. Any cyclic effects in prosody, i.e., generalizations that can be explained by letting certain grammatical constraints apply throughout the derivation, where later cycles render generalizations at earlier cycles opaque, would constitute such evidence. Exploring this question, however, would go beyond the scope of this paper, and the present cyclic algorithm is but one out of a family of conceivable recursive approaches.

## 4.3 Relative Boundary Ranks and the Prosodic Hierarchy

How does the claim that the interface between syntax and prosody only fixes relative ranks jibe with the theory of the *prosodic hierarchy*? The theory of the prosodic hierarchy proposes that prosodic boundaries of different strength are categorically different, and these categories are organized in a hierarchical way. Phonological categories

lower on the hierarchy define boundaries that are weaker compared to boundaries of categories higher on the hierarchy:[17]

(67) Prosodic Hierarchy (Selkirk, 1986, 384):




The relational view that the syntax-phonology interface only provides relative ranks is by no means incompatible with the assumption of a prosodic hierarchy. It is crucial to distinguish the claim that we the *generalization* about relative boundary strength must be stated recursively and only fixes relative ranks from the claim that prosodic *representation* is recursive.

Suppose that the strongest version of the prosodic hierarchy theory is correct, and that there is only a small set of categorically different prosodic domains, and no recursion such that one domain is embedded in a domain with the same label is allowed. If rather than fixing the particular ranks, the interface only fixes relative ranks, then the phonological categories have to be used in a way compatible with these relative ranks, but which line in the metrical grid will line up with a particular category of the prosodic hierarchy should be flexible.

This view can still capture some of the implicational generalizations that were the motivation for the prosodic hierarchy. For example, if a rule applies within a domain $P_i$ it necessarily occurs within all domains $P_j$, $j < i$. I will use the segmental rule of flapping in English to illustrate the point (cf. Kahn, 1976, Gussenhoven, 1986).[18] Suppose that the flapping domain is $\Phi$, and the next domain down on the prosodic hierarchy is $\phi$, and the next domain up is the intonational phrase *IP*. Flapping can but need not occur in coordinate structures:

(68) a. a car or a rat?

b. a cat?or a rat?

We can explain is if in the implementation of the prosody of the structure, phonology provides the option of either aligning line i or i+1 as corresponding to a certain prosodic domain:[19]

(69) Implementing Boundary Ranks

[17] I do not believe that syllables and feet are really prosodic domains of the same kind as phonological phrases, intermediate phrases, and intonational phrases, and the following discussion will only assume a flexible implementation for these higher prosodic domains.

[18] Thanks to Charles Reiss for suggesting this kind of example to me.

[19] The actual value of i has no relevance, since only relative strengths counts. A complete output must comprise all prosodic levels according to the prosodic hierarchy theory, so the final representation has to also include the higher layers of the prosodic hierarchy on top of the grid provided by the interface.

a. Implementing Line i as $\Phi$

| | | | | | | |
|---|---|---|---|---|---|---|
| *line i+1* | × | | | × | $)_{IP}$ | |
| *line i* | × | $)_{\Phi}$ | | × | $)_{\Phi}$ | |
| | a cat | | or a | rat | | |

b. Implementing Line i+1 as $\Phi$

| | | | | | | |
|---|---|---|---|---|---|---|
| *line i+1* | × | | | × | $)_{\Phi}$ | |
| *line i* | × | $)_{\phi}$ | | × | $)_{\phi}$ | |
| | a cat | | or a | rat | | |

The category labels have to be consistent with the decision on which line corresponds to $\Phi$; any equal and stronger boundary must be also at least be of type $\Phi$, and any weaker boundary must not align with a $\Phi$ break. It might be that the inventory of categories is small, and certain distinctions lower in the grid get 'washed out'. This scenario is still compatible with the claim that only relative ranks get fixed at the interface, and it makes interesting predictions. Deciding that line i in the grid corresponds to $\Phi$ boundaries has consequences in more complex structures:

(70)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *line i+2* | × | | | × | | | | × | | ) |
| *line i+1* | × | | | × | | ) | | × | | ) |
| *line i* | × | | ) | × | | ) | | × | | ) |
| | a | cat | | and a | rat | | and a | | hat | |

The key prediction is that the distribution of flapping domains cannot contradict the boundary ranks determined by syntax, i.e., it is not possible to flap across a strong boundary and not flap across a weak boundary in the same expression. If this is correct, then in renditions of the the very same expressions, two expressions A and B may or may not be in the same flapping domain, but A and B should be more likely to phrase in two separate $\Phi$ if either A or B is complex and contains a boundary. Conversely, they should be more likely to phrase together if they are separated by a boundary that has to be *weaker* compared to some other boundary.

This is confirmed when looking at the flapping of *cat* in typical renditions of the string *a cat or a rat and a hat* depending on the syntactic bracketing:[20]

(71) Syntax: (a cat or a rat) and a hat

Possible Prosodies:
(a car or a rat$^{\gamma}$)$_{\Phi}$(and a hat$^{\gamma}$)$_{\Phi}$
((a car or a rar )$_{\phi}$(and a hat$^{\gamma}$)$_{\phi}$)$_{\Phi}$
((a cat$^{\gamma}$)$_{\Phi}$(or a rat$^{\gamma}$)$_{\Phi}$)$_{IP}$ (and a hat$^{\gamma}$)$_{IP}$

What is predicted to be impossible is flapping across the stronger boundary is when there is no flapping across the a weaker boundary:

[20] Effects like this are amply discussed in the literature under the heading 'branchingness-effects,' e.g. Zec and Inkelas (1990), Ghini (1993), Dresher (1994), Elordieta et al. (2003), Pak (2005), and Prieto (2005).

(72) Syntax: (a cat or a rat) and a hat

Prosody: *(a cat$^{\gamma}$ )$_{\Phi}$(or a rar and a hat$^{\gamma}$)$_{\Phi}$

In a rendition of (71), it is likely that there is no flapping after the first conjunct and no flapping after the second conjunct. And it should be possible to change matters by further embedding the structure, and make flapping more likely to occur after *cat*, and this indeed seems to be the case:

(73) a dog and (a car or (a rar and a hat$^{\gamma}$.)

Phonological domains can thus be used to encode relative prosodic ranks, and the proposal that the interface only fixes relative ranks is compatible with the assumption of a prosodic hierarchy.

Flappping, and related phonological processes that are often characterized as postlexical 'fast speech rules' (Kaisse, 1985), can involve bigger or smaller chunks. Which level in the prosodic representation is mapped to a single phonological domain such as $\Phi$ is flexible. Flapping, for instance, can even occur across sentence boundaries (Kahn, 1976). Based on this observation, Nespor and Vogel (cf. 1986, 222ff) categorize flapping as an 'utterance level' phonological rule and analyze domain boundaries that block flapping as utterance boundaries. But this mischaracterizes the actual distribution: Very often flapping does not span the entire utterance. This problem prompted Nespor and Vogel (1986) to introduce restructuring rules to account for the fact that intonational boundaries may occur within sentences. A restructuring rule is held responsible, for instance, for the fact that items in a list can be separated by intonational phrase breaks (p. 201). Under the view proposed here the syntax-phonology interface does *not* fix the label, but merely requires that items on a list be separated by boundaries of equal rank, which renders such restructuring rules unnecessary.

In looking for evidence for or against the relational view, care must be taken not to confound phonological processes that apply within prosodic domains from those that are in fact morpho-syntactically conditioned. Some phonological processes that were used to motivate the prosodic hierarchy might actually not be tied to surface prosody at all, but occur in syntactic and morphologically determined domains (cf. Hasegawa, 1979, Kaisse, 1985). Tranel (1990) identifies cases in which liaison in French is obligatory across a pause, and similarly Pak (2005) presents evidence that surface phrasing does not line up with liaison domains. Chen (1987), Hsiao (2002) observe that the tone sandhi domains in Taiwanese do not correspond to surface prosody and can be broken up by prosodic phrasing induced by focus.

