# Constraints and Resources in Natural Language Syntax and Semantics

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LaTeX2e Guidelines
by
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**CENTER FOR THE STUDY
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# Introduction

This document describes guidelines for authors submitting contributions to the second volume in *Studies in Constraint-Based Lexicalism*, edited by Gosse Bouma, Erhard Hinrichs, Geert-Jan Kruijff, Richard Oehrle.


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# 1

# Contour and Structure. A Categorial Account of Alignment

Herman Hendriks

In this paper it is argued that within the proof-theoretic sign-based categorial analysis of intonation presented in Hendriks (1999), the problem of alignment, which has been characterized as 'one of the earliest and most intractable problems in prosodic phonology', does not even arise. The alignment of pitch accents with the prosodically strongest syllable of their domain is a problem for prosodic phonology, because a level of 'accentual phrase' cannot be defined for English. This impossibility can be attributed to the fact that the relevant 'accentual phrase' may either be considerably bigger or substantially smaller than a prosodic word. However, on the natural and straightforward assumption that lexical items have themselves prosodically headed phonological forms, the observed indifference of English pitch accent assignment to phonological levels follows without any further stipulation in the proof-theoretic sign-based grammar formalism, due to the fact that the resulting system accommodates a completely uniform account of lexical and phrasal prosodic headedness.

## 1.1

In the paper 'Alignment and Prosodic Heads' (Pierrehumbert 1994), pitch accent assignment in English is characterized as '[o]ne of the earliest and most intractable problems in prosodic phonology'. (Pierrehumbert 1994: 273–274.)

> Intonation contours in English consist of one or more pitch accents plus boundary tones marking phrasal edges. Each pitch accent is aligned with the most prominent syllable of

> its domain. [...] That is, the head of the pitch accent is aligned with the prosodic head of the associated text. (Pierrehumbert 1994: 278.)

However,

> [p]itch accent assignment in English is a prosodic problem because [...] pitch accents are aligned with the prosodically strongest syllable of their domain. (The position of boundary tones is also prosodically determined, but by grouping rather than prominence.) The main difference between pitch accent assignment and what are considered to be standard examples of prosodic phonology is that standard examples involve lexical processes, while pitch accent is post-lexical; the well-formedness of the accent placement is determined with respect to the intonation phrase, a prosodic unit which can only be formed after words are combined into sentences. (Pierrehumbert 1994: 278.)

It is primarily the latter aspect that causes the trouble:

> The problem has been intractable because the major regularities governing accent placement have proved difficult to express in several successive versions of autosegmental and metrical phonology. (Pierrehumbert 1994: 278.)

More in particular:

> Pitch accent assignment in English presents what is perhaps the worst outstanding problem for the level-ordering hypothesis of Selkirk (1984), Nespor and Vogel (1986) and Beckman (1986). Although a level of 'accentual phrase' can be defined in some other languages such as Japanese (see e.g. Poser 1985, Beckman 1986, Pierrehumbert and Beckman 1988), it is impossible to do so for English. The difficulty arises because the accentual phrase can either be bigger than a prosodic word or smaller than a prosodic word. (Pierrehumbert 1994: 279.)

The problem can be illustrated as follows. According to the pragmatic focus/ground approach, sentences can consist of a focus and a ground. The *focus* is the informative part of the sentence, the part that (the speaker believes) expresses 'new' information in that it makes some contribution to the hearer's mental state. The *ground* is the non-informative part of the sentence, the part that expresses 'old' information and anchors the sentence to what is already established or under discussion in (the speaker's picture of) the hearer's mental state. Although sentences may lack a ground altogether, sentences without focus do not exist.

Now, if an English sentence only expresses new information—for example because it answers the question *What's up?*—, it will typically contain a single focal pitch accent which is aligned with its prosodic head, that is, with the prosodically most prominent syllable of the sentence. Thus, in a transitive all-focus sentence such as (1.1), it is the direct object noun phrase of the verb *likes* that will be accented:

(1.1) Kim likes JIM.

Following Pierrehumbert (1980), we will take tune, or intonation contour, to be a sequence of low (L) and high (H) tones, made up from pitch accents, phrase accents and boundary tones. Beckman and Pierrehumbert (1986) and Pierrehumbert and Hirschberg (1990) distinguish six pitch accents: two simple tones, H* and L*, and four complex ones, L*+H, L+H*, H*+L, H+L*, where the '*' indicates that the tone is aligned with a stressed syllable.

Tune meaning is assumed to be built up compositionally, and 'intonation contour is used to convey information to the hearer about how the propositional content of the [...] utterance is to be used to modify what the hearer believes to be mutually believed'. (Pierrehumbert and Hirschberg 1990: 289.) Thus in English, H* pitch accent is associated with the focus of the sentence, while L+H* pitch accent serves to mark topics (which will be discussed below).

We will use SMALL CAPS for expressions that bear H* pitch accents, and **boldface** for expressions that bear L+H* pitch accents. (H* accent and L+H* accent are called A accent and B accent, respectively, in Jackendoff 1972.)[1]

The prosodic head of the sentence may also be embedded more deeply. Observe that if the direct object of the transitive verb of an all-focus sentence is a compound noun phrase such as *the boss*, it is the common noun of the noun phrase, rather than the determiner, that supplies the most prominent syllable of the sentence:

(1.2) Eve fears the BOSS.

The examples (1.1) and (1.2) illustrate the fact that pitch accent assignment is indeed post-lexical, as was noted above, in the sense that accent

[1] The system of the present paper restricts itself to the distribution of H* and L+H* pitch accents. A grammar that exhausts the full gamut of intonation contours studied in Pierrehumbert and Hirschberg 1990 may retain the elegance of the restricted system proposed here by actually *decomposing* Pierrehumbert and Hirschberg's grammar of intonation (something which is suggested in Hobbs 1990).

placement is determined with respect to prosodic units which can only be considered after words have been combined into sentences.

Still, pitch accent assignment is not an entirely post-lexical matter. While (1.1) and (1.2) show that the relevant prosodic unit can be considerably bigger than a prosodic word, it is equally obvious that units which are substantially smaller than a prosodic word have a crucial role to play as well. It is, for example, the lexical prosodic structure of the word *broccoli* which is responsible for the fact that the focal pitch accent in the all-focus sentence (1.3) is aligned with the first syllable of the direct object:

(1.3) Pam loves BROCcoli.

In addition to this, moreover, it can be observed that pitch accent assignment always involves the most prominent syllable of its domain, quite independent of the type of pitch accent that is involved.

Thus the pragmatic topic/comment approach splits the set of subexpressions of a sentence into a *topic*, the—typically sentence-initial—part that expresses what the sentence is about, and a *comment*, the part that expresses what is said about the topic. Topics are points of departure for what the sentence conveys, they link it to previous discourse. (We will not go further into the interpretation of topic and focus. The interested reader might wish to consult Hendriks 1998 and Rooth 1992.)

Sentences may be topicless: so-called 'presentational' or 'news' sentences such as the above examples (1.1–1.3) consist entirely of a comment. But if an English transitive sentence such as *Jim knows Pam* contains a topical subject—for example because it answers the question *What about Jim?*—, it will not only contain a focal H* pitch accent which is aligned with its prosodic head, that is, the direct object noun phrase of the transitive verb, but also an additional topical L+H* pitch accent aligned with the subject of the sentence:

(1.4) **Jim** knows PAM.

Within its domain—the subject of the sentence—, the alignment of this topical L+H* pitch accent observes the same regularities as the alignment of the focal H* pitch accent, in that this pitch accent also attaches to the prosodically most prominent syllable. In other words: both types of pitch accent exploit the same notion of prosodic head.

This is illustrated by the examples (1.5) and (1.6). So, if the topical subject of the sentence is a compound noun phrase such as *the boss*, it is the common noun of the noun phrase, rather than the determiner, that supplies the most prominent syllable of the topic.

(1.5) The **boss** wants Eve.

And, again, it is the lexical prosodic structure of the word *broccoli* which is responsible for the fact that the L+H* pitch accent in the topical subject of (1.6) is aligned with the first syllable of that word:

(1.6) **Broc**coli haunts Kim.

Below we will argue that the sign-based categorial grammar that was presented in Hendriks (1999) is capable of elegantly handling both the phrasal and the lexical alignment of pitch accents with the prosodically strongest syllable of their domain.

In Section 1.2, the basic system for focal H* pitch accent assignment will be presented, as well as its treatment of the post-lexical all-focus examples (1.1) and (1.2). In Section 1.3, the system is extended with the means for assigning topical L+H* pitch accents. These means are employed in an analysis of the topic-focus post-lexical examples (1.4) and (1.5).

Finally, Section 1.4 departs from the proposals of Hendriks (1999) in that it will propose a straightforward minor modification of the way in which the grammar is applied, which builds on the fully natural assumption that lexical items themselves have prosodically headed phonological forms as well.

