PARTS OF WORDS: COMPOSITIONAL

SEMANTICS FOR PROSODIC CONSTITUENTS

by

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A dissertation submitted to the

Graduate School—New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Linguistics

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New Brunswick, New Jersey

October, 2002

Abstract

Focus below the word level (e.g. *Jill only brought home a stalag*MITE *from the cave*) and coordination of parts of words (*ortho and periodontists*) show that the compositional processes of focus and coordination apply to units that lack an independent meaning. Such constructions are interpreted through *phonological decomposition*, which assigns denotations to otherwise meaningless phonological units. The denotation of a focused or coordinate part is a string of sound (so the word part *mite* denotes its own sound), and the rest of the word denotes a function from sounds to word meanings: *stalag* denotes a function that for each sound α yields the meaning of the word *stalag*α, and *dontist* maps a sound α to the meaning of the word α*dontist*.

The grammar of focus and coordination works the same way above and below the word level. Given phonological decomposition, the alternative set (Rooth 1985, 1992b) for *stalag*MITE includes the meanings of the words *stalagmite* and *stalactite*— meanings formed by applying the denotation of *stalag* to a string of sound; this alternative set is used in computing the restriction on *only*. The sentence *Bill and Martha are ortho and periodontists* is true in case Bill is an orthodontist and Martha is a periodontist by virtue of a cumulative inference (Scha 1981), since Bill stands in the *dontist* relation to the string *ortho*, and Martha to the string *perio*. Cumulative conjunction is motivated independently, accounting for multiple plurality readings of coordinate plural adjectives (Italian *quadrati e rotondi* 'square-pl and round-pl' applies to a minimum of four objects).

Only prosodic units the size of a foot or larger can be focused or coordinated: *a morphological or* PHONO*logical solution* and *morpho and phonological* are fine, but **morphology or* PHONO*logy* and **morpho and phonology* are ungrammatical because the morphemes *phono*, *morpho* are not prosodic constituents in *phonology*, *morphology*.

Echo questions are interpreted via focus semantics, which licenses them on word parts (*Mononga-*WHAT*?*), and exempts them from locality restrictions in general. Echo questions are only "metalinguistic" when they occur on word parts; this is because below the word level, compositional semantics is sensitive to the form of linguistic expressions.

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Acknowledgments

Thanks to all the people that helped me make it through my years in graduate school. Roger Schwarzschild has been my mentor probably since we first met in Tel Aviv before I ever came to Rutgers (though I wasn't aware of it till quite a while later). My committee members Veneeta Dayal, Alan Prince and Hubert Truckenbrodt were instrumental in setting me in a direction that led to this dissertation. Ede Zimmermann's influence was evident long before he joined the committee officially as the external member; the treatment of phonological decomposition as breaking up a word meaning into a function-argument structure, which is the basis for this dissertation, can be traced directly to a conversation I had with him at Au Bon Pain in Spring 2000.

I learned a lot from members of my first qualifying paper committee Jane Grimshaw, Maria Bittner and Ken Safir, and from the other faculty members at Rutgers, all of whom helped shape the linguist that I am now. I benefited a great deal from ties with the Rutgers Center for Cognitive Science, in particular Ernie Lepore, Zenon Pylyshyn, Suzanne Stevenson, Matthew Stone and Karin Stromswold. Special thanks to Joanna Stoehr for keeping everything running smoothly.

Special thanks to my professors at Tel Aviv University who introduced me to Linguistics and supported me in coming to Rutgers, and to the many members of the Israeli linguistic community for keeping in touch while I was away. Thanks to all the linguists who took interest in my work and helped me advance it—the list is so long I don't even know where to start.

Fellow students have shared everything with me, from exchanging linguistic data and theories to organizing meetings and conferences to potlucks, parties and other fun stuff. Graduate school wouldn't have been the same without Michal Barak, Ahmadu Kawu, Tom Werner, Luba Butska, Yoko Futagi, Daphna Heller, Markus Hiller, Madeline Holler, Graham Horwood, Zsuzsa Nagy, Nicole Nelson, Susanne Preuss, Heather Robinson, Alex Zepter and all the rest.

Thanks to my family and friends back home who have been supportive from far away. Uri Horesh has been a friend long before we became colleagues. And Nancy Hall is greatly responsible for keeping me sane in the past three years.

Contents

Chapter 1

Introduction

1.1 The problem

The dissertation investigates a range of constructions where compositional semantic processes apply to linguistic units that appear to lack an independent meaning. The two prime cases are focus below the word level (1) and coordination of parts of words (2).

(1) Jill only brought home a stalagMITE from the cave.

(2) Bill and Martha are ortho and periodontists.

Sentence (1) exhibits association with focus—prominence on the syllable *mite* reflects a restriction on the interpretation of *only*: the sentence can be true if Jill returned from the cave with a stalagmite and a host of other objects, as long as she didn't bring home a stalactite. Association with focus is considered to be a compositional semantic process because focus constrains the meaning of *only* in a predictable way. For instance, the sentence *Lee only kissed* CHRIS *in the garden* entails that Lee did not kiss anyone else, while the sentence *Lee only* KISSED *Chris in the garden* entails that Lee didn't go beyond kissing. We see that *only* serves to exclude certain propositions, and which propositions these are is determined by the meanings of the focused and unfocused parts of the complement of *only*.

Coordination is likewise compositional: the meaning of an expression *A and B* depends on the meaning of the expression *A* and the meaning of the expression *B*. The meaning of *and* in sentence (2) is the familiar meaning found elsewhere in the language; we have no problem judging the truth conditions of the sentence—it is true as long as one person at least is an orthodontist and the other is a periodontist.

The problem posed by (1) and (2) for conventional semantic theories is that it is not clear what focus and coordination operate on. What are the meanings of the focused constituent *mite*, or the coordinate constituent *ortho*? While these constituents may have meanings in a lexical-semantic or etymological sense, these are not the kinds of meanings that feed processes like focus and coordination. We thus have a problem if we want to sustain the idea that focus and coordination in these structures are the same as found at other places.

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Indeed, previous treatments have dismissed structures like (1) and (2) from semantic analysis altogether. Focus below the word level has been characterized as "metalinguistic"—a statement about the linguistic expression itself, rather than its meaning (Selkirk 1984; Rochemont 1986). This fails to capture the real truth-conditional effect of focus in (1) on the domain of *only*. Coordination of parts of words was claimed to be a surface reflex of coordination of whole words, derived through a a special rule of phonological deletion (Höhle 1982; Booij 1985). This suffers from an empirical inadequacy, as it predicts that (2) should be synonymous with *Bill and Martha are orthodontists and periodontists*, while in fact they differ in meaning: the former is true if Bill is an orthodontist and Martha is a periodontist, while the latter is false.

The above proposals sacrifice the intuition that focus and coordination in (1) and (2) have their familiar meanings, in order to maintain the idea that arbitrary word parts do not have the kinds of meanings that participate in compositional semantics. I believe no such sacrifice is necessary. In the dissertation I show that natural language has a process of *phonological decomposition*, which assigns denotations to grammatical units that do not have an independent meaning. The assigned denotations are model-theoretic objects that participate fully in compositional semantics. The dissertation develops the semantics of phonological decomposition, and explores phonological constraints on its application.

1.2   Semantics

The view of semantics taken in this dissertation is model-theoretic: linguistic expressions denote objects (entities, functions) in a model, and the rules of semantic composition determine the meanings of complex expressions from the meanings of the constituents that make them up. It is in this sense that word parts like *ortho*, *perio* and *dontist* lack an independent meaning. The morphemes that make up *orthodontist* and *periodontist* do have etymologies: *ortho*, *peri* and *odous* are Greek words meaning 'straight' or 'correct', 'around', and 'tooth'; *ist* is a morpheme meaning something like 'specialist'. But the semantic process that combines these meanings to arrive at the meanings *orthodontist* 'a specialist in correcting irregularities in teeth' and *periodontist* 'a specialist in treating tissues and structures surrounding the teeth' is not the same as model-theoretic semantic composition—it is not even clear if the morphemes are associated with objects in the model, and if so then what objects they would denote. However, the meaning of focus and the meaning of *and* are model-theoretic objects that combine through semantic composition, and it is for this reason that model-theoretic denotations need to be found for word parts.

An explanation of the term 'word' is also in order: when talking about the semantics, I use this term to refer to those morphosyntactic units whose denotation is specified directly, not through the process of semantic composition. These are the terminal nodes of the structure that is interpreted by the semantics, and they do not as a rule coincide with morphological or syntactic words; the grammatical structure that is being interpreted can extend below syntax to include, for example, morphological structure, if meanings are assigned to morphemes that are interpreted compositionally (cf. Di Sciullo and Williams 1987, who argue for separation of the syntactic and mor-

phological components based on their formal properties alone, given the observation that compositional interpretation exists in both syntax and morphology).

As an illustration we can look at the distinction between the expressions *blackboard* and *floorboard* (these will play a role in the discussion of coordination of parts of words, chapter 4, section 4.2.5). Both of these expressions are morphological words, as shown by their characteristic stress pattern. The expression *blackboard* is a semantic primitive: while its meaning is related to the meanings of *black* and *board*, it is not predictable from them. In contrast, the meaning of *floorboard* is composed from the meanings of *floor* and *board* (any board that constitutes a floor is a floorboard). So while their morphosyntactic status may be the same, *blackboard* is a 'word' in our sense—its model-theoretic meaning is assigned directly—while *floorboard* is a complex expression. Basic expressions in the semantics are still phonologically complex, and phonological decomposition assigns model-theoretic denotations to phonological parts of basic expressions.

There is an obvious difference between the familiar compositional semantics and the semantics necessary for interpreting structures like (1) and (2). Semantic composition is generally insensitive to the phonological form of a linguistic expression: nothing about the semantics of English would change if the English word for 'dog' were pronounced *kelev*, as in Hebrew; the word would still be used in the same contexts it is used now, and with the same contribution to meaning. This is not the case for constructions like (1) and (2). The implication in (1) that Jill did not bring home a stalactite but may have brought other things from the cave is directly related to the fact that the words *stalagmite* and *stalactite* share all but the last syllable. It would not be possible to construct a sentence like (2), with coordination of parts of words, if the meaning 'orthodontist' were not lexicalized as a word ending in the string *dontist*. This gives us an important constraint on a process like phonological decomposition: the denotations it creates must make reference to the form of the words they are derived from.

My proposal is that phonological decomposition works as follows: the denotation of a focused or coordinate part is the sound of that part itself, so the word parts *mite* in (1) and *ortho* and *perio* in (2) denote their own sounds. Sounds are objects in the model (entities of type *e*). The rest of the word—the unfocused part, or the part outside the coordinate structure—denotes a function from sounds to word meanings, which retrieves the original meaning of the word. Thus, *stalag* denotes a function that for each sound α yields the meaning of the word *stalagα*, if such a word exists; similarly, *dontist* maps a sound β to the meaning of the word β*dontist*. The meanings of two parts of a single word combine through the composition rule of function application to yield the meaning of the word they form; focus and coordination have access to the individual word parts, and they manipulate them to arrive at the meanings of focus constituents and coordinate structures.

Building the form of the word into the meaning gives phonological decomposition somewhat of a metalinguistic flavor: the meaning encodes something about the expression itself. Unlike previous treatments, which saw reference to form as a reason to exclude these constructions from the realm of semantics, the current proposal is that reference to form fits in with ordinary semantic interpretation. Reference to form takes place when the semantics needs access to a linguistic expression that lacks an independent meaning. "Metalinguistic" interpretations are thus not exceptions to the

semantics, but rather a part of it.

One final terminological note: I chose the term *phonological decomposition* in order to emphasize that this is a process by which meanings are assigned to word parts that are phonologically realized, and to distinguish this process from the unrelated notion of lexical decomposition. The idea behind lexical decomposition is that lexicalized meanings are often semantically complex, and this complexity is reflected in their behavior; meaningful insights can thus be gained by looking at the semantic primitives that make up these complex meanings. Phonological decomposition looks at linguistic units that are semantically primitive but phonologically complex, and assigns denotations to the phonological parts that do not have an independent meaning, allowing the application of semantic processes to such parts.

1.3   Phonology

The semantics of phonological decomposition assigns denotations to arbitrary word parts. One might expect that any word part can receive such a denotation; however, we only find focus below the word level and coordination of parts of words when the focused and coordinate parts satisfy certain phonological requirements.

Phonological decomposition is only possible with word parts that form prosodic constituents. This accounts for the contrast between the grammatical focus and coordinate structures in (3) and the ungrammatical ones in (4) (cf. Booij 1985; Okada 1999).

(3)   a. a morphological or PHONOlogical solution

b. phono and morphological

(ˌphono)(ˈlogi)cal, (ˌmorpho)(ˈlogi)cal

(4)   a.*morphology or PHONOlogy

b.*phono and morphology

pho(ˈnolo)gy, (ˌmor)(ˈpholo)gy,

The morphemes *phono* and *morpho* are identifiable in both (3) and (4); however, they only form prosodic constituents in the words *phonological* and *morphological*, not in *phonology* and *morphology*. Our observation is that phonological decomposition can only simulate denotations for word parts that are prosodic constituents.

The phonological requirements on coordination of parts of words do not make a two-way distinction between structures that are acceptable and ones that are not. There is a well-defined class of expressions like ?*cran and strawberries* and ?*peri and telescopes* that while being unacceptable to most English speakers are much better than unintelligible structures like (4b). These are structures where the coordinate parts are metrical feet, but stress falls on the initial (coordinate) foot. The same three-way distinction is displayed by another phonological process in English—expletive infixation (McCarthy 1982): ?*cranbloodyberry* and ?*telebloodyscope* are definitely better than infixation into a foot as in *psychobloodylogy*, but still markedly worse than infixation before a foot with primary stress as in *psychobloodylogical*.

The prosodic constraints on the application of phonological decomposition raise the possibility that semantic interpretation in general is sensitive to prosodic structure: the availability of decompositional denotations only for prosodic units of a certain minimal size may be indicative that denotations as a rule are only assigned to prosodic units (cf. Steedman 2000a,b).

1.4 Overview of the dissertation

Chapter 2 is a treatment of focus below the word level. The theory of phonological decomposition is developed in conjunction with alternative semantics for focus (Rooth 1985, 1992b). The denotation of a focused word part is its own sound, and that of the unfocused part is a function from sounds to word meanings; from this it follows that the alternative set for a word with a focused part is the set of meanings of words that share the unfocused part. The alternative set of a word like *stalag*MITE, with focus on the final syllable, comes out to be the set of meanings "stalagmite" and "stalactite", as desired. The chapter also looks at the phonological constraints on the application of phonological decomposition, and concludes that what determines if a word part can be focused is its prosodic status rather than semantic factors.

Chapter 3 develops a theory of plurality and coordination; this will later be used in the treatment of coordination of parts of words, but the motivation for this theory is independent. The theory is based on the observation that coordinate plural adjectives are "multiply plural": while English *square and round cookies* can apply to two cookies, one of each shape, Italian *biscotti quadrati e rotondi* 'cookies square-pl and round-pl' can only apply to a group of four or more cookies, two of which are square and two round. This leads to the conclusion that plural expressions only include pluralities in their denotation (cf. Chierchia 1998), and that cumulative ("non-Boolean") conjunction is available not only for nominals but for adjectives as well (cf. Scha 1981; Krifka 1990). The availability of multiple plurality readings for adjectives is subject to conjunction weakening (Winter 1996, 2001), which only allows these readings when the predicates are contradictory.

Chapter 4 is a theory of coordination of parts of words. Phonological decomposition is used to interpret NPs like *ortho and periodontists* at surface level, so the meaning of plural *dontists* can apply to the meaning of the coordinate structure *ortho and perio*. Plural *dontists* allows a cumulative inference from *Bill is an orthodontist* and *Martha is a periodontist* to *Bill and Martha are ortho and periodontists*, just like a transitive verb allows the inference from *Bill kissed Sally* and *Martha kissed Don* to *Bill and Martha kissed Sally and Don* (Scha 1981). Phonological constraints allow coordination of parts of words only when the coordinate parts are prosodic constituents, thus ruling out structures like **morpho and phonology*.

Chapter 5 is an exploration of echo questions. Following an observation by Hockey (1994) I argue that the pitch accent on an echo *wh*-phrase is a reflex of focus; denotations of echo questions are derived through focus semantics, which explains why echo questions are not subject to locality restrictions. Focus below the word level immediately explains echo questions on parts of words (*the Mononga*-WHAT *River?* Janda 1985); focus also correctly yields sets of question denotations as the meaning of

second-order questions (echo responses to questions, e.g. *who did* WHO *invite?*).

Chapter 6 concludes the dissertation by taking a brief look at some additional issues: a general discussion of compositionality and why we want a compositional analysis for the problems raised in the dissertation; expectations regarding syntactic idioms; and a parallel with lexical access, which associates meanings with parts of words based on phonological similarities much like the process of phonological decomposition.

Chapters 2, 3 and 4 were written originally as independent papers; in adapting them for inclusion in the dissertation I kept the changes minimal, so each of them can be read independently of the rest of the dissertation. Chapter 5 presupposes the analysis of focus below the word level in chapter 2, though the main theoretical points do not in particular involve the semantics of parts of words, so for the most part the chapter can be read independently too.

Chapter 2

Focus below the word level

2.1 Introduction

This chapter deals with cases where intonational focus is realized on a different syllable in a word than the one stress normally falls on. The effect is very similar to the familiar effect of focus on higher constituents. The following example illustrates this point: Bolinger (1961, p. 93) describes a cartoon from the *New Yorker* (April 14, 1956, p. 36) where a man stands upside down, with his feet on the ceiling, in a psychiatrist's office; the psychiatrist says the following sentence to the man's wife (throughout this chapter I use SMALL CAPS to show prominence characteristically associated with focus).

(1) ... our first concern is to persuade the patient that he is a stalagMITE. [last syllable underlined in the original]

This sentence implies that the patient thinks he is a stalactite. The mechanism at work appears quite simple: prominence on the syllable *-mite* presupposes a context where both stalagmites and stalactites are salient (a more detailed account will be given in section 2.3.2). The link between the two concepts must follow not only from their semantic relatedness, but also from the fact that the words denoting these concepts are similar in form, otherwise we have no explanation why the contrasting syllable is prominent.

My claim is that this is an instance of focus, and should be analyzed through a theory of focus. Prominence on word parts can display additional characteristics of focus, for instance association with a focus-sensitive adverb like *only* (Jackendoff 1972; Rooth 1985, 1992b; von Stechow 1989; Krifka 1991, 1992).

(2) John only brought home a stalagMITE from the cave.

Here prominence on the syllable *-mite* serves to indicate the restriction on the domain of *only*, in a manner similar to focus on words and higher constituents. The location of prominence thus has an effect on the sentence's truth conditions: the sentence implies that John did not bring home a stalactite, but does not say anything about what else he might have brought; the sentence is thus true in case John returns from the cave with a stalagmite and a rock.

Focus below the word level appears in other languages as well, as in the following example from Hebrew, a language where intonational focus behaves in a similar (though not identical) way to English.

(3) astronawtim higiu   la-yareax,   aval KOZMOnawtim hayu rišonim ba-xalal.
     astronauts   arrived to.the-moon but cosmonauts   were first   in.the-space
     'Astronauts reached the moon, but cosmonauts were first in space.'

Prominence in KOZMO*nawtim* 'cosmonauts' is due to focus—the unmarked stress pattern is *kozmo'nawtim*. Here too we see that the placement of focus has to do with the phonological similarity between the words.

Since intonational focus has a similar function above and below the word level, we want to give it a uniform treatment. The problem we face is that focus relates phonological prominence to compositional meanings, which certain parts of words do not have; in the standard view of semantics, such parts of words are simply inaccessible to compositional processes. The word parts *stalag-* and *-mite*, for instance, appear to lack any compositional meaning at all, and are in this respect similar to semantically empty prefix-stem constructions such as *suf-fer* (Aronoff 1976). In order to allow the theory of focus to take care of all the examples above we need to extend the semantics so that it can deal with units that do not have an independent meaning.

Previous treatments of focus have shied away from providing such an extension. When focus below the word level is encountered, for example in Selkirk (1984, p. 271) and Rochemont (1986, p. 6), it is labeled as "metalinguistic" or "paralinguistic" and not discussed further. This sort of labeling places focus below the word level outside the general theory of focus, and does little to explain how it works. I argue that with a proper theory of meanings for opaque word parts we can show that focus operates the same way above and below the word level.

I propose that semantics has a process of *phonological decomposition*, which assigns meanings to units that lack an independent meaning. Parts of words in focus constructions receive meanings in the following manner: the focused part denotes a string of sound, and the rest of the word is a function from sounds to word meanings. The relation between the meanings of the parts and the meaning of the whole word is thus fully compositional, in the sense that the semantic rules yield the correct meaning of the word when the meanings of the parts are given. A theory of focus can therefore apply to parts of words without any modification, and indeed the analysis is compatible with more than one theory of focus. Additionally, since the meanings of parts of words are actual sounds, phonological decomposition captures the intuition that compositional semantics below the word level is sensitive to the phonological shape of its constituents.

For the underlying semantic theory of focus I choose the alternative semantics of Rooth (1985, 1992b) and subsequent work. Nothing in my theory hinges on this particular framework, and I believe it can be equally well developed with structured meanings (von Stechow 1989; Krifka 1991, 1992). Arguments in favor of one framework over another are based on differences in expressive power: for example, Rooth (1996a) objects to the structured meaning approach because it is too expressive—it would allow, for instance, the characterization of a verb *tolfed* where *tolfed* ϕ meant "told the focus of ϕ that ϕ". The debate between the focus theories is orthogonal to the question of

focus below the word level, and any theory of focus would require meanings for the focused word parts in order to incorporate them into the semantics. I develop my semantics using a basic version of alternative semantics because a simple theory of focus serves to highlight the contribution of phonological decomposition. The underlying theory of alternative semantics for focus is outlined in the next section (section 2.2), and my proposal for the semantics of word parts is developed in the following one (section 2.3), where it is used in conjunction with alternative semantics to account for focus below the word level. The rest of the chapter explores the nature of alternative sets (section 2.4), prosodic constraints on the distribution of focus (section 2.5), and consequences of the theory on the syntactic representation of focus (section 2.6).

2.2   Alternative semantics

According to alternative semantics (Rooth 1985, 1992b), intonational focus signifies alternatives to the meanings of syntactic constituents. Every constituent is thus associated with two semantic values: the ordinary semantic value $[\![\cdot]\!]^o$ is the familiar denotation, and the focus semantic value $[\![\cdot]\!]^f$ is a set of alternative denotations. Focus semantic values are computed compositionally, along with the ordinary semantic values.

Intonational focus is made accessible to semantic interpretation through syntactic marking on constituents, which will be noted here with a subscript $[]_F$. I choose to interpret natural language directly rather than through the use of a translation language, for reasons that will become apparent in section 2.3.1. English expressions will be assigned typed denotations. Following von Stechow (1989) I will assume that type t is the type of propositions, that is sets of possible worlds, as in Cresswell (1973); type e is the type of individuals, and types of the form ab are functions from denotations of type a to denotations of type b. For conciseness and clarity I will often use variables, functional notation and set notation in my exposition; these are to be understood as part of the metalanguage, and do not constitute a formal translation language. I also simplify matters by assuming that the denotation assignment $[\![\cdot]\!]$ is a function, without specifying a mechanism for the resolution of ambiguous English expressions.