This relative view is further supported by evidence that stronger syntactic boundaries only tendencially correlate with stronger prosodic boundaries, but there is one-to-one relationship between the two (Price et al., 1991); that the same syntactic break can correspond to stronger or weaker prosodic breaks in produciton as long as its relative strength to other boundaries in the same utterance is consistent (Schafer et al., 2000); and that rather than absolute boundary strength, boundary strength relative to other boundaries is crucial in parsing (Carlson et al., 2001, Clifton et al., 2002).

In sum, the present theory is *compatible* with stipulating a prosodic hierarchy. But it raises the question of whether it is in fact *correct* that boundaries of different ranks are always categorically distinguished, as the prosodic hierarchy theory postulates. Evidence for relative nesting of domains of equal phonological type comes from pitch scaling effects (Ladd, 1986, 1988, Kubozono, 1989, 1992, van den Berg et al., 1992, Féry and Truckenbrodt, 2004). This is further supported by findings that prosodic boundaries are scaled relative to other boundaries in production (Wagner, 2005). Articulatory studies have also revealed a number of gradient phonetic cues to boundary strength. For example, domain-initial strengthening reflects relative boundary strength, such that stronger boundaries are associated with more domain initial strengthening (cf. Keating, to appear, and references therein). There is also perceptual evidence for relative rather than absolute boundary strength. de Pijper and Sanderman (1994) report that listeners are much better at judging relative boundary strength than absolute category.

To be sure, there are properties of prosodic phrasing that seem categorical, and it could well be that there are both categorical distinctions and within these, additional recursive nesting, as proposed in Ladd (1986). Ladd (1992) called these type of structures 'compound prosodic domains.' See also Dresher (1994) for interesting evidence in favor of this view. Recursive prosodic domains are also used in (Truckenbrodt, 1995, Selkirk, 1996, 2005).

One case in which a prosodic domain edge may be syntactically fixed are certain tonal elements that align with the ends of certain constituents. A good example are the intonational tones that delimit speech-act-sized domains. A case in point are the tones that occur in intonational languages like English at the end of contrastive topics or sentences (Selkirk, 2005). But these might actually be tonal morphemes that come with their own semantic meaning and are aligned with syntactic constituent boundaries, just like the suffixes and particles that express similar meanings in many languages. If we analyze such syntactically fixed boundaries as syntactic object with their own structure and semantics, as proposed in early generative grammar by Stockwell (1960), then they do not contradict the relative view of the interface mapping. This migh also account for boundaries in many languages in Central and South America which show a syntactically determined intonational boundary (e.g., Aissen, 1992).

The degree to which prosodic implementation distinguishes boundaries of different ranks either categorically or quantitatively remains a question for future research, but is orthogonal to the main point here, which is that the *interface from syntax to phonology* only fixes *relative* ranks.

## 4.4 Relative Ranks *vs.* Designated Categories

Theories of syntax-phonology mapping often directly relate certain types of syntactic constituents to certain categories of prosodic constituents (Selkirk, 1986, Chen, 1987, Selkirk, 1995, Truckenbrodt, 1995, 1999). This means that there are particular syntactic constituents that end up delimiting the edges of designated prosodic domains

with a particular label. This notion of designated categories for prosodic domains was expressed in Selkirk (1996, 444) as follows:

(74) The edge-based theory of the syntax-prosody interface
Right/Left edge of $\alpha \rightarrow$ edge of $\beta$,
$\alpha$ is a syntactic category, $\beta$ is a prosodic category.

The edge-based approach has the virtue of allowing us to disregard most of the syntax of an expression: Only certain edges count. Certain abstract *syntactic* categories, such as 'XP,' align with certain *prosodic* categories.

The pattern observed in coordinate structures clearly favors the relational view, however, and speaks against the designated-category approach. First of all, the designated-category approach cannot explain that phonological domains such as the flapping domain are used flexibly to encode boundary ranks, as discussed above. But the problem with the designated-category hypothesis goes further: It cannot even explain why there are different boundaries in coordinate structures in the first place.

The syntactic status of the relation between the coordinates in the nested structures we looked at is always the same: Either DP conjunction or disjunction. The information that determines which types of phonological junctures are likely to be used resides in the *relation* of the coordinates to each other. This type of effect is completely unexpected in theories that operate with designated syntactic categories. Since each coordinate in a coordinate structure should be mapped to the same prosodic category (maybe by XP-alignment), they should all be mapped to the same designated category (maybe the phonological phrase, $\Phi$):

(75) * (Lysander)$_\Phi$ (and Hermia)$_\Phi$ (or Demetrius.)$_\Phi$

The constraint Wrap-XP (Truckenbrodt, 1995), which was proposed to counteract edge-alignment constraints and favor representations in which any XP is completely contained in a phonological domain, would favor a single domain when outranking edge-alignment, but would equally lead to a flat structure:

(76) * (Lysander and Hermia or Demetrius)$_\Phi$

Generalizations about prosody in coordinate structures make reference to relative strength of boundaries between conjuncts. Consider the following constraint on the prosody of coordinate structures proposed in Taglicht (1998, 192):

(77) *Coordination Constraint (CC)*
For any coordinating node X, if any two daughter nodes of X are separated by an IP boundary, all the daughter nodes of X must be separated by IP boundaries.

Taglicht's constraint is a special case of the more general constraint on relative boundary strength proposed here, which is recursive in nature. This argument against designated categories is valid independent of whether prosodic boundaries are distinguished categorically or gradiently.

There is also a parallel between edge-marking and the relative-rank hypothesis proposed here: Certain types of syntactic information are ignored, either the constituency within cycles or all syntactic information except the edges of certain syntactic constituents. The two theories make very different predictions, however, in how exactly prosodic domains line up with syntactic constituents in domains other than coordinate structures, as the last part of the paper will explore.

## 5 Beyond Coordinate Structures: Missing Boundaries

The discussion so far has been based entirely on evidence from coordinate structures. One way to test whether the model can be extended to other types of structures is to look at apparent counterexamples. In the remainder of the paper, I will look at two types of mismatches: one involves structures that are prosodically flat but seem to be syntactically articulated; the other involves involves apparent bracketing contradictions between prosodic and syntactic structures. This section looks at the first type of apparent mismatch.

The basic problem can be illustrated with a simple example. Consider an ambiguous arithmetic formula. Prosody can disambiguate the bracketing:

(78) a. 3 | + 5 || * 4 (= 40)

b. 3 || + 5 | * 4 (= 23)

That arithmetic formulas are often prosodically disambiguated has been shown in various experimental studies (O'Malley et al., 1973, Streeter, 1978). There is another pronunciation, however, that is used in certain contexts and which is prosodically flat:

(79) 3 | + 5 | * 4 (= 40)

This is the prosody that one might give this expression if one expects the addressee to compute the formula online while listening. Linguistically speaking, it involves a simple list of calculation instructions, which are to be computed in the order given. [21] In a formular that involves more than just a few operations, it would quickly become impossible to unambiguously signal the correct bracketing, and the list option is a foolproof and very economic way of getting across the right meaning of a complex arithmetic formula—provided of course it was converted into a format that is equivalent to left-branching throughout. A list will also allow the addressee to forget the precise linguistic material preceding the current point in the utterance, at least if she is able to update the intermediate result.