As a result of this modification, the grammar accommodates a completely uniform account of lexical and phrasal prosodic headedness. As shown by the analyses of the lexical all-focus and topic-focus examples (1.3) and (1.6), the observed indifference of English pitch accent assignment to phonological levels follows without any further stipulation in the resulting system.

## 1.2

In this section we will present the basic system for focal H* pitch accent assignment that was introduced in Hendriks (1999), and show how it applies to the examples (1.1) and (1.2). Basically, the formalism is a both intonationally/syntactically and semantically/informationally interpreted version of an extension of the non-associative calculus of Lambek (1961). The signs, the grammatical resources of this formalism, are Saussurian form-meaning units which reflect the fact that the dimensions of linguistic form and meaning contribute to well-formedness in an essentially parallel way:

(1.7) intonational term $\triangleleft$ category $\triangleright$ informational term

The calculus **D** that functions as the proof-theoretic categorial engine of the grammar represents sequents as composed of such multidimensional signs. It instantiates a minimal 'base logic', which makes no assumptions at all about structural aspects of grammatical resource management, since the formalism is based on a—'dependency'; cf. Moortgat and Morrill (1991)—doubling of the non-associative Lambek (1961) calculus **NL**, the 'pure logic of residuation'. In this double system, the phonological head/non-head opposition is captured by decomposing the product into a left-dominant and a right-dominant variant and obtaining residuation duality for both variants.

First, focusing on the categories, we define a *sequent* as an expression $\Gamma \Rightarrow C$, where $\Gamma$, the *antecedent* of the sequent, is a structured term, and $C$, the *consequent* or *goal* of the sequent, is a category. The set CAT of categories is based on some finite set ATOM of atomic categories and is defined as the smallest set such that:

(1.8)
$$\begin{gathered}\text{ATOM} \subseteq \text{CAT; and}\\ \text{if } A \in \text{CAT and } B \in \text{CAT, then}\\ (B\underset{*}{\backslash}A) \in \text{CAT}, (A\overset{*}{/}B) \in \text{CAT}, (A{*}\!\bullet B) \in \text{CAT and}\\ (B\overset{*}{\backslash}A) \in \text{CAT}, (A\underset{*}{/}B) \in \text{CAT}, (A\bullet\!{*}B) \in \text{CAT}.\end{gathered}$$

The set TERM of structured terms is defined as the smallest set such that:

(1.9)
$$\begin{gathered}\text{CAT} \subseteq \text{TERM; and}\\ \text{if } \Gamma \in \text{TERM and } \Delta \in \text{TERM, then}\\ [\Gamma\,,\Delta] \in \text{TERM and } [\Gamma\,\text{`}\,\Delta] \in \text{TERM}.\end{gathered}$$

The categories $(B\underset{*}{\backslash}A)$, $(A\overset{*}{/}B)$ and $(A{*}\!\bullet B)$ are associated with structures $[\Gamma\,,\Delta]$ that have their prosodic head in their left-hand side, and the categories $(B\overset{*}{\backslash}A)$, $(A\underset{*}{/}B)$ and $(A\bullet\!{*}B)$ are associated with structures $[\Gamma\,\text{`}\,\Delta]$ that have their prosodic head in their right-hand side.[2] More precisely: structured terms $\Delta$ of category $(B\underset{*}{\backslash}A)$ combine with structured terms $\Gamma$ of category $B$ on their left-hand side to form prosodically left-dominant structured terms $[\Gamma\,,\Delta]$ of category $A$; structured terms $\Gamma$ of category $(A\overset{*}{/}B)$ combine with structured terms $\Delta$ of category $B$ on their right-hand side to form prosodically left-dominant structured terms $[\Gamma\,,\Delta]$ of category $A$; and the category $(A{*}\!\bullet B)$ represents prosodically left-dominant structured terms $[\Gamma\,,\Delta]$ in which $\Gamma$ and $\Delta$ are of category $A$ and $B$, respectively. Likewise, structured terms $\Delta$ of category $(B\overset{*}{\backslash}A)$

[2] Thus ' and , 'embrace' their prosodic heads in the structured terms, while the relative position of $*$ with respect to $\backslash$, $/$ and $\bullet$ indicates the direction of prosodic dominance in the category operators.

combine with structured terms $\Gamma$ of category $B$ on their left-hand side to form prosodically right-dominant structured terms $[\Gamma \,`\, \Delta]$ of category $A$; structured terms $\Gamma$ of category $(A /_{*} B)$ combine with structured term $\Delta$ of category $B$ on their right-hand side to form prosodically right-dominant structured terms $[\Gamma \,`\, \Delta]$ of category $A$; and the category $(A {\bullet}_{*} B)$ represents prosodically right-dominant structured terms $[\Gamma \,`\, \Delta]$ in which $\Gamma$ and $\Delta$ are of category $A$ and $B$, respectively.

These characterizations are reflected in the calculus **D**, which has the axioms and inference rules specified in (1.10) through (1.16) below (where $A$, $B$, $C$ denote categories, $\Gamma$ and $\Delta$ structured terms, and $\Gamma\{\Delta\}$ represents a structured term $\Gamma$ containing a distinguished occurrence of the structured subterm $\Delta$):

$$\frac{}{A \Rightarrow A}\,[Ax] \qquad \frac{\Delta \Rightarrow A \quad \Gamma\{A\} \Rightarrow C}{\Gamma\{\Delta\} \Rightarrow C}\,[Cut] \tag{1.10}$$

$$\frac{\Delta \Rightarrow B \quad \Gamma\{A\} \Rightarrow C}{\Gamma\{[\Delta \,,\, B \backslash_{*} A]\} \Rightarrow C}\,[\backslash_{*} L] \qquad \frac{[B \,,\, \Gamma] \Rightarrow A}{\Gamma \Rightarrow B \backslash_{*} A}\,[\backslash_{*} R] \tag{1.11}$$

$$\frac{\Delta \Rightarrow B \quad \Gamma\{A\} \Rightarrow C}{\Gamma\{[\Delta \,`\, B \overset{*}{\backslash} A]\} \Rightarrow C}\,[\overset{*}{\backslash} L] \qquad \frac{[B \,`\, \Gamma] \Rightarrow A}{\Gamma \Rightarrow B \overset{*}{\backslash} A}\,[\overset{*}{\backslash} R] \tag{1.12}$$

$$\frac{\Delta \Rightarrow B \quad \Gamma\{A\} \Rightarrow C}{\Gamma\{[A \overset{*}{/} B \,,\, \Delta]\} \Rightarrow C}\,[\overset{*}{/} L] \qquad \frac{[\Gamma \,,\, B] \Rightarrow A}{\Gamma \Rightarrow A \overset{*}{/} B}\,[\overset{*}{/} R] \tag{1.13}$$

$$\frac{\Delta \Rightarrow B \quad \Gamma\{A\} \Rightarrow C}{\Gamma\{[A /_{*} B \,`\, \Delta]\} \Rightarrow C}\,[/_{*} L] \qquad \frac{[\Gamma \,`\, B] \Rightarrow A}{\Gamma \Rightarrow A /_{*} B}\,[/_{*} R] \tag{1.14}$$

$$\frac{\Gamma\{[A \,,\, B]\} \Rightarrow C}{\Gamma\{A \,{}_{*}{\bullet}\, B\} \Rightarrow C}\,[{}_{*}{\bullet} L] \qquad \frac{\Gamma \Rightarrow A \quad \Delta \Rightarrow B}{[\Gamma \,,\, \Delta] \Rightarrow A \,{}_{*}{\bullet}\, B}\,[{}_{*}{\bullet} R] \tag{1.15}$$

$$\frac{\Gamma\{[A \,`\, B]\} \Rightarrow C}{\Gamma\{A {\bullet}_{*} B\} \Rightarrow C}\,[{\bullet}_{*} L] \qquad \frac{\Gamma \Rightarrow A \quad \Delta \Rightarrow B}{[\Gamma \,`\, \Delta] \Rightarrow A {\bullet}_{*} B}\,[{\bullet}_{*} R] \tag{1.16}$$

Observe that the calculus **D** is indeed a doubling of the non-associative Lambek calculus: both (1.10), (1.11), (1.13), (1.15) and (1.10), (1.12), (1.14), (1.16) constitute an isomorphic copy of **NL**.