All focus does is induce alternatives, so it should not affect ordinary semantic values; focus marking is thus ignored when these are computed. The focus semantic value of an expression is a set of alternatives to its ordinary semantic value. If a syntactic constituent is marked with focus, then any substitution for its meaning can constitute an alternative (provided that it is of the same semantic type). The focus semantic value is thus the entire set of denotations that match the ordinary semantic value in type.

(4) $[\![A_F]\!]^f = D_\tau$, when A is an expression of English and $[\![A_F]\!]^o \in D_\tau$.

As for expressions that are not focus marked, we must distinguish between those expressions that are terminal nodes in the grammatical tree and thus receive an interpretation directly (basic expressions), and higher constituents which receive their interpretation through the compositional process. For the former there are no alternative meanings other than the meaning of the expression itself, so the set of alternatives is a singleton set that includes the ordinary semantic value as a sole member.

(5) $\llbracket A \rrbracket^f = \{\llbracket A \rrbracket^o\}$, when A is a basic expression that is not focus marked.

Unfocused expressions whose ordinary semantic value is determined compositionally will receive their focus semantic value in an analogous way.

(6) Let A be a constituent whose meaning is derived from the meanings of its sub-constituents $B_1, \ldots, B_n$ through a semantic rule $\mathcal{R}$:

$$\llbracket A \rrbracket^o = \mathcal{R}(\llbracket B_1 \rrbracket^o, \ldots, \llbracket B_n \rrbracket^o)$$

then: $\qquad \llbracket A \rrbracket^f = \{\mathcal{R}(\beta_1, \ldots, \beta_n) | \beta_1 \in \llbracket B_1 \rrbracket^f \wedge \cdots \wedge \beta_n \in \llbracket B_n \rrbracket^f\}$

For example, if the constituent $[_A BC]$ receives its meaning through the semantic rule of function application so that

$$\llbracket A \rrbracket^o = \llbracket B \rrbracket^o(\llbracket C \rrbracket^o)$$

then the focus semantic value of A is defined as

$$\llbracket A \rrbracket^f = \{\beta(\gamma) | \beta \in \llbracket B \rrbracket^f \wedge \gamma \in \llbracket C \rrbracket^f\}$$

that is, the set of all the results of applying a member of $\llbracket B \rrbracket^f$ to a member of $\llbracket C \rrbracket^f$.

The computation of focus semantic values follows the strategy of Rooth (1985), von Stechow (1989) and most subsequent work in distinguishing between rules for basic expressions (5) and non-basic expressions (6). This distinction deserves further comment. This paper is concerned with focus on units that are smaller than the basic units that are assigned meaning, so we should ask ourselves if the distinction between basic and non-basic expressions is clearly defined. We see the problem, for instance, in sentences (1) and (2): the word *stalagmite* is a basic expression of English, but with a focused part (*stalag*MITE) it becomes a complex expression, since focus is interpreted on only part of the word. I will assume that the grammatical structure interpreted by the semantics is unambiguous as to whether or not a constituent is a terminal node: if focus is marked on part of a word then this word is a complex expression, even if the same word unfocused would be a basic expression. Consequently, there is no ambiguity as to which rule should apply in determining the focus semantic value of a constituent. (Note that this issue is not related to my choice of direct interpretation for natural language expressions: if I used a translation language, the problem would be located in the translation process rather than the interpretation process. The question arises because the semantics has to interpret units that are smaller than what normally receives basic denotations.)

We could avoid the whole question of basic and non-basic expressions by revising the definitions in (5) and (6) so that the former would be used for all expressions—basic and complex—that do not dominate any focus marks, and the latter would be reserved for expressions that are not focus marked themselves but dominate a focused constituent (such expressions are necessarily complex). We can verify that the two strategies are equivalent, since they only differ in the rule they use for determining the focus semantic value of a complex expression that does not dominate any focus marks, and in this case the rules (5) and (6) yield the same results.

(7) Suppose an expression A contains no focus marks.

By rule (5) we get $[\![A]\!]^f = \{[\![A]\!]^o\}$.

But A's constituents $B_1, \ldots, B_n$ do not contain focus marks either.

Therefore $[\![B_1]\!]^f, \ldots, [\![B_n]\!]^f$ are the singleton sets $\{[\![B_1]\!]^o\}, \ldots, \{[\![B_n]\!]^o\}$.

And by rule (6) we get $[\![A]\!]^f = \{\mathcal{R}([\![B_1]\!]^o, \ldots, [\![B_n]\!]^o)\} = \{[\![A]\!]^o\}$.

So we could get rid of the reference to the notions of basic and non-basic expressions; however, I see no reason to do this. The standard treatment has the advantage that the relation between focus marking and the rule that determines the focus semantic value is local and direct: one needs only to check whether or not the constituent being evaluated has a focus mark. The alternative strategy requires either looking at focus marking on all the daughter constituents, or checking the focus semantic values of the immediate daughters in order to determine if the constituent in question dominates any focus marks. Since I assume there will be no ambiguity as to whether a constituent is basic or complex, I will continue with the standard rules. (One could imagine a grammar set up differently, where such an ambiguity could arise; in this case the alternative strategy for determining focus semantic values may be preferred.)

The contribution of focus to the semantics is limited to creating the alternative denotations; what is done with these is a matter for other semantic operations. The aim of this chapter is to provide a semantics for parts of words that explains their use in focus constructions. In order to do so we have to first look at how the alternative sets are used; this will enable us to determine what values the alternative sets should be for expressions that contain focus below the word level, and from these we will be able to figure out what meanings for parts of words can create these alternative sets. We therefore turn to cases where focus has a truth conditional effect, as it does on focus-sensitive operators like *only*.

2.2.1 Association with focus

When focus affects the interpretation of an operator like *only* we say that the operator *associates* with the focus. I will use a theory of association based on Rooth (1992b), in which association relations are mediated by context: *only* is interpreted relative to some context, which is also reflected by focus. In a sentence like (8) below, *only* serves to tell us that there are certain things that Mary did not do; these are determined through the context of the utterance, and reflected in the focus: sentence (8) is appropriate when Mary did not introduce to Sue anybody other than Bill, though she may have introduced Bill to someone else.

(8) Mary only introduced BILL to Sue.

Association relations will be represented in the syntax. When *only* associates with focus, then the information in the context that serves to restrict the interpretation of *only* is represented at the level of logical form (LF) as a variable that is coindexed with *only* and adjoined to a focus operator. A sentence such as (8) can therefore have the LF in (9), where *only* is coindexed with the context variable C_4, which is adjoined to the focus interpretation operator $\sim$ and to the VP that is the scope of *only*.

(9) Mary only$_4$ [$_{VP}$ [$_{VP}$ introduced BILL$_F$ to Sue] $\sim C_4$].

The meaning of *only* is interpreted relative to the meaning of the context variable, whose meaning is in turn constrained by the focus interpretation operator.

This syntactic characterization of association with focus is somewhat problematic: Schwarzschild (1997b) points out that it would be an odd thing if focus were to serve two disparate functions—a "pragmatic" role as a discourse regulator and a "semantic" role as a restrictor of operators like *only*. Schwarzschild proposes that focus always reflects discourse appropriateness, and as such it affects the possibilities of domain selection for *only*, accounting for association with focus (see also Kadmon 2001, pp. 330–339). Martí (2001) also notes an empirical problem with this "direct" relation between focus and quantifier domains, as it predicts that certain restrictions on quantifiers should be systematically unavailable, where in fact they do exist. The problem of how to exactly characterize association relations is however orthogonal to the question of the meanings of parts of words, so I will continue with the simpler formalism which stipulates association relations in the syntax.

We should note that our association mechanism does not predict when an operator like *only* associates with focus—it only says how focus affects operators when it does associate with them (Schwarzschild 1997b does make predictions in this regard). The failure of an operator to associate with an intonationally marked focus is seen in the following example (Rooth 1992b, p. 109).

(10) People who GROW rice generally only EAT rice.

In the most natural reading of this sentence, *only* is interpreted relative to a context that includes properties like "eat corn", "eat potatoes" and the like; these properties are not in the alternative set $[\![EAT_F \text{ rice}]\!]^f$, which includes properties like "drink rice", "smell rice" and so on. The proposal in Rooth (1992b) says that the failure of *only* to associate with focus in (10) is the result of an LF where *only* is not coindexed with the focus interpretation operator (a reading where *only* does associate with the focus is also available, though it is much less salient, presumably because it doesn't make much sense). Likewise, I will not be concerned with the question of when and why association with focus obtains, and I will simply assume it is given (Rooth 1996b suggests that in sentence (10) there may actually be prominence on *rice* which is not easily perceptible, and consequently *only* may associate even in this example; I discuss this possibility in section 2.5.1).

Starting with the meaning of *only*, the intuition is that sentence (8) is true in those worlds where the only property of Mary, from among the contextually relevant properties, is the property of introducing Bill to Sue. Let's assume that (the ordinary semantic value of) the variable C_4 is a set containing the contextually relevant properties; then (9) is true in those worlds where the only property of Mary that is both true and in $[\![C_4]\!]^o$ is the property of introducing Bill to Sue. The top VP in (9) is thus a function that maps individuals into sets of worlds as described above.

(11) $x \mapsto \{w | \forall P[w \in P(x) \wedge P \in [\![C_4]\!]^o \rightarrow P = [\![\text{introduced BILL}_F \text{ to Sue}]\!]^o]\}$

In words: the meaning of the top VP in (9) is the function that maps every individual to the set of worlds where the only property that applies to this individual, from among the properties in $[\![C_4]\!]^o$, is the property of introducing Bill to Sue.

The connection between focus and the context that is represented by C_4 comes from the focus interpretation operator $\sim$. The focus interpretation operator does not uniquely determine the value of $[\![C_4]\!]^o$, but rather serves to constrain it (the set case of Rooth 1992b, p. 93): $[\![C_4]\!]^o$ is a subset of the focus semantic value of the VP to which it is adjoined, and it contains both the ordinary semantic value of the VP plus at least one additional distinct member.

(12)   a. $[\![C_4]\!]^o \subseteq [\![\text{introduced BILL}_\text{F} \text{ to Sue}]\!]^f$

      b. $[\![C_4]\!]^o \supsetneq \{[\![\text{introduced BILL}_\text{F} \text{ to Sue}]\!]^o\}$

Now the ordinary semantic value $[\![\text{introduced BILL}_\text{F} \text{ to Sue}]\!]^o$ is the property of introducing Bill to Sue. The focus semantic value $[\![\text{introduced BILL}_\text{F} \text{ to Sue}]\!]^f$ is determined by the alternative semantics from the previous section; this turns out to be the set of properties of the form "introduced y to Sue" where y stands for some individual.

$$(13)\ [\![\text{introduced BILL}_\text{F} \text{ to Sue}]\!]^f = \left\{ \begin{array}{l} \text{``introduced Bill to Sue''} \\ \text{``introduced Mary to Sue''} \\ \text{``introduced John to Sue''} \\ \ldots \end{array} \right\}$$

So in the end, we get the following paraphrase for the meaning of sentence (8): of a certain salient set of properties of the form "introduced y to Sue", which includes the property "introduced Bill to Sue" and at least one additional distinct property, the only one which applies to Mary is the property "introduced Bill to Sue".

This is our account of association with focus. What we want to do is to apply it to focus on parts of words. Sentence (2), repeated below, can have the logical form in (14), with *only* coindexed with the context variable C_2—a structure similar to (9) above.

(2) John only brought home a stalagMITE from the cave.

(14) John only$_2$ [$_\text{VP}$ [$_\text{VP}$ brought home a stalag[MITE]$_\text{F}$ from the cave] $\sim C_2$].

The interpretation of *only* works the same way as before: it says that from a context of salient properties, the only one that applies to John is that of bringing home a stalagmite from the cave. We also know what this context of salient properties should include: it should include the property of bringing a stalagmite from the cave, and the property of bringing a stalactite from the cave. We therefore know, at the very least, that these two properties should be included in the focus semantic value of the lower VP in (14). I further claim that these should be the only properties in this focus semantic value. This is based on the intuition that sentence (2) is true if John returns from the cave with a stalagmite and some other stuff, say a rock, as long as he doesn't bring home a stalactite.

One could argue, of course, that the focus semantic value of the lower VP in (14) does include additional properties, but these somehow do not make it into the meaning of the context variable C_2. This is allowed, since the meaning of the variable is not identified with the focus semantic value of the adjoined VP but only constrained by it. But such a claim misses the point twice: first of all, it fails to explain why the

final syllable of *stalagmite* is prominent. And second, it is exactly this prominence that confines the context to stalagmites and stalactites alone. If stress on *stalagmite* is in its normal position, as in (15), then the relevant context for the interpretation of *only* can be wider.

(15) John only brought home a staLAGmite from the cave.

This sentence can be considered false in case John returns from the cave with a stalagmite and a rock; I find it much harder to judge (2) to be false in this scenario. So the positioning of prominence on the final syllable of *stalagmite* in effect excludes any properties other than the two mentioned above from the relevant context for the interpretation of *only*; it is only natural to assume that this is done through the focus semantic value.

I therefore maintain that focus in (2) should be marked on the stressed syllable, and that focus semantic values are determined by this marking. Working down from the focus semantic value of the lower VP in (14), we find that the focus semantic value $[\![\text{stalag[mite]}_{\text{F}}]\!]^f$ should be the set consisting of the denotations of the words *stalagmite* and *stalactite*. My claim is that this is due to the phonological similarity between the words, not to their semantic relatedness. The next step then is to develop a semantics for parts of words based on their phonological composition; this semantics will give us the desired focus semantic values for words that have focus marking on their parts.

2.3   The semantics of word parts

We have come to the conclusion that the focus semantic value of the word *stalag*MITE$_{\text{F}}$, with focus on the last syllable, should be the set consisting of the denotations of the words *stalagmite* and *stalactite*. Here I develop a semantics for parts of words that will yield exactly this result. Phonological decomposition will give to parts of words meanings that combine to give the ordinary meanings of the original words, and also yield correct alternative semantic values based on the focus marking of the word parts. We need to specify the meanings of the constituent parts so that the compositional semantic rules will result in the correct ordinary semantic values and focus semantic values.

2.3.1   Phonological decomposition

Let's start with the assumption that the ordinary semantic values of word parts form a function-argument structure, so that when one part applies to the other, the meaning of the original word is retrieved. As for focus semantic values, we observe that the focus semantic value of a complex expression can be thought of informally as a lambda abstract over the ordinary semantic value of that expression, with the focused part replaced by a variable (cf. Jackendoff 1972). Abstraction is straightforward if the focused part is the argument and the rest of the word is a function. In a word like *stalag*MITE$_{\text{F}}$, then, the meaning of *stalag* will be a function from meanings of focused parts to word meanings, that when supplied with the meaning of MITE$_{\text{F}}$ results in the denotation of *stalagmite*, that is its ordinary semantic value. Notice how focus plays a

role in determining the ordinary semantic values of the word parts: it is focus marking that decides which word part is the function, and which is the argument.

We need to determine the full specification of the function denoted by *stalag*. We go back to the rules that determine alternative values (section 2.2). Since *stalag* is not focused, we know from the rule in (5) that its focus semantic value is the unit set containing its ordinary semantic value. The rule in (4) tells us that the focus semantic value of MITE_F is the set of all denotations matching in type (we still don't know what it is). The focus semantic value of the whole word *stalag*MITE_F is, by the rule in (6), the set of all the results of applying $[\![\text{stalag}]\!]^o$ to the denotations in $[\![\text{MITE}_F]\!]^f$. But we also know that the focus semantic value of the whole word should be the set containing the denotations of *stalagmite* and *stalactite*. So here is a proposal that will yield the desired results.

(16) $[\![\text{stalag}]\!]^o$ is the function f such that:

$$f([\![\text{MITE}_F]\!]^o) = [\![\text{stalagmite}]\!]^o,$$
$$f([\![\text{TITE}_F]\!]^o) = [\![\text{stalactite}]\!]^o,$$
$$\text{and } f(\alpha) \text{ is undefined for all other } \alpha.$$

Notice how it doesn't matter what the meanings of the word parts MITE_F and TITE_F are, or even what type they are, as long as the meaning of *stalag* operates on these meanings in the way specified above. But we want to derive the meanings of parts of words in a principled way, that will predict that alternatives to words with focused parts have to be similar in form.

I make the following concrete proposal: the focused part of a word will denote its own sound, which is an object of type e. Thus, in a sentence like (1) or (2), the focused syllable *mite* simply denotes the sound [ma^{j}t].

(17) $[\![\text{MITE}_F]\!]^o \in D_e$: the string [ma^{j}t].

Incidental evidence that the meaning of the focused word part is indeed an object of type e is that word parts in echo questions are replaced by *what* rather than *which* (echo questions are discussed in chapter 5).

(18)   a. This is a stalag-what?

b.*This is a stalag-which?

Referring to strings of sound by their own mention is not surprising: there even exist predicates that apply exclusively to such meanings, as in the sentence *mite begins with a sonorant and tite begins with an obstruent*. I claim that it is exactly this denotation that we see in focused parts of words; this provides the desired connection between the form of a word part and its meaning.

To get the meaning of the unfocused part we employ the standard procedure for using a lambda calculus: we know the meaning of the whole and one of its constituents, so we define the meaning of the other constituent as a function that takes us from the first constituent to the whole. The unfocused part will be a function that takes a sound and returns the original meaning of the word.

(19) Let A be the unfocused part of a word, and let τ be the type of the whole word. Then $\llbracket A \rrbracket^o \in D_{e\tau}$ is the function $h : D_e \to D_\tau$ such that for all $\beta \in D_e$, $h(\beta) = \llbracket A\beta \rrbracket^o$ if $A\beta$ is a word and $\llbracket A\beta \rrbracket^o \in D_\tau$, undefined otherwise.

A few notes are in order regarding the formulas above. The symbol A stands for an expression of English, and the symbol β stands for a denotation, that is an object in the model. The symbol β plays an additional role, however: since the meaning of the focused part of a word is identified with its phonological form, then in all the cases of interest β is also an expression of English. Thus, the sequence $A\beta$ stands for the concatenation of the phonological characterization of an expression A with an alternative meaning β, which is itself the phonological characterization of a linguistic expression. This is all that matters for the semantics; anticipating the discussion of the phonology in section 2.5.1, I will add that the concatenation operation does not refer to linear strings of segments, but is rather an operation on phonological structures, i.e. prosodic constituents (see in particular the discussion on page 28).

It is now clear why I have chosen to interpret natural language directly, rather than through the use of a translation language: since we are dealing with denotations that are also linguistic expressions, adding a layer of a translation language would just make the definitions more cumbersome. It turns out that the function h in (19) is undefined not only for many sounds that it could take as an argument, but also for all other objects of type e that do not denote sounds. This is not surprising, as many denotations of a functional type are only partial functions (for example, feeding the transitive verb *eat* with the direct object *thoughtfulness* results in nonsense).

We now apply the mechanism for generating alternatives to the meanings of parts of words. The definition of the functions in (19) guarantees that the ordinary semantic value of a decomposed word is the same as that of the word when it is left intact as a terminal node on the tree. The focus semantic values for words which have focused parts come out as follows.

(20) Let AB_F be a word with a focused part B_F; let τ be the type of AB ($\llbracket AB \rrbracket^o \in D_\tau$). Then:

$\llbracket B_F \rrbracket^f = D_e$ (4)

$\llbracket A \rrbracket^o$ is the function $h : D_e \to D_\tau$ such that for all $\beta \in D_e$, $h(\beta) = \llbracket A\beta \rrbracket^o$ if $A\beta$ is a word and $\llbracket A\beta \rrbracket^o \in D_\tau$, undefined otherwise.   (19)

$\llbracket A \rrbracket^f = \{ \llbracket A \rrbracket^o \}$ (5)

$\llbracket AB_F \rrbracket^f = \{ \llbracket A \rrbracket^o(\beta) | \beta \in D_e \}$ (6)
$\qquad = \{ \llbracket A\beta \rrbracket^o | A\beta$ is a word and $\llbracket A\beta \rrbracket^o \in D_\tau \}$

So the focus semantic value of the focused syllable is the entire domain of individuals D_e, and the focus semantic value of a word with a focused part comes out to be the set of denotations (matching in type) of words that share the unfocused phonological material. For example, the alternative set for *stalag*MITE$_F$ comes out to be a set with two members, the meanings "stalagmite" and "stalactite".

The nature of the phonological representation that constitutes the meaning of word parts deserves further comment. We need a measure of flexibility when we apply the

definition in (19) to the word part *stalag* in order to get it to work. The reason is that application of the meaning of *stalag* to the alternative string *tite* yields the meaning of the word *stala[g]tite*, with a voiced [g]. While this is the pronunciation used by many speakers of American English, others use it in free variation with *stala[k]tite* (voiceless [k]), and yet others use *stala[k]tite* exclusively. The semantics of (19) predicts that for the latter group of speakers, the meaning "stalactite" should not be an alternative to *stalag*MITE$_F$, but this is not the case. A similar problem with phonetic detail appears in the following sentence, from a news broadcast on September 18, 2001 (thanks to Nancy Hall for bringing this example to my attention).

(21) I'd like to see the market show stability rather than VOLAtility.

As I will argue in section 2.5.1, focus has to be marked on metrical feet, so in the above example it has to be marked on the word part *vola*; this leaves *-tility* as the unfocused part, and it has to apply to the alternative *sta* to yield the meaning of *stability*, not *statility. I thus conclude that the meanings formed by phonological decomposition through the rule in (19) can overlook minor segmental differences, particularly at the edges of a constituent; an exact characterization of the differences that can be thus ignored awaits further study.

2.3.2 Givenness and deaccenting

The above discussion keeps the semantics of focus without change: the difference between focus above and below the word level, namely the sensitivity of focus below the word level to the form of linguistic expressions, stems from differences in the meanings of words and word parts, not from the theory of focus. There are two advantages to keeping the theories separate. For one, parts of words need their own meanings outside of focus constructions, as in coordinate structures (see chapter 4). Second, an independent semantics for parts of words means that we are not restricted to a particular way of doing focus semantics. The theory as it now stands is as good as the underlying theory of focus—it inherits its merits as well as its weak points. At the moment we do not have an account for the accent pattern in Bolinger's example (1), repeated below.

(1) ...our first concern is to persuade the patient that he is a stalagMITE.

This sort of deaccenting which is dependent on previous discourse (or even the non-linguistic environment) does not fall under the theory of focus presented in section 2.2.1. A treatment of this phenomenon within the alternative semantics framework is provided by Schwarzschild (1999); the meanings for parts of words developed above extend that account to deal with examples like (1).

Schwarzschild proposes that the distribution of focus is governed by a notion of givenness: every constituent must be entailed by prior discourse, modulo focus marking. In essence, givenness requires that for each constituent there should be an antecedent, such that in every possible world that the antecedent is true in, some alternative of the constituent is true (which alternative is true may vary with worlds). Schwarzschild defines a notion of general entailment that holds between constituents of different semantic types, making givenness a constraint on various kinds of constituents, but the details are not important for our purpose.

We can use Schwarzschild's givenness account to explain the accent pattern in Bolinger's example (1). The sentence contains a number of pitch accents, but we can safely assume that in the subordinate clause *he is a stalagmite*, the only pitch accent is on the syllable *mite*. The focus semantic value of the clause $[\![\text{he is a stalag}\text{MITE}_\text{F}]\!]^f$ is therefore the set of propositions {"he is a stalactite","he is a stalagmite"}. The context must supply an antecedent which entails that at least one member of the pair is true; some natural candidates are the propositions "he is a stalactite", "he is a stalagmite", "he is a cave formation deposited by dripping water". The sentence has no such antecedent, so one has to be accommodated. I do not have a detailed theory of how such an accommodation process works, but somehow the position of the patient hanging from the ceiling together with the presence of a psychiatrist allow us to accommodate the proposition that the patient thinks he's a stalactite; this includes the constituent "he is a stalactite", which serves as the required antecedent.