The expression with flat prosody in (79) does not differ from the left-branching expression with an articulated prosody in (78a) in the arithmetic formula that is communicated, but it differs in how this meaning is conveyed linguistically: It involves a list structure rather than a nested syntactic expression. What assures that (79) is interpreted correctly is the convention to interpret lists from left to right, rather than

[21] This is the prosody that a teacher might use when playing the game 'RechenknigIn' ('Calculation King/Queen'), common German schools, in which the teacher lists calculation instructions and whoever loses track of the current result has to sit down. The last one standing is the Calculation Royal.

right to left. This is of course the only practical option, imagine the listener would have to wait until the end of a long list of calculation instructions before calculating everything from the end to the beginning. In the following we will look at other types of cases that involve a flat prosody and at first sight seems to require syntactic nesting, and find evidence that in fact they involve list-like structures, parallel to (79).

## 5.1 VP Modifiers

Prosody is often not as articulated as the syntactic structures underlying an expression would suggest. The prosody of VP modifiers generally does not seem to reflect what one might take to be the syntactic bracketing. Stacked VP-final adverbials receive a 'flat' prosodic realization in that the adverbials are separated by boundaries of equal strength (Taglicht, 1984, 67):

(80) She saw him once,| in 1939, | outside the Albert Hall, | after a concert

One common analysis of right-peripheral VP-adverbials is that they take scope over the VP material preceding them, leading to a 'right-ascending' structure (Andrews, 1983). Their prosody, however, is not what we would expect in a left branching structure:

(81) ?? She saw him once, | in 1939, || outside the Albert Hall, ||| after a concert.

In fact, the prosody of such VP-modifier sequences is more similar to flat coordinate structures:

(82) once, in 1939, outside the Albert Hall, and after a concert.

Why do (80) (82) have similar prosodies, at least in terms of boundary strength? Larson (2005) argues that VP-adverbials are in fact event predicates (Davidson, 1967, Parsons, 1990). In Larson's analysis, several event predicates are tied to a single event by existential closure:

(83) a. Lysander kissed Hermia in the forest for an hour.

b. $\exists$ e [ kiss(L, H, e) & in-the-forest(e) & for-an-hour (e)].

If this is correct, then sequences of event predicates form *associative* domains. They form lists of modifiers, and can be analyzed as coordinate structures, as was first suggested in Taglicht (1984, 67). This analysis is analogous to the analysis of the flat prosody in the arithmetic formula in (79). If lists of modifiers are interpreted left to right, it is no surprise that they often appear to show the scope that is expected from the 'right-ascending', i.e., left-branching analysis Andrews (1983, 695):

(84) a. John knocked on the door intentionally twice.

b. John knocked on the door twice intentionally.

But Larson (2005) gives convincing arguments that this is not really a case of scope taking. In the present analysis, it is an effect of the convention of incremental interpretation, following Phillips (1996). The claim that the bracketing is not linguistically fixed does not mean that their *order* is free. In fact, word order in actual coordinate structures is not necessarily free, either. The following coordinate structures are ordered based on chronology, scalar strength, and set-subset relations, respectively, and random permutations would seem more marked:

(85) a. open Monday, Tuesday and Friday
b. big, bigger, biggest
c. Friends, Romans, countrymen, lend me...

There are more similarities between flat coordinate structures and sequences of VP-adverbials. According to various c-command tests (cf. Larson, 1988, Pesetsky, 1995, Phillips, 1996), they seem to be right-branching, as would be expected for associative domains, at least for the binary branching/cyclic view of syntax assumed here.[22] One piece of evidence comes from NPI-licensing:

(86) a. Lysander kissed nobody in any forest at any time.
b. John spoke rarely during any of our meetings. (Larson, 2005)

Another piece of evidence comes from variable binding:

(87) a. Sue spoke to every child on his or her birthday.
b. John spoke during every session for as long as it lasted.

There are also syntactic facts that at first sight seem to support the opposing, right-ascending analysis. Pesetsky (1995, 230, examples adapted) observes that the constituency observed in VP-fronting is what would be expected if VP-modifiers attached high, outside of the VP:[23]

(88) John said he would give the book to them in the garden on Tuesday...
a. ...and give the book to them in the garden on Tuesday he did.
b. ...and give the book to them he did in the garden on Tuesday.
c. * ...and give the book he did to them in the garden on Tuesday.
d. * ...and give he did the book to them in the garden on Tuesday.

However, even in the base order different bracketings are possible, and it is plausible that the structure of VP-fronting is in fact based on this alternative bracketing, which indeed may very well be right-ascending and involve right-ward movement:[24]

[22] And it would similarly be expected in the n-ary branching analysis of VP modification (Jackendoff, 1977), assuming that linear precedence is the relevant notion for licensing in n-ary branching nodes (Culicover and Jackendoff, 2005).

[23] A similar argument presented in favor of a high adjunction of VP modifiers in Pesetsky (1995) is their behavior in VP ellipsis. In VP ellipsis, adjuncts can be left and substituted, while arguments are obligatorily ellided. Additional issues for the right-descending view are discussed in Lasnik (1997).

[24] In order to explain left-to-right binding of anaphors in structures similar to (89), or even into fronted modifiers in structures such as (88) as reported in Pesetsky (1995), one would need to posit that the right-ward dislocated modifers reconstruct.

(89) a. He gave the book to them in the garden on Tuesday.
b. He gave the book to them || in the garden on Tuesday.
c. ?* He gave the book || to them in the garden on Tuesday.
d. * He gave || the book to them in the garden on Tuesday.

The fact that theme and dative argument differ from modifiers both with respect to their phrasing VP-fronting suggests that they cannot simply be analyzed as event predicates. We will return to the analysis of arguments of different kinds below.

In sum, both syntactic and semantic properties of VP-modifiers are compatible and in fact support the analysis of multiple right-peripheral VP-modifiers as lists, as would be expected given their flat prosody.

## 5.2 Depictive Predicates

There is another kind of modifier can be analyzed analogously to right-peripheral VP-adverbials: depictive predicates. Consider first subject-oriented secondary depictive predicates. They are prosodically similar to VP-adverbs in that they do not induce strong prosodic boundaries in a sequence of predicates:

(90) Hermia was dancing, completely drunk, without any fear, unaware of the abyss.

Pylkkänen (2002, 27) discusses evidence that depictive predicates share semantic properties with VP-Adverbs. Similar to VP-adverbs, the state described by a depictive predicate must hold during the event described by the verb, i.e. they can be analyzed as predicates that attribute a property to an event. That secondary predicates indeed have to be eventive, Pylkkänen argues, is evidenced by the fact that individual-level predicates sound odd in depictive predications (Rothstein, 1983, 153):

(91) *? I met Mary drunk/in high spirits/*tall/*stupid.

In Pylkkänen's analysis, depictives differ from VP-adverbs only in that in addition to the event argument, they also have an unsaturated individual argument of type *e*. The event argument, just as in the case of VP-adverbs, is bound by existential closure; the e-type individual variable is bound by a c-commanding nominal argument.

If secondary predicates form a list structure and form an associative domain, just as VP-adverbs do, then a right-branching right-descending structure is expected. Indeed, subject-oriented secondary predicates are c-commanded by the direct object, as is evidenced by variable binding, suggesting that they are indeed put together with the preceding VP by the default right-branching structure expected in a cycle:

(92) The teacher rewarded every child$_i$ convinced of his$_i$ or her$_i$ worthiness.

Under this analysis, the structure of the VP can be assumed to be essentially that of a coordination or list of predicates, which contain argument and event variables that are bound by c-commanding material.

A prediction for the prosody of depictive predicates is that it should not disambiguate between whether or not a secondary predicate is subject- or object-oriented, since both are event predicates that differ only in the index on the individual variable they contain. Consider the following sentence, mentioned in Lehiste (1973):

(93) The patient left the operating room in good condition.

The more salient interpretation of (93) is that the patient left in good condition. In a context with an exceptionally rowdy patient, however, the reading in which it is the room that is reported to be left in good condition might be the intended one. Since in both cases the secondary predicate *in good condition* is an event predicate that conjoins with *left the operating room*, and differs only in the index of the empty argument inside, the prosody should be the same for the two readings.[25]

The present analysis also predicts that the order between VP-modifiers and depictive predicates should not be fixed by their syntax. Indeed, the order between them is much more flexible than often suggested. An object depictive can either follow or precede a VP adverbial, without an articulated prosody:

(94) The kidnapping had a happy ending.

a. The militants released the victim | on his birthday | in very good condition.

b. The militants released the victim | in very good condition | on his birthday.