As noted above, the calculus **D** is used in a so-called sign-based set-up. That is: the calculus functions as the proof-theoretic engine of a grammar that represents sequents as composed of multidimensional *signs*. More formally, SIGN, the set of signs, is the following set:

$$\{\varphi \triangleleft C \triangleright \gamma \mid \varphi \in \textsc{pros} \text{ and } C \in \textsc{cat} \text{ and } \gamma \in \textsc{sem}\} \tag{1.17}$$

The sets PROS and CAT are defined in (1.21) below and (1.8) above, respectively, and SEM is the set of simply-typed lambda terms built up from variables and (possibly) constants using abstraction, application, projection and pairing. Based on (1.17), the sign-based set TERM of structured terms is now defined as the smallest set such that:

(1.18)
$$\text{SIGN} \subseteq \text{TERM}; \text{ and}$$
$$\text{if } \Gamma \in \text{TERM and } \Delta \in \text{TERM}, \text{ then}$$
$$[\Gamma \,,\, \Delta] \in \text{TERM and } [\Gamma \,\text{`}\, \Delta] \in \text{TERM}.$$

For a structured term $\Gamma$, the sequence $s(\Gamma)$ of signs of $\Gamma$ is defined as follows:

(1.19)
$$s(\alpha \triangleleft C \triangleright \tau) = \alpha \triangleleft C \triangleright \tau; \text{ and}$$
$$s([\Gamma \,,\, \Delta]) = s([\Gamma \,\text{`}\, \Delta]) = s(\Gamma), s(\Delta).$$

The sign-based grammar derives sequents $\Gamma \Rightarrow S$, where $\Gamma$ is a structured term (as defined in (1.18) above) and $S$ is a sign (see (1.17) above). Its axioms and rules are listed in (1.22) through (1.35) below. Observe that apart from the respective assignments $\varphi \triangleleft$ and $\triangleright \gamma$ of prosodic (intonational) and semantic (informational) terms to categories, this system is identical to the calculus **D** specified in (1.10) through (1.16) above. We will pay no attention to the—standard—assignment of semantic terms. The assignment of prosodic terms proceeds in an analogous—though type-free—fashion. First, the set of simple prosodic terms is defined as the union of some (possibly empty) set CON of prosodic constants and an infinite set VAR of prosodic variables:

(1.20)
$$\text{VAR} = \{f_i \mid i \in \mathbb{N}\}$$

Next, the set PROS of prosodic terms is defined as the smallest set satisfying the following:

(1.21)
$$\text{VAR} \cup \text{CON} \subseteq \text{PROS};$$
$$\langle \varphi \,,\, \psi \rangle \in \text{PROS if } \varphi \in \text{PROS and } \psi \in \text{PROS } (\textit{head left}); \text{ and}$$
$$\langle \varphi \,\text{`}\, \psi \rangle \in \text{PROS if } \varphi \in \text{PROS and } \psi \in \text{PROS } (\textit{head right}).$$

Head-left prosodic terms $\langle \varphi \,,\, \psi \rangle$ and head-right prosodic terms $\langle \varphi \,\text{`}\, \psi \rangle$ will have their prosodic head in their left-hand side subterm $\varphi$ and their right-hand side subterm $\psi$, respectively.

Furthermore, every category occurrence in a derivable sequent $\Gamma \Rightarrow S$ is assigned a prosodic term: the categories in the antecedent term $\Gamma$ are assigned distinct prosodic variables, and the single category in the consequent sign $S$ is assigned a possibly complex prosodic term. In (1.22) through (1.35) below, the expressions $\varphi$ and $\psi$ denote arbitrary prosodic terms, and $f, g$ and $h$ represent prosodic variables. In the prosodic domain, we let the expression $\varphi[\psi \to \chi]$ denote the result of replacing all occurrences of the subterm $\psi$ in $\varphi$ by occurrences of the term $\chi$. This may involve more than mere substitution for prosodic variables. Thus, prosodically, in (1.22) through (1.35) below, axioms amount to identity (assignment of $f$ to antecedent and goal category), the rules *Cut* and $\underset{*}{\backslash}L, \overset{*}{/}L$ and $\overset{*}{\backslash}L, \underset{*}{/}L$ to substitution ($\varphi[f \to \psi]$ and $\varphi[f \to \langle \psi \,, g \rangle]$ and $\varphi[f \to \langle \psi \,‘\, g \rangle]$), the rules $\underset{*}{\backslash}R, \overset{*}{/}R$ and $\overset{*}{\backslash}R, \underset{*}{/}R$ to taking a subterm ($\varphi$, of $\langle f \,, \varphi \rangle$ and $\langle f \,‘\, \varphi \rangle$), and the rules ${}^{*}\!\bullet R$ and $\bullet^{*}R$ to the construction of a head-left and head-right term ($\langle \varphi \,, \psi \rangle$ and $\langle \varphi \,, \psi \rangle$), respectively, but the rules ${}^{*}\!\bullet L$ and $\bullet^{*}L$ involve the replacement of the occurrences of complex prosodic terms $\langle f \,, g \rangle$ and $\langle f \,‘\, g \rangle$ in $\varphi$ by occurrences of a prosodic variable $h$.

In the context of a proof, we will assume that all prosodic variables $f, g$ and $h$ assigned to an axiom instance or introduced in the conclusion of a $\underset{*}{\backslash}L, \overset{*}{\backslash}L, \overset{*}{/}L, \underset{*}{/}L, {}^{*}\!\bullet L$ or $\bullet^{*}L$ inference are different. This has the same consequences as the parallel assumption concerning semantic variables: the prosodic variables $f_1, \ldots f_n$ assigned to the antecedent categories of a sequent $\Gamma \Rightarrow S$ are all different, they make up the variables of the prosodic term $\varphi$ assigned to the consequent category, and they occur exactly once in $\varphi$.

(1.22)
$$\frac{}{f \triangleleft A \triangleright u \Rightarrow f \triangleleft A \triangleright u}\ [Ax]$$

(1.23)
$$\frac{\Delta \Rightarrow \psi \triangleleft A \triangleright \alpha \quad \Gamma\{f \triangleleft A \triangleright u\} \Rightarrow \varphi \triangleleft C \triangleright \gamma}{\Gamma\{\Delta\} \Rightarrow \varphi[f \to \psi] \triangleleft C \triangleright \gamma[u \to \alpha]}\ [Cut]$$

(1.24)
$$\frac{\Delta \Rightarrow \psi \triangleleft B \triangleright \beta \quad \Gamma\{f \triangleleft A \triangleright u\} \Rightarrow \varphi \triangleleft C \triangleright \gamma}{\Gamma\{[\Delta \,, g \triangleleft B \underset{*}{\backslash} A \triangleright x]\} \Rightarrow \varphi[f \to \langle \psi \,, g \rangle] \triangleleft C \triangleright \gamma[u \to x(\beta)]}\ [\underset{*}{\backslash}L]$$

(1.25)
$$\frac{\Delta \Rightarrow \psi \triangleleft B \triangleright \beta \quad \Gamma\{f \triangleleft A \triangleright u\} \Rightarrow \varphi \triangleleft C \triangleright \gamma}{\Gamma\{[\Delta \,‘\, g \triangleleft B \overset{*}{\backslash} A \triangleright x]\} \Rightarrow \varphi[f \to \langle \psi \,‘\, g \rangle] \triangleleft C \triangleright \gamma[u \to x(\beta)]}\ [\overset{*}{\backslash}L]$$

(1.26)
$$\frac{\Delta \Rightarrow \psi \triangleleft B \triangleright \beta \quad \Gamma\{f \triangleleft A \triangleright u\} \Rightarrow \varphi \triangleleft C \triangleright \gamma}{\Gamma\{[g \triangleleft A \overset{*}{/} B \triangleright x \,, \Delta]\} \Rightarrow \varphi[f \to \langle g \,, \psi \rangle] \triangleleft C \triangleright \gamma[u \to x(\beta)]}\ [\overset{*}{/}L]$$

(1.27)
$$\frac{\Delta \Rightarrow \psi \triangleleft B \triangleright \beta \quad \Gamma\{f \triangleleft A \triangleright u\} \Rightarrow \varphi \triangleleft C \triangleright \gamma}{\Gamma\{[g \triangleleft A \underset{*}{/} B \triangleright x \,‘\, \Delta]\} \Rightarrow \varphi[f \to \langle g \,‘\, \psi \rangle] \triangleleft C \triangleright \gamma[u \to x(\beta)]}\ [\underset{*}{/}L]$$

(1.28)
$$\frac{[f \triangleleft B \triangleright v \,, \Gamma] \Rightarrow \langle f \,, \varphi \rangle \triangleleft A \triangleright \alpha}{\Gamma \Rightarrow \varphi \triangleleft B \underset{*}{\backslash} A \triangleright \lambda v.\alpha}\ [\underset{*}{\backslash}R]$$

(1.29) $$\frac{[f \triangleleft B \triangleright v \text{‘} \Gamma] \Rightarrow \langle f \text{‘} \varphi \rangle \triangleleft A \triangleright \alpha}{\Gamma \Rightarrow \varphi \triangleleft B \overset{*}{\backslash} A \triangleright \lambda v.\alpha}\ [\overset{*}{\backslash} R]$$

(1.30) $$\frac{[\Gamma\, , f \triangleleft B \triangleright v] \Rightarrow \langle \varphi\, , f \rangle \triangleleft A \triangleright \alpha}{\Gamma \Rightarrow \varphi \triangleleft A \overset{*}{/} B \triangleright \lambda v.\alpha}\ [\overset{*}{/} R]$$