Focus on the syllable *mite* in the above example is crucial for the correct interpretation: if the whole word *stalagmite* were focused, then the set of alternatives to the clause *he is a stalagmite* would be much wider; consequently, the clause would also be licensed by accommodating the proposition that the patient thinks he's an icicle, as suggested by Bolinger. The implication that the patient thinks he is a stalactite would be lost.

We should take a closer look at the role of the meanings for parts of words in the above account of deaccenting in (1). In order to predict which kind of proposition should be accommodated, the analysis requires the correct focus semantic value for the clause *he is a stalag*MITE$_\text{F}$. The accommodation process itself makes no particular use of meanings for parts of words—all it needs is the focus semantic value of the clause, which gives the necessary licensing conditions and hence the correct implication through accommodation.

But meanings for parts of words play a crucial role when we take the contextual information as given, and try to predict the accent patterns, for instance predicting that accent must fall on the syllable *mite* if stalactites are already salient in the discourse. The givenness requirement does not penalize gratuitous focus marking; at the extreme, givenness predicts that an utterance where every constituent is marked by focus is licensed by any discourse. But natural language does not allow this: focus marking is normally kept to a minimum. Schwarzschild incorporates this into his theory as an independent principle (p. 156). Now this principle also holds for parts of words: in the situation depicted in the *New Yorker* cartoon (1), the psychiatrist must use focus on the syllable *-mite*. Phonological decomposition gives this a straightforward interpretation: since the word parts participate in the semantics as independent elements, focus marking on part of a word is preferred over focus on the whole word, when both options are licensed by givenness. The observation that word parts count for determining the minimal amount of material to be focused is an additional argument for treating parts of words as independently functioning constituents.

With phonological decomposition, parts of words actually have their own meanings. Therefore, parts of words can also be considered "given", in the technical sense of Schwarzschild (1999): a constituent is given if discourse entails the proposition formed through existential closure of all of its arguments. In a discourse where stalactites are salient, the word *stalagmite* will not be given, because the existence of a stalactite does

not entail the existence of a stalagmite. But the word part *stalag* is given, because the existence of a stalactite entails the proposition $\exists\alpha\exists\beta[[\![\text{stalag}]\!](\beta)(\alpha)]$. Since the word part *stalag* is given, focus must fall on the word part *-mite*.

2.3.3 The "Tanglewood" examples

The last two sections succeeded in explaining our initial data of focus below the word level by using the semantics for parts of words with two "flavors" of alternative semantics theory—the basic theory of association via syntactic representation, and the theory of deaccenting given material. There are other focus constructions below the word level that cannot be treated by the theory developed so far. For example, the "Tanglewood" sentences of Kratzer (1991) have counterparts below the word level. Here I show that generalizing our theory to account for these data only requires a revision of the underlying theory of focus, and does not mandate a change in the semantics of word parts.

Kratzer (1991) proposes a modification to the procedure that computes focus semantic values in Rooth (1985) in order to account for examples like the following.

(22) I only [$_{\text{VP}}$ went to TANGLEWOOD$_{\text{F}}$ because you did].

I can use this sentence to defend myself against the accusation of being a copycat—the sentence can imply, for instance, that I didn't go to Block Island because you did, or that I didn't go to Elk Lodge because you did. But the intuition is that this sentence does not exclude propositions like "I went to Block Island because you went to Elk Lodge". Therefore, the focus semantic value of the marked VP in (22) should include the set of properties in (23).

(23)
$$\left\{ \begin{array}{l} \text{"went to Block Island because you went to Block Island"} \\ \text{"went to Elk Lodge because you went to Elk Lodge"} \\ \text{"went to Tanglewood because you went to Tanglewood"} \\ \dots \end{array} \right\}$$

Kratzer notices that the standard method of computing alternatives has no way to ensure that in each alternative to the VP, the object of *to* in the matrix clause will be the same as the object of *to* in the subordinate clause. Let's assume that ellipsis is interpreted through syntactic reconstruction, where focus marks are copied along with other syntactic material.

(24) I only [went to TANGLEWOOD$_{\text{F}}$ because you did [go to TANGLEWOOD$_{\text{F}}$]]

Every alternative to the VP will now have to pick one element from the alternative set of the focused word TANGLEWOOD, and one element from the alternative set of its copy; but there's no guarantee that these will be the same.

The "Tanglewood" examples can be replicated below the word level: I can use sentence (25) to defend myself against a copycat accusation.

(25) I only [$_{\text{VP}}$ moved to MiddleBURY$_{\text{F}}$ because you did].

Here too we get the intuition that the sentence does not exclude me moving to Middlesex because you moved to Middlebush. So the focus semantic value of the marked VP in (25) should include the set of properties in (26).

(26)
$$\left\{ \begin{array}{l} \text{``moved to Middlebush because you moved to Middlebush''} \\ \text{``moved to Middlesex because you moved to Middlesex''} \\ \text{``moved to Middlebury because you moved to Middlebury''} \\ \dots \end{array} \right\}$$

The intuitions above and below the word level are the same, and we expect phonological decomposition to supply meanings that will fit into whatever solution we give to the problem above the word level. There is an interesting difference, because in the alternative set (26) each copy has to be identical in form to its antecedent, and this is not generally a constraint on ellipsis constructions (cf. the sentence *John kissed his mother because Mary did*, which can be interpreted "because Mary kissed *her* mother"). However, phonological decomposition correctly predicts that identity in form is necessary in (26), because meaning is form for focused parts of words, so identity in meaning entails identity in form.

   Kratzer proposes to force the covariation of alternatives to focused constituents and their copies by identifying each focus mark with an index, which is copied in syntactic reconstruction; a designated assignment function is added to the algorithm for the computation of alternatives to guarantee that in each alternative to a constituent, all focused elements with the same index will receive the same alternative value. Formulating this proposal in our framework of direct interpretation, we define the class H of assignment functions as all the functions h from indices and types to denotations, such that for every index n and type τ, $h(n,\tau) \in D_\tau$. Individual alternatives are computed with respect to particular assignments h; these are defined in a way that mirrors our previous definition of focus semantic values (I use the notation $[\![\cdot]\!]_h$ with a subscript in order to emphasize that the symbol h stands for a particular function, in contrast to the notation for ordinary and focus semantic values).

(27) $[\![A_{Fn}]\!]_h = h(n,\tau)$, when A is an expression of English and $[\![A_{Fn}]\!]^o \in D_\tau$.

(28) $[\![A]\!]_h = [\![A]\!]^o$, when A is a basic expression that is not focus marked.

(29) Let A be a constituent whose meaning is derived from the meanings of its subconstituents $B_1, \dots, B_n$ through a semantic rule $\mathcal{R}$:

$$[\![A]\!]^o = \mathcal{R}([\![B_1]\!]^o, \dots, [\![B_n]\!]^o)$$

then:
$$[\![A]\!]_h = \mathcal{R}([\![B_1]\!]_h, \dots, [\![B_n]\!]_h)$$

The focus semantic value of an expression is the set of denotations with respect to all possible assignments h.

(30) $[\![A]\!]^f = \{[\![A]\!]_h | h \in H\}$

With the revised focus semantics, phonological decomposition predicts the correct alternative set (26) for sentence (25). Let's say that the focus mark on BURY$_F$ in (25) has

the index 3. Then the first alternative in (26) obtains when the assignment is chosen such that $h(3, e)$ is the string *bush* (recall that strings of sound are objects of type *e* that can serve as arguments for functions denoted by parts of words); the second alternative obtains when $h(3, e) = sex$, and so on.

We have now seen how the semantics of parts of words can work with three variants of alternative semantics. Meanings for parts of words are also compatible other versions, as well as with theories of focus outside the alternative semantics framework, for instance structured meaning theories (e.g. von Stechow 1989; Krifka 1991, 1992) and theories of focus movement (e.g. Chomsky 1976; Rooth 1996a). The semantic mechanism in these two types of theories is the same: the meaning of a constituent with a focused part is represented by performing a lambda abstraction over the focused part. The denotation of a focused word part is the argument of a function, so abstraction is straightforward, and results in the desired meanings. The semantics of phonological decomposition is thus compatible with all the theories of focus that I am aware of. Focus marking on parts of words does raise syntactic problems, in particular for theories of focus movement; these will be discussed in section 2.6.2.

2.4 The computation of alternatives

Phonological decomposition is a way of modeling the observed fact, that alternatives to words that have a focused part have to be similar in form: the meanings of the word parts reflect the form of the word, and therefore the alternatives can be computed in terms of meaning alone. This is the standard approach of alternative semantics. However, there exist proposals that suggest that the set of alternatives that is used, for example, in restricting the meaning of *only*, should be a set of alternative forms, and that the computation of alternatives is an operation on linguistic expressions rather than meanings. Could focus below the word level be an argument in favor of computing the alternatives this way? Below I review several proposals for treating alternatives as sets of expressions, and conclude that the evidence points in favor of viewing alternatives as meanings.

Blok and Eberle (1999) claim that alternatives should be determined by substituting words. They propose that the set of alternatives is restricted by semantic relations between words, which they represent in a hierarchical structure. For example, the alternatives for a word like *lager* will only be words denoting kinds of beer such as *ale* and *stout*. Furthermore, Blok and Eberle claim that the alternatives are language-specific: since German and English divide the space of beers differently, the following sentences have different alternative sets, even though they have an identical meaning (German *Pils* is considered synonymous with English *lager*).

(31) John trinkt nur PILS.
     John drinks only Pils

(32) John only drinks LAGER.

This approach is criticized by Cohen (1999), who suggests that while the alternatives that are lexicalized in a language may be the first ones that come to mind, they do not

necessarily have a truth conditional effect. Cohen considers the situation where John only drinks lager and Kölsch (which, according to Blok and Eberle, is an alternative to Pils in German); he argues that in this situation both (31) and (32) are false, while Blok and Eberle's account predicts that (32) is true.

I agree with Cohen that Kölsch is still a beer for English speakers, and therefore as long as John drinks Kölsch and Kölsch is not a lager, sentence (32) is false, even if English speakers cannot classify Kölsch as any particular kind of beer. As Cohen acknowledges in a footnote, the situation may be more complicated if speakers of different languages divide the space of possible meanings differently. For example, suppose John only drinks lager and another beverage, which is considered a beer by German speakers but not by English speakers (this implies that English *beer* and its German counterpart *bier* are not synonymous). In a context where John's beer-drinking habits are discussed, German (31) can be considered to be false, while English (32) is true. According to the theory outlined in section 2.2.1, this is not a consequence of different focus semantic values for the German and English expressions, but rather the effect of external context on the interpretation of *only* (recall that focus only provides part of the restriction). At least at the level at which association with *only* takes place, we need a representation of meaning, not form.

There are reasons to believe that the alternative sets must also be constrained—they should consist of possible natural language meanings: Schwarzschild (1993) points out that identifying the alternative set of a focused constituent with the entire space of functions matching it in type, as done in (4) above, leads to a peculiar problem. Intuitively, a sentence such as *John only* SWIMS$_F$ should not imply, for example, that Mary doesn't swim. However, according to the definition of focus semantic values in (4), the alternative set $[\![\text{SWIMS}_F]\!]^f$ includes the property that maps every individual to the set of worlds in which Mary swims.

(33) $x \mapsto \{w | w \in [\![\text{Mary swims}]\!]^o\}$

If this property were to enter into the context $[\![C]\!]^o$ that is used in evaluating *only* then the sentence *John only* SWIMS$_F$ would imply that the worlds where John only swims are worlds where Mary doesn't swim.

(34) $[\![\text{John only SWIMS}_F]\!]^f =$
$\{w | \forall P[w \in P([\![\text{John}]\!]^o) \land P \in [\![C]\!]^o \to P = [\![\text{SWIMS}_F]\!]^o]\}$

We thus need some principled way of not allowing the property in (33) to ever enter into a context relevant for the interpretation of *only*. As suggested by Kadmon (2001, section 15.3, pp. 307–309), it would be even better to remove it from the set of possible alternative properties. The property in (33) is a constant function, and the role of these in the semantics of natural language seems rather limited (but they do appear, for instance, in the denotation of the expression *constant function* and the denotations of expressions that specify them explicitly, such as *the function that maps every individual to the set of worlds in which Mary swims*).

Philippe Schlenker (personal communication) suggests that this is evidence that the alternative set should actually consist of expressions rather than meanings: since there are no natural language expressions that correspond to properties like (33), such

properties are automatically excluded if focus semantic values are taken to be sets of expressions. I do not find this argument very compelling, because as we saw in the preceding paragraph, one can explicitly construct an expression that denotes a property like (33). We already know that alternatives need not be lexicalized as single words: the sentence *John only walks* can imply that John doesn't ride a bicycle, even though there is no single word that means "ride a bicycle". So this proposal runs into the same problem it has tried to solve, only this time one has to state which expressions don't count as alternatives rather than which meanings. Since among the things that do not count as alternatives we find notions like "constant function", it seems to me that a characterization in terms of meaning is more appropriate.

Another argument against having meanings as the alternative values is given by Fox (1999), who proposes that alternatives should rather be syntactic logical forms (Fox 2000 says that either logical forms or structured meanings will do). The argument is based on ellipsis constructions. Rooth (1992a) has shown that alternative values can explain a similarity between ellipsis and phonological reduction. However, the similarity is not complete: while both (35a) and (35b) have a true reading (that is, seven is equal to seven), this reading is present in the prosodically reduced (36a) but not in the ellipsis sentence (36b), which says that seven is equal to five (numbers are used in order to avoid violations of Principle C of the binding theory; phonologically reduced material is typeset in a smaller font).

(35)   a. 5 is equal to itself, and 7 is equal to itself too.

      b. 5 is equal to itself, and 7 is too.

(36)   a. 5 is equal to 5, and 7 is equal to itself too.

      b. 5 is equal to 5, and 7 is too.

Rooth argues that prosodic reduction is allowed in (36a) because the proposition expressed by the first conjunct is identical to that in (35a): the VP *is equal to itself*, which bears no pitch accent, is licensed by the antecedent *5 is equal to 5*, which expresses the same proposition as *5 is equal to itself*. Sentence (36b) cannot receive this interpretation because on top of the above licensing, ellipsis also requires syntactic reconstruction, and at the syntactic level the antecedents in (36b) and (35b) are different.

Fox (1999) argues against reconstruction in the ellipsis case, and proposes that it is only subject to a licensing condition similar to that which licenses phonological reduction. He notes the following contrast in acceptability (section 3.2, p. 83).

(37)*John proved that I'm innocent. FINGERPRINTS$_F$ did, too.

(38) John proved that I'm innocent. Fingerprints that BILL$_F$ presented did, too.

Fox gives the following explanation to the above contrast. There are two homophonous verbs *prove* in English—an agentive verb and a non-agentive verb; I will annotate them *prove$_A$* and *prove$_N$* for clarity. The former is used in sentences like *John proved$_A$ that I'm innocent*, and the latter in sentences like *fingerprints proved$_N$ that I'm innocent*. Now the second clause in (37) cannot receive the interpretation "fingerprints proved$_N$ that I'm innocent" because such an interpretation has to be licensed by an antecedent of

the form "x proved$_N$ that I'm innocent", and such an antecedent is not to be found. Nor can the clause receive any other interpretation, since the only interpretation that would be licensed is "fingerprints proved$_A$ that I'm innocent", and this is incoherent because the subject is inappropriate for an agentive verb. So how come (38) is acceptable? Because the sentence contains the unaccented part *fingerprints that . . . presented*, which Fox calls *accommodation seeking material*. This allows accommodation of the sentence *John proved$_A$ that I'm innocent with fingerprints*, which entails the non-agentive sentence *fingerprints proved$_N$ that I'm innocent*, and this licenses a coherent interpretation for the second clause in (38).

Under this explanation, syntactic reconstruction in ellipsis constructions is not only unnecessary, it is impossible as it would reconstruct the wrong verb *prove* in (38). But with reconstruction gone we are faced with the problem of how to account for Rooth's observation about the contrast in (35)–(36). Fox proposes to solve this by having alternative sets that consist of syntactic logical forms rather than semantic representations.

I do not find Fox's explanation for the contrast between (37) and (38) very convincing. His account would predict that (39) below should be as acceptable as (38), since it too contains accommodation seeking material. In my judgment, however, it is markedly degraded.

(39) ?John proved that I'm innocent. Fingerprints that BILL$_F$ found did, too.

The same goes for examples (40) and (41), which are used by Fox (2000) to illustrate the same point (these are repeated in Fox 1999, note 12, p. 89). This would predict that (42) should be as good as (41), but I feel it isn't.

(40) *What John said revealed my identity. BILL$_F$ did, too.

(41) Bill revealed my identity. What JOHN$_F$ said did, too.

(42) ?Bill revealed my identity. What JOHN$_F$ discovered did, too.

I propose that the contrast noted by Fox has to do with an agentive interpretation for atypical agents. The fact that Bill presented the fingerprints or said whatever he said implies that he, in a sense, also proved my innocence or revealed my identity, and this is what allows an agentive verb in the ellipsis clause; if Bill just found the fingerprints or discovered whatever he did then no implication arises with regard to Bill's agentivity, and consequently an agentive verb is not allowed. Under this explanation, agentivity of the verb in the ellipsis clause matches that of the verb in the antecedent, so Fox's objection to syntactic reconstruction is removed. The argument for the inclusion of syntactic information in the alternative sets no longer follows.

I conclude that the arguments for specifying the alternative sets syntactically rather than semantically are not convincing. In return I have given two main arguments in favor of computing the alternative sets by semantic means: givenness requires the use of the semantic notion of entailment, and it also applies to parts of words, as shown at the end of section 2.3.2; excluding constant functions from alternative sets is also defined in semantic terms. The balance is thus in favor of the semantic characterization of alternative values, and this requires giving meanings to parts of words.

2.5   Focusability and prosodic structure

The semantics of phonological decomposition can interpret focus on any part of a word. This leads to two kinds of problems. On the one hand, the theory is too strong: it predicts focus marking on parts of words where it is in fact impossible, as in the following example from Bolinger (1986, p. 104).

(43) You say it blasts easily? — No, it ˈBLASTED easily (*blastED).

The semantics has no problem interpreting the starred structure, and thus fails to predict its ungrammaticality.

At the same time, the semantics fails to predict the location of focus in the following sentences (the first one I heard in natural speech on more than one occasion; the latter two are from Bolinger 1961, p. 93).

(44) This is the INdependent variable ... and this is the DEpendent variable.

(45) natural REgularity ("in a context that implied an opposition to IRregularity").

(46) Avoid foods that are indiˈgestible—favor those that are DIgestible.

We see the problem, for instance, in (44): prior discourse contains the word *independent*, so all parts of the word *dependent* should be given; there is no apparent reason to put accent on anything but the default syllable. The same holds for (45) and (46).

2.5.1   Focus marking and foot structure

Both of the above problems are explained if phonological decomposition is constrained phonologically, so it can only apply to prosodic units the size of a metrical foot or larger. This gives a straightforward explanation to the non-availability of focus on the contrasting syllable in (43), because the contrast is in the weak syllable of a foot: (ˈbla.sted) (the period marks a syllable boundary, and parentheses show the grouping of syllables into feet). Since focus should be minimal (cf. section 2.3.2), we would expect it to be marked on the final syllable. However, if the minimal unit for focus marking is a foot, we get focus on a whole foot as in (43).

The same hypothesis also explains accent placement in (44)–(46). The word *independent* has the prosodic structure (inde)(pendent), with two metrical feet (the structural details of the *pendent* part are not important for this example, but see discussion of *informant* later in this section). Focus is marked on the entire foot (inde), so the semantics assigns meanings to the word parts (inde) and (pendent). It follows that the word *dependent* will not be considered given, because there is no antecedent that entails it; however, the word part (pendent) is given. Focus thus has to be marked on the novel element *de*. The same holds for the other examples, given their metrical structures: i(rregu)(lari)ty, (regu)(lari)ty; (indi)(gesti)ble, (di)(gesti)ble.

The following contrast is an additional demonstration that focus marking respects the footing of a word. The words *phonological* and *phonology* differ in their unmarked metrical patterns: the morpheme *phono* forms a foot in (ˌphono)(ˈlogi)cal but not in pho(ˈnolo)gy. This difference affects the possibility of marking focus on the string *phono*.

(47) This is a morphological problem that gets a (ˈPHONO)(ˌlogi)cal solution.

(48) I have trouble with morphology, but he will only discuss pho(ˈnolo)gy.

<div align="right">

* (ˈPHONO)(ˌlogy).

? (ˈPHO)(ˌnolo)gy.

</div>

In (47), where *phono* is contained in a foot, it can receive the pitch accent of a focus constituent; prominence relations between the feet change as a result. But in (48) we see that focus cannot be marked on *phono*, despite the fact that it is a morpheme: the second option, where footing of the word has changed, is completely ungrammatical; judgments differ with regard to the the last option, where no foot boundaries have been destroyed but a new foot has been created.

  Two qualifications need to be made to the statement that focus has to be marked on existing metrical feet. First, we have just seen that it is possible to focus a syllable that is normally unfooted, as in PHO*nology*, even if the acceptability is marginal; more will be said on such examples below. Second, weak syllables are much more readily focused when the pronunciation of the word is the subject matter of discussion. Compare the following sentences.

(49) I didn't say plumbing, I said plumbER.

(50) The problem wasn't the plumbing, it was the ˈPLUMBER.

<div align="right">

* plumbER.

</div>

Whereas focus on the contrasting part is natural in (49), it is much less acceptable in (50). I do not have a precise explanation for this observation; one could imagine that the explicit discussion of pronunciation simply allows speakers to entertain more prosodic analyses than they normally do. The discussion below pertains to examples where focus falls on a word part when pronunciation itself is not the topic of discussion.

  Focus can change the metrical structure of a word, if only in a limited way: assuming that a stressed syllable is always the head of a metrical foot, the following examples show that the final syllable has been promoted to the status of a foot. Sentence (51) is taken from Bolinger (1986, p. 104); sentence (52) shows that focus on the syllable *mant* is also possible when pronunciation is not the subject matter of the discussion.

(51) We got the information from your informer. — You mean from my inforMANT.

(52) While his main source of income was working as a police informer, he made a few extra bucks as a language inforMANT.

When not focused, the final syllable of *informant* is stressless. It is not clear to me whether it is incorporated as the weak syllable of a foot together with the preceding syllable, or if it is left unfooted: strictly bimoraic footing would make the syllable *for* a foot by itself; however, since the nucleus of unstressed *mant* is a syllabic nasal, the syllable is light and as such it may constitute the weak syllable of a foot (Pater 2000 argues that syllables with nasal nuclei in pre-tonic position are parsed exactly this way). The acceptability of focus on a weak syllable depends on how good a foot it would form. With a full vocalic nucleus, *mant* is a heavy syllable and thus can easily form a foot in its own right. Note that the vowel in focused MANT is a schwa [ə], as there is no

reason to assume any other underlying vowel; syllabic nasals that are reduced forms of an underlying full vowel can have that vowel when focused (e.g. the syllabic nasal in *San Fr[ŋ]cisco*, which is an underlying [æ]—cf. *Fr[æ]nciscan*—reduced as a result of pressure to form a foot with the preceding syllable; see Pater 2000, p. 247).