Similarly, a subject-depictive can either precede or follow a VP adverbial:

(95) The Mars Mission succeeded.

a. The astronaut stepped out of the spaceship | just before sunrise | amazed at the scenery.

b. The astronaut stepped out of the spaceship | amazed at the scenery | just before sunrise.

A well-known constraint on the relative order between object depictive and subject depictive is that the latter allegedly cannot precede the former (Carrier and Randall, 1992):

(96) a. John$_i$ sketched the model$_j$ nude$_j$ drunk as a skunk$_i$.

b. * John$_i$ sketched the model$_j$ nude$_i$ drunk as a skunk$_j$.

However, the reason for this restriction may just be that this example is four-way ambiguous. This configuration becomes much better if the depictive predicates contain material that helps disambiguate, and if one of the arguments is inanimate, which further prevents interference, world knowledge will point to the right dependency:

[25] Déchaine (1993, 152) argues that subject-oriented depictives have to set off from the VP by an intonational boundary. I Recorded 16 native speakers on a set of examples but I could not confirm this. A more thorough discussion of the production data must wait until another time.

(97) Bill is a vengeful person.

a. After hearing about the editor's problem with eyesight he submitted the paper | in a very small font | with glee.

b. After hearing about the editor's problem with eyesight he submitted the paper | with glee | in a very small font.

There may be pragmatic and processing reasons that make certain orderings more natural than others, but as we saw this is not atypical of list structures.

## 5.3 Additional Arguments

Another case in which several constituents seem prosodically on par are sentences that contain certain additional nominal arguments, arguments that are not part of the argument list of the predicate, such as benefactives:

(98) a. Lysander | baked a cake | in the afternoon | for Hermia.

b. Lysander | baked a cake | for Hermia | in the afternoon.

Many theories treat the direct object as an argument of the verb, and the benefactive argument as being introduced by a different functional head. Part of the reason for making this difference is the intuition that a benefactive is optional, and can be added to just about any sentence that involves an agent, while the thematic role of the direct object here is closely tied to the meaning of a verb of creation such as *bake*.

The status of the subject in (98) is more controversial. Some theories of argument structure treat agents just like the direct object as an argument of the verb (e.g. Bierwisch (1983), Grimshaw (1990)); but there are also theories that introduce agents with a separate functional head, analogous to the benefactive, even if they are clearly not or at least not always optional. One piece of evidence that subjects are indeed not arguments of the main predicate is that the thematic role of the subject is not fixed by the verb, but depends on the combination of the verb and the direct object it combines with (Marantz, 1984). Schein (1993) presents intricate semantic arguments for this view and argues that subjects are an argument of a separate event predicate. According to Kratzer (1996) and Pylkkänen (2002), agentive subjects are arguments of an inflectional *voice* head that takes the VP as its complement, which is the reason for its c-commanding (and consequently preceding) position relative to the VP.

Kratzer (forthcoming) presents crucial evidence in favor of an event predicate analysis of the agent and against an analogous analysis of the theme argument: and direct objects should be treated as proper arguments of the verb. The event predicates can be tied together by existential closure and form a list-like structure. The meaning of (98) is the following:

(99) $\exists e.[\mathit{voice}(e)(\mathit{Lysander}) \,\&\, \mathit{bake}(e)(\mathit{cake}) \,\&\, \mathit{BEN}(e)(\mathit{Hermia})]$

A property of this analysis is that the combination of the event predicates obeys the associative law, just as in any other coordination or list structure. The bracketing within the list is not crucial:

(100) [[ ( voice(e)(Lysander) & bake(e)(cake) ) & BEN(e)(Hermia) ]] = [[ voice(e)(Lysander) & (bake(e)(cake) & BEN(e)(Hermia)) ]]

We expect then that a list of additional arguments and other event predicates should be set off by prosodic boundaries of equal strength. This is compatible with speakers' intuitions about the prosody of these structures. Futhermore, if the separate event predicates form an associative domain, then we would expect that they should form a right-branching structure (applying standard c-command tests). There is indeed evidence for left-to-right c-command:

(101) a. Every guest baked a cake for his host.

b. He reedited every movie for its main actor.

The analysis of VP-modifiers, depictive predicates and additional arguments discussed takes them to consist of event predicates that are combined in a list structure. We will now turn to a structure that is also prosodically flat, but not actually a list. However, it shares the crucial property of being associative.

## 5.4 Predicate Sequences

Another type of prosodically flat structure is exemplified by the sequences of predicates in the following sentence:

(102) She wanted | to try | to begin | to plan | to move.

The last predicate is always accented, and each of the other predicates can be accented in principle. In determining where exactly accents are placed rhythm plays a role. The prosody is very similar to that of a list of predicates, in that the predicate sequence receives a 'flat' prosody, i.e., the boundaries between the predicates are perceived as being equal in strength, just as in an actual list:

(103) to want, | to try | , to begin, | to plan, | and to move.

Given the flat prosody, the expectation is that the domain is associative. But how can we interpret the predicates when the bracketing is changed? A simple way to think about how predicates can be interpreted given a different bracketing is to posit the possibility of $\lambda$-abstraction:

(104) ( $\lambda x$. wanted to try to begin x) ([$_{VP}$ to plan to move]).

$\lambda$-abstraction turns a sequence of predicates, the lowest of which lacks its complement into a one-place predicate. The denotation of the final expression is not changed by this restructuring, since the denotation of the moved VP semantically reconstructs to the complement position of *begin* due to the $\lambda$-abstract. In other words, the law of association holds:

(105) $[\![A(BC)]\!] = [\![(AB)C]\!]$

It is crucial to identify the constraints on this kind of restructuring, since otherwise every structure could be taken to be associative. For $\lambda$-abstraction, the idea would be that the constraints are those that restrict syntactic movement, plus restrictions on the semantic type of variable involved (maybe only individuals and one-place predicates). An alternative view to the one involving variables and $\lambda$-abstraction is the one taken in Categorial Grammar. Steedman (1985, et. seq.) proposes that any sequence of predicates can be composed in more than one way. He uses the notion 'functional composition,' an operation of meaning composition used in Categorial Grammar in addition to 'functional application.' Steedman (2001, 2004) use a rule of forward function composition:

(106) Forward composition (simplified)
$X/Y : f \quad Y/Z : g \Rightarrow X/Z : \lambda x.f(gx)$

Note that forward composition also does not alter the truth conditions of the outcome, i.e. , the associative law holds. The combination of function application and $\lambda$-abstraction or forward composition has the effect that sequences of functors form associative domains. Just as in the case of associative domains in coordinate structures, these structures receive a 'flat' prosody in which the elements are separated by prosodic boundaries of equal strength.

The possibility of different phrasings in predicate sequences observed in Selkirk (1984, 294) can be analyzed as right-node raising (or forward composition within Categorial Grammar):

(107) a. Jane | tried to begin to learn Spanish.
b. Jane tried | to begin to learn Spanish.
c. Jane tried to begin | to learn Spanish.
d. Jane tried to begin to learn | Spanish.

Similar to list structures, such additional bracketings need a motivation in terms of information structuring.

## 5.5 Modified Adjectives

Modified Adjectives, like sequences of predicates, receive a 'flat' prosody, such that the boundary after each adjective is of equal strength:

(108) A beautiful big old tree.

It is interesting to compare the case of a sequence of adjectives (109a) to cases also involving modifiers of adjectives (109b), which would presumably have a left-branching structure:

(109) a. [ A [ big [ old tree ] ].
b. [ A [ [ very old ] tree ].