(1.31) $$\frac{[\Gamma \text{‘} f \triangleleft B \triangleright v] \Rightarrow \langle \varphi \text{‘} f \rangle \triangleleft A \triangleright \alpha}{\Gamma \Rightarrow \varphi \triangleleft A \underset{*}{/} B \triangleright \lambda v.\alpha}\ [\underset{*}{/} R]$$

(1.32) $$\frac{\Gamma\{[f \triangleleft A \triangleright u\, , g \triangleleft B \triangleright v]\} \Rightarrow \varphi \triangleleft C \triangleright \gamma}{\Gamma\{h \triangleleft A {}^{*}\!\bullet B \triangleright y\} \Rightarrow \varphi[\langle f\, , g\rangle \to h] \triangleleft C \triangleright \gamma[u \to (y)_0, v \to (y)_1]}\ [{}^{*}\!\bullet L]$$

(1.33) $$\frac{\Gamma\{[f \triangleleft A \triangleright u \text{‘} g \triangleleft B \triangleright v]\} \Rightarrow \varphi \triangleleft C \triangleright \gamma}{\Gamma\{h \triangleleft A \bullet^{*} B \triangleright y\} \Rightarrow \varphi[\langle f \text{‘} g\rangle \to h] \triangleleft C \triangleright \gamma[u \to (y)_0, v \to (y)_1]}\ [\bullet^{*} L]$$

(1.34) $$\frac{\Gamma \Rightarrow \varphi \triangleleft A \triangleright \alpha \quad \Delta \Rightarrow \psi \triangleleft B \triangleright \beta}{[\Gamma\, , \Delta] \Rightarrow \langle \varphi\, , \psi \rangle \triangleleft A {}^{*}\!\bullet B \triangleright \alpha \star \beta}\ [{}^{*}\!\bullet R]$$

(1.35) $$\frac{\Gamma \Rightarrow \varphi \triangleleft A \triangleright \alpha \quad \Delta \Rightarrow \psi \triangleleft B \triangleright \beta}{[\Gamma \text{‘} \Delta] \Rightarrow \langle \varphi \text{‘} \psi \rangle \triangleleft A \bullet^{*} B \triangleright \alpha \star \beta}\ [\bullet^{*} R]$$

In keeping with the set-up outlined above, we will assume that the lexicon is a collection of lexical signs $\varphi \triangleleft C \triangleright \gamma$, where $\varphi$ is a prosodic term, $C$ is syntactic category, and $\gamma$ is a semantic term of type $\textsc{type}(C)$.

Given a lexicon $L$, we will say that a (possibly compound) sign $\varphi' \triangleleft C \triangleright \gamma'$ is in the language of $L$ if and only if for some derivable sequent $\Gamma \Rightarrow \varphi \triangleleft C \triangleright \gamma$ such that $s(\Gamma) = f_1 \triangleleft C_1 \triangleright v_1, \ldots, f_n \triangleleft C_n \triangleright v_n$, there are lexical signs $\varphi_1 \triangleleft C_1 \triangleright \gamma_1 \in L$, $\ldots$, $\varphi_n \triangleleft C_n \triangleright \gamma_n \in L$ such that $\varphi [\!- f_1 \to \varphi_1, \ldots, f_n \to \varphi_n -\!] = \varphi'$ and $\gamma\, [\, v_1 \to \gamma_1, \ldots, v_n \to \gamma_n\, ] = \gamma'$.

Observe that the sequence $s(\Gamma)$ of signs of a structured term $\Gamma$ has been defined in (1.19) above. The expression $\gamma\, [\, v_1 \to \gamma_1, \ldots, v_n \to \gamma_n\, ]$ standardly denotes the result of simultaneously and respectively substituting $v_1, \ldots, v_n$ by $\gamma_1, \ldots, \gamma_n$ in $\gamma$, and the expression $\varphi [\!- f_1 \to \varphi_1, \ldots, f_n \to \varphi_n -\!]$ refers to the result of performing the following prosodic substitution:

(1.36) $$\begin{array}{rcl} \langle \varphi\, , \psi \rangle [\!- \vec{s} -\!] & = & \varphi [\!- \vec{s} -\!]\ \psi [\!= \vec{s} =\!] \\ \langle \varphi \text{‘} \psi \rangle [\!- \vec{s} -\!] & = & \varphi [\!= \vec{s} =\!]\ \psi [\!- \vec{s} -\!] \\ f [\!- \vec{s}, f \to \mathit{term}, \vec{s}\,' -\!] & = & \text{TERM} \\ \langle \varphi\, , \psi \rangle [\!= \vec{s} =\!] & = & \varphi [\!= \vec{s} =\!]\ \psi [\!= \vec{s} =\!] \\ \langle \varphi \text{‘} \psi \rangle [\!= \vec{s} =\!] & = & \varphi [\!= \vec{s} =\!]\ \psi [\!= \vec{s} =\!] \\ f [\!= \vec{s}, f \to \mathit{term}, \vec{s}\,' =\!] & = & \text{term} \end{array}$$

The prosodic substitution defined in (1.36) is a ‘forgetful mapping’ that takes care of the assignment of focal H* pitch accent to the prosodic terms which are substituted for the prosodic variables in the initial prosodic term. In the process, there is an important difference between the two substitution modes $\{\!|\ \ldots\ |\!\}$ and $\{\!\|\ \ldots\ \|\!\}$: performing a substitution $\varphi\{\!|\ \vec{s}\ |\!\}$ will result in an expression that contains a single H* pitch accent, while executing $\varphi\{\!\|\ \vec{s}\ \|\!\}$ will yield an expression that lacks H* pitch accents. Note that the assignment of focal H* pitch accent proceeds in such a way that the accent is always aligned with the prosodically most prominent subexpression of a given structure, since it consistently follows its path down via prosodic heads.[3]

We are now in a position to provide the analyses of the examples (1.1) and (1.2).[4]

(1.37) $$\text{Kim likes J\textsc{im}} \triangleleft s \triangleright \textsc{like}(j)(k)$$

First, as regards example (1.1), Kim likes JIM, it can be observed that the sign (1.37) belongs to the language of the lexicon $L = \{Kim \triangleleft n \triangleright k, likes \triangleleft (n\overset{*}{\backslash}s)\underset{*}{/}n \triangleright \textsc{like}, Jim \triangleleft n \triangleright j\}$, in view of the fact that $[f \triangleleft n \triangleright x \text{ ‘ } [g \triangleleft (n\overset{*}{\backslash}s)\underset{*}{/}n \triangleright y \text{ ‘ } h \triangleleft n \triangleright z]] \Rightarrow \langle f \text{ ‘ } \langle g \text{ ‘ } h\rangle\rangle \triangleleft s \triangleright y(z)(x)$ is a derivable sequent: the type-logical part of its derivation is given in (1.38), and the prosodic and semantic interpretation of (1.38) are specified in (1.39) and (1.40), respectively:

(1.38) $$\dfrac{n \Rightarrow n \qquad \dfrac{n \Rightarrow n \quad s \Rightarrow s}{[n \text{ ‘ } n\overset{*}{\backslash}s] \Rightarrow s}\,[\overset{*}{\backslash}L]}{[n \text{ ‘ } [(n\overset{*}{\backslash}s)\underset{*}{/}n \text{ ‘ } n]] \Rightarrow s}\,[\underset{*}{/}L]$$

(1.39) $$\dfrac{h \Rightarrow h \qquad \dfrac{f \Rightarrow f \quad g'' \Rightarrow g''}{[f \text{ ‘ } g'] \Rightarrow \langle f \text{ ‘ } g'\rangle}}{[f \text{ ‘ } [g \text{ ‘ } h]] \Rightarrow \langle f \text{ ‘ } \langle g \text{ ‘ } h\rangle\rangle}$$

---

[3]As a consequence of this architecture, we have that performing a prosodic substitution in different prosodic terms may result in one and the same string, something which holds by virtue of the possibility that $\varphi\{\!|\ f_1 \rightarrow \varphi_1, \ldots, f_n \rightarrow \varphi_n\ |\!\} = \varphi'\{\!|\ f_1 \rightarrow \varphi_1, \ldots, f_n \rightarrow \varphi_n\ |\!\}$. This can be exploited in an account of what is known as *focus projection*, that is: the fact that a single prosodic form such as *Kim likes* JIM can correspond to different information packagings, for example $[_{\mathrm{F}}$*Kim likes* JIM$]$ (in answer to the question *What's new?*), *Kim* $[_{\mathrm{F}}$*likes* JIM$]$ (in answer to the question *What about Kim?*) and *Kim likes* $[_{\mathrm{F}}$JIM$]$ (in answer to the question *Who does Kim like?*). Discussion of this phenomenon will have to be resumed on another occassion.