We find that while focus can attract stress and even form a new foot, it can not move heads of feet into a weak position: aside from the focused part, prominence relations in *in̩forˈMANT* are the same as in *inˈfor.mant* (contrast this with *ˌin.forˈma.tion*). Nor can focus perform profound segmental changes: note how the word *stalac*TITE, with focus on the final syllable, has the same segmental composition as unmarked [stəˈlækˌtajt]; focus thus differs from a process like affixation that produces *stalactitious*, where stress shift results in different vowels: [ˌstæləkˈtɪʃəs]. Phonologically, focus marking is similar to the post-lexical Rhythm Rule, which also respects footing, hence *poˈlice officer* rather than **ˈpolice officer* (for those speakers who normally pronounce *poˈlice* and not *ˈpolice*).

Why does phonological decomposition respect the metrical constituency of a word, and apply only to units the size of a foot or larger? One possible explanation is that it follows from the grammar of focus: focus is marked with a pitch accent, and pitch accents associate with stressed syllables (Selkirk 1984, 1995b). If a syllable must be stressed prior to receiving focus, and in order to receive stress a syllable has to be the head of a metrical foot, then focus has to be marked on feet in order to get phonologically realized. A consequence would be that focus has to be marked at a level where words are already specified for metrical structure (this goes along with the observation in Bolinger 1961, that words but not sentences have a default stress pattern independent of information structure). However, we have seen that focus can target a syllable that is not normally stressed.

The idea that focus has to be marked on units the size of a metrical foot or larger as a consequence of the rules of pitch accent association with a stressed syllable suffers from a further problem. Selkirk (1984), who advocates the pitch accent association rules, assumes together with most other researchers that focus is marked by a pitch accent (the observation that pitch rather than some other physical property is used to mark contrast dates back at least to Coleman 1914). However, Rooth (1996b) shows that in some cases focus-sensitive adverbs like *only* may associate with constituents that are prominent in intensity (loudness) and duration rather than pitch (Partee 1999 cites papers by Christine Bartels and Manfred Krifka in Kamp and Partee 1997 that point to similar conclusions). The conditions under which this happens are rather complex: the element that associates with the adverb must have a discourse antecedent (it must in some sense be given), it must be embedded below another focus-sensitive operator (in Rooth's terms, it is of *second occurrence*), and it must follow the pitch accent associated with the higher focus-sensitive operator. These conditions can also obtain below the word level, and we observe the same effect.

(53) The ceiling in the cave was so high, that the children were only able to pick stalagMITES. Even BILL only brought a stalagˈmite from the cave.

The reader can verify that all the conditions hold; and indeed, the syllable *mite* does not differ from adjacent material in pitch, though it is unquestionably prominent.

Rooth (1996b) raises the possibility that second occurrence focus is marked by a pitch accent even in examples like (53), but because it follows a nuclear accent (Pierrehumbert 1980), this accent lacks any marked pitch though other acoustic properties are still present (this would also explain the lack of a perceptible pitch accent on *rice* in sentence (10) from section 2.2.1 on page 12). A second possibility is that the phonological marking for association with focus is not accent but rather some metrical property, and may thus be phonologically distinct from the marking of given and new information by pitch accents. The possibility of focus marking without a pitch accent still fits in with the requirement that focus be marked on a foot, since increased intensity and duration are also characteristic of stressed syllables, and indeed focus in examples like (53) is perceived as stress; it must therefore be marked on a unit that can receive stress, that is a foot. The requirement that focus be marked on a prosodic unit the size of a foot or larger can still be the result of the grammar of focus, but if the latter possibility is correct it cannot be a consequence of pitch accent association.

I believe that the requirement that focus should be marked on existing prosodic structure, with only a limited possibility to change it, is not a a consequence of the grammar of focus in particular, but rather constitutes part of the grammar of phonological decomposition itself, and as such it reflects a more fundamental aspect of the organization of grammar, namely what kind of grammatical units can participate in the semantics. Recall that phonological decomposition splits the meaning of a lexical item into two components, each of which is assigned to part of the phonological representation. But the phonological representation itself is not just a string of segments—it has the structure of syllables and feet. The issue is not whether prosodic structure is specified in the underlying structure of lexical items (see e.g. Booij and Lieber 1993) or if it is fully predictable; either way, it is clear that expressions have prosodic structure at a certain level of representation. The same sensitivity of phonological decomposition to prosodic constituency is displayed in coordination of parts of words (chapter 4), so this sensitivity seems to reflect something basic about phonological decomposition. A natural interpretation is that phonological decomposition assigns meanings to the prosodic constituents that make up a word, not to arbitrary parts of the linear segmental representation. An intriguing extension of this idea is that perhaps semantic interpretation overall has to proceed along the lines of prosodic rather than morphosyntactic constituents; see Steedman (1991, 2000a,b) for a grammar built along those lines.

2.5.2   Focusability: phonology or semantics?

The previous section has provided an explanation why some word parts can be marked by focus while others cannot be: the determining factor is phonological, namely the requirement that focus should be marked on a foot and that it cannot destroy existing prosodic structure. This stands in contrast to suggestions in the literature, which tie the availability of focus to the semantic transparency of word parts. Chomsky (1970) states in a footnote that "the focus must be composed of full lexical items"; this amounts to the claim that the semantics of focus can only apply to units that have an independent lexical meaning. Bolinger (1986, p. 104) uses both semantic and phonological notions: "... many words contain some rather transparently distinctive affixes, and the less bound these are, the easier it is to accent them separately". I will now examine

these claims in greater detail, and show that what underlies this notion of semantic transparency is in fact the phonological intuition discussed in the preceding section.

The relation between focusability, semantic transparency and phonological constituency is discussed explicitly by Wennerstrom (1993), who argues that semantically transparent prefixes ("analyzable" in her terms) form independent prosodic words within the lexical word, and that focusability can be used as a diagnostic for this property. Wennerstrom is unclear about the reason for this relation: is it a semantic property of the prefixes that makes them focusable, or is it their prosodic constituency? On the one hand Wennerstrom writes "...pitch accent due to focus associates with prefixes that play a role in the information structure of the discourse" (p. 322), which seems to imply that focus is allowed because of the semantics of the prefixes. However, in the same paragraph she continues "the prosodic word is the minimum domain for PAA [pitch accent association], a process which links pitch accent to the highest grid mark within a focused ω [prosodic word]"; this implies that it is prosodic structure that allows focus to be marked on a prefix.

So let's look at the hypothesis that it is indeed the semantic properties of certain affixes that determine whether or not they can be focused. The following are some of the examples characterized by Wennerstrom as analyzable (p. 311).

(54) This function is DEcreasing here, but INcreasing there.

(55) John expected to be promoted, and was shocked at being DEmoted.

(56) I still say she's a very effective manager; it's the equipment that's DEfective.

The analyzability of these prefixes is anything but clear. The semantic import of the prefix *in-* in *increasing* is not apparent (etymologically it is the *in* of direction, meaning roughly 'into', *Oxford English Dictionary*), and the prefix *de-* in *defective* has little more to contribute than a general feel of negativity. And while Wennerstrom explains that "the opaque prefix-stem combinations *promoted* and *effective* do not carry the focus", she acknowledges in a footnote that the prefix in *promoted* can also receive stress. Indeed, if sentence (55) is reversed it is much easier to stress the prefix in *promoted* (57a), and rather odd to keep stress on the prefix in *demoted* alone (57b); deaccenting the prefix *pro* in the latter case is only possible if it is understood that John's being promoted is already under discussion, so the entire word *promoted* is deaccented (57c).

(57)   a. John expected to be demoted, and was surprised at being PROmoted.

         b.*John expected to be DEmoted, and was surprised at being PROˈMOTED.

         c. John expected to be DEmoted, and was SURPRISED at being promoted.

Semantic transparency thus fails to give an account of when focus is possible on parts of words and when it is not. On the other hand, prosodic constituency does provide an explanation: all the prefixes in (54)–(56) occur right before a main stress in the unmarked structure of the word, which means they either form a foot themselves or are unfooted.

(58) in(ˈcrea.sing), (ˌde)(ˈcrea.sing);

pro(ˈmo.ted), (ˌde)(ˈmo.ted);

e(ˈffective), (ˌde)(ˈfective).

Focus on the prefixes above is therefore the result of their prosodic status; there is no need to refer to their semantic properties.

So what is the origin of the intuition that semantic transparency is responsible for the distribution of focus below the word level? We have seen that focus can be marked on units as small as a foot. Independently, Raffelsiefen (1993) shows that a certain class of prefixes, which can be characterized through a historical notion of compositionality, form prosodic words in English. The following set of contrasts shows differences in the pronunciation of prefixes that arguably share the same underlying segmental representation. Examples (59)–(61) show how a phonological process is blocked when the prefix is transparent; in examples (62)–(63) we see certain segments that are present following a transparent but not an opaque prefix.

(59)	Stress shift:	ˈimpetus (*im* = ?)	imˈproper (*im* = 'not')
(60)	Trisyllabic laxing:	[æ]symptotic (*a* = ?)	[eʲ]symmetrical (*a* ='not')
(61)	Vowel reduction:	r[ɛ]n[ə]vation (*re* = ?)	r[i]l[oʷ]cation (*re* = 'again')
(62)	Aspiration:	dis[t]urb (*dis* = ?)	dis[tʰ]rust (*dis* = 'not')
(63)	[h] before [ə]:	pro[∅ə]bition (*pro* = ?)	pro[hə]waiian (*pro* = 'for')

The above examples all make a good case for the claim that prefixes which are semantically compositional form their own prosodic words (Raffelsiefen shows that the notion of compositionality which determines prosodic word status is a diachronic notion that links meaning shift over time in morphologically related forms). Now, since each prosodic word includes at least one metrical foot, it follows that these prefixes can be focused. We thus have an important class of focusable prefixes which are characterized through some semantic notion. But these are not the only word parts that can be focused. Indeed, Raffelsiefen (1999, p. 162) claims that independent phonological diagnostics show that some of the focused prefixes in Wennerstrom (1993) do not form prosodic words, even though they are focusable. The correct characterization of focusability is prosodic—focus is marked on feet—and the correlation between semantic transparency and focusability is only indirect.

A second claim about the relation between focus and semantic transparency is that focus is interpreted differently when it appears on transparent and opaque word parts. This is articulated by Selkirk (1984, p. 271).

> We should distinguish between the intonational meaning associated with a prominence on affixes like [*in-*, *un-*, and *non-*] and the meaning associated with prominence on affixes not meaningful in themselves, such as might occur in the contrast between TRANS*fer* and RE*fer*, for example. In such cases something of a metalinguistic statement seems to be involved: possibly a comment is being made *about* the morphemes themselves. The "intonational meaning" in such instances is analogous to that found when

syllables rather than morphemes are being contrasted: *I said co*FFIN*, not co*FFEE. It is also analogous to the pitch accenting of one of the parts of a frozen compound: *I said king*FISHER*, not king*PIN.

Perhaps the generalization is that pitch accents can be assigned to anything of the level word or below, but that a pitch-accent-bearing element is only interpreted along the lines of a normal focused constituent when it has an identifiable separate meaning. When the pitch-accent-bearing element cannot be interpreted in this way, the presence of pitch accent is interpreted instead in metalinguistic terms.

The claim that focus on word parts is metalinguistic, or a comment about the parts themselves, seems to reflect the lack of a good semantic theory for such word parts. Phonological decomposition eliminates the need for a distinction between "normal focused constituents" and "metalinguistic" interpretation; both cases receive an identical treatment as far as the theory of focus goes, and the difference stems from the fact that the meaning for the opaque word parts makes reference to their form, since it is derived by phonological decomposition. It is not quite clear to me what would amount to a comment about word parts, but reflecting discourse givenness and restricting the domain of *only* seem like interpretations "along the lines of a normal focused constituent". Thus, focus on the last syllable of *stalag*MITE in examples (1) and (2) should be considered "normal" in Selkirk's terms, even though *mite* does not have a lexical meaning, and it is doubtful if it is even a morpheme (etymologically it isn't: *stalagmite* derives from Greek *stalagma* 'a dropping', *Oxford English Dictionary*). The same can be said for the Hebrew example (3), where focus shifts the prominence to the initial syllable of KOZMO*nawtim* 'cosmonauts': the sentence is not necessarily about the term *kozmonawtim*—it can also be interpreted as a statement about the space achievements of the Soviets.

At the same time, phonological decomposition gives an explanation to the intuition that there is something metalinguistic about focus below the word level. This is because the meanings for parts of words make reference to the form of the word. Rather than take this as a reason to exclude such focus from the discussion, I have shown that acknowledging such meanings allows us to use a single theory for focus above and below the word level.

2.6 Focus marking in the syntax

Throughout this chapter I have assumed that intonational focus is marked as a syntactic feature. In this I followed most of the prominent analyses of focus, which assume that the phonological and semantic aspects of focus are mediated by a representation in the syntax (notable exceptions are Bolinger 1961, 1972, 1986 and Schmerling 1976, but these works do not offer an explicit semantics to go with the placement of accent). Syntactic mediation is often a consequence of the architecture of the entire linguistic system. Such is the view expressed by Culicover and Rochemont (1983) and repeated in Rochemont (1986) and Rochemont and Culicover (1990): the phonological and semantic components of grammar are autonomous; each independently interprets

a syntactic representation. Therefore, if a correlation is found between an aspect of phonology and an aspect of semantics, it must be the result of some marking in the syntax.

In light of this view of syntactic mediation between phonology and semantics, focus below the word level has an immediate consequence for the theory of syntax: if focus is represented in the syntax, and focus is marked on parts of words, then parts of words must be represented in the syntax. The term "syntax" is used here in its wide sense, meaning whatever the grammatical object is that is interpreted by the semantics. For instance, Di Sciullo and Williams (1987) argue that grammar includes two distinct generative components, syntax and morphology; they allow the semantics to give a compositional interpretation to objects of both kinds. Focus marking on parts of words is compatible with their proposal—it will not be marked in "syntax proper", but it will be accessible to semantic interpretation. But syntactic focus marking on parts of words does put constraints on the use of syntactic mechanisms to account for the distribution of focus marks. I discuss two such claims from the literature—focus projection (section 2.6.1) and focus movement (section 2.6.2).

2.6.1   Focus projection

Focus marks in the syntax were introduced in Jackendoff (1972) as a way to connect the semantic and phonological aspects of focus; the role of syntax is limited to hosting focus marks, which according to Jackendoff "can be associated with any node in the surface structure" (p. 240). In a similar way, Culicover and Rochemont (1983) assign focus marks (a "strong" feature in their terminology) to any node in the syntactic tree, and this marking then independently affects prosodic prominence relations and receives semantic interpretation. This way of assigning focus marks poses no problem below the word level, as long as word parts are represented at the level of structure where focus is marked. A proposal that invokes syntax for the distribution of focus is given by Steedman (2000a,b), who proposes that focus features ("theme" and "rheme") are passed on from lexical items to higher constituents through the mechanism of syntactic combination. This too is compatible with focus marking on parts of words, because the inheritance relations are clearly defined in the syntactic structure.

Focus marking on parts of words poses a serious challenge to theories that use more elaborate syntactic mechanisms to account for the distribution ("projection") of focus marks (Selkirk 1984, 1995b; Rochemont 1986). The assumption behind these theories is that focus can only be assigned to terminal nodes that bear accent, and focus marking on higher constituents is the result of syntactic projection rules (Gussenhoven 1983, 1999 offers a similar theory with a different perspective: he works from a given representation with focus marking at all syntactic levels to predict which marks will be realized as pitch accents, based on a syntactic mechanism similar to that of Selkirk and Rochemont). For example, the projection rules in Selkirk (1984, 1995b) state that focus marks on phrasal constituents are licensed by focus on their heads or internal arguments, but not adjuncts. The motivation behind this sort of account is contrasts such as the following (Selkirk 1984, pp. 231–232).

 (64) JOHN bought a red TIE.

```
              NP                                      DP
           /      \                                /      \
        Det        N̄                            D          AP
         a        /  \                           a        /   \
               AP      N                               A       NP
              red     tie                             red      tie
```
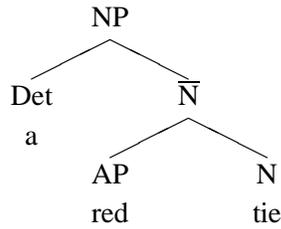
Figure 2.1: *red* as adjunct   Figure 2.2: *red* as head
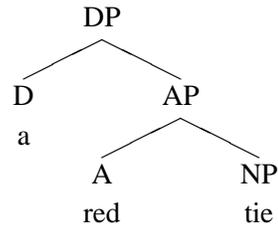
(65) JOHN bought a RED tie.

Selkirk points out that (65) is not appropriate unless the discourse contains a contrasting phrase such a *bought a blue tie*; sentence (64) does not need such a contrast. Selkirk concludes that the entire VP may receive a focus mark in (64) but not in (65); this is explained if prominence on the adjunct *red* does not license focus on the VP, or in other words focus does not "project" from *red* to the VP. (This argument presupposes a syntax where the adjective is an adjunct to the noun, as in Figure 2.1; it is incompatible with an analysis where an adjective is a head that takes an NP complement, as in Figure 2.2 following Abney 1987.)

    A syntactic characterization of focus projection leads to an immediate problem below the word level, because the notions of head, argument and adjunct have to be defined for parts of words too. Selkirk (1984, p. 271) assumes that such notions are indeed defined: "Such a prefix [*in-*, *un-*, or *non-*] will of course always have narrow focus ... since it is not the head of its word constituent". But these definitions have to do with the morphological makeup of words (cf. Selkirk 1982), and we have seen that focus can fall on word parts that are not even morphemes at all. If we want to sustain the idea that the distribution of focus marks is governed by syntactic means, we have to extend the notions of head, argument and adjunct to all parts of words that can receive focus. Alternatively, we should abandon the syntactic characterization of focus projection.

    Schwarzschild (1999) gives reason to doubt the usefulness of syntactic focus projection. Recall that Selkirk (1984) concluded that the VP in (65) above cannot receive a focus mark ("broad focus"); this broad focus is what the theory uses to account for question-answer congruence. But Schwarzschild observes that there are cases where question and answer pairs suggest that there should be broad focus on the VP, even when prominence is not on an argument (p. 146).

(66) John drove Mary's red convertible. What did he drive before that?

     — He drove her BLUE convertible.

If it is a focus mark on the VP that allows question-answer pairs, then the VP in the answer in (66) should receive one. But Selkirk's projection rules do not allow focus marks to project from the AP *blue* to the VP. Schwarzschild concludes that the syntactic account of focus projection is wrong, and instead proposes that a focus constituent can be marked phonologically by a pitch accent anywhere within it. Schwarzschild's

example can be reproduced with focus below the word level (the following example is based on a dialogue between Anjelica Huston and Martin Landau in *Crimes and Misdemeanors*, written and directed by Woody Allen, Orion Pictures 1989).

(67) The radio is playing Schumann now. What did it play earlier?

　　— It played SchuBERT.

If focus marking is necessary for question-answer congruence then focus should project from the syllable *bert* to the NP *Schubert*, though it is hard to see how this can be characterized syntactically. The problem is solved by accepting Schwarzschild's proposal, which eliminates syntactic focus projection.

2.6.2　Focus movement

Focus below the word level also appears to rule out theories that propose to interpret focus through a syntactic movement operation like quantifier raising (QR). For example, Chomsky (1976, p. 344) proposes that the logical form (LF) of the sentence *Bill likes* JOHN is something like *The x such that Bill likes x—is John*; more recently, Rooth (1996a) has proposed a variant of alternative semantics where alternatives are determined by syntactic movement of the focused element. Semantically, this movement operation is interpreted as lambda abstraction, and phonological decomposition provides the desired meanings for this operation when focus is marked on part of a word. Syntactically, however, focus movement of part of a word appears to cause an island violation. The ungrammaticality of (68) shows that word parts cannot undergo overt *wh*-movement (cf. the grammatical echo question (69)).

(68)*What did John bring a stalag- from the cave?

(69) John brought a stalag-what from the cave?

Furthermore, words also appear to be islands to *wh*-dependencies that do not require overt movement (70), while association with focus is possible across such domain boundaries (71)

(70)*Sue knows who has appointments with what-dontists.

　　(cf. Sue knows who has appointments with which specialists.)

(71) Sue knows only who has appointments with ORTHOdontists.

So if we were to adopt a theory of focus movement, it would have to be constrained even less than covert *wh*-movement, since words would not constitute islands to such movement.

　　Arguments against syntactic movement of focus constituents were a main motivation for the *in-situ* theory of focus interpretation in Rooth (1985). Rooth (1996a) argues that many of these earlier arguments are flawed; however, as far as I can tell his claim does not apply to the argument against movement of multiple foci that associate with a single operator. Rooth (1985) notes that this seems to require an unfamiliar kind of movement, as in the following sentence (from Anderson 1972).

(72) John claims that he could sell refrigerators to the Eskimos, but in fact he couldn't even sell WHISKEY to the INDIANS.

Von Stechow (1989) notes a similar problem with the interpretation of *even* as a nominal quantifier in Karttunen and Peters (1979), and points out that it would not generalize to the association of *even* with multiple foci without some unusual syntactic assumptions. Von Stechow stresses that the problem is not with the semantics, but with the syntax. The island violations that would arise from focus movement below the word level provide an additional argument against an account of focus which requires syntactic movement.

2.6.3   Is syntactic focus marking necessary?

The emerging view is that the role of syntax in focus constructions is limited to hosting focus marks, that is mediating between semantics and phonology. Interesting generalizations about the interpretation, realization and distribution of intonational focus are stated in semantic and phonological terms, and syntax has little to contribute. This begs the question whether we need a syntactic representation of focus at all. As mentioned in the beginning of this section, I use syntactic focus marks because of the general architecture of the system, where phonology and semantics only interact through the syntactic representation. Eliminating focus marks would require that certain rules or generalizations directly relate semantic interpretation to pitch prominence, and developing such a theory goes beyond the scope of this dissertation (see Schwarzschild 1997a for a theory along these lines).

Chapter 3

Conjunction weakening and morphological plurality

3.1 Introduction

This chapter examines a characteristic which I will call "multiple plurality", where the conjunction of two morphologically plural predicates requires a subject whose denotation consists of at least four individuals. I argue that this should be taken as evidence that plural expressions only include plural entities in their extension, and as evidence for the existence of cumulative ("non-Boolean") conjunction on predicates. The semantics developed in this chapter will be used in the account of coordination of parts of words in chapter 4; the motivation here is independent of that account.

As an example, think of the following situation: a teacher is asked to send all the children of medium height to participate in a play; however, the class only consists of tall children and short children. The teacher can explain why no children were sent by uttering (1) in Hebrew or (2) in English:

(1) ha-yelad-im gvoh-**im** ve-nemux-**im**
    the-child-pl tall-**pl**   and-short-**pl**

(2) The children are tall and short.

The two sentences above appear like straightforward translations of one another; however, they are not exactly synonymous. English (2) can also be uttered by a parent of two children, one tall and one short, while Hebrew (1) requires at least two tall children and two short children to make the sentence true. It is natural to attribute this characteristic of multiple plurality in Hebrew to the plural morphology that appears on each of the conjuncts. A similar thing happens in Spanish: each conjunct is marked with plural morphology, and the sentence receives a multiple plurality interpretation.