In examples like (109), the prosodic difference may be masked by another phenomenon. There is some evidence from the observed prominence pattern, that the examples do differ in phrasing, just as would be predicted. The prominence pattern in (109b) is obscured by the fact that *old* can be destressed for rhythmic reasons:

(110) A vèry old trée

This confound can be removed by adding further material and removing the clash between *old* and *tree*:

(111) a. A very òld mystèrious trée.

b. A bìg òld mystèrious trée.

The distribution of secondary stress reveals the prosodic structure. The difference in prominence between *very* and *big* in (111a) and (111b) can be explained if *very old* together form a prosodic unit. Since the last element within that foot is perceived as most prominent, as outlined in (48), *old* will be more prominent compared to *very*. This is not observed in (111b). The prosodic bracketing facts in adjectival modification are thus compatible with the proposal here.

## 5.6 Non-compositional Structures?

Uriagereka (2008) discusses an interesting pattern of iteration that can be observed with certain words:

(112) a. She's a very very very pretty girl.

b. Never never never never call John again.

These sentences involve the repetition of a word for emphatic purposes, but the individual repeated instances do not seem to be interpreted separately, e.g., the various negations that are part of the meaning of 'never' do not cancel each other out. The prosody is flat in that the repetitions are separated by boundaries of equal strength. Given the 'flat' prosody, the prediction would be that this expression should involve a compositional meaning that is *associative*. But according to Uriagereka (2008), these types of expressions are not compositional at all.[26]

However, it seems that a compositional analysis can and should be given here. If lists are structures that are iteratively combined by a set union operator,[27] then we can interpret expressions such as [very, very, very, very] as involving set union of sets with identical elements. Set union is an associative operation, and the union of sets with identical elements returns an identical set:

(113) $(\{a\} \cup \{a\}) \cup \{a\} = \{a\} \cup (\{a\} \cup \{a\}) = \{a\}$

[26] Thanks to an anonymous reviewer for pointing this out as a potential problem for the claims of this paper.

[27] This analysis is discussed in more detail in Wagner (2005)

The proposed analysis of the iteration constructions semantic is the denotation of each instance is actually a set containing the expression rather than the meaning of the expression itself, and the set union of all instances is again just a set containing the expression.[28] This analysis captures the meta-linguistic flavor of the construction.

The fact that the additional instances of the duplicated word is redundant, and the complex expression that means the same thing as a simpler expression with only one instance triggers a Gricean implicature that is the source of an emphatic effect that is similar to focusing that word.[29] The Gricean reasoning behind the implicature would be that the maxim of quantity should rule out redundant duplication, so the unduplicated form should be preferred, unless there is an alternate reason for duplication, an obvious one being emphasis.

The analysis of *very very very* is then that it involves a standard list. One can easily find instances of uses of the duplication pattern on Google that explicitly indicate that the speaker interpreted the iteration as a list:

(114) a. very very very and so on tired

b. very very very etc. wrong

The alternative analysis proposed in Uriagereka (2008) would be to analyze the expression as a syntax-less, truly flat expression, different from other kinds of lists as they were discussed in the previous sections in not having a compositional semantics. This seems undesirable to me, and a last resort analysis adopted only if an analysis that uses independently motivated tools and a compositional analysis was impossible.

There is also an empirical problem with the alternative approach. There is a simple reason why it cannot be the case that the 'non-compositional' meaning is *incompatible* with syntactic structuring, as claimed in Uriagereka (2008): The same kind of expression can be built including an articulated bracketing.[30] In fact, a search for *very*

[28] In order to get to the meaning the expression to compose with the rest of the sentence we either need an additional operator that picks out an element from as set, or we assume that in natural language we can freely shift between an expression and a set containing that expression (c.f. Schwarzschild, 1996).

[29] The distribution of this kind of iterative duplication is not as broad as the distribution of prosodic focus as a means of emphasis, and seems to occur more frequently with certain specific words (*never*, *very* as opposed to *sometimes*, *often*). Maybe the duplication process is not fully productive, and has an idiomatic component. One correct prediction of the analysis presented here that this duplication is odd with function words (Uriagereka, 2008), which due to a lack of alternatives can only be focused in a narrow set of contexts, e.g., as a metalinguistic correction.

[30] Uriagereka (2008, 190) in fact tests this prediction and reports that any kind of structuring is ungrammatical, based on judgments from Spanish:

(i) *Yo estoy [muy muy] [muy muy] cansada.
'I am very very very very tired'

This is not the case in English, according the judgments of my informants. I didn't get a clear pattern from two Spanish speaking informants I asked. At least two bracketings that do seem to be possible even in Spanish are the following:

(ii) a. muy || muy, muy, muy
laluna.tv/media/5275/2_-_Hoy_estoy_muymuy_muy_muy_cabreada.../

b. muy muy muy muy || muy
http://search.everyzing.com/viewMedia.jsp?res=390206729&dedupe=1&col=es-all-public-ep&e=19200647&il=es&num=10&mc=es-all&start=10&q=%22muy+muy+muy+muy

*very very very* in the audiofiles tracked by the website everyzing.com leads to many results, and more than half of the first 30 hits at the time when I checked involved additional bracketing. Among the attested ones are the following:

(115) a. vèry very || vèry very x́

b. vèry very very || vèry x́

c. vèry || vèry very very x́

Adding spurious additional bracketing to the already spurious iteration may again simply trigger added emphasis by virtue of Gricean reasoning. This would explain that hyperbolic ring of expressions like (115). We observed that more generally one can add bracketing in cases that look like they should be associative for information structure reasons, as discussed in section 2.3. In sum, there is no reason to assume that the meaning of this kind of iterative expression requires any special treatment of the sort proposed in Uriagereka (2008), and the compositional approach using an analysis that can be applied to lists more generally can capture it quite well.

## 5.7 Possessors

A more problematic type of prosodically 'flat' expression are possessor sequences, which are evidently *left-branching*:

(116) John's brother's wife's dog's house.

Larson and Cho (1999), however, discusses evidence that this left-branching structure might not be the underlying one. Consider the following example:

(117) John's former house:

a. A former house that belongs to John (dispreferred).

b. A house that formerly belonged to John (preferred).

*John's former house* is ambiguous, and for pragmatic reasons the preferred reading is (117b). The surface left-branching structure gives the wrong bracketing for this reading, however. Larson and Cho (1999) argue that at the underlying level, the structure is right-branching, and then a reversal in word order between possessor and possessee takes place.

A right-branching underlying structure is exactly what is expected if possessor sequences are formed in a single cycle. How exactly the reordering takes place when the cycle is linearized, and whether or not possessor sequences can plausibly be analyzed as semantically associative, remain questions for future inquiry.

Clearly, it would require a much closer look to understand the cross-linguistic variation in the availability of this kind of iteration.

## 6 Beyond Coordinate Structures: Misplaced Boundaries

Let us now turn to a different kind of mismatch, one in which the prosodic and syntactic bracketing stand in outright contradiction. Consider a structure that is syntactically right-branching: [ A [ BC ]]. If the prosodic boundary separating A and B is weaker than that separating B and C, this would be a clear violation of the hypothesis of attachment and prosody, repeated below:

(9) Hypothesis about Attachment and Prosody:
In a sequence $A \prec B \prec C$, if the boundary separating A and B is weaker than the one separating B and C, then [[AB] C]; if it is is stronger, then [A [BC]].

What is interesting about this kind of mismatch is that edge-alignment was designed to be able to account for them. If only the right or left edge of certain constituents is visible for the alignment of prosodic categories, then systematic mismatches are predicted, including the ones discussed below.

But an alternative explanation for apparent mismatches could be that syntax allows for different ways of constructing similar meanings. This can be illustrated by a kind of apparent mismatch from Shattuck-Hufnagel and Turk (1996, 201), where an NP is separated from the preposition it is an argument of by a prosodic break:

(118) Sesame Street is brought to you by: || The Children's Television workshop.