[4]On the informational side, we will assume that proper names such as *Kim* and *Jim* are assigned individual constants $k$ and $j$, while verbs, determiners and nouns such as *likes*, *the* and *boss* are represented as logical constants LIKE, THE and BOSS of appropriate types that will not be analyzed further here. The latter also holds for the constant TOPIC that figures in the translation $\lambda R\lambda y\lambda x.[\textsc{topic}(x) \wedge R(y)(x)]$ of the abstract defocusing operator $\epsilon$ to be discussed below. A proposal concerning its analysis is offered in Hendriks (1998).

(1.40)
$$\frac{z \Rightarrow z \qquad \dfrac{x \Rightarrow x \qquad y'' \Rightarrow y''}{[x \,‘\, y'] \Rightarrow y'(x)}}{[x \,‘\, [y \,‘\, z]] \Rightarrow y(z)(x)}$$

The process of prosodic substitution is displayed in (1.41), while (1.42) presents the result of performing the required semantic substitution:

(1.41)
$$\begin{gathered}
\langle f \,‘\, \langle g \,‘\, h \rangle\rangle \{\!|\, f \to Kim, g \to likes, h \to Jim \,|\!\} \;= \\
f \{\!|\, f \to Kim, g \to likes, h \to Jim \,|\!\} \, \langle g \,‘\, h \rangle \{\!|\, f \to Kim, g \to likes, h \to Jim \,|\!\} \;= \\
\text{Kim } \langle g \,‘\, h \rangle \{\!|\, f \to Kim, g \to likes, h \to Jim \,|\!\} \;= \\
\text{Kim } g \{\!|\, f \to Kim, g \to likes, h \to Jim \,|\!\} \; h \{\!|\, f \to Kim, g \to likes, h \to Jim \,|\!\} \;= \\
\text{Kim likes } h \{\!|\, f \to Kim, g \to likes, h \to Jim \,|\!\} \;= \\
\text{Kim likes J}\textsc{im}
\end{gathered}$$

(1.42)
$$y(z)(x)[x \to k, y \to \text{LIKE}, z \to j] = \text{LIKE}(j)(k)$$

We now turn to the analysis of example (1.2), Eve fears the BOSS:

(1.43)
$$\text{Eve fears the BOSS} \lhd s \rhd \text{FEAR}(\text{THE}(\text{BOSS}))(e)$$

The sign (1.43) can be shown to belong to the language of the lexicon $L = \{Eve \lhd n \rhd e, fears \lhd (n \overset{*}{\backslash} s) /_{*} n \rhd \text{FEAR}, the \lhd n /_{*} c \rhd \text{THE}, boss \lhd c \rhd \text{BOSS}\}$, because the sequent $[f \lhd n \rhd x \,‘\, [g \lhd n \overset{*}{\backslash} (s /_{*} n) \rhd y \,‘\, [h \lhd n /_{*} c \rhd z \,‘\, k \lhd c \rhd w]]] \Rightarrow \langle f \,‘\, \langle g \,‘\, \langle h \,‘\, k \rangle\rangle\rangle \lhd s \rhd y(z(w))(x)$ is a derivable sequent: (1.44) represents the type-logical part of its derivation; the prosodic and semantic interpretation of (1.44) appear in (1.45) and (1.46), respectively; and the results of performing the relevant prosodic and semantic substitutions are listed in (1.47) and (1.48), respectively.

(1.44)
$$\frac{\dfrac{c \Rightarrow c \qquad n \Rightarrow n}{[n /_{*} c \,‘\, c] \Rightarrow n}\,[/_{*}L] \qquad \dfrac{n \Rightarrow n \qquad s \Rightarrow s}{[n \,‘\, n \overset{*}{\backslash} s] \Rightarrow s}\,[\overset{*}{\backslash} L]}{[n \,‘\, [(n \overset{*}{\backslash} s) /_{*} n \,‘\, [n /_{*} c \,‘\, c]]] \Rightarrow s}\,[/_{*}L]$$

(1.45)
$$\frac{\dfrac{k \Rightarrow k \qquad h' \Rightarrow h'}{[h \,‘\, k] \Rightarrow \langle h \,‘\, k \rangle} \qquad \dfrac{f \Rightarrow f \qquad g'' \Rightarrow g''}{[f \,‘\, g'] \Rightarrow \langle f \,‘\, g' \rangle}}{[f \,‘\, [g \,‘\, [h \,‘\, k]]] \Rightarrow \langle f \,‘\, \langle g \,‘\, \langle h \,‘\, k \rangle\rangle\rangle}$$

(1.46)
$$\frac{\dfrac{w \Rightarrow w \qquad z' \Rightarrow z'}{[z \,‘\, w] \Rightarrow z(w)} \qquad \dfrac{x \Rightarrow x \qquad y'' \Rightarrow y''}{[x \,‘\, y'] \Rightarrow y'(x)}}{[x \,‘\, [y \,‘\, [z \,‘\, w]]] \Rightarrow y(z(w))(x)}$$

(1.47)
$$\begin{gathered}
\langle f \,‘\, \langle g \,‘\, \langle h \,‘\, k \rangle\rangle\rangle \{\!|\, f \to Eve, g \to fears, h \to the, k \to boss \,|\!\} = \\
\text{Eve fears the BOSS}
\end{gathered}$$

$$y(z(w))(x)[x\!\rightarrow e, y\!\rightarrow \textsc{fear}, z\!\rightarrow \textsc{the}, w\!\rightarrow \textsc{boss}] = \textsc{fear}(\textsc{the}(\textsc{boss}))(e) \tag{1.48}$$

## 1.3

In the minimal system of the previous section, each expression is assigned exactly one focal H* pitch. However, we saw above that if an English transitive sentence contains a topical subject, then it may not only contain a focal H* pitch accent aligned with its prosodic head, that is: the direct object noun phrase of the transitive verb, but also an additional L+H* pitch accent aligned with the subject of the sentence. Within the domain of the subject of the sentence, the alignment of this L+H* pitch accent observes the same regularities as the alignment of H* pitch accent, in that it attaches to the prosodically most prominent syllable in that domain.

In order to account for the occurrence of L+H* pitch accents in English, the double pure logic of residuation of Section 1.2 will now be enriched with the minimal logical rules of the unary modal operators $\Diamond$ and $\boxed{\downarrow}$ which can be found in Moortgat (1996) (where $\boxed{\downarrow}$ denotes Moortgat's $\Box^{\downarrow}$).[5] It may be noted that these operators are used in a pure, basic way as well: they do not figure in structural postulates, but are associated with unary brackets which serve to demarcate specific phonological domains (something which is also suggested in Morrill 1994), within which special pitch accents are assigned in the process of prosodic substitution. The type-logical rules for these operators are given in (1.49) and (1.50), and sign-based versions appear in (1.51–1.54):

$$\frac{\Gamma\{A\} \Rightarrow B}{\Gamma\{[\boxed{\downarrow}A]\} \Rightarrow B}\,[\boxed{\downarrow}L] \qquad \frac{[\Gamma] \Rightarrow A}{\Gamma \Rightarrow \boxed{\downarrow}A}\,[\boxed{\downarrow}R] \tag{1.49}$$

$$\frac{\Gamma\{[A]\} \Rightarrow B}{\Gamma\{\Diamond A\} \Rightarrow B}\,[\Diamond L] \qquad \frac{\Gamma \Rightarrow A}{[\Gamma] \Rightarrow \Diamond A}\,[\Diamond R] \tag{1.50}$$

$$\frac{\Gamma\{f \triangleleft A \triangleright u\} \Rightarrow \psi \triangleleft B \triangleright \beta}{\Gamma\{[f \triangleleft \boxed{\downarrow}A \triangleright u]\} \Rightarrow \psi[f\!\rightarrow\langle f\rangle] \triangleleft B \triangleright \beta}\,[\boxed{\downarrow}L] \tag{1.51}$$

$$\frac{[\Gamma] \Rightarrow \langle\varphi\rangle \triangleleft A \triangleright \alpha}{\Gamma \Rightarrow \varphi \triangleleft \boxed{\downarrow}A \triangleright \alpha}\,[\boxed{\downarrow}R] \tag{1.52}$$

[5]Slightly different rules for unary modal operators were initially introduced by Morrill (1992) against the background of the class of so-called *functional* models, where the unary and binary operators are interpreted in terms of unary and binary functions, respectively. In the larger class of so-called *relational* models which is assumed by Moortgat (1996), on the other hand, the unary and binary operators are interpreted in terms of binary and ternary relations, respectively.