(3) Esos niño-s   son alto-**s** y   bajo-**s**
    those child-pl are tall-**pl** and short-**pl**

(Thanks to José Camacho, Beto Elias and Manuel Español Echevarría for their judgments on Spanish. For reasons unclear to me, Spanish speakers only accept this sentence with *esos niños* "those children" in the subject, not with *los niños* "the children". While many speakers of Spanish and Hebrew require that there be at least two children of each height, some are content with two of one height and only one of the other; all speakers reject the sentences if there is one child of each height. I will ignore this variability now, accepting the majority judgment.)

   Attributive adjectives also exhibit multiple plurality when morphologically plural adjective phrases are coordinated. There is a very clear contrast between Italian (4) and its near-translation to English (5) (thanks to Ivano Caponigro for the Italian example).

(4) I   biscott-**i** quadrat-**i** e   rotond-**i** sono al   cioccolato,
    the cookie-**pl** square-**pl** and round-**pl** are   PREP+DEF chocolate

    e   quello triangolare è alla   vaniglia.
    and that   triangular   is PREP+DEF vanilla

(5) The square and round cookies are chocolate, and the triangular one is vanilla.

Whereas English (5) can talk about three cookies, one of each shape, Italian (4) is only true if there are at least two square cookies and two round ones (chocolate, of course).

   The goal of this chapter is to explain how the multiple plurality requirement comes about, and the consequences this has on our understanding of plurality and conjunction. Multiple plurality receives a straightforward explanation if we accept the following assumptions.

(6) Plural morphology is interpreted literally as semantic plurality: morphologically plural expressions only include pluralities in their extension.

(7) Cumulative (plural-forming, "non-Boolean") conjunction is available for adjectives as well as for nominals.

Literal interpretation of the plural morphemes (see recently Chierchia 1998) ensures that each conjunct is instantiated by at least two individuals; cumulative conjunction (Scha 1981; Krifka 1990) allows coordinate predicates to have a denotation with mixed referents, some of which instantiate the first predicate while the others instantiate the second. Cumulative conjunction of plural predicates thus results in a multiply plural predicate.

   While cumulative conjunction and multiple plurality are readily available with nominals, their occurrence with adjectives is rather limited. This is because cumulative conjunction is restricted by two additional factors.

(8) Cumulative conjunction of adjectives is only available when their lexical meanings are incompatible (conjunction weakening).

(9) Syntactic number agreement is needed independently of semantic interpretation of plural morphology.

Conjunction weakening (Winter 1996, 2001) allows the cumulative conjunction of non-nominals only when their meanings are incompatible, that is when their intersective

("Boolean") conjunction is contradictory; syntactic number agreement does not allow the coordination of singular adjectives to be plural, blocking the cumulative conjunction of singular adjectives.

The rest of the chapter examines the above four claims in detail. The claims (6), (7), (8), and (9) are discussed in sections 3.2, 3.3, 3.4, and 3.5 respectively. These sections concentrate on predicative adjectives, because they are semantically simpler; attributive adjectives are discussed in section 3.6, and final remarks are made in section 3.7.

3.2   The representation of plurality

In order to account for the facts in (1)–(3) we need a theory of plurality. I will assume a structured domain of individuals, where plural objects are of the same type as singular individuals, namely type *e* (Leonard and Goodman 1940). The choice of representing pluralities as mereological sums (objects of type *e*) rather than as sets of type *et* is just a matter of convenience, in order to keep the types low. The domain of individuals has the structure of a free *i*-join semilattice (in the terms of Landman 1991), which is isomorphic to a structure where pluralities are freely formed sets of individuals.

My claim is that expressions that bear plural morphology only include plural objects in their extensions, and thus contrast with expressions that lack number marking. English *tall* is unspecified for number; it has both singular and plural objects in its extension, and is closed under plural formation (10). Hebrew *gvoh-im* 'tall-pl' has an overt plural morpheme, so it only has plural elements in its extension; it is the closure under plural formation of singular *gavoah* 'tall.sg', minus the singular individuals (11). I interpret natural language directly; lambda abstraction and other logical notation are used in the metalanguage for clarity, and PL is a metalanguage symbol for the set of all plural objects (individuals that are not atomic).

(10) Let $\mathcal{T}$ be (the characterizing function of) the set of all tall individuals. Then
$$[\![\text{tall}]\!] = \lambda\alpha.\exists n \in \mathbb{N}, \alpha_1, \ldots, \alpha_n[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \wedge \forall i \leq n[\mathcal{T}(\alpha_i)]]$$

(11) $[\![\text{gvoh-im}]\!] =$
$$\lambda\alpha.\alpha \in \text{PL} \wedge \exists n \in \mathbb{N}, \alpha_1, \ldots, \alpha_n[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \wedge \forall i \leq n[[\![\text{gavoah}]\!](\alpha_i)]]$$

The assumption that morphologically plural expressions do not include singularities in their denotation is not unproblematic. Examples like (12) below (van Eijck 1983) suggest that morphologically plural common nouns like *men* should include singularities (individual men) in their extension, because the sentence is false if even one man walks.

(12) No men walk.

The argument goes as follows: examples like (12) suggest that singularities need to be included in the extension of plural expressions; this assumption does not pose other problems to the semantics of plurals; so it is safe to conclude that as a general rule, extensions of plural expressions include singular individuals.

The above argument rests crucially on the second premise, that the inclusion of singularities in the extension of plural expressions does not do any harm. An obvious

challenge to this premise is that a sentence like *I saw boys in the park* is judged false if I only saw one boy. This can be argued to be a matter of pragmatics: the sentence may be semantically true, but pragmatically inappropriate given the alternative expression *I saw a boy in the park*. This pragmatic account does not generalize to the cases of multiple plurality. A situation with one tall child and one short one cannot be characterized by the Hebrew sentence (1). Yet there is no alternative sentence with singular expressions: sentence (13) is ungrammatical (the source of ungrammaticality will be discussed in more detail in section 3.5).

(13) *ha-yelad-im gavoah ve-namux
     the-child-pl tall.sg and-short.sg

If the plural expressions *gvoh-im* and *nemux-im* include singularities in their denotations, we expect Hebrew (1) to be semantically true for two children, one of whom is tall and the other short, just like English (2). The pragmatic account given above fails to explain why the sentence is inappropriate.

Chierchia (1998) makes another argument against including singularities in the extension of plural expressions: he argues that it explains why mass nouns do not appear in the plural. In his theory, expressions with plural morphology receive a denotation that is disjoint from that of the corresponding singular expressions; mass nouns are inherently plural, so with plural morphology they end up denoting nothing. In response to examples like (12), Chierchia rejects the naive interpretation that *no* requires disjointness of its restrictor (*men*) and scope (*walk*); instead he proposes that *no* operates on the *ideal* generated by its restrictor, where an ideal $\pi(\alpha)$ is defined as the set of all elements which are components of the join of α: $\{\beta | \beta \leq \bigvee \alpha\}$. This allows him to maintain the idea that plural expressions only include pluralities in their extension.

Chierchia has provided a solution for the problem of the quantifier *no*; something similar could be done for *only* (Hoeksema 1983), treating it as a quantifier of some sort. However, the problem posed by (12) is much more pervasive. Plural expressions appear to include singularities in their denotation in a variety of negative contexts (the following are modeled after examples by Karina Wilkinson and Roger Schwarzschild, respectively).

(14) It is not the case that students from Germany came to the conference.

(15) Students from Germany failed to come to the conference.

In a situation where one student from Germany came to the conference, are the above sentences true or false? A naive interpretation of *it is not the case* as propositional negation and of *failed to come* as the complement of *came* would predict that if plural expressions denote literal pluralities, the sentences are true in the above situation, but if plural expressions include singularities in their extension then the sentences are false. On the most accessible reading, sentences (14) and (15) are indeed false, pointing toward the inclusion of singularities in the denotation of plural expressions. However, I believe that at least (14) can also be construed as true, if there is a pitch accent on *students*. The source of the ambiguity is the negative expression, and the latter interpretation looks like a case of "external negation" (Horn 1985), where it is exactly plurality which is denied.

It appears then that Chierchia was right in identifying the negative expression in (12) as the reason the common noun *men* looks as if it ranges over singularities and pluralities alike, but he was wrong in describing this as a lexical property of the quantifier *no*. Rather, the applicability of *men* to singularities should be tied to the fact that it appears in a negative context, in a way that is yet to be explained. The ambiguity of (14) shows that even in negative contexts it is possible to pick out plural denotations for common nouns.

I conclude that the assumption that plural expressions include singularities in their extension is no less problematic than the assumption I make, that plural expressions only denote pluralities; the difference between negative and positive contexts should be addressed through an examination of the semantics of negative expressions. In the meantime it is safe to assume that plural morphology is interpreted literally as semantic plurality; this literal interpretation forms the first part of the explanation of multiple plurality.

3.3   Cumulative conjunction of predicates

The other element in the account of multiple plurality is the interpretation of conjunction. The most basic meaning of the English word *and* and its counterparts in other languages is often considered to be propositional conjunction—a binary operation on truth values that is true in case both of the operands are true, false otherwise. This accounts for the use of *and* between sentences. The use of *and* between other constituents can be explained via a general type shifting paradigm which interprets all constituent coordination at the propositional level (Gazdar 1980; Partee and Rooth 1983). I will call this use *intersective* conjunction. Some uses of the word *and*, however, appear to fall outside this paradigm. For example, sentence (16) is not equivalent to (17).

(16) John and Mary met.

(17) John met and Mary met.

Given our theory of plurality, this non-equivalence receives a natural explanation if the coordinate subject of (16) is taken to denote a plural object, the join of John and Mary. Following Link (1983), I will assume that when *and* coordinates individuals of type *e* it can denote the join operation; I use the symbol $\oplus$ in the metalanguage to stand for this operator.

(18) $[\![\text{John and Mary}]\!] = [\![\text{John}]\!] \oplus [\![\text{Mary}]\!]$

This use of *and* will be called *cumulative* conjunction; it is argued to apply in the nominal domain, at least for referring nominals (Hoeksema 1988). Cumulative conjunction on type *et* is also defined using the join operator; I defer this discussion until (24) below in order to address the issue of cumulative conjunction on categories other than nominals.

My claim is that the multiple plurality requirement in (1) *ha-yelad-im gvoh-**im** ve-nemux-**im*** 'the children are tall (pl.) and short (pl.)' is evidence for the existence of cumulative (plural-forming) conjunction not only on nominals, but on adjectives as

well (cf. Krifka 1990; Sharvit 1999). An alternative possibility is that the coordinate predicate in (1) may actually be a nominal, perhaps with the adjectives as modifiers of a null pronoun, meaning something like "tall ones and short ones" (Hilda Koopman, personal communication). Hebrew does allow lexical adjectives to act as nominals in certain contexts, as in the following sentence.

(19) ha-namux (ha-ze) hu sofer mefursam
     the-short   the-this PR writer famous
     "The/this short [person] is a famous writer"

Notice however that predicative nominals usually require a pronominal copula (glossed as PR in the above example), while the adjectives in (1) appear without such an element. Furthermore, a nominal interpretation is impossible when the adjective is modified by a degree phrase.

(20)*ha-namux mi-meter   va-xeci (ha-ze) hu sofer mefursam
     the-short   than-meter and-half the-this PR writer famous
     "The/this shorter than 1.50m. . . "

However, a cumulative reading is possible with degree-modified adjectives, as seen below in (21); this sentence is also subject to a multiple plurality requirement (thanks to Rajesh Bhatt for pointing out the relevance of this example).

(21) ha-yelad-im gvoh-**im** mi-meter   va-xeci ve-nemux-**im** mi-meter   šlošim
     the-child-pl tall-**pl**   than-meter and-half and-short-**pl**   than-meter thirty
     "The children are taller than 1.50m and shorter than 1.30m."

I conclude that the predicates in (1) and (21) are indeed adjectives, so we need cumulative conjunction outside the nominal domain.

    The need for cumulative conjunction on categories other than nominals is independent of multiple plurality. Take for example the following sentence.

(22) Students from Germany and from Switzerland met at the conference.

On the most natural reading of (22), the PP *from Germany and from Switzerland* does not pick out individuals who are both from Germany and from Switzerland. Rather, it picks a collection of individuals, based on a cumulative inference such as the following (Scha 1981).

(23) Hans is from Germany.
     Fritz is from Switzerland.

     Hans and Fritz are from Germany and from Switzerland.

In order to capture this kind of inference, we need the following interpretation for cumulative conjunction of type *et*: an object α is in the denotation of a coordinate expression of type *et* if it is the join of two objects α_1 and α_2, where α_1 is a member of the first conjunct and α_2 is a member of the second (Link 1983; Krifka 1990; a set-theoretic analog is the set product operation of Heycock and Zamparelli 1999, 2000). The coordinate PPs will therefore receive the following meaning, shown graphically on a lattice structure in Figure 3.1.
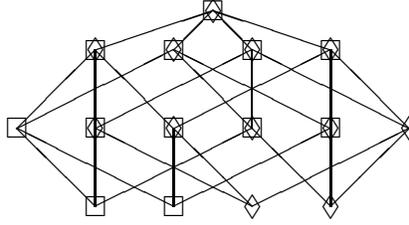
Figure 3.1: Conjunction of PPs. □ from Germany, ◊ from Switzerland.
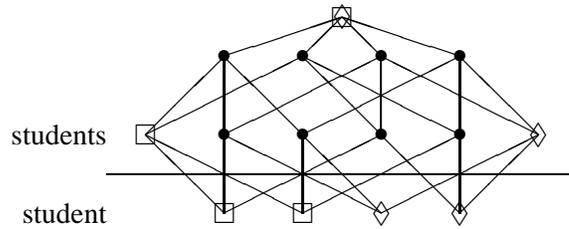
Figure 3.2: Conjunction of plural NPs.

(24) $[\![$from Germany and from Switzerland$]\!] =$
$\lambda\alpha.\exists\alpha_1,\alpha_2[\alpha = \alpha_1 \oplus \alpha_2 \wedge [\![$from Germany$]\!](\alpha_1) \wedge [\![$from Switzerland$]\!](\alpha_2)]$

Coordination of the predicative adjectives in (1) and (2) is interpreted much the same way: the cumulative conjunction of *tall* and *short* is analogous to the meaning in (24) above; the fact that the Hebrew adjectives bear plural morphology will give rise to the multiple plurality requirement.

As an illustration of conjunction with multiple plurality we can take an English sentence similar to (22) above, where instead of coordinating PPs we coordinate full NPs, which are marked for number. The subject NP in (25) gets a meaning through cumulative conjunction, which is given below in (26).

(25) Students from Germany and students from Switzerland met at the conference.

(26) $[\![$students from Germany and students from Switzerland$]\!] =$
$\lambda\alpha.\exists\alpha_1,\alpha_2[\alpha = \alpha_1 \oplus \alpha_2 \wedge [\![$students from G.$]\!](\alpha_1) \wedge [\![$students from Sw.$]\!](\alpha_2)]$

Assuming that each of the plural conjuncts only includes pluralities in its extension, we get a multiple plurality meaning for the conjoined NP subject; this is shown graphically in Figure 3.2. The conjoined plural predicates in (1) receive a similar interpretation.

(27) $[\![$gvoh-**im** ve-nemux-**im**$]\!] =$
$\lambda\alpha.\exists\alpha_1,\alpha_2[\alpha = \alpha_1 \oplus \alpha_2 \wedge [\![$gvoh-**im**$]\!](\alpha_1) \wedge [\![$nemux-**im**$]\!](\alpha_2)]$

A further point to note is that the denotations of *gvoh-im* 'tall-pl' and *nemux-im* 'short-pl' are necessarily disjoint. The objects α_1 and α_2 in the above formula must therefore

be non-overlapping, and since each of them is a plurality, their join α is a multiple plurality. If α_1 and α_2 were allowed to overlap then a simple plurality of children, each of whom is both tall and short, would suffice to make sentence (1) true. But this is impossible, given the lexical meanings "tall" and "short". Cumulative conjunction, combined with the incompatibility of the meanings "tall" and "short", gives rise to multiple plurality in (1).

I have argued that coordinate predicates can be interpreted through cumulative conjunction, an operation which is distinct from the intersective conjunction that shifts all coordination to the type of propositions t. It is interesting to note that in sentences like the ones below, where one of the conjuncts is modified by a propositional adverbial (*perhaps*), there can be no cumulative interpretation.

(28) #ha-yelad-im gvoh-im ve-ulay   nemux-im
　　　 the-child-pl tall-pl   and-perhaps short-pl

(29) #The children are tall and perhaps short.

The above sentences are incoherent; they definitely can't mean "some of the children are tall, and the others are perhaps short". This is explained if the adverbial *perhaps* in such sentences mandates a propositional interpretation of *and* (Schein 1997), since in that case there is no source for the cumulative reading.

3.4   Conjunction weakening

If cumulative conjunction is available for predicates, we should expect to see cumulative conjunction with all kinds of coordinated expressions. However, we only see cumulative conjunction when the predicates are incompatible in their meaning, as are "tall" and "short". In other cases the only reading we get is one with intersective (propositional) conjunction.

(30) ha-yelad-im gvoh-**im** ve-raz-**im**
　　　 the-child-pl tall-**pl**   and-thin-**pl**

(31) The children are tall and thin.

Sentences (30) and (31) are virtually identical in meaning; unlike (1) and (2) they entail the sentence *the children are tall*, and the Hebrew sentence does not have a multiple plurality requirement. This is all expected if *and* is interpreted as intersective conjunction. But how come the above sentences are not ambiguous between an intersective and a cumulative reading?

The answer lies in the strongest meaning hypothesis (Winter 1996, 2001, following work on reciprocals by Dalrymple *et al.* 1994, 1998). This hypothesis states that plural predicates receive an interpretation using "the logically strongest truth conditions … that are not contradicted by known properties of the singular predicate(s)" (Winter 2001, p. 342). Intersective conjunction is stronger than cumulative conjunction, because (the characterizing set of) the intersective conjunction of predicates is a subset of (the characterizing set of) their cumulative conjunction.

(32) Suppose the intersective conjunction of two predicates *A* and *B* is true of an object α.

$$A(\alpha) \wedge B(\alpha)$$

Now for any α, $\alpha = \alpha \oplus \alpha$. The following formula is therefore true (just choose $\alpha_1 = \alpha_2 = \alpha$).

$$\exists \alpha_1, \alpha_2 [\alpha = \alpha_1 \oplus \alpha_2 \wedge A(\alpha_1) \wedge B(\alpha_2)]$$

Therefore the cumulative conjunction of *A* and *B* is also true of α.

The strongest meaning hypothesis thus states that the weaker form, i.e. cumulative conjunction, is only available when the stronger (intersective) one is contradictory (this idea is already present in Krifka 1990). Given the architecture of our theory, the strongest meaning hypothesis is a filtering strategy: from the two meanings for coordination it selects the strongest one which is consistent. A similar architecture is advocated by Dalrymple *et al.* (1994, 1998).

An alternative is Winter's own rendering of the strongest meaning hypothesis. In his theory conjunction is always intersective; plural objects are formed only in the nominal domain, as a result of type shifts that apply to DPs. In this architecture, the strongest meaning hypothesis has to be seen as a repair strategy: coordination of predicates is always strong (intersective), but when the result is contradictory the meaning is weakened. Weakening is a general process that applies to a variety of constructions, and in the case of coordinate structures it yields a reading which is virtually identical to what would be derived via cumulative conjunction.

I believe that multiple plurality gives reasons to adopt the view that the strongest meaning hypothesis is a filtering strategy rather than a repair strategy. There exist sentence pairs where intersective conjunction yields identical but contradictory readings for the two sentences, while cumulative conjunction assigns the sentences readings that differ with regard to multiple plurality. Since the intersective readings of the two sentences are the same, a repair strategy would have to build additional factors into the repair mechanism, namely the interpretation of plural morphology; in the filtering architecture, multiple plurality is already a consequence of cumulative conjunction. The remainder of this section presents the data and goes through the argument in detail.

Sentence (33) below, with plurality marked on each conjunct, is subject to a multiple plurality requirement, so it requires at least two children of each age; sentence (34), with plurality marked above the conjunction, does not have such a requirement, and it can be true with one child of each age. These judgments are very robust (I have not found a good English gloss for *ben*; the construction *ben n* means "*n* years old").

(33) ha-yelad-im bn-**ei**   šeš ve-bn-**ei**   ševa
      the-child-pl ben-**pl** six and-ben-**pl** seven
      "The children are six years old and seven years old."

(34) ha-yelad-im bn-**ei**   šeš ve-ševa
      the-child-pl ben-**pl** six and-seven
      "The children are six and seven years old."

The above readings are indeed the result of conjunction weakening: sentences with similar structures but non-contradictory predicates do not have such readings. In (35)

and (36) the predicates are compatible; the sentences are synonymous, and each entails both that the children are black-eyed and that the children are black-haired. Neither sentence exhibits multiple plurality.

(35) ha-yelad-im šxor-**ei** ‘enayim ve-šxor-**ei** se‘ar
the-child-pl black-**pl** eyes and-black-**pl** hair
"The children are black-eyed and black-haired."

(36) ha-yelad-im šxor-**ei** ‘enayim ve-se‘ar
the-child-pl black-**pl** eyes and-hair
"The children are black-eyed and -haired."

By embedding the predicates of (33) and (34) in a temporal clause we can see a nice illustration that it is the contradiction between being six years old and being seven years old that allows conjunction weakening. Sentences (37) and (38) are ambiguous—they each have a reading where the temporal clause denotes a single time interval, as well as a reading which is interpreted as a conjunction of temporal clauses (how the latter reading comes about is a separate problem which would take us too far away from the present discussion; for our purposes it is sufficient to note that this reading exists).

(37) ha-yelad-im bikr-u ecel doda klara kše-hem hay-u bn-**ei** šeš ve-bn-**ei**
the-child-pl visited-pl at aunt Clara when-they was-pl ben-**pl** six and-ben-**pl**

ševa
seven

"The children visited Aunt Clara when they were six years old and seven years old."

(38) ha-yelad-im bikr-u ecel doda klara kše-hem hay-u bn-**ei** šeš ve-ševa
the-child-pl visited-pl at aunt Clara when-they was-pl ben-**pl** six and-seven
"The children visited Aunt Clara when they were six and seven years old."

On the single time reading (the children visited Aunt Clara once, at a time when they were six and seven) the sentences differ with respect to multiple plurality: sentence (37) requires at least two children of each age, like (33), while sentence (38) is fine with only one of each age, like (34). On the multiple time reading (the children visited Aunt Clara when they were six and when they were seven) the sentences are synonymous, and neither requires more than two children altogether. This is because visiting at the age of six and visiting at the age of seven are not contradictory, so conjunction is interpreted as intersective.

How do we get the difference in meaning between (33) and (34)? Let's first show that the predicates turn out to be contradictory on the intersective interpretation of *and*. I take the denotation of *ben* to be a relation between individuals and lengths of time; $[\![ben]\!](\alpha, \tau)$ is true if α is an individual of age τ. The words *šeš* and *ševa* denote the lengths of six years and seven years, respectively (numerals denote length in years by convention, just like in English *she is six*; for ages that are not measured in years the unit length must be given explicitly, as in *ben šiša xodašim* 'six months old'). Given these meanings, we can derive the denotations of the predicates *bnei šeš ve-bnei ševa*

and *bnei šeš ve-ševa* (the metalanguage symbols 6 and 7 stand for the lengths of six years and seven years, respectively).