The prosody here might actually reflect the surface constituent structure, if this sentence is analyzed as involving string-vacuous *rightward movement*. This syntactic approach to mismatches makes different predictions from the view that prosodic boundaries can be inserted optionally, since syntactic rebracketing should obey systematic constraints.

Consider a simple case of coordination of two transitive predicates that take the same direct object and their prosody relative to that argument (adapted from McCawley, 1998, 275):

(119) a. Tom washed and dried || the dishes.
b. * Tom washed || and dried the dishes.

According to McCawley, the only way to obtain a prosodic break behind the first transitive predicate *wash* is to also put a break behind the second predicate:[31]

(120) Tom washed || and dried || the dishes.

This is what would be expected if the boundaries reflect the syntactic structure, rather than being optionally thrown in for pragmatic reasons. The prosody of this sentence reflects the fact that the constituent *the dishes* is not part of the second conjunct but attaches highert.

If prosodic boundaries indeed reflect syntax in this way, then we can directly test syntactic theories using prosodic means. Consider cases of right-node raising:

[31] It is not clear whether the second boundary is stronger or equal in strength to the first, but for McCawley's claim it is crucial that it is not weaker.

(121) She wanted to begin || but then decided to postpone || writing her dissertation.

If the second boundary above is stronger than the first, it would favor the movement view of right-node raising (cf. Ross, 1967) or the categorial grammar analysis (Steedman, 1991), since they both predict *writing her dissertation* to attach outside of *wanted to begin but then decided to postpone*; a weaker second boundary would support Hartmann (2001) who analyze RNR as ellipsis in the first conjunct.[32]

The general line of argument taken here is that mismatches might disappear once we properly understand the surface syntax. This approach follows the lead of work in Categorial Grammar (Steedman, 1985, Moortgart, 1988, Steedman, 1991, et seq.). The syntactic analysis of apparent bracketing mismatches correctly rules out certain kinds of mismatches that have been found impossible (Shattuck-Hufnagel and Turk, 1996, 198), precisely those that cannot be derived by rightward movement or other syntactic tools that may derive unorthodox constituent structures:

(122) a. George and Mary give blood.

b. George and Mary || give blood.

c. George || and Mary || give blood.

d. * George || and Mary give blood.

RNR of *and Mary give blood* is impossible because this is not a syntactic constituent. Topicalization of *George* is impossible because of the coordinate structure constraint. There no way to derive a syntactic phrase structure that matching the prosodic phrasing in (122d).

In this section we will discuss more evidence that apparent mismatches between prosody and syntax really involve unorthodox constituent structures, for example those derived by RNR or exraposition construals. And apparent optional prosodic boundaries turn out to reflect *choices between different syntactic construals*, yielding expressions with identical or at least very similar meanings.

[32] Some experimental evidence against the ellipsis approach was presented in Bachrach and Katzir (2007), but the issue remains controversial. There is one class of cases in which the right-node-raised constituent intuitively groups with the second conjunct: When the right-node-raised constituent is unaccented, as is the case with predicates, or pronouns and other given NPs. Here are some examples that native speakers almost always read out with an unaccented right-node-raised constituent:

(1) a. ...Thatcher's legacy and image loom large over the British psyche for both those who loved and those who hated her. ...
www.samizdata.net/blog/archives/000635.html

b. [Context about FDR] ... Jack discovered that some loved and some hated FDR. ...
www.adhiratha.net/www/oral-history/MAThesis/4pub$_h$tm/MAT2$_B$04.htm

c. ... While in 2005 we had the impression that his career was flourishing, dividing the scene into those that loved and those that hated him for his outstanding virtuosity, ...
http://www.tokafi.com/newsitems/notforgotten/

This lack of a prosodic boundary in RNR may be a systematic property of constituents that undergo prosodic subordination. See Wagner (2005) for more discussion.

## 6.1 Relative Clauses

Restrictive relative clauses are often taken to be an instantiation of a bracketing mismatch between syntax and prosody. The claim is that in the following relative clause constructions, an intonational break separates the head from the relative clause although they should form a constituent:[33]

(123) a. the house | that Jack built (Chomsky, 1961, 127)

b. This is the cat | that caught the rat | that stole the cheese. (Chomsky, 1965, Chomsky and Halle, 1968)

The relative clause forms its own phonological domain and is separated from the head of the relative clause by a boundary that is stronger than the boundary that precede the head. According to *SPE*, the assumed bracketing in syntax is as follows:

(124) This is [ the cat that caught [ the rat that stole the cheese. ]]

The solution proposed in Lieberman (1967, 120) and in *SPE* was that a readjustment rebrackets (124) into a different structure in which the three clauses are treated as on par: "The resulting structure appears then as a conjunction of elementary sentences (that is, sentences without embeddings). This allows us to say that intonation breaks precede every occurrence of the category S (sentence) in the surface structure, and that otherwise the ordinary rules prevail" (*SPE*, 372). This readjustment was interpreted by Reich (1969) and Langendoen (1975) as a result of processing language by means of a finite-state grammar.

While the characterization of restructuring in SPE resulted in a different syntactic surface structure, later approaches considered the 'readjustment' to be an effect of the mapping of syntactic structure to prosodic structure, which resulted in a mismatch between prosody and syntax (i.a. Nespor and Vogel, 1986, 57, 257). In this section, I will give some arguments in favor of a syntactic approach—the main point that I want to make is that there is evidence for a *syntactic* bracketing that *matches* the prosody.

In a natural rendition of (124) the boundaries after the verbs are usually weaker than those preceding the relative clause. This is exemplified in (125a), which is the preferred phrasing compared with (125b):

(125) a. that caught the rat | that stole the cheese

b. that caught | the rat that stole the cheese

The prosody in (125b) may be appropriate in a context that has narrow focus on the direct object, but is otherwise not the preferred phrasing. If the phrasing that corresponds to the syntactic bracketing that *Aspects* and *SPE* assumed is possible, at least under certain circumstances, any theory that automatically maps the syntax

[33] Note that the relative clauses must be restrictive since non-restrictive relative clauses do not permit the relative pronoun *that* (McCawley, 1998, 445):

(i) ?? Mary, that John asked for help, thinks John is an idiot.

to a mismatching prosody is not desirable. In the familiar 'mother goose' nursery rhyme about 'the house that Jack built,' the last line can be pronounced such that the head and last relative clause are not separated by a prosodic break as strong as the ones ending the preceding lines, again suggesting that there are two different possible phrasings for restrictive relative clauses (also discussed in Ladd, 2008):

(126) This is the cat, |
that killed the rat, |
that ate the malt, |
that lay in the house that Jack built.

But how can the apparently mismatching prosodic break preceding at least the first three relative pronouns be derived? The possibility discussed here is that extraposition is involved, and what appears to be a choice between two possible ways to map syntax to prosody actually is a choice between two different syntactic construals, 'extraposed' and 'non-extraposed.' I use the term 'extraposition' to refer to the phenomenon, without implying a movement analysis—in fact, recent literature converges on positing base-generation rather than movement.[34] In particular, I will adopt the analysis (c.f. Hulsey and Sauerland, 2006) that extraposed relative clauses contain an unpronounced constituent, matching the head, that raises within the relative clause, and I will assume with Koster-Moeller and Hackl (2008) that the unpronounced constituent in extraposed relative clauses is a DP. We can think of it as an anaphoric pronoun that is bound by the DP that is modified by the relative clause. Extraposition of restrictive restrictive relative clauses is certainly possible:

(127) I saw the cat yesterday that caught the rat on Monday that had stolen the cheese on Sunday.