(1.53)
$$\frac{\Gamma\{[f \triangleleft A \triangleright u]\} \Rightarrow \psi \triangleleft B \triangleright \beta}{\Gamma\{f \triangleleft \Diamond A \triangleright u\} \Rightarrow \psi[\langle f\rangle \rightarrow f] \triangleleft B \triangleright \beta}\ [\Diamond L]$$

(1.54)
$$\frac{\Gamma \Rightarrow \varphi \triangleleft A \triangleright \alpha}{[\Gamma] \Rightarrow \langle\varphi\rangle \triangleleft \Diamond A \triangleright \alpha}\ [\Diamond R]$$

Because (1.51–1.54) introduce unary brackets, which constitute a new type of prosodic structure, we will now provide an extension of the definition of prosodic substitution $\varphi[\!\!-\ f_1 \rightarrow \varphi_1, \ldots, f_n \rightarrow \varphi_n\ -\!\!]$ that was given in (1.36):

(1.55)
$$\begin{array}{rcl}
\langle\varphi\,,\psi\rangle[\!\!-\ \vec{s}\ -\!\!] & = & \varphi[\!\!-\ \vec{s}\ -\!\!]\ \psi[\!\!=\ \vec{s}\ =\!\!] \\
\langle\varphi\,`\,\psi\rangle[\!\!-\ \vec{s}\ -\!\!] & = & \varphi[\!\!=\ \vec{s}\ =\!\!]\ \psi[\!\!-\ \vec{s}\ -\!\!] \\
\langle\varphi\rangle[\!\!-\ \vec{s}\ -\!\!] & = & \varphi[\!\!\equiv \vec{s} \equiv\!\!] \\
a[\!\!-\ \vec{s}, f \rightarrow term, \vec{s}\,'\ -\!\!] & = & \textsc{term} \\
\langle\varphi\,,\psi\rangle[\!\!=\ \vec{s}\ =\!\!] & = & \varphi[\!\!=\ \vec{s}\ =\!\!]\ \psi[\!\!=\ \vec{s}\ =\!\!] \\
\langle\varphi\,`\,\psi\rangle[\!\!=\ \vec{s}\ =\!\!] & = & \varphi[\!\!=\ \vec{s}\ =\!\!]\ \psi[\!\!=\ \vec{s}\ =\!\!] \\
\langle\varphi\rangle[\!\!=\ \vec{s}\ =\!\!] & = & \varphi[\!\!\equiv \vec{s} \equiv\!\!] \\
a[\!\!=\ \vec{s}, f \rightarrow term, \vec{s}\,'\ =\!\!] & = & \text{term} \\
\langle\varphi\,,\psi\rangle[\!\!\equiv\ \vec{s}\ \equiv\!\!] & = & \varphi[\!\!\equiv\ \vec{s}\ \equiv\!\!]\ \psi[\!\!=\ \vec{s}\ =\!\!] \\
\langle\varphi\,`\,\psi\rangle[\!\!\equiv\ \vec{s}\ \equiv\!\!] & = & \varphi[\!\!=\ \vec{s}\ =\!\!]\ \psi[\!\!\equiv\ \vec{s}\ \equiv\!\!] \\
\langle\varphi\rangle[\!\!\equiv\ \vec{s}\ \equiv\!\!] & = & \varphi[\!\!\equiv \vec{s} \equiv\!\!] \\
a[\!\!\equiv\ \vec{s}, f \rightarrow term, \vec{s}\,'\ \equiv\!\!] & = & \textbf{term}
\end{array}$$

As above, the substitution $\varphi[\!\!-\ \vec{s}\ -\!\!]$ produces an expression that contains a single focal H* pitch accent, and the substitution $\varphi[\!\!=\ \vec{s}\ =\!\!]$ generates an expression in which no H* pitch accent is assigned. In addition, we now have that carrying out a substitution $\varphi[\!\!\equiv\ \vec{s}\ \equiv\!\!]$ will lead to an expression which carries a topical L+H* pitch accent. Note that this assignment of L+H* pitch accent indeed proceeds in such a way that it is always aligned with the prosodically most prominent subexpression of a given structure inside its domain, which is demarcated by the unary brackets that come with the operator $\Diamond$, since just as the assignment of H* pitch accents, the assignment of L+H* pitch accent consistently follows its path down via prosodic heads.

We will now provide analyses of the examples (1.4), **Jim** knows Pam, and (1.5), The **boss** wants Eve, in which we will assume that the topichood of the subjects is taken care of by an 'abstract' defocusing operator, the lexical sign $\epsilon \triangleleft ((\Diamond n \overset{*}{\backslash} s) /_{*} n) /_{*} ((n \overset{*}{\backslash} s) /_{*} n) \triangleright \lambda R \lambda y \lambda x.[\textsc{topic}(x) \wedge R(y)(x)]$, where $\epsilon$ denotes the empty string. This operator is a higher-order functor that combines with the transitive verb and affects the intonational and informational interpretation of the sentence in which it occurs in the required way (cf. Hendriks 1999).

(1.56) $\quad$ **Jim** knows PAM $\triangleleft\, s \,\triangleright [\textsc{topic}(j) \wedge \textsc{know}(p)(j)]$

The sign (1.56) belongs to the language of the lexicon $L = \{Jim \triangleleft n \triangleright j, \epsilon \triangleleft ((\Diamond n \overset{*}{\backslash} s)\underset{*}{/} n)\underset{*}{/}((n\overset{*}{\backslash}s)\underset{*}{/}n) \triangleright \lambda R\lambda y\lambda x.[\textsc{topic}(x) \wedge R(y)(x)], knows \triangleleft (n\overset{*}{\backslash}s)\underset{*}{/}n \triangleright$ $\textsc{know}, Pam \triangleleft n \triangleright p\}$, since $[[f \triangleleft n \triangleright x]\text{‘}[[g \triangleleft ((\Diamond n\overset{*}{\backslash}s)\underset{*}{/}n)\underset{*}{/}((n\overset{*}{\backslash}s)\underset{*}{/}n) \triangleright y \text{‘}\, h \triangleleft (n\overset{*}{\backslash}s)\underset{*}{/}n \triangleright z]\text{‘}\, k \triangleleft n \triangleright w]] \Rightarrow \langle\langle f\rangle \text{‘} \langle\langle g \text{‘} h\rangle \text{‘} k\rangle\rangle \triangleleft s \triangleright y(z)(w)(x)$ is a derivable sequent: the type-logical part of its derivation is given in (1.57); the prosodic and semantic interpretation of (1.57) are specified in (1.58) and (1.59), respectively; and the results of performing the relevant prosodic and semantic substitutions can be found in (1.60) and (1.61).

(1.57)
$$\dfrac{(n\overset{*}{\backslash}s)\underset{*}{/}n \Rightarrow (n\overset{*}{\backslash}s)\underset{*}{/}n \qquad \dfrac{n \Rightarrow n \qquad \dfrac{\dfrac{n \Rightarrow n}{[n] \Rightarrow \Diamond n}[\Diamond R] \qquad s \Rightarrow s}{[[n]\text{‘}\Diamond n\overset{*}{\backslash}s] \Rightarrow s}[\overset{*}{\backslash}L]}{[[n]\text{‘}[(\Diamond n\overset{*}{\backslash}s)\underset{*}{/}n \text{‘} n]] \Rightarrow s}[\underset{*}{/}L]}{[[n]\text{‘}[[((\Diamond n\overset{*}{\backslash}s)\underset{*}{/}n)\underset{*}{/}((n\overset{*}{\backslash}s)\underset{*}{/}n)\text{‘}(n\overset{*}{\backslash}s)\underset{*}{/}n]\text{‘}n]] \Rightarrow s}[\underset{*}{/}L]$$

(1.58)
$$\dfrac{h \Rightarrow h \qquad \dfrac{k \Rightarrow k \qquad \dfrac{\dfrac{f \Rightarrow f}{[f] \Rightarrow \langle f\rangle} \qquad g''' \Rightarrow g'''}{[[f]\text{‘}g''] \Rightarrow \langle\langle f\rangle\text{‘}g''\rangle}}{[[f]\text{‘}[g'\text{‘}k]] \Rightarrow \langle\langle f\rangle\text{‘}\langle g'\text{‘}k\rangle\rangle}}{[[f]\text{‘}[[g\text{‘}h]\text{‘}k]] \Rightarrow \langle\langle f\rangle\text{‘}\langle\langle g\text{‘}h\rangle\text{‘}k\rangle\rangle}$$

(1.59)
$$\dfrac{z \Rightarrow z \qquad \dfrac{w \Rightarrow w \qquad \dfrac{\dfrac{x \Rightarrow x}{[x] \Rightarrow x} \qquad y''' \Rightarrow y'''}{[[x]\text{‘}y''] \Rightarrow y''(x)}}{[[x]\text{‘}[y'\text{‘}w]] \Rightarrow y'(w)(x)}}{[[x]\text{‘}[[y\text{‘}z]\text{‘}w]] \Rightarrow y(z)(w)(x)}$$

(1.60) $\quad \langle\langle f\rangle\text{‘}\langle\langle g\text{‘}h\rangle\text{‘}k\rangle\rangle\{\!\!\{ f \to Jim, g \to \epsilon, h \to knows, k \to Pam \}\!\!\} =$
**Jim** knows PAM