(39) $[\![\text{bnei šeš ve-bnei ševa}]\!] = [\![\text{bnei šeš}]\!] \sqcap [\![\text{bnei ševa}]\!]$
   $= \lambda\alpha.[\![\text{bnei}]\!](\alpha,6) \sqcap \lambda\alpha.[\![\text{bnei}]\!](\alpha,7)$
   $= \lambda\alpha.[\![\text{bnei}]\!](\alpha,6) \wedge [\![\text{bnei}]\!](\alpha,7)$

(40) $[\![\text{šeš ve-ševa}]\!] = \lambda P.P(6) \wedge P(7)$
   $[\![\text{bnei šeš ve-ševa}]\!] = \lambda T \lambda\alpha.T(\lambda y.[\![\text{bnei}]\!](\alpha,y))([\![\text{šeš ve-ševa}]\!])$
   $= \lambda\alpha.\lambda P.P(6) \wedge P(7)(\lambda y.[\![\text{bnei}]\!](\alpha,y))$
   $= \lambda\alpha.[\![\text{bnei}]\!](\alpha,6) \wedge [\![\text{bnei}]\!](\alpha,7)$

We see that on the strong interpretation of *and*, the predicate *bnei šeš ve-ševa* turns out to have the same meaning as *bnei šeš ve-bnei ševa*. This meaning is contradictory (assuming an "exactly" reading of age numerals, where a seven year old is not also six years old), so the strongest meaning hypothesis will apply. The strongest meaning hypothesis must yield different readings for (33) and (34): the former must receive a multiple plurality reading, while the latter must not.

   The current model will give each predicate the meaning derived independently by cumulative conjunction. In (33), where two full predicates are coordinated, the predicate will receive a reading akin to (27).

(41) $[\![\text{bnei šeš ve-bnei ševa}]\!] =$
   $\lambda\alpha.\exists\alpha_1,\alpha_2[\alpha = \alpha_1 \oplus \alpha_2 \wedge [\![\text{bnei šeš}]\!](\alpha_1) \wedge [\![\text{bnei ševa}]\!](\alpha_2)]$

In (34), coordination takes place at the level of the object, below the predicate. I will assume that expressions of type *eet*, like transitive verbs and *bnei*, allow a cumulative relation between their arguments (Scha 1981); plural morphology on transitive *bnei* restricts its subject to pluralities, in a manner analogous to that in (11).

(42) $[\![\text{bnei}]\!] = \lambda\beta\lambda\alpha.\alpha \in \text{PL} \wedge \exists n,m \in \mathbb{N},\alpha_1,\dots,\alpha_n,\beta_1,\dots,\beta_m[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n$
   $\wedge \beta = \beta_1 \oplus \cdots \oplus \beta_m \wedge \forall i \leq n \exists j \leq m [[\![\text{ben}]\!](\alpha_i,\beta_j)]$
   $\wedge \forall j \leq m \exists i \leq n [[\![\text{ben}]\!](\alpha_i,\beta_j)]]$

(43) $[\![\text{bnei šeš ve-ševa}]\!] = [\![\text{bnei}]\!](6 \oplus 7)$
   $= \lambda\alpha.\alpha \in \text{PL} \wedge \exists n \in \mathbb{N},\alpha_1,\dots,\alpha_n[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n$
   $\wedge \forall i \leq n [[\![\text{ben}]\!](\alpha_i,6) \vee [\![\text{ben}]\!](\alpha_i,7)]$
   $\wedge \exists i \leq n [[\![\text{ben}]\!](\alpha_i,6)] \wedge \exists i \leq n [[\![\text{ben}]\!](\alpha_i,7)]]$

Our model thus produces the desired readings: the meaning in (41) is multiply plural while that in (43) is not.

   As a repair strategy, the strongest meaning hypothesis would have to weaken the meaning derived through intersective conjunction in (39)/(40). According to the theory presented in Winter (1996, 2001), coordination of the nominals *šeš* and *ševa* could in fact receive a cumulative interpretation (precisely because they are nominals), but the assumption there is that the plural marker on the predicate in (34)/(40) is inherently distributive, so the meaning of the predicate turns out to be the same. The meaning of the conjoined predicate in (39) is identical to that in (40), so if we want to sustain

a repair architecture and still get distinct weakened readings, the weakening process must have access to the units below the level of the conjoined predicate.

Let us be a bit more explicit about what a repair theory would look like if we wanted it to account for the multiple plurality facts. Winter (1996, 2001) defines weakening at the propositional level based on the *normal universal form* of the proposition (a form involving only universal quantification), which is derived from the proposition's basic meaning relative to a tuple of predicates involved. We have seen that the basic meaning of the predicates in (33) and (34) is the same, namely the one derived in (39)/(40). The difference must be attributed to the tuple of predicates which make up the normal universal form: for (33) it will be the two unary predicates *bnei šeš* and *bnei ševa*, whereas for (34) it will be the single binary predicate *bnei*. In Winter's system pluralities are not mereological sums but rather sets of individuals, and predication takes place on the individuals that make up these sets. The normal universal forms of (33) and (34) will therefore be as follows.

(44) ⟦ha-yelad-im bnei šeš ve-bnei ševa⟧
$= \forall \alpha \in$ ⟦ha-yelad-im⟧$\forall \beta \in \{$⟦bnei šeš⟧, ⟦bnei ševa⟧$\} : \beta(\alpha)$

(45) ⟦ha-yelad-im bnei šeš ve-ševa⟧
$= \forall \alpha \in$ ⟦ha-yelad-im⟧$\forall \tau \in \{6, 7\} :$ ⟦bnei⟧(α, τ)

The weakened reading is derived from the normal universal form in light of some known lexical properties of the predicates involved, in this case the knowledge that a child cannot be six and seven years old at the same time. In the weakened reading, the universal quantifiers of the normal universal form are replaced by the requirement that the number of relations be maximal, given the above lexical knowledge. Now for both sentences, the weakened reading will be true if each child is either six or seven, since any additional instantiations of the relations in (44) and (45) would contradict the lexical knowledge.

We still haven't derived distinct meanings for the two sentences above, that is we haven't accounted for the multiple plurality requirement of (33). Worse, the weakened reading as it stands does not even capture the correct truth conditions without multiple plurality: the relations in (44) and (45) are maximized if all of the children are of one age (say six), so in such a case the sentences are predicted to be true, contrary to intuition. One line of defense (Yoad Winter, personal communication) is that in the above situation the sentences are pragmatically inappropriate, just like a disjunction implies that both of the disjuncts are applicable. I believe this line of defense doesn't hold, in light of the following contrast.

(46) The children are six or seven—in fact, they're all six.

(47) #The children are six and seven—in fact, they're all six.

Sentence (46) shows that the disjunction gives rise to a conversational implicature; it can be canceled with additional context. This is not the case in (47), where the addition makes the sentence contradictory. The requirement that each of the conjuncts should be instantiated is therefore stronger than a conversational implicature. In a weakening

theory, this requirement has to be explicitly made part of the strongest meaning hypothesis; however, this requirement is already built into the definition of cumulative coordination, so in the architecture advocated here, where the strongest meaning hypothesis chooses between two independently constructed meanings, no additions have to be made (Heycock and Zamparelli 1999, 2000 make a similar observation: cumulative or "split" coordination requires at least one element from each conjunct; this is built into their semantics through the set product operation, which is isomorphic to the cumulative conjunction used here).

Now we can see how a weakening theory would deal with the multiple plurality requirement of sentence (33): we first require that every conjunct be instantiated by at least one relationship (as deemed necessary by the discussion in the preceding paragraph), and then add the requirement that every *plural* conjunct be instantiated by at least *two* relationships. This complicates the definition of a weakened reading, but it seems necessary in light of the data.

How does this compare to the filtering architecture? In the modification I have just proposed to the weakening theory, plural morphology plays a double role: predicates that apply to plural arguments must have a plural denotation (which includes singular individuals), regardless of morphology; in addition, the definition of weakened readings must refer explicitly to plural morphology. This latter role is remarkably similar to the claim that morphologically plural expressions, including plural predicates, literally denote pluralities. In the filtering theory this applies generally, while in the modified weakening theory it is specific to the weakening process. The main difference between the theories, then, comes out to be that the filtering approach accepts cumulative conjunction, whereas the modified weakening theory derives these effects in a roundabout way. The weakening theory fits in well with Winter's program, which sets out to show that conjunction is always intersective, and any apparent cumulative effects come about as the result of independent processes. The cost, however, is the admission of a weakening process which includes an ad-hoc mechanism that is built specifically to mimic cumulative conjunction and multiple plurality.

3.5   Conjunction of singular predicates

Admitting non-propositional conjunction for predicates leads to the expectation that the cumulative conjunction of two singular predicates should yield a plural predicate. After all this is what happens with the coordination of proper names, e.g. *John and Mary*, as well as other nominals. But for APs and VPs this is hopelessly wrong.

(13) *ha-yelad-im gavoah ve-namux
        the-child-pl tall.sg   and-short.sg

(48) *dani   ve-yosi   gavoah ve-namux
        Danny and-Yossi tall.sg   and-short.sg

(49) *John and Bill eats a doughnut and drinks coffee (respectively).

The sentences above are all ill formed, even though the intended meaning is perfectly clear. Having a coordinate subject in (48) or the word *respectively* in (49) doesn't help.

Based on the interpretation of conjoined plural predicates, I have argued above that the semantics should allow cumulative conjunction; it would seem odd if this were not available for singular predicates. Indeed, it seems to me that the problem in the above sentences is not with the meaning, but with the syntax.

We may note that coordination of singular NPs in Hebrew is syntactically plural, but coordination of singular APs is singular. We can illustrate this with words that are ambiguous between nouns and adjectives, for instance color terms like *adom* 'red' and *šaxor* 'black'. As color names these words are nouns, and when coordinated they form a plural NP (50); note the obligatory use of the pronominal copula (cf. sentence (19) on page 41). When color terms function as adjectives their conjunction cannot be predicated of a plural subject (51).

(50) ha-cvaʕ-im ba-tmuna   hem adom ve-šaxor
      the-color-pl in.the-picture PR   red.sg and-black.sg
      "The colors in the picture are red and black"

(51)*ha-dgal-im ba-tmuna   adom ve-šaxor
      the-flag-pl in.the-picture red.sg and-black.sg

I believe the above contrasts are not due to a difference in meaning, or to differences in the availability of cumulative conjunction between nouns and adjectives. Indeed, when the adjectives are plural as in (52) below, we do get a coherent reading, with cumulative conjunction and multiple plurality.

(52) ha-dgal-im ba-tmuna   adum-im ve-šxor-im
      the-flag-pl in.the-picture red-pl   and-black-pl
      "The flags in the picture are red and black"

(Multiple plurality obtains when we require each flag to be of one color—then we need at least two red flags and two black ones to make the sentence true. The sentence is also true with just two flags in case each flag has two colors, red and black. Winter 2001 argues that the latter kind of reading—part of each flag is red and the other is black— is not an instance of conjunction weakening, following the observation by Lasersohn 1995 that such readings do not exist for the majority of predicates, but are limited to colors and material adjectives. Lasersohn's proposal is that color combination predicates like *red and black* are derived from coordinate NPs; in light of example (51), we should note that the operation that derives such adjectives must convert the coordination of singular nouns, a plural NP, into a singular adjective.)

Our conclusion is that on top of the semantic interpretation of plurality, there are syntactic requirements of agreement; these prevent cumulative conjunction from surfacing on singular adjectives in general, even though semantically there is no reason why cumulative conjunction should not be available.

3.6   Attributive adjectives

I have mentioned in the introduction that the same pattern of multiple plurality that we have seen on predicative adjectives also exists with attributive adjectives that are morphologically plural. Examples (4) and (5) in Italian and English are repeated below.

(4) I   biscott-**i** quadrat-**i** e   rotond-**i** sono al   cioccolato,
     the cookie-**pl** square-**pl** and round-**pl** are   PREP+DEF chocolate

     e   quello triangolare è alla   vaniglia.
     and that   triangular   is PREP+DEF vanilla

(5) The square and round cookies are chocolate, and the triangular one is vanilla.

As expected, English (5) can talk about three cookies, one of each shape, while Italian (4) requires at the minimum two square cookies and two round ones. Not surprisingly, Hebrew patterns like Italian—the following sentence says that there are at least two square cookies and two round ones.

(53) ha-ugiy-**ot**   ha-meruba-**ot** ve-ha-agul-**ot**   hen be-taʿam šokolad,
     the-cookie-**pl** the-square-**pl** and-the-round-**pl** PR in-taste   chocolate

     ve-ha-mešulešet   be-taʿam vanil.
     and-the-triangular in-taste   vanilla

In Hebrew, an adjective can act as a nominal, as we see above in *ha-mešulešet* 'the triangular [one]'; one might think, then, that the coordinate structure above involves coordination of two NPs *[ha-ugiy-ot ha-meruba-ot] ve-[ha-agul-ot]* 'the square cookies and the round [ones]'. The Italian example (4) shows that we get cumulative conjunction in a structure where coordination is unambiguously between adjectives.

   The coordination of singular attributive adjectives in Hebrew is still syntactically singular, so it cannot modify a plural head noun.

(54)*ha-yelad-im ha-gavoah ve-ha-namux   mesaxk-im kadursal
     the-child-pl the-tall.sg and-the-short.sg play-pl   basketball

This has to be qualified: the above string is acceptable with an intonation break separating the coordinate adjective from the rest of the sentence.

(55) ha-yelad-im, ha-gavoah ve-ha-namux,   mesaxk-im kadursal
     the-child-pl   the-tall.sg and-the-short.sg play-pl   basketball
     "The children, the tall one and the short one, are playing basketball"

The coordinate structure here is appositive, and this is another instance of adjectives acting as nominals without a head noun. We can verify that this is indeed the case by trying to modify the adjectives with degree phrases—the result is ungrammatical.

(56)*ha-yelad-im, ha-gavoah mi-meter   va-xeci ve-ha-namux   mi-meter   šlošim,
     the-child-pl   the-tall.sg than-meter and-half and-the-short.sg than-meter thirty

     mesaxk-im kadursal
     play-pl   basketball

     "The children, the taller than 1.50m and shorter than 1.30m. . . "

We also note that the adjectives in the appositive structure do not have to be contradictory, so this is not a case of conjunction weakening.

(57) ha-yelad-im, ha-gavoah ve-ha-raze,　　mesaxk-im kadursal
　　　the-child-pl　the-tall.sg　and-the-thin.sg play-pl　　basketball
　　　"The children, the tall one and the thin one, are playing basketball"

Rather, these appositive constructions are simply coordinations of NPs. Coordinate singular adjectives are singular, whether predicative or attributive.

　　Cumulative readings also show up with coordinate adjectives that are not intersective and cannot appear in predicative position at all, like *former and current*.

(58)　The Bush family gathered for dinner at their Texas ranch; the former and current presidents argued the whole time.

Assuming that adjectives like *former* and *current* are of type $(et)et$, the interpretation of (58) requires cumulative conjunction for that type (see Krifka 1990 for an attempt to generalize cumulative conjunction beyond type et). In Hebrew, the translation of *the former and current presidents* results in a multiply plural NP, with at least two former presidents and two current ones.

(59)　ha-nesi-**im**　　　ha-kodm-**im**　ve-ha-noxexiy-**im**
　　　the-president-**pl** the-former-**pl** and-the-current-**pl**

The only way to say sentence (58) in Hebrew is with an intonation break around the coordinate structure, making it a coordination of singular NPs rather than adjectives.

(60)*ha-nesi-im　　　　ha-kodem　　ve-ha-noxexi　　hitvakxu kol ha-zman
　　　the-president-pl the-former.sg and-the-current.sg argued　all　the-time

(61)　ha-nesi-im,　　　ha-kodem　　ve-ha-noxexi,　　hitvakxu kol ha-zman
　　　the-president-pl the-former.sg and-the-current.sg argued　all　the-time
　　　"The presidents, the former one and the current one, argued the whole time"

3.7　Conclusion

I have argued that multiple plurality should be taken as evidence that plural morphology on an expression excludes singularities from its denotation, and that cumulative conjunction is an operation that is generally available. The existence of cumulative conjunction on adjectives gives additional force to the claim that it is available for nominals too. This semantics of plurality and conjunction will be used in chapter 4 to explain the difference between the coordination of whole words (*orthodontists and periodontists*) and that of parts of words (*ortho and periodontists*).

　　The limited occurrence of cumulative conjunction on adjectives is the result of the strongest meaning hypothesis. But why does the strongest meaning hypothesis exist in the first place, that is, why should natural language employ such a filtering strategy when it tolerates ambiguity in many other places? And why should this filtering strategy apply to adjectives, when coordinated nominals routinely receive a cumulative interpretation? Adopting Winter's architecture, where the strongest meaning hypothesis is a repair strategy, only reverses the question: why does natural language employ such a repair strategy, while other structures are simply understood as contradictory? I

do not have an answer to this question, but the data suggest that it may be related to the question of syntactic number: how come coordinated singular APs form a singular AP, whereas coordinated singular NPs form a plural NP. The difference does not seem to lie in the semantics of coordination, because cumulative coordination is available for plural adjectives.

Another question concerns speaker variation: as I mentioned in the introduction, some speakers of Hebrew and Spanish accept sentences (1) and (3) with a weaker multiple plurality effect, whereby only one of the conjuncts must have a plural referent (all speakers reject the sentences if all conjuncts have single referents). My theory does not predict that such variation should be possible. At the moment I do not see how this can be treated without an ad hoc stipulation, so I leave the question open.

Chapter 4

Coordination of parts of words

4.1 Introduction

In this chapter I argue that the correct interpretation of coordination of parts of words, as in (1) below, requires a semantics that interprets coordination at the level of the visible string, thus assigning separate meanings to the word parts *ortho*, *perio*, and *dontists* (an orthodontist is a specialist in straightening teeth; a periodontist specializes in gums and supporting structures).

   (1) ortho and periodontists

The chapter develops such a semantics, which is based on the principle of phonological decomposition from chapter 2 (to be reiterated shortly); it also explores the phonological constraints on coordinate structures below the word level.

    The evidence that interpretation has to be at surface level comes from plural morphology. Specifically, the NP *ortho and periodontists* is not synonymous with *orthodontists and periodontists*. Suppose that Bill is an orthodontist and Martha is a periodontist; then sentence (2a) below has a reading on which it is true, whereas sentence (2b) does not have a true reading.

   (2)   a. Bill and Martha are ortho and periodontists.   (true)

         b. Bill and Martha are orthodontists and periodontists.   (false)

The contrast is similar to the ones below: if Mike is married to Mary and Jim is married to Jill, then (3a) is true and (3b) is false. Also, sentence (4a) can be true, while (4b) is incoherent.

   (3)   a. Mike and Jim are husbands of Mary and Jill.   (true)

         b. Mike and Jim are husbands of Mary and husbands of Jill.   (false)

   (4)   a. Konishki and Takanohana are heavy and light sumo wrestlers.

        b.#Konishki and Takanohana are heavy sumo wrestlers and light sumo wrestlers.

The explanation of the last two contrasts is straightforward: sentence (3a) can be true in a monogamous situation because the noun *husbands* allows a cumulative relation between its two plural arguments (Scha 1981), while in (3b) each predicate conjunct is plural, so each must apply to a plural argument. In sentence (4a) the coordinate adjective *heavy and light* modifies the head noun *sumo wrestlers*; the entire NP is plural, but it can felicitously apply to a pair of one heavy sumo wrestler and one light one. The predicate in sentence (4b) is formed by coordinating two plural NPs; it thus implies that each of the sumo wrestlers is both heavy and light.

Both of these contrasts are the consequence of coordination at different syntactic levels—sentences (3a) and (4a) have coordination below the level of the predicate, while in (3b) and (4b) coordination is between predicates. Drawing on this parallel, we conclude that in (1) the conjunction *and* operates on the word parts *ortho* and *perio*. The structure relevant to interpretation must therefore be (5) below, with coordination at the surface level.

(5) [ortho and perio]dontists

The challenge, then, is to provide a semantics for word parts that will allow us to interpret structures like (5) with the correct truth conditions; this would require assigning separate meanings to the word parts *ortho*, *perio*, and *dontists*. We do want to preserve the meaning of the conjunction *and*—intuitively, it has the same meaning in (5) as it has elsewhere in the language.

I propose that the desired semantics can be formulated through the use of phonological decomposition, which derives the meanings of *ortho* and *dontist* from the meaning of *orthodontist*: in a construction like (5), the coordinate word parts denote strings of sound, and the rest of the word is a function from sounds to word meanings. The ordinary interpretation of conjunction then allows these denotations to combine, and results in the correct meaning for the full NP *ortho and periodontists*.

The semantics necessary for interpreting coordination of parts of words is developed in section 4.2. Section 4.3 looks at phonological constraints on the coordination of word parts, which are important in ruling out certain configurations predicted possible by the semantics. Finally, section 4.4 compares the present approach to previous suggestions in the literature, which offered to explain coordination of parts of words as the product of a deletion rule.

4.2   A semantics for the coordination of word parts

4.2.1   Plurality and conjunction

Our semantics will have to capture the following difference: the NP *ortho and periodontists* can denote a pair of people, one of whom is an orthodontist and the other a periodontist, while *orthodontists and periodontists* cannot denote such a pair: it can either denote a pair of people who are each both an orthodontist and a periodontist, or a group of people of whom at least two are orthodontists and two periodontists. The source of the difference is the location of plural morphology: there is one plural morpheme on the entire NP *ortho and periodontists*, whereas in *orthodontists and periodontists* there is a plural morpheme on each conjunct.

The underlying theory of plurality and conjunction that will be used in deriving the contrast between the above two NPs is the theory developed in chapter 3; it includes the following elements.

(6) Plurality is represented via a structured domain of individuals; plural objects are formed by a join operation $\oplus$, and are of the same type as singular individuals, namely type e. (Leonard and Goodman 1940)

(7) Plural morphology is interpreted as semantic plurality: plural expressions only include pluralities in their extension. (see for example Chierchia 1998)

(8) Coordination can receive a cumulative (plural-forming or "non-Boolean") interpretation. (Link 1983; Krifka 1990)

The assumptions about plurality (6) and (7) state that plural NPs like *orthodontists* and *periodontists* denote sets of strictly plural objects.

(9) $[\![\text{orthodontists}]\!] =$
$\lambda\alpha.\alpha \in \text{PL} \wedge \exists n \in \mathbb{N}, \alpha_1, \ldots, \alpha_n[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \wedge \forall i \leq n[[\![\text{orthodontist}]\!](\alpha_i)]]$

$[\![\text{periodontists}]\!] =$
$\lambda\alpha.\alpha \in \text{PL} \wedge \exists n \in \mathbb{N}, \alpha_1, \ldots, \alpha_n[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \wedge \forall i \leq n[[\![\text{periodontist}]\!](\alpha_i)]]$

(I interpret natural language directly rather than through the use of a translation language. For conciseness and clarity I will often use variables and functional notation in my exposition, these are to be understood as part of the metalanguage and do not constitute a formal translation language. The symbol PL stands for the set of pluralities, that is individuals that are not atomic).

As for coordination, the assumption in (8) states that when *and* coordinates expressions of type e it can denote the join operation on the domain of individuals $\oplus$.

(10) $[\![\text{Bill and Martha}]\!] = [\![\text{Bill}]\!] \oplus [\![\text{Martha}]\!]$

Cumulative conjunction for common nouns (type et) is defined as follows: an object α is in the denotation of a coordinate common noun if it is the join of two objects α_1 and α_2, where α_1 is in the denotation of the first conjunct and α_2 is in the denotation of the second (Link 1983; Krifka 1990).