Suppose now that this sentence really involves a list of three clauses, the second contains an unpronounced constituent that matches *the cat*, the third contains an unpronounced constituent that matches *the rat*. This would correspond to the surface bracketing posited in *SPE* for the problematic cases:

(128) [ [ This is the cat ] [ that caught the rat ] [ that stole the cheese ] ]

But how can we test whether the problematic prosody really goes along an extraposition ocnstrual? Adverbs can be used to force extraposition as in (127), but how can we control for extraposition in the absence of overt intervening material?

Hulsey and Sauerland (2006) argue that extraposition is impossible if the head of the relative clause is an idiom chunk:[35]

[34] One argument against a movement analysis comes from relative clauses with split antecedents (Perlmutter and Ross, 1970, 350):

(i) A man entered the room and a woman went out who were quite similar.

[35] While I could replicate the contrast between these two examples here, there is not doubt that it is much less clearcut than reported in Hulsey and Sauerland (2006), and for some idioms with a less transparent meaning most speakers reject relativization altogether. I quote the example with the judgments reported there.

(129) a. Mary praised the headway that John made.

b. * Mary praised the headway last year that John made.

If extraposition is involved in rendering the prosody in (124), then we expect to see an effect of idiom chunks on prosody. Consider the following constructions, the first two of which are idiomatic. A prosody that groups the head with the following relative clause is acceptable:

(130) a. This was entirely due | to the advantage that he took of the new system.

b. This was entirely attributable | to the headway that he made with the new proposal.

c. This was entirely due | to the surplus that she had made the year before before.

The prediction is now that the 'mismatching' prosody discussed in *SPE* should be odd when the head of the relative clause is an idiom chunk. This is confirmed by impressionistic data collected from several native speakers, who sense a contrast in acceptability between the following examples:[36]

(131) a. ?? This was entirely due to the advantage | that he took of the new system.

b. ?? This was entirely attributable to the headway | that he made with the new proposal.

c. This was entirely due to the surplus | that she had made the year before before.

Additional examples, adapted from ones found online and run by native speakers, further confirm that placing a boundary after an idiomatic RC head is dispreferred:

(132) a. # That is probably why Disney is courting George Lucas, trying to repair the bridges | that were burnt in the Eisner administration.
blog.tystoybox.com/20070925/disney-vs-islands-of-adventure/

b. # I sincerely appreciate the hoops | that everyone jumped through to complete my project.
www.truestonedistributing.com/index.php?pg=port&action=testimonials

c. # The mainstream media continues to supersaturate the airwaves with talk of the disgruntled, petulant child and the fit | that he threw at the training camp of the Philadelphia Eagles.
www.docsports.com/2005-nfl-season-preview.html

[36] The judgment is reminiscent of cases with focus within idioms, which are infelicitous since there is no alternative for a focused material that would make sense as a replacement given the idiomatic interpretation of the structure:

(i) ?* She *KICKED* the bucket.

Maybe the idiom restriction is a consequence of extraposition requiring focus on the head of the relative clause.

This contrast constitutes evidence for the claim that the 'mismatching' prosodic bracketing observed in *SPE* and *Aspects* requires syntactic extraposition, weakening the case for a bracketing paradox between syntax and prosody.[37]

A comparison with German supports the extraposition-analysis of the English data. The OV word order in embedded clauses has the effect that extraposition is easy to diagnose—it is not string-vacuous as in English. Consider the following example, similar to the one discussed in *SPE*:

(133) Ich glaube dass dies die Katze ist, die die Ratte gejagt hat, die den Käse
I believe that this the cat is that the rat caught has, that the cheese
gestohlen hat.
stolen has

'I think this the cat that caught the rat that stole the cheese.'

The relative clauses are extraposed, the head is separated from its relative clause by the predicate. Without extraposition, the structure would be a center-embedded structure, and end up unintelligible:

(134) ?* Ich glaube dass dies die Katze die die Ratte die den Käse gestohlen hat gejagt hat ist.

Similarly to the case of English, extraposition is strange in German when the head of the relative clause is an idiom chunk.

(135) a. Peter war über den Bären den Maria ihm aufgebunden hatte
Peter was about the bear that Maria him given had
verärgert.
annoyed

'Peter was annoyed about the prank that Maria played on him.'

b. ?* Peter war über den Bären verärgert, den Maria ihm aufgebunden hatte.

The analysis of the 'extraposed' relative proposed in Hulsey and Sauerland (2006) posit that the relative clause is a predicate that contains a variable, which attaches as an adjunct and combines by predicate modification with its overt head

[37] There is another property that might distinguish different types of relative clauses. Restrictive relative clauses are sometimes but not always subordinated. Bresnan (1972, 337) illustrates the problem with the following two examples (due to Stockwell, 1972):

(ii) a. Introduce me to the man you were tálking about.

b. I'll lend you that bóok I was talking about.

According to Bresnan, there is also a semantic difference between the relative clauses: if the relative clause receives nuclear stress, then it is used to pick out one out of a set of alternatives defined by the head noun. In the sentence with nuclear stress on the head noun, however, there is no such partitive reading. For a potential explanation for the intuition reported by Bresnan see the discussion of focus and givenness in Wagner (2006). By adding a modifier like *the year before* in the example used here, it becomes natural to leave the relative clause accented.

counter-part outside the relative clause ('matching' analysis). The relative clause is merged as an adjunct where it is pronounced.[38]

The interpretation of the relative clause is thus fixed indirectly by which external NP gets to bind the variable in the relative clause. A sequence of relative clauses can then be seen as a list of modifiers. A different bracketing between them does not affect the meaning, since their meaning comes about by binding a variable within the relative clause. We expect then a flat prosody between several relative clauses. This is in fact attested, both for nested and stacked relatives. The following sentence is ambiguous between a reading in which Mary had been looking for the cat or the rat:

(136) This is the cat, that caught the rat, that Mary had been looking for.

The prosody that was often taken to indicate a mismatch between syntax and prosody was argued here to be a reflex of 'extraposition,' i.e., of a different syntactic construal that permits to adjoin the relative clause remotely and structurally removed from its head. It may well be that the choice beteween the extraposed and non-extraposed construal is partly driven by reasons of parsability and ease of processing, and/or to pronounceablity, as discussed in *SPE* (p. 372) and also in Lieberman (1967, 120–121). This is suppported by the parallel to the German examples, where failure to extrapose results in unparsability.[39]

## 6.2 Coordinate 'Extraposition'

A crosslinguistically common pattern of prosodic phrasing is to group the first coordinate of a coordinate structure with a preceding predicate:

(137) (Predicate A) (and B)

Once again, this looks like a counterexample to the hypothesis on attachment and prosody (9). Although *A and B* apparently form a constituent to the exclusion of the predicate, the phrasing groups the predicate and the first coordinate together.

In Tiberian Hebrew (Dresher, 1994, 19), for example, fixed expressions, such as 'good and evil' in (138a), are phrased together, but otherwise, the predicate frequently phrases with the first coordinate (138b):

(138) a. (yōḏʕē) (ṭoḇ wārāʕ)
knowers (of)good and.evil (Gen. 3.5)

b. (kabbēḏ ʾet-ʾāḇīḵā) (wəʾeṯ-ʾimmeḵā)
Honor ACC-your.father and.ACC-your.mother (Deut. 5.16)

[38] See also the analysis of extraposition of adjuncts in terms of 'later merger' discussed in Fox and Nissenbaum (1999) and Fox (2002).

[39] Non-restrictive relative clauses are always preceded by a prosodic break, and their analysis is probably similar to that of extraposed relative clauses as adjuncts that attach higher than regular relative clauses do. The situation there is complicated though because they also come with their own intonational tune. See Potts (2005) for recent discussion.

Phrasing in Tiberian Hebrew is reflected by spirantization (underlining) which applies to post-vocalic stops within a phonological phrase. According to Dresher, it is also directly encoded by the Masoretic system of accents. The same 'mismatching' prosody is possible in English:

(139) a. She kissed || Lysander | and Demetrius.
b. She kissed | Lysander || and Demetrius.