(1.61) $\quad y(z)(w)(x)[x \to j, y \to \lambda R\lambda y\lambda x.[\textsc{topic}(x) \wedge R(y)(x)],$
$z \to \textsc{know}, w \to p] = [\textsc{topic}(j) \wedge \textsc{know}(p)(j)]$

Example (1.5) is analyzed as follows:

(1.62) $\quad$ The **boss** wants EVE $\triangleleft\, s \,\triangleright [\textsc{topic}(\textsc{the}(\textsc{boss})) \wedge$
$\textsc{want}(e)(\textsc{the}(\textsc{boss}))]$

The sign (1.62) is in the language of $L = \{the \triangleleft n\underset{*}{/}c \triangleright \textsc{the}, boss \triangleleft c \triangleright$ $\textsc{boss}, \epsilon \triangleleft ((\Diamond n\overset{*}{\backslash}s)\underset{*}{/}n)\underset{*}{/}((n\overset{*}{\backslash}s)\underset{*}{/}n) \triangleright \lambda R\lambda y\lambda x.[\textsc{topic}(x) \wedge R(y)(x)], wants \triangleleft$ $(n\overset{*}{\backslash}s)\underset{*}{/}n \triangleright \textsc{want}, Eve \triangleleft n \triangleright e\}$, on account of the fact that $[[[f \triangleleft n\underset{*}{/}c \triangleright$

$x \mathbin{\text{‘}} g \triangleleft c \triangleright y]] \mathbin{\text{‘}} [[h \triangleleft ((\Diamond n \backslash^{*} s) /_{*} n) /_{*} ((n \backslash^{*} s) /_{*} n) \triangleright z \mathbin{\text{‘}} k \triangleleft (n \backslash^{*} s) /_{*} n \triangleright v] \mathbin{\text{‘}} l \triangleleft n \triangleright w]] \Rightarrow$ $\langle\langle\langle f \mathbin{\text{‘}} g\rangle\rangle \mathbin{\text{‘}} \langle\langle g \mathbin{\text{‘}} h\rangle \mathbin{\text{‘}} k\rangle\rangle \triangleleft s \triangleright y(z)(w)(x)$ is a derivable sequent, as shown by derivation (1.63) and its respective prosodic and semantic interpretations in (1.64) and (1.65). The results of performing the relevant prosodic and semantic substitutions are listed in (1.66) and (1.67), respectively:

(1.63)
$$\dfrac{(n \backslash^{*} s) /_{*} n \Rightarrow (n \backslash^{*} s) /_{*} n \qquad \dfrac{n \Rightarrow n \qquad \dfrac{\dfrac{\dfrac{c \Rightarrow c \quad n \Rightarrow n}{[n /_{*} c \mathbin{\text{‘}} c] \Rightarrow n}\,[/_{*}L]}{[[n /_{*} c \mathbin{\text{‘}} c]] \Rightarrow \Diamond n}\,[\Diamond R] \qquad s \Rightarrow s}{[[[n /_{*} c \mathbin{\text{‘}} c]] \mathbin{\text{‘}} \Diamond n \backslash^{*} s] \Rightarrow s}\,[\backslash^{*} L]}{[[[n /_{*} c \mathbin{\text{‘}} c]] \mathbin{\text{‘}} [(\Diamond n \backslash^{*} s) /_{*} n \mathbin{\text{‘}} n]] \Rightarrow s}\,[/_{*}L]}{[[[n /_{*} c \mathbin{\text{‘}} c]] \mathbin{\text{‘}} [[((\Diamond n \backslash^{*} s) /_{*} n) /_{*} ((n \backslash^{*} s) /_{*} n) \mathbin{\text{‘}} (n \backslash^{*} s) /_{*} n] \mathbin{\text{‘}} n]] \Rightarrow s}\,[/_{*}L]$$

(1.64)
$$\dfrac{k \Rightarrow k \qquad \dfrac{l \Rightarrow l \qquad \dfrac{\dfrac{\dfrac{g \Rightarrow g \quad f' \Rightarrow f'}{[f \mathbin{\text{‘}} g] \Rightarrow \langle f \mathbin{\text{‘}} g\rangle}}{[[f \mathbin{\text{‘}} g]] \Rightarrow \langle\langle f \mathbin{\text{‘}} g\rangle\rangle} \qquad h''' \Rightarrow h'''}{[[[f \mathbin{\text{‘}} g]] \mathbin{\text{‘}} h''] \Rightarrow \langle\langle\langle f \mathbin{\text{‘}} g\rangle\rangle \mathbin{\text{‘}} h''\rangle}}{[[[f \mathbin{\text{‘}} g]] \mathbin{\text{‘}} [h' \mathbin{\text{‘}} l]] \Rightarrow \langle\langle\langle f \mathbin{\text{‘}} g\rangle\rangle \mathbin{\text{‘}} \langle h' \mathbin{\text{‘}} l\rangle\rangle}}{[[[f \mathbin{\text{‘}} g]] \mathbin{\text{‘}} [[h \mathbin{\text{‘}} k] \mathbin{\text{‘}} l]] \Rightarrow \langle\langle\langle f \mathbin{\text{‘}} g\rangle\rangle \mathbin{\text{‘}} \langle\langle h \mathbin{\text{‘}} k\rangle \mathbin{\text{‘}} l\rangle\rangle}$$

(1.65)
$$\dfrac{v \Rightarrow v \qquad \dfrac{w \Rightarrow w \qquad \dfrac{\dfrac{\dfrac{y \Rightarrow y \quad x' \Rightarrow x'}{[x \mathbin{\text{‘}} y] \Rightarrow x(y)}}{[[x \mathbin{\text{‘}} y]] \Rightarrow x(y)} \qquad z''' \Rightarrow z'''}{[[[x \mathbin{\text{‘}} y]] \mathbin{\text{‘}} z''] \Rightarrow z''(x(y))}}{[[[x \mathbin{\text{‘}} y]] \mathbin{\text{‘}} [z' \mathbin{\text{‘}} w]] \Rightarrow z'(w)(x(y))}}{[[[x \mathbin{\text{‘}} y]] \mathbin{\text{‘}} [[z \mathbin{\text{‘}} v] \mathbin{\text{‘}} w]] \Rightarrow z(v)(w)(x(y))}$$

(1.66)
$$\begin{gathered}\langle\langle\langle f \mathbin{\text{‘}} g\rangle\rangle \mathbin{\text{‘}} \langle\langle h \mathbin{\text{‘}} k\rangle \mathbin{\text{‘}} l\rangle\rangle \{ f \rightarrow \mathit{the}, g \rightarrow \mathit{boss}, \\ h \rightarrow \epsilon, k \rightarrow \mathit{wants}, l \rightarrow \mathit{Eve} \} = \\ \text{The } \textbf{boss} \text{ wants } \textsc{Eve}\end{gathered}$$

(1.67)
$$\begin{gathered}z(v)(w)(x(y))[x \rightarrow \textsc{the}, y \rightarrow \mathit{boss}, \\ z \rightarrow \lambda R \lambda y \lambda x.[\textsc{topic}(x) \wedge R(y)(x)], v \rightarrow \textsc{want}, w \rightarrow e] = \\ [\textsc{topic}(\textsc{the}(\textsc{boss})) \wedge \textsc{want}(e)(\textsc{the}(\textsc{boss}))]\end{gathered}$$

## 1.4

In order to account for the sublexical cases of pitch accent assignment, we will continue to assume that the lexicon is a collection of lexical signs $\varphi \triangleleft C \triangleright \gamma$, where $\varphi$ is a prosodic term, $C$ is syntactic category, and $\gamma$ is a semantic term of type $\textsc{type}(C)$. However, the lexical assignment of prosodic terms $\varphi$ will involve more than mere constants, since also complex prosodic terms may be asssigned.

In addition to this, we will now say that given a lexicon $L$, a (possibly compound) sign $\varphi' \triangleleft C \triangleright \gamma'$ is in the language of $L$ if and only if for some derivable sequent $\Gamma \Rightarrow \varphi \triangleleft C \triangleright \gamma$ such that $s(\Gamma) = f_1 \triangleleft C_1 \triangleright v_1, \ldots, f_n \triangleleft C_n \triangleright v_n$, there are lexical signs $\varphi_1 \triangleleft C_1 \triangleright \gamma_1 \in L, \ldots, \varphi_n \triangleleft C_n \triangleright \gamma_n \in L$ such that $\{\!|\, \varphi[f_1 \to \varphi_1, \ldots, f_n \to \varphi_n] \,|\!\} = \varphi'$ and $\gamma\,[\,v_1 \to \gamma_1, \ldots, v_n \to \gamma_n\,] = \gamma'$.