(11) $[\![\text{orthodontists and periodontists}]\!] =$
$\lambda\alpha.\exists\alpha_1, \alpha_2[\alpha = \alpha_1 \oplus \alpha_2 \wedge [\![\text{orthodontists}]\!](\alpha_1) \wedge [\![\text{periodontists}]\!](\alpha_2)]$

We thus get the desired reading for *orthodontists and periodontists*: there must be at least two orthodontists and two periodontists in any group denoted by (11); it may be the same individuals who are practitioners of both kinds, or different individuals (in the latter case the size of the group is greater than two).

4.2.2   Phonological decomposition

We now turn to the NP *ortho and periodontists*. The denotation of this NP can include groups consisting of just one orthodontist and just one periodontist, and we want to

capture this in a similar fashion to the NPs *husbands of Mary and Jill* and *heavy and light sumo wrestlers*. In order to do so we must assign an interpretation to the word parts *ortho*, *perio* and *dontist*. My proposal is to derive the meanings for the word parts from the meanings of the complete words through phonological decomposition, in a manner similar to that proposed in chapter 2: the denotations of the word parts will form a function-argument structure that, when put together, will retrieve the meanings of the original words. The singular common nouns *orthodontist* and *periodontist* denote properties of individuals (type *et*). I will assume that *ortho* and *perio* simply denote strings of sounds, which are individuals of type *e*.

(12)   a. $[\![\text{ortho}]\!] \in D_e$: the string *ortho*.

      b. $[\![\text{perio}]\!] \in D_e$: the string *perio*.

Given the denotations of *ortho* and *perio*, the semantics will have to give *dontist* a functional meaning of type *eet*, like that of a transitive verb: it will take as its first argument an object whose meaning is a string of sounds, and return the meaning of the word which is the concatenation of that string with the string *dontist* (see the discussion in chapter 2 following example (19) on page 16 for notes on the following representation).

(13) $[\![\text{dontist}]\!] \in D_{eet}$: the function $h : D_e \to D_{et}$ such that for all $\alpha \in D_e$, $h(\alpha) = [\![\alpha\text{dontist}]\!]$ if $\alpha dontist$ is a word and $[\![\alpha\text{dontist}]\!] \in D_{et}$, undefined otherwise.

With the above definition, the composition of *dontist* with *ortho* and with *perio* yields the expected results.

(14)   a. $[\![\text{dontist}]\!]([\![\text{ortho}]\!]) = [\![\text{orthodontist}]\!]$

      b. $[\![\text{dontist}]\!]([\![\text{perio}]\!]) = [\![\text{periodontist}]\!]$

We now have the building blocks that derive the meaning of *ortho and periodontists*. Starting with the constituent *ortho and perio*, we notice that *and* operates here between two objects of type *e*, so the meaning of the coordinated constituent is the join of these objects, that is a plural object of type *e* (just like *Bill and Martha*).

(15) $[\![\text{ortho and perio}]\!] = [\![\text{ortho}]\!] \oplus [\![\text{perio}]\!] \in D_e$

Now *dontists* has to apply to this object—it is, after all, of the right type. The meaning of plural *dontists* will be derived from the meaning of singular *dontist* by restricting its subject (the outer argument) to plurals and allowing a cumulative relation between its two arguments, as is the case with plural transitive verbs (Scha 1981). We get the following meaning for plural *dontists*.

(16) $[\![\text{dontists}]\!] =$
$\lambda\beta\lambda\alpha.\alpha \in \text{PL} \wedge \exists n,m \in \mathbb{N}, \alpha_1,\ldots,\alpha_n, \beta_1,\ldots,\beta_m[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \wedge \beta = \beta_1 \oplus \cdots \oplus \beta_m \wedge \forall i \leq n \exists j \leq m \, [[\![\text{dontist}]\!](\alpha_i,\beta_j)] \wedge \forall j \leq m \exists i \leq n \, [[\![\text{dontist}]\!](\alpha_i,\beta_j)]]$

Applying the meaning of *dontists* in (16) to the meaning of *ortho and perio* in (15) will give us the meaning of the NP *ortho and periodontists*.

(17) $\llbracket \text{dontists} \rrbracket (\llbracket \text{ortho} \rrbracket \oplus \llbracket \text{perio} \rrbracket)$
$$\begin{aligned}
&= \lambda\alpha.\alpha \in \text{PL} \wedge \exists n, m \in \mathbb{N}, \alpha_1, \ldots, \alpha_n, \beta_1, \ldots, \beta_m [\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \\
&\qquad \wedge (\llbracket \text{ortho} \rrbracket \oplus \llbracket \text{perio} \rrbracket) = \beta_1 \oplus \cdots \oplus \beta_m \\
&\qquad \wedge \forall i \leq n \exists j \leq m [\llbracket \text{dontist} \rrbracket(\alpha_i, \beta_j)] \wedge \forall j \leq m \exists i \leq n [\llbracket \text{dontist} \rrbracket(\alpha_i, \beta_j)]] \\
&= \lambda\alpha.\alpha \in \text{PL} \wedge \exists n \in \mathbb{N}, \alpha_1, \ldots, \alpha_n [\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \\
&\qquad \wedge \forall i \leq n [\llbracket \text{dontist} \rrbracket(\alpha_i, \llbracket \text{ortho} \rrbracket) \vee \llbracket \text{dontist} \rrbracket(\alpha_i, \llbracket \text{perio} \rrbracket)] \\
&\qquad \wedge \exists i \leq n [\llbracket \text{dontist} \rrbracket(\alpha_i, \llbracket \text{ortho} \rrbracket)] \wedge \exists i \leq n [\llbracket \text{dontist} \rrbracket(\alpha_i, \llbracket \text{perio} \rrbracket)]] \\
&= \lambda\alpha.\alpha \in \text{PL} \wedge \exists n \in \mathbb{N}, \alpha_1, \ldots, \alpha_n [\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \\
&\qquad \wedge \forall i \leq n [\llbracket \text{orthodontist} \rrbracket(\alpha_i) \vee \llbracket \text{periodontist} \rrbracket(\alpha_i)] \\
&\qquad \wedge \exists i \leq n [\llbracket \text{orthodontist} \rrbracket(\alpha_i)] \wedge \exists i \leq n [\llbracket \text{periodontist} \rrbracket(\alpha_i)]]
\end{aligned}$$

We find that *ortho and periodontists* denotes the set of all plural objects that are composed of singular individuals where each such individual is either an orthodontist or a periodontist, and at least one such individual is an orthodontist and one is a periodontist. In particular, one such plural object is the join of the orthodontist Bill and the periodontist Martha. So our semantics succeeds in interpreting the NP *ortho and periodontists* at surface level.

The meaning in (16) can take an object of any cardinality, so it is not restricted to operating on coordinate structures of two terms. The meaning of the expression *ortho, perio and endo*, for instance, is the join of the meanings of the individual conjuncts: $\llbracket \text{ortho} \rrbracket \oplus \llbracket \text{perio} \rrbracket \oplus \llbracket \text{endo} \rrbracket$. Plugging this into the meaning of *dontists* in (16) we find that the meaning of *ortho, perio and endodontists* is the set of all plural objects composed of singular individuals where each such individual is either an orthodontist, a periodontist or an endodontist, with at least one individual of each specialty. This correctly captures our intuitions about sentences like *the Kandou sisters are ortho, perio and endodontists*.

4.2.3 Phonological decomposition of singular NPs

Coordination of parts of words is also possible in singular NPs; such coordinate structures can only apply to singular individuals (18), not to pluralities (19).

(18) Bill is an ortho and periodontist.

(19)*Bill and Martha are an ortho and periodontist.

(A reviewer for *Lingua* points out that sentence (19) becomes fine if we add *respectively* at the end: *Bill and Martha are an ortho and periodontist, respectively*. This should be attributed to the semantics of *respectively*, as it does not fall out of the current analysis in a straightforward way. Extending the semantics to incorporate the adverb *respectively* would take us too far from the present discussion, so I leave this as a problem for future research).

The denotation of *dontist* in both (18) and (19) is the function (13), repeated below, derived by phonological decomposition.

(13) $\llbracket \text{dontist} \rrbracket \in D_{eet}$: the function $h : D_e \to D_{et}$ such that for all $\alpha \in D_e$, $h(\alpha) = \llbracket \alpha\text{dontist} \rrbracket$ if $\alpha\textit{dontist}$ is a word and $\llbracket \alpha\text{dontist} \rrbracket \in D_{et}$, undefined otherwise.

This meaning only takes strings of sounds as its first argument, not pluralities. But it should be able to take pluralities—morphologically, the expression *dontist* only specifies that its outer argument is singular. We thus need to allow a cumulative relation between the arguments, the same way as with plural *dontists*, and at the same time restrict the outer argument to singularities only (SG is a metalanguage symbol for the set of all singularities, that is atomic individuals).

(20) Let $\mathcal{D}$ be the definition of $[\![\text{dontist}]\!]$ in (13). Then
$$[\![\text{dontist}]\!] = \lambda\beta\lambda\alpha.\alpha \in \text{SG} \wedge \exists n, m \in \mathbb{N}, \alpha_1, \ldots, \alpha_n, \beta_1, \ldots, \beta_m [\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \wedge \beta = \beta_1 \oplus \cdots \oplus \beta_m \wedge \forall i \leq n \exists j \leq m [\mathcal{D}(\alpha_i, \beta_j)] \wedge \forall j \leq m \exists i \leq n [\mathcal{D}(\alpha_i, \beta_j)]]$$

Since α in the above expression is necessarily singular we know that $n = 1$; the expression can thus be simplified as follows.

(21) Let $\mathcal{D}$ be the definition of $[\![\text{dontist}]\!]$ in (13). Then $[\![\text{dontist}]\!] = \lambda\beta\lambda\alpha.\alpha \in \text{SG} \wedge \exists m \in \mathbb{N}, \beta_1, \ldots, \beta_m [\beta = \beta_1 \oplus \cdots \oplus \beta_m \wedge \forall j \leq m [\mathcal{D}(\alpha, \beta_j)]]$

Notice that the cumulative relation in (21) does not depend on plural morphology—it obtains whenever a relation holds between two arguments, at least one of which is plural (see also Schwarzschild 1994, section 5.2 for cumulative relations in singular transitive verbs with plural objects).

The meaning (21), when applied to the plurality $[\![\text{ortho}]\!] \oplus [\![\text{perio}]\!]$, will give the correct meaning for the coordinate structure *ortho and periodontist*.

(22) $[\![\text{dontist}]\!]([\![\text{ortho}]\!] \oplus [\![\text{perio}]\!])$
$= \lambda\alpha.\alpha \in \text{SG} \wedge \exists m \in \mathbb{N}, \beta_1, \ldots, \beta_m [([\![\text{ortho}]\!] \oplus [\![\text{perio}]\!]) = \beta_1 \oplus \cdots \oplus \beta_m$
$\qquad \wedge \forall j \leq m [\mathcal{D}(\alpha, \beta_j)]]$
$= \lambda\alpha.\alpha \in \text{SG} \wedge \mathcal{D}(\alpha, [\![\text{ortho}]\!]) \wedge \mathcal{D}(\alpha, [\![\text{perio}]\!])]$
$= \lambda\alpha.\alpha \in \text{SG} \wedge [\![\text{orthodontist}]\!](\alpha) \wedge [\![\text{periodontist}]\!](\alpha)$

This meaning applies to any individual who is both an orthodontist and a periodontist, but not to pluralities of any kind.

4.2.4   Alternatives to phonological decomposition

Phonological decomposition yields the correct reading for the NP *ortho and periodontists*. Is it possible to get this reading without such a process? In this section I will follow a number of intuitively appealing ideas, and show that when they are fully worked out, they amount to something very similar to phonological decomposition.

The first thing we notice is that the word parts *ortho*, *peri* and *(o)dontist* are morphemes, and as such they have lexical meanings and etymologies. However, I believe that these meanings are largely irrelevant. Many speakers can identify the morpheme *ortho* in words like *orthodontist*, *orthopedics*, *orthography* and *orthodox*, without knowing the etymological meaning of the root and what it contributes to each of these words. More importantly, the root meanings are not the kind of meaning that is associated with a model theoretic entity which can combine with the meaning of *and*. What matters, then, is the ability to recognize *ortho* as part of a bigger word, whose meaning is known; the meanings of the individual morphemes thus have to be derived from the meanings of the words they form.

One alternative to phonological decomposition would be to treat the words *orthodontist* and *periodontist* as idiomatically combining expressions, a term that Nunberg, Sag, and Wasow (1994) use for expressions like *pull strings*: the expression is idiomatic, yet speakers understand each of its constituents as making a distinct contribution to the idiomatic meaning. For instance, the word *strings* in the expression *pull strings* has a meaning roughly equivalent to "connections", and this meaning can act independently—it can be modified by an adjective (23a) or a relative clause (23b), it can be topicalized (23c), and it can be referred to by a pronoun (23d).

(23)   a. pull high-ranking strings

       b. Pat got the job by pulling strings that weren't available to anyone else.

                                                              (Nunberg *et al.* 1994, p. 500)

       c. Those strings, he wouldn't pull for you.   (Nunberg *et al.* 1994, p. 501)

       d. Kim's family pulled some strings on her behalf, but they weren't enough to
          get her the job.   (Nunberg *et al.* 1994, p. 502)

We see that while the parts of *pull strings* have special meanings, the expression as a whole is compositional. Interpreting a word like *orthodontist* as an idiomatically combining expression would involve assigning the word part *dontist* a meaning roughly equivalent to "dental specialist", and giving the word part *ortho* a modifier meaning like "teeth straightener". Of course, these meanings will be restricted to the word parts when they occur in *orthodontist*, so we do not expect to find a word like *ortholinguist meaning "a linguist who straightens teeth", just like we cannot use the word *strings* to mean "connections" outside the context of the expression *pull strings*.

I find a number of problems with this way of assigning meanings to word parts. The motivation for the analysis of certain idioms as compositional expressions is the observation that the parts can also carry the special meanings on their own, as in the examples in (23) above. But we do not find this behavior with word parts like *ortho*, *perio* and *dontist*, so there is less of a reason to think that these parts carry the same kind of special meanings.

Second, the analysis of Nunberg *et al.* (1994) relies on the concept of figuration, and idioms are explained as conventionalized uses of figurative language. We can see that this is true with an expression like *pull strings*: even though *pull* receives a specialized meaning in this expression, it retains the thematic structure of the standard lexical meaning of *pull*. Figuration also explains why near-synonyms are often interchangeable in idiomatically combining expressions (e.g. *hold a gun/pistol to one's head*). However, it is hard to see how the concept of figuration can apply to a word part: it seems intuitively wrong to consider "teeth straightener" to be a figurative meaning of *ortho*, when *ortho* does not have a meaning in the first place.

There still may be another way speakers assign meanings to parts of words, and this is through the use of word paradigms: while the lexical or etymological meanings of the morphemes that make up *orthodontist* and *periodontist* are not model theoretic entities, speakers may use the paradigm to extract suitable model theoretic denotations for the morphemes. We will see that following up on this idea leads to results that basically amount to phonological decomposition.

The idea behind this approach is that speakers use the phonological and semantic similarities of the words *orthodontist* and *periodontist* (as well as other words in this paradigm) to assign meanings to the morphemes: the morpheme *dontist* will receive the meaning component that is common to all the words in the paradigm—presumably something like "dental specialist"—while the morphemes *ortho* and *perio* will have the meaning components that are unique to *orthodontist* and *periodontist*, respectively. What could these meanings be? We can not treat *ortho* and *perio* as intersective modifiers, in a manner analogous to *heavy and light sumo wrestlers*, that is treat *dontist* like we would treat a common noun of type *et*, and *ortho* and *perio* like intersective adjectives of the same type, so that $[\![ortho]\!]([\![dontist]\!]) = \lambda\alpha.[\![ortho]\!](\alpha) \wedge [\![dontist]\!](\alpha)$. The reason is that under such a semantics, the composed predicate $[\![ortho]\!]([\![dontist]\!])$ would apply, for instance, to a person who is an orthopedist and a periodontist, but not an orthodontist; if Bill is such a person and Martha is a periodontist, then the sentence *Bill and Martha are ortho and periodontists* would be predicted to be true, contrary to intuition (thanks to Cécile Meier for pointing this out).

A second possibility is that the word parts receive meanings that combine through a more elaborate mechanism. For instance, if the part *perio* in *periodontist* is interpreted with a meaning like "gums", then the relation between the meanings of the morphemes and that of the whole word would be like the relation of the meanings of *foot* and *doctor* to the meaning of *foot doctor*. It is not immediately clear what meaning would be assigned to the morpheme *ortho*, but presumably a suitable meaning could be found. However, the question of what the meaning of *ortho* should be points to a general problem with this approach to extracting meanings for word parts. While compound formation as in *foot doctor* is clearly a productive process with predictable results, its semantics is neither simple nor straightforward, as it involves many possible semantic relations which are determined by lexical knowledge and sometimes through extra-linguistic context (see Downing 1977; Hoeksema 2000). Extracting a morpheme meaning that will combine through compounding seems like a lot of work, apparently without significant benefits—the word part *perio* does not mean "gums" outside the context of *periodontist* (and related *periodontics*).

Another observation that casts doubt over a compounding analysis for the word parts is that coordination of parts of compositional compounds appears to be more difficult than that of word parts.

(24) foot and eye doctors

While the phrase (24) can truthfully apply to two people, one of whom is a podiatrist (foot-doctor) and the other an ophthalmologist (eye-doctor), it requires a strong supporting context (e.g. *Mama put the twins through medical school in the hope that they would become brain surgeons; consequently she was disappointed when they ended up as foot and eye doctors*). Without such a supporting context, speakers I have consulted are less likely to accept *Bill and Martha are foot and eye doctors* than they are to accept (2a) *Bill and Martha are ortho and periodontists*. I do not have an explanation for this difference, but it may have to do with the fact that compounding itself is semantically complicated and partly context-dependent.

A third way to assign meanings to morphemes in a paradigm is to give them functional denotations—the meanings of the morphemes *ortho* and *perio* will simply be

functions that respectively map the denotation of *dontist* to the denotations of *ortho-dontist* and *periodontist* (see also Hoeksema 2000 for the application of such functional meanings in morphology). These will be meanings of type $(et)et$, the same semantic type as non-intersective adjectives like *former* and *current*; we have already seen that such meanings are subject to cumulative conjunction, as in example (58) from chapter 3, repeated as (25) below.

(25) The Bush family gathered for dinner at their Texas ranch; the former and current presidents argued the whole time.

Extracting functional denotations for the word parts *ortho* and *perio* is simple and straightforward, and it does not suffer from the problems of an intersective type meaning or a compound meaning. But functional meanings are exactly what is employed by phonological decomposition, only in reverse—the way I have defined phonological decomposition, the coordinate parts are the arguments and the element outside the coordinate structure is the function. The reason for this choice is that it results in a simpler cumulative conjunction operation, since the coordinate parts are of a lower type; but phonological decomposition would also work if we chose function and argument the other way around.

It turns out, then, that when we work out the paradigms approach to extracting meanings for word parts, the results are essentially the same as phonological decomposition. It is difficult for me to see what word paradigms add here. The advantage of phonological decomposition is that it explicitly encodes the form of the word into the functional denotation, capturing the intuition that a coordinate structure like *ortho and periodontists* is only possible because the words *orthodontist* and *periodontist* share part of their phonological makeup—semantic similarity is not sufficient. If, however, it turns out that word paradigm meanings are needed, perhaps for some other part of the grammar, then phonological decomposition can be thought of as the semantic process that gives meanings to such word paradigms.

4.2.5   The applicability of phonological decomposition

We need to restrict phonological decomposition so that a meaning like that given to *dontist* in (13) would not be available in just any context. A meaning derived by phonological decomposition should only be available when a word part is in a construction where it actually forms part of a word, not when it stands alone. Strings of sound can denote themselves, so the following two sentences are practically synonymous.

(26) *Ortho* is disyllabic.

(27) The string *ortho* is disyllabic.

However, it is impossible to substitute an expressions of the form *the string . . .* for part of a word in a coordinate structure: the following sentence is plain gibberish (thanks to Caroline Heycock for drawing this to my attention).

(28)*Bill and Martha are the string *ortho* and the string *perio* dontists.

There are two ways to explain the ungrammaticality of (28): either *ortho* and *the string ortho* are not synonymous (they have different model-theoretic denotations), or the word part *dontists* in (28) cannot have the meaning (16) derived by phonological decomposition. The idea that *ortho* in a coordinate structure does not denote the string itself appears to be supported by the following contrast, which involves a periphrastic structure that serves to clarify the speaker's intent.

(29) Ortho—I mean the string—is disyllabic.

(30)*Bill and Martha are ortho—I mean the string—and periodontists.

But this is not strong evidence, because clarification periphrastics are generally not good between prenominal modifiers and their head nouns.

(31) This wood is orange—I mean the color.

(32)*This is an orange—I mean the color—tree.

(33)*This is an orange—I mean the color—and green tree.

It seems fairly clear that *orange* in the sentence *this is an orange tree* can denote a color—this is perhaps not the most salient reading, but precisely because of that we would expect that a clarification should be possible. Yet sentence (32) is ungrammatical, because of the position of the periphrastic sentence. This is also the reason for ungrammaticality in (30), so it does not constitute evidence against identifying the denotation of *ortho* with the string itself.

If *ortho* and *the string ortho* are indeed synonymous (and likewise for *perio*), then the ungrammaticality of (28) should be the result of phonological decomposition failing to apply to the word part *dontist*. I see a number of ways that this can be enforced: one is to rule out structures like (28) on the basis of syntax alone, for instance if word parts are of a syntactic category other than NP; this way the structure NP-*dontist* is simply not generated. An alternative would be to allow this syntactic configuration, but not give *dontists* the *eet*-type meaning necessary to interpret the structure. This views phonological decomposition as an active process, which assigns the functional denotations to word parts only in a particular configuration, when the word part in question is sister to another word part (or a conjunction of word parts). In this sense structures with phonological decomposition are similar to the idiomatically combining expressions of Nunberg *et al.* (1994) discussed in the previous section, since there too the parts only have their special meanings in the presence of one another. At the moment I do not have an argument in favor of one of the above proposals over the other.

A second place where phonological decomposition should not apply is when a morphological word is itself compositional, that is when the meaning of the word is independently predicted from the meanings of its parts. This explains why coordination is impossible in sentence (34), due to Alan Prince, as opposed to the perfectly coherent (35).

(34)*For our renovation project we need new black and floorboards.

(35) For our renovation project we need new blackboards and floorboards.

The coordinate structure *black and floorboards* is somewhat awkward phonologically (because of its stress pattern, see section 4.3.2), but this cannot be the sole cause of the ungrammaticality of (34) because both *black and whiteboards* and *side and floorboards* are markedly better (the latter only when it talks about boards that make the sides and floors, not the piece of furniture known as a sideboard). The ungrammaticality of (34) has the feeling of zeugma—the coordination of items that play different syntactic or semantic roles—as in the following contrast (Bauer 1998, p. 75).

(36) ?We saw a landscape dotted with wind- and flour-mills.

(37) We saw a landscape dotted with wind- and water-mills.

The oddity of (36) is a consequence of the different semantic relations of *wind* and *flour* to *mill*. Bauer shows that the prohibition against zeugma applies to a variety of coordinate structures.

(38) He's a good father and husband / ?accountant

(39) ?He ran up the road and the flag.