Are syntax and prosody really in a mismatch? The first step is to note that 'extraposition' is possible (Munn, 1993):

(140) John bought a book yesterday, and a newspaper.

But is extraposition always involved in the mismatching phrasing? How can we tell? A look at OV structures is instructive. Let us consider intransitive predicates:

(141) a. A student attends, and one professor from another department.
b. * A student attend, and one professor from another department.

The obligatory first coordinate agreement observed in 'extraposition' structures suggests that what may look at first sight like right-ward movement of the second coordinate really involves stripping (Hankamer and Sag, 1976, 409), the second conjunct is in fact an entire sentence with most material elided. If the second coordinate was really able to 'move' to the right, the agreement pattern should be the same as when in situ. For VO structures, the prediction is now that prosody should correlate with first/second coordinate agreement; the judgments are very subtle though:

(142) a. In the seminar room there are/?is | a teacher and two students.
b. In the seminar room there ?are/is a teacher | and two students.

A better way to force the 'extraposition' structure is to employ the adverb 'too,' and here the judgments are unambiguous. Consider first the OV-case:

(143) a. # John and Mary have arrived, too. So two people have arrived.
b. John has arrived, and Mary, too. So two people have arrived.

Sentence (143a) reports on one event of arrival involving two people, whereas (143b) reports on two events of arrival with one person. The interpretive properties of (143b) point toward a stripping analysis rather than literal extraposition. We are looking at a list of two sentences, the second of which is a fragment.

A similar set of facts is expected now for the case of the direct object, but the effect of extraposition will not result in a different word order this time.However, there are prosodic differences, such that forcing the two-event reading using 'too' forces the 'mismatching' prosody:[40]

(144) a. I saw John, | and Mary, too. So I saw two people.

[40] This observation was made already in Downing (1970).

b. # I saw John and Mary, | too. So I saw two people.

Conversely, we can try to use the adverb *together* to *prevent* extraposition:

(145) a. John and Mary arrived together.

b. ?# John arrived, || and Mary together.

Again, the facts are as expected in the case of VO structures: The 'mismatching' phrasing is at least dispreferred:

(146) a. ?# I saw John, || and Mary, together.

b. I saw John | and Mary, || together.

The idea that what looks like a syntax-prosody mismatch is really due to a matching bracketing in syntax is further supported by a restriction on phrasing in Tiberian Hebrew observed in Dresher (1994, 19).

(147) a. (kī-ḥemʾā ūdbaš) (yōkēl)
for-curds and.honey shall.eat

b. * (kī-ḥemʾā) (ūdbaš yōkēl)

The reason for this restriction proposed here is simply that there is no leftward 'extraposition.' If the boundary following the first coordinate is stronger than the one preceding it, 'extraposition' (i.e., coordinating something bigger while gapping part of the matieral) has taken place. The two prosodies involve a choice between two different syntactic structures. What's interesting is that this again is a case where a nested expression finds an alternative realization involving a list: Stripping involves a paratactic coordination of two sentences, the second of which is a fragment.

The type of mismatch discussed here and in the previous discussion on relative clauses has been used in earlier literature to argue for the edge-marking theory of prosody-syntax mapping (Chen, 1987, Selkirk, 1986, et seq.). It is easy to derive a 'mismatching' phrasing from the basic syntactic bracketing based on right-edge marking from the mismatching syntactic structure:

(148) a. [saw [John$_{XP}$ [ and Mary$_{XP}$]$_{\bar{X}}$ ]$_{XP}$.

b. (saw John)$_{\Phi}$ (and Mary)$_{\Phi}$.

However, in both the case of relative clauses and conjoined arguments, the mismatch turned out to be illusory, and thus the original motivation for edge-alignment is thus diffused. More importantly, for the cases discussed here, the edge-marking approach would *wrongly permit deriving the right phrasing from the wrong syntax*. In other words, while the edge-marking theory is compatible with a syntactic analysis involving 'extraposition,' there is nothing that *forces* such an analysis, and the observed prosody should be equally compatible with the basic syntactic structure without 'extraposition.'

The more restrictive theory that prohibits this type of mismatch makes the correct predictions for the syntactic analysis based on the prosodic facts. The apparent

optional between two prosodies turned out to be a choice between two different syntactic construals, which each map syntax to prosody in a straightforward way, and in fact can differ semantically in subtle ways.

There are other types of mismatches between prosody and syntax that would require more discussion, especially the cross-linguistically pervasive mismatches in the placement of certain heads and clitics, i.e., the kinds of constituents often subject to prosodic subodination (Wagner, 2005). One type of example directly relates to coordinate structures: In some languages the connector in coordinate structure is sometimes placed *within* the second coordinate, and the generalization about where exactly it is placed seems to require reference to prosody (see Agbayani and Golston, to appear, for a recent discussion). To what extend such mismatches in the literature require a revision of the more syntactic view prosodic phrasing proposed here remains to be seen.

## 7 Conclusion

The prosody of linguistic expressions, just like their semantic interpretation, reflects their internal compositional structure. Prosodic boundary ranks reflect the compositional structure of expressions in a much more direct fashion than usually assumed. Instead of viewing the prosodic representation as a separate representation, completely independent of syntax, we can see it, at least up to a point, as *another way of representing syntactic information*. A similar view is defended in Steedman (2004), and also in Liberman (1975, 258): “Thus the most basic assumptions of our theory depend on the idea that the phonological component is not so much a destruction of structure, which maps a complex tree onto a simple serial ordering of segments, as a transmutation of structure, which maps a structure suitable for operations in one domain (syntax and semantics) onto a structure suitable for use in another domain (the motor control of articulatory gestures, and its perceptual analogue).”

This compositional view of prosody was found to be better suited to account for the prosody of coordinate structures than the prevalent edge-alignment approach, which would predict a flat prosody in coordinate structures independent of their internal bracketing. The original motivation in favor of edge-alignment came from certain apparent bracketing mismatches. However, a closer look at the syntax in representative examples suggests the prosody does not mismatch syntax after all. If this conclusion is correct, then we can take prosodic evidence seriously as a source of syntactic evidence. In cases where syntactic and prosodic evidence seem in contradiction, we may have to rethink our syntactic analysis.

The generalization about boundary strength in English can only be captured in reference to the recursive structure of syntax. Recursion was recently characterized as the defining aspect of the human language faculty (Hauser et al., 2002). This is a controversial view however. Pinker and Jackendoff (2005) and Hunyadi (2006) discuss that recursion might be shared by other cognitive domains; Everett (2005) argues that at least one language lacks recursion: Pirahã; and Christiansen and Chater (1999) even argue that there is no true recursion in English. Prosody may be a useful tool to

further elucidate the recursivity of languages, since it provides a window into their compositional structure.

Human beings are not particularly good at processing nested structures and seem to prefer to keep recursive depth at a minimum. Apparent mismatches between syntax and prosody were found to be due to strategies that allow for constructing complex meaning with list-like structures. It is conceivable that languages vary in the degree to which they have developed strategies to avoid nesting. The Handbook of Amazonian languages Derbyshire and Pullum (1986), for example, describes several languages in which paratactic constructions are frequently used to express types of meanings which would be construed using nested expressions in English, i.a., Apalai, Canela-Krahô, and Pirahã.[41] This does not necessarily mean that certain meanings cannot be conveyed,[42] as the example of arithmetic formulas that can be presented as lists illustrates. It may just be that in some languages the use of strategies to construe complex meaning as lists is even more ubiquitous than in English.

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[41] The same is reported for Mẽbengokre (cf. Salanova, 2007, 63).

[42] Although Everett (2005) made a strong claim in this direction, which generated lively discussion, see Nevins et al. (2007) and responses.

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