The sequence $s(\Gamma)$ of signs of a structured term $\Gamma$ is a notion that was defined in (1.19) above. Note that the phrase '$\{\!|\, \varphi[f_1 \to \varphi_1, \ldots, f_n \to \varphi_n] \,|\!\}$' has come to replace the phrase '$\varphi\{\!|\, f_1 \to \varphi_1, \ldots, f_n \to \varphi_n \,|\!\}$' that figured in the corresponding definition in the previous section. The subexpression $\varphi[f_1 \to \varphi_1, \ldots, f_n \to \varphi_n]$ of this phrase standardly denotes the result of simultaneously and respectively substituting $f_1, \ldots, f_n$ by $\varphi_1, \ldots, \varphi_n$ in $\varphi$, just as the expression $\gamma\,[\,v_1 \to \gamma_1, \ldots, v_n \to \gamma_n\,]$ denotes the result of simultaneously and respectively substituting $v_1, \ldots, v_n$ by $\gamma_1, \ldots, \gamma_n$ in $\gamma$. But, importantly, instead of having the prosodic substitution that was defined in (1.36) and extended in (1.55), we will now assume that $\{\!|\, \varphi \,|\!\}$ is defined by the structurally fully parallel rewrite relation given in (1.68) below:

(1.68)

$$
\begin{array}{rcl}
\{\!|\, \langle \varphi , \psi \rangle \,|\!\} & = & \{\!|\, \varphi \,|\!\}\; \{\!\|\, \psi \,\|\!\} \\
\{\!|\, \langle \varphi \,`\, \psi \rangle \,|\!\} & = & \{\!\|\, \varphi \,\|\!\}\; \{\!|\, \psi \,|\!\} \\
\{\!|\, \langle \varphi \rangle \,|\!\} & = & \{\!\|\!|\, \varphi \,|\!\|\!\} \\
\{\!|\, \mathit{constant} \,|\!\} & = & \textsc{constant} \\
\{\!\|\, \langle \varphi , \psi \rangle \,\|\!\} & = & \{\!\|\, \varphi \,\|\!\}\; \{\!\|\, \psi \,\|\!\} \\
\{\!\|\, \langle \varphi \,`\, \psi \rangle \,\|\!\} & = & \{\!\|\, \varphi \,\|\!\}\; \{\!\|\, \psi \,\|\!\} \\
\{\!\|\, \langle \varphi \rangle \,\|\!\} & = & \{\!\|\!|\, \varphi \,|\!\|\!\} \\
\{\!\|\, \mathit{constant} \,\|\!\} & = & \text{constant} \\
\{\!\|\!|\, \langle \varphi , \psi \rangle \,|\!\|\!\} & = & \{\!\|\!|\, \varphi \,|\!\|\!\}\; \{\!\|\, \psi \,\|\!\} \\
\{\!\|\!|\, \langle \varphi \,`\, \psi \rangle \,|\!\|\!\} & = & \{\!\|\, \varphi \,\|\!\}\; \{\!\|\!|\, \psi \,|\!\|\!\} \\
\{\!\|\!|\, \langle \varphi \rangle \,|\!\|\!\} & = & \{\!\|\!|\, \varphi \,|\!\|\!\} \\
\{\!\|\!|\, \mathit{constant} \,|\!\|\!\} & = & \textbf{constant}
\end{array}
$$

Since $\{\!|\, \varphi[f_1 \to \varphi_1, \ldots, f_n \to \varphi_n] \,|\!\} = \varphi'$ according to definition (1.68) whenever $\varphi' = \varphi\{\!|\, f_1 \to \varphi_1, \ldots, f_n \to \varphi_n \,|\!\}$ on account of definition (1.55), the prosodic results of the previous sections are all preserved. Besides, we are now in a position to provide the analyses of the examples (1.3), Pam loves BROCcoli, and (1.6), **Broc**coli haunts KIM.

(1.69) Pam loves BROCcoli $\triangleleft\, s \,\triangleright$ LOVE$(b)(p)$

First, it can be observed that the sign (1.69) belongs to the language of the lexicon $L = \{\mathit{Pam} \triangleleft n \triangleright p, \mathit{loves} \triangleleft (n \overset{*}{\backslash} s) \underset{*}{/} n \triangleright \textsc{love}, \langle\langle \mathit{broc} , \mathit{co} \rangle , \mathit{li} \rangle \triangleleft n \triangleright b\}$, because the sequent $[f \triangleleft n \triangleright x \text{‘} [g \triangleleft (n \overset{*}{\backslash} s) /_{*} n \triangleright y \text{‘} h \triangleleft n \triangleright z]] \Rightarrow \langle f \text{‘} \langle g \text{‘} h \rangle\rangle \triangleleft s \triangleright y(z)(x)$ is derivable: its derivation is identical to that of the sign (1.37), of which the type-logical part was given in (1.38), while the prosodic and semantic interpretation of (1.38) were specified in (1.39) and (1.40), respectively. The results of performing the relevant prosodic and semantic substitutions are listed in (1.70) and (1.71), respectively:

(1.70) $$\langle f \text{‘} \langle g \text{‘} h \rangle\rangle [f \to Pam, g \to loves, h \to \langle\langle broc \, , co \rangle \, , li \rangle] = \langle Pam \text{‘} \langle loves \text{‘} \langle\langle broc \, , co \rangle \, , li \rangle\rangle\rangle$$

(1.71) $$y(z)(x)[x \to p, y \to \textsc{love}, z \to b] = \textsc{love}(b)(p)$$

Rewriting the prosodic term in (1.70) results in (1.72):

(1.72) $\dashv \langle Pam \text{‘} \langle loves \text{‘} \langle\langle broc \, , co \rangle \, , li \rangle\rangle\rangle \vdash \; = \;$ Pam loves BROCcoli

Finally, we present the analysis of example (1.6):

(1.73) **Broc**coli haunts KIM $\triangleleft s \triangleright [\textsc{topic}(b) \wedge \textsc{haunt}(k)(b)]$

Note that the sign (1.73) belongs to the language of $L = \{\langle\langle broc \, , co \rangle \, , li \rangle \triangleleft n \triangleright b, \epsilon \triangleleft ((\Diamond n \overset{*}{\backslash} s) /_{*} n) /_{*} ((n \overset{*}{\backslash} s) /_{*} n) \triangleright \lambda R \lambda y \lambda x . [\textsc{topic}(x) \wedge R(y)(x)], haunts \triangleleft (n \overset{*}{\backslash} s) /_{*} n \triangleright \textsc{haunt}, Kim \triangleleft n \triangleright k\}$, as $[[f \triangleleft n \triangleright x] \text{‘} [[g \triangleleft ((\Diamond n \overset{*}{\backslash} s) /_{*} n) /_{*} ((n \overset{*}{\backslash} s) /_{*} n) \triangleright y \text{‘} h \triangleleft (n \overset{*}{\backslash} s) /_{*} n \triangleright z] \text{‘} k \triangleleft n \triangleright w]] \Rightarrow \langle\langle f \rangle \text{‘} \langle\langle g \text{‘} h \rangle \text{‘} k \rangle\rangle \triangleleft s \triangleright y(z)(w)(x)$ is a derivable sequent: the derivation of this sign is identical to that of (1.56), of which the type-logical part was presented in (1.57), while the prosodic and semantic interpretation of (1.57) were given in (1.58) and (1.59), respectively. The results of performing the relevant prosodic and semantic substitutions are listed in (1.74) and (1.75), respectively:

(1.74) $$\langle\langle f \rangle \text{‘} \langle\langle g \text{‘} h \rangle \text{‘} k \rangle\rangle [f \to \langle\langle broc \, , co \rangle \, , li \rangle, g \to \epsilon, h \to haunts, k \to Kim] = \langle\langle\langle\langle broc \, , co \rangle \, , li \rangle\rangle \text{‘} \langle\langle \epsilon \text{‘} haunts \rangle \text{‘} Kim \rangle\rangle$$

(1.75) $$y(z)(w)(x)[x \to b, y \to \lambda R \lambda y \lambda x . [\textsc{topic}(x) \wedge R(y)(x)], z \to \textsc{haunt}, w \to k] = [\textsc{topic}(b) \wedge \textsc{haunt}(k)(b)]$$

And rewriting the prosodic term in (1.74) results in (1.76):

(1.76) $\dashv \langle\langle\langle\langle broc \, , co \rangle \, , li \rangle\rangle \text{‘} \langle\langle \epsilon \text{‘} haunts \rangle \text{‘} Kim \rangle\rangle \vdash \; =$
**Broc**coli haunts KIM

## 1.5

By way of conclusion, then, we observe that the completely uniform analysis of lexical and phrasal prosodic headedness provided by the present proof-theoretic sign-based categorial approach is the key to an account of the observed indifference of English pitch accent assignment to phonological levels, since it is this fully general and abstract notion of prosodic head that is exploited by the various pitch accents, quite independent of the particular type of pitch accent involved, in the sense that all pitch accents are invariably aligned with the prosodically strongest syllable of their domain.

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