(40) ?She left in a hurry and in a taxi / in tears

If this is the source of the ungrammaticality of (34) then the semantic relations of *black* and *floor* to *board* must be different. Now, the word *blackboard* is definitely not compositional: blackboards are not necessarily black, nor are they necessarily boards. A floorboard, on the other hand, is just a board which makes up a floor; there is no reason to think that the word *floorboard* is anything but a compositional compound. If we limit the process of phonological decomposition so that it does not apply to structures that are already compositional we get an explanation for why *black and floorboards* is indeed a case of zeugma—it requires two different senses of *board*: one is derived by phonological decomposition, the other is the familiar word. The restriction of phonological decomposition to opaque constructions also precludes phonological decomposition from saving sentences (38)–(40).

   We conclude that phonological decomposition cannot apply to structures that are already compositional. The reason for this may be that phonological decomposition is an interpretive strategy that applies as a last resort, when the semantics has nothing else to work with; if an element already has a meaning, the additional work of phonological decomposition is unnecessary.

4.2.6   Coordinate parts with number marking

Let's look again at the underlying cause for the contrast between the NPs *ortho and periodontists* and *orthodontists and periodontists*: the former has one plural morpheme on the entire NP, whereas the latter has a plural morpheme on each conjunct. This leads to the following expectation: if each coordinate part were to bear plural morphology, then each of the conjuncts would correspond to a plural entity, and therefore coordination of parts should have the same meaning as coordination of whole words. This is borne out:

a noun phrase like *orthodontists and pedists* is phonologically ill-formed because the coordinate parts bear main stress (see section 4.3.2), but we still have the intuition that it would not apply to a pair of one orthodontist and one orthopedist, but would rather require two practitioners of each profession.

We find grammatical instances of number marking on the coordinate parts in Hebrew. Number is usually marked on the heads of Hebrew compounds; number marking on the non-head—singular *sefer* and plural *šinayim* below—is irrelevant in determining the number of the compound (cf. Borer 1988).

(41) SINGULAR   PLURAL
    bet sefer   bat-**ei** sefer   'school' (lit. 'house-book')
    rofe šinayim   rof-**ei** šinayim   'dentist' (lit. 'doctor-teeth')

In a small class of compounds, however, number is marked on both parts.

(42) SINGULAR   PLURAL
    sgan aluf   sgan-**ei** aluf-**im**   'lieutenant colonel'   (*sgan-**ei** aluf)
    tat aluf   tat-**ei** aluf-**im**   'brigadier general'   (*tat-**ei** aluf)

Hebrew compounds are considered to be morphological words because of their syntactic behavior, namely that they do not allow extraction (Borer 1988). As far as the semantics goes, the compounds *sgan aluf* and *tat aluf* should be considered to have atomic meanings because of their opacity. The morpheme *sgan* is also an independent word meaning 'deputy', and *tat* is a prefix with a meaning similar to 'sub-'; in combination with *aluf*, both of the compounds denote ranks that are below *aluf* 'major general'. However, exactly what ranks these are and how they are ordered with respect to one another is completely conventional, and does not follow from the meanings of the individual morphemes. (There is another sense in which the terms *sgan aluf* and *tat aluf* may be thought to be compositional: parallel ranks in various security forces have a similar structure. Thus, *sgan aluf*, *sgan nicav*, *sgan gondar* and *sgan tafsar* are parallel ranks, respectively, in the Israeli Defense Force, National Police, Prison Service and Firefighting Service; the same goes for *tat aluf*, *tat nicav*, *tat gondar* and *tat tafsar*. While these terms are related, the lexical meanings of their word parts are like those of *ortho* and *perio*—meanings that do not have a straightforward model-theoretic interpretation.)

When compounds with number marking on both parts are coordinated, we find that coordination of parts requires that each conjunct correspond to a plural referent, just like coordination of full compounds. Both of the sentences below require there to be at least two lieutenant colonels and two brigadier generals at the party.

(43) etmol   hayu ba-mesiba sgan-**ei**   aluf-**im**   ve-tat-**ei**   aluf-**im**
    yesterday were at.the-party deputy-**pl** general-**pl** and-sub-**pl** general-**pl**
    "At the party yesterday there were lt. colonels and brigadier generals"

(44) etmol   hayu ba-mesiba sgan-**ei**   ve-tat-**ei**   aluf-**im**
    yesterday were at.the-party deputy-**pl** and-sub-**pl** general-**pl**
    "At the party yesterday there were lt. colonels and brigadier generals"

Our semantics should now explain why the above two sentences receive the same meaning. Coordination of full NPs (43) works the same way as with *orthodontists and periodontists*; coordination of parts (44) will have to take the plural marking on the conjuncts into account.

We start, as before, by noting that the coordinate parts denote strings of sounds; these sounds include the plural morphemes, which are within the coordinate parts.

(45)   a. $[\![\text{sgan-ei}]\!] \in D_e$: the string *sgan-ei*.

       b. $[\![\text{tat-ei}]\!] \in D_e$: the string *tat-ei*.

The element outside the coordinate structure receives a functional meaning of type *eet*, from sounds to common noun meanings.

(46) $[\![\text{aluf-im}]\!] \in D_{eet}$: the function $h : D_e \to D_{et}$ such that for all $\alpha \in D_e$, $h(\alpha) = [\![\alpha\text{aluf-im}]\!]$ if α*aluf-im* is a word and $[\![\alpha\text{aluf-im}]\!] \in D_{et}$, undefined otherwise.

This will combine with the previous meanings to yield the desired results.

(47)   a. $[\![\text{aluf-im}]\!]([\![\text{sgan-ei}]\!]) = [\![\text{sgan-ei aluf-im}]\!]$

       b. $[\![\text{aluf-im}]\!]([\![\text{tat-ei}]\!]) = [\![\text{tat-ei aluf-im}]\!]$

Notice how we had to use the plural *aluf-im* rather than singular *aluf* in our phonological decomposition, unlike our use of singular *dontist* (example (13) in section 4.2.2, page 56). This is because the coordinate parts themselves contain plural morphemes, so their phonological concatenation with singular *aluf* would result in a non-word: if we had tried to combine the meanings in (45) with the *eet*-type meaning of *aluf*, we would not get a meaning that we could later build on.

(48)   a. $[\![\text{aluf}]\!]([\![\text{sgan-ei}]\!])$: Undefined (no word **sgan-ei aluf*)

       b. $[\![\text{aluf}]\!]([\![\text{tat-ei}]\!])$: Undefined (no word **tat-ei aluf*)

The significance of this is evident: whereas previously we introduced cumulativity through the derivation of plural *dontists* from singular *dontist*, such a move with *aluf-im* would be useless. Rather, we will have to define the cumulative inference of *aluf-im* with reference to its basic *eet*-type meaning.

The word part *aluf-im* should allow a cumulative relation between its two plural arguments (just like *dontists*): we add this cumulativity to the definition of *aluf-im*.

(49) Let $\mathcal{A}$ be the definition of $[\![\text{aluf-im}]\!]$ in (46). Then
$[\![\text{aluf-im}]\!] = \lambda\beta\lambda\alpha.\alpha \in \text{PL} \land \exists n, m \in \mathbb{N}, \alpha_1, \ldots, \alpha_n, \beta_1, \ldots, \beta_m [\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n \land \beta = \beta_1 \oplus \cdots \oplus \beta_m \land \forall i \leq n \exists j \leq m [\mathcal{A}(\alpha_i, \beta_j)] \land \forall j \leq m \exists i \leq n [\mathcal{A}(\alpha_i, \beta_j)]]$

The coordinate constituent *sgan-ei ve-tat-ei* denotes a plural object of type *e*, just like *ortho and perio*.

(50) $[\![\text{sgan-ei ve-tat-ei}]\!] = [\![\text{sgan-ei}]\!] \oplus [\![\text{tat-ei}]\!] \in D_e$

Applying the meaning of *aluf-im* in (49) to the meaning of *sgan-ei ve-tat-ei* in (50) gives us the meaning of the NP *sgan-ei ve-tat-ei aluf-im*.

(51) $[\![\text{aluf-im}]\!]([\![\text{sgan-ei}]\!] \oplus [\![\text{tat-ei}]\!])$

$\quad = \lambda\alpha.\alpha \in \text{PL} \wedge \exists n, m \in \mathbb{N}, \alpha_1, \ldots, \alpha_n, \beta_1, \ldots, \beta_m[\alpha = \alpha_1 \oplus \cdots \oplus \alpha_n$

$\quad\quad \wedge ([\![\text{sgan-ei}]\!] \oplus [\![\text{tat-ei}]\!]) = \beta_1 \oplus \cdots \oplus \beta_m$

$\quad\quad \wedge \forall i \leq n \exists j \leq m [\mathcal{A}(\alpha_i, \beta_j)] \wedge \forall j \leq m \exists i \leq n [\mathcal{A}(\alpha_i, \beta_j)]$

$\quad = \lambda\alpha.\alpha \in \text{PL} \wedge \exists \alpha_1, \alpha_2[\alpha = \alpha_1 \oplus \alpha_2 \wedge \mathcal{A}(\alpha_1, [\![\text{sgan-ei}]\!]) \wedge \mathcal{A}(\alpha_2, [\![\text{tat-ei}]\!])]$

$\quad = \lambda\alpha.\alpha \in \text{PL} \wedge \exists \alpha_1, \alpha_2[\alpha = \alpha_1 \oplus \alpha_2 \wedge [\![\text{sgan-ei aluf-im}]\!](\alpha_1)$

$\quad\quad \wedge [\![\text{tat-ei aluf-im}]\!](\alpha_2)]$

We find that *sgan-ei ve-tat-ei aluf-im* denotes the set of all plural objects that are the join of two objects, one of which is in the denotation of *sgan-ei aluf-im* and the other in the denotation of *tat-ei aluf-im*. Each such object will include at least two lieutenant colonels and two brigadier generals, as desired.

Performing phonological decomposition on the plural form *aluf-im* does not exclude the possibility of phonological decomposition on singular *aluf*, which could then be pluralized; this would allow the ungrammatical construction **sgan ve-tat alufim* 'deputy.sg and sub.sg general-pl', with the prediction that it denotes the set of pluralities which consist of one lieutenant colonel and one brigadier general. The ungrammaticality of this construction should be blocked on the syntactic grounds of number mismatch (see also chapter 3, section 3.5).

I now address a potential objection to my analysis above: one might claim that the NP *sgan-ei ve-tat-ei aluf-im*, with coordination of parts, receives the same interpretation as a coordination of full NPs because the conjoined elements are the heads of the compound, unlike the English example *ortho and periodontists*. I am actually not sure about the headedness of the above compounds, despite the formal similarity to construct states, and I think the fact that number is doubly marked by morphology may be an indication that the headedness relation is not straightforward. More importantly, coordination of singular terms shows a contrast between compounds of the type we were looking at and truly headed compounds. If it were a matter of conjoining heads, one might expect that conjunction of singular heads should be plural; this is what we see, for instance, in the following sentence (as mentioned above, the plurality of *šinayim* "teeth" does not affect the number marking of the compound).

(52) etmol   hay-u ba-mesiba rofe   ve-rof-at   šinayim
      yesterday were-**pl** at.the-party doctor.m.**sg** and-doctor-f.**sg** teeth
      "At the party yesterday there were a male dentist and a female dentist"

But when we coordinate parts of a singular compound of the type discussed throughout this section, the result is still singular, whereas coordination of singular compounds is plural. We thus see a contrast between (53) and (54), where the latter is ungrammatical because the singular subject does not agree with the plural verb.

(53) etmol   hay-u ba-mesiba sgan   aluf   ve-tat   aluf
      yesterday were-**pl** at.the-party deputy.**sg** general.**sg** and-sub.**sg** general.**sg**
      "At the party yesterday there were a lt. colonel and a brigadier general"

(54)*etmol   hay-u ba-mesiba sgan   ve-tat   aluf
      yesterday were-**pl** at.the-party deputy.**sg** and-sub.**sg** general.**sg**

Coordination of parts of a singular compound is fine when it can felicitously refer to a single individual, as in (55) (a single person cannot hold two ranks at the same time, but the coordinate structure *sgan ve-tat aluf* 'deputy.sg and sub.sg general.sg' does have the meaning of a single person with two ranks, as seen for example when talking about the same person at different times).

(55) dani   hikir et matan vilnai betor sgan   ve-tat   aluf
     Danny knew acc Matan Vilnai as   deputy.**sg** and-sub.**sg** general.**sg**
     "Danny knew Matan Vilnai as a lt. colonel and a brigadier general"

The reading of the singular NP *sgan ve-tat aluf* 'deputy.sg and sub.sg general.sg' in (55) is derived in exactly the same way as that of singular *ortho and periodontist* in section 4.2.3. The denotation of the part outside the conjunction, *aluf*, is a function of type *eet* derived by phonological decomposition.

(56) $[\![$aluf$]\!] \in D_{eet}$: the function $h : D_e \to D_{et}$ such that for all $\alpha \in D_e$, $h(\alpha) = [\![\alpha\text{aluf}]\!]$
     if $\alpha aluf$ is a word and $[\![\alpha\text{aluf}]\!] \in D_{et}$, undefined otherwise.

To this function we add a cumulative relation between the arguments, since morphology only specifies that the outer argument is singular.

(57) Let $\mathcal{B}$ be the definition of $[\![$aluf$]\!]$ in (56). Then $[\![$aluf$]\!] = \lambda\beta\lambda\alpha.\alpha \in \text{SG} \wedge \exists m \in \mathbb{N}, \beta_1, \ldots, \beta_m[\beta = \beta_1 \oplus \cdots \oplus \beta_m \wedge \forall j \le m[\mathcal{B}(\alpha, \beta_j)]]$

This meaning, when applied to the plurality $[\![$sgan$]\!] \oplus [\![$tat$]\!]$, will give the correct meaning for the coordinate structure *sgan ve-tat aluf* 'deputy.sg and sub.sg general.sg', allowing it to apply to singularities only, not pluralities.

(58) $[\![$aluf$]\!]([\![$sgan$]\!] \oplus [\![$tat$]\!])$
     $= \lambda\alpha.\alpha \in \text{SG} \wedge \exists m \in \mathbb{N}, \beta_1, \ldots, \beta_m[([\![$sgan$]\!] \oplus [\![tat]\!]) = \beta_1 \oplus \cdots \oplus \beta_m$
              $\wedge \forall j \le m[\mathcal{B}(\alpha, \beta_j)]]$
     $= \lambda\alpha.\alpha \in \text{SG} \wedge \mathcal{B}(\alpha, [\![$sgan$]\!]) \wedge \mathcal{B}(\alpha, [\![tat]\!])]$
     $= \lambda\alpha.\alpha \in \text{SG} \wedge [\![$sgan aluf$]\!](\alpha) \wedge [\![$tat aluf$]\!](\alpha)$

   To review what we have seen so far: the coordinate NP *ortho and periodontists* can apply to a pair consisting of one orthodontist and one periodontist. In order to capture this fact, the semantics must interpret the structure [ortho and perio]dontists. I have introduced the semantics of phonological decomposition, which assigns meanings to arbitrary word parts: the coordinate parts denote their own sounds, and the rest of the word denotes a function from sounds to word meanings. These denotations of word parts, together with the ordinary meaning of conjunction, combine to yield the correct interpretation of number. The semantics also gives the desired interpretation when number is marked on the coordinate parts, as in the Hebrew examples discussed in the last section.

4.3   Phonological constraints

Phonological decomposition allows us to interpret coordination of parts of words at surface level, yielding the correct interpretation for plural morphology on the conjuncts (or lack thereof). The semantics, however, does not make a distinction between

grammatical strings like *ortho and periodontists* and ungrammatical ones like ?*cran and strawberries* or ?*peri and telescopes*. And indeed it should not: it is phonological rather than semantic factors that are responsible for the above contrast. This section explores the phonological constraints on the coordination of parts of words.

4.3.1   Phonology and etymology

Before I go into the details of the phonology, I want to address a concern that the contrast just mentioned may be the result of the words *orthodontist* and *periodontist* being in some sense more "compositional" than the words *cranberry* and *strawberry*. This may be true from a historical or etymological point of view; synchronically, however, there is no difference in compositionality.   Speakers of English can readily identify the morphemes *-berry* and *-dontist*, since the words that contain them share some common aspects of meaning. But the morphemes *cran*, *straw*, *ortho*, and *perio* seem just about equally opaque. There is nothing more to the meaning of *cran* and *straw* other than the kind of berry they help signify. The term *orthodontist* is in common use, and it seems reasonable to assume that speakers learn it as a unit; the relation to words like *orthodox* and *orthography* is fairly obscure.   The word *periodontist* is much less familiar, and it is not at all easy to arrive at its meaning, despite familiarity with the morpheme *peri* in words like *perimeter* and *periphery*.   It appears that synchronically, the words *orthodontist* and *periodontist* are just as opaque as *strawberry* and *cranberry*.

So where do speakers get the intuition that *orthodontist* and *periodontist* are more compositional than *strawberry* and *cranberry*? I believe this is a phonological intuition, rather than a semantic one.   Some speakers are more content with *boysen and huckleberries* than with ?*cran and strawberries*, even though it is hard to see in what sense it is more compositional. Furthermore, speakers are happy to accept *ortho and periodontists* even when they do not know exactly what a periodontist is, simply assuming it is some kind of dental specialist. This would be hard to explain if acceptability were tied to knowledge of the lexical meaning of the word part *perio*.

Another possibility is that compositionality is not an intuition about meaning, but rather an intuition about combinatorial properties: speakers are aware that the morphemes *ortho* and *peri* form a variety of compounds, whereas *cran* and *straw* are less productive in this sense (note, however, that in contemporary English, *cran* is used productively and rather transparently in compounds or blends like *cranapple* and *crangrape*).   The fact that *ortho* and *peri* belong to the scientific, learned vocabulary may also give speakers the impression that they are, or should be, more transparent, even if the speaker doesn't know why. But the combinatorial properties still do not explain the coordination facts. If it were the combinatorial properties alone that allowed coordination of parts, we should expect structures like ?*peri and telescopes* to be well formed, since the morphemes that make up *periscope* and *telescope* are identifiable as much as those of *periodontist* and *orthodontist*.   Our conclusion regarding the intuition that coordination of parts is allowed by compositionality of lexical meaning, etymological compositionality, or even morphological structure is that the intuition is wrong; the difference between the well formed examples and the ungrammatical ones is due to the phonology.

4.3.2 Description of the prosodic facts

Phonological restrictions on structures with coordinated word parts have been extensively discussed in the literature on Dutch and German (Höhle 1982; Booij 1983, 1985; Wiese 1992, 1996; Kleinhenz 1997; Smith 2000); I will defer the discussion of these languages until later in this section, and start by looking at English. Our first observation is that the coordinate parts must be separated from the rest of the word by a certain prosodic juncture. Okada (1999) gives minimal contrasts such as the following (p. 350).

(59) a.*physio and psychologies

  b. physio and psychological

Semantic factors do not explain the contrast between the above examples. Nor can the contrast be attributed to morphological structure, as *physio* and *psycho* are identifiable morphemes in both examples. Rather, the contrast is a matter of prosodic (metrical) structure: a single foot may not span segmental material from both the coordinate and non-coordinate parts (in the following example the offending foot is underlined).

(60) a.*physio and psy(ˈcholo)(ˌgies)

  b. (ˌphysio) and (ˌpsycho)(ˈlogi)cal

We can formulate a first approximation of the prosodic constraint on coordination of parts of words—material from the coordinate part and the part outside the coordinate structure may not be prosodified into one foot. An alternative way to state this is that there must be a foot boundary between the coordinate part and the rest of the word.

The above restriction still does not predict the ungrammaticality of ?*cran and strawberries*, since *cran*, *straw* and *berries* can all be parsed into separate feet. I think that this is desirable. While it is true that ?*cran and strawberries* is unacceptable to many (perhaps most) speakers, it is still markedly better than **physio and psychologies*. The requirement that the coordinate and non-coordinate parts be separated by a foot boundary just sets the minimum threshold—a coordinate structure that fails to pass it is completely ruled out. Structures that satisfy this requirement have varying degrees of acceptability, depending on other prosodic considerations.

An absolute requirement at the foot level combined with additional, weaker preferences is manifest in another English construction—expletive infixation (McCawley 1978; McMillan 1980; McCarthy 1982; thanks to Mark Steedman for pointing out the relevance of this construction). The main insight into the prosody of expletive infixation is given in McCarthy (1982): an infix, normally a swear word like *fuckin* or *bloody*, has to be attached adjacent to a foot boundary. This proposal correctly predicts that the only possible infixation site in the word *orthodontist* is between the feet (ortho) and (dontist): *orthobloodydontist*. However, McCarthy notes (p. 588) that expletive infixation is severely degraded even between two feet, if the infix follows the foot with primary stress. Thus, words like ˈcranˌberry and ˈteleˌscope will yield the rather marginal ?*cranbloodyberry* and ?*telebloodyscope*; these are definitely better than infixation into a foot as in *psychobloodylogy, but still markedly worse than infixation before a foot with primary stress (*orthobloodydontist*, *psychobloodylogical*).

Like expletive infixation, coordination of parts of words is sensitive to the location of primary stress—it is strongly dispreferred when primary stress is on the coordinate parts. It is instructive at this point to look at the two coordinate structures *?micro and telescopes* and *?micro and telescopic*. The two expressions have a similar morphological and syntactic makeup, and both are at best marginal, bordering on ungrammaticality; but each structure is bad for a different reason. The problem with *?micro and telescopes* is phonological, since primary stress falls on the coordinate parts (cf. *ˈmicroˌscopes*, *ˈteleˌscopes*, and also the marginality of *?microbloodyscope*, *?telefuckinscope*). There is no problem with the semantics—it is clear what this construction should mean and where such a meaning could be used (e.g. in place of the direct object of *our store sells microscopes and telescopes*). The opposite holds of *?micro and telescopic*, which is well-formed phonologically (cf. *ˌmicroˈscopic*, *ˌteleˈscopic*, also *microbloodyscopic*, *telefuckinscopic*): here the problem is with the meaning of the coordinate structure—the meanings of *microscopic* and *telescopic* are rather unrelated, so it is hard to conceive of a situation where they can be coordinated. *Microscopic* means something like "very small", while *telescopic* means either "having to do with a telescope" or "having the shape of concentric tubes feeding into one another". Furthermore, when the adjectives are attributive and apply to the same object they normally appear in succession rather than coordinated (*a microscopic telescopic lens*, just like *a small telescopic lens* rather than *?a small and telescopic lens*). The coordinate structure *?micro and telescopic* sounds odd simply because it is hard to find a sensible use for it—the sentence *?this gadget is micro and telescopic* makes as much sense as *?this gadget is microscopic and telescopic*.

Another prosodic generalization is that the free conjunct—the one that is not adjacent to the complement word part outside the coordinate structure—invariably forms a prosodic word (the prosodic word is one element in a hierarchy of prosodic constituents, see for example Selkirk 1980, 1986; Nespor and Vogel 1982, 1986; these prosodic constituents typically constitute domains for the application of phonological rules, i.e. a particular rule is restricted to apply within a certain domain or at its edge). I know of two tests that can detect a prosodic word boundary in English: stem-final tensing and [ɾ] intrusion. Stem-final tensing prohibits the reduction of non-low vowels to schwa (Chomsky and Halle 1968; Halle and Mohanan 1985), and applies at the end of a prosodic word (Booij and Rubach 1987); intrusive [ɾ] appears in certain dialects of English between a non-diphthongal vowel and a following vowel, when the two vowels are separated by a prosodic word boundary (McCarthy 1993). The examples below—(61) for all English speakers and (62) for those speakers with [ɾ] intrusion—show that the first conjunct in the coordinate structure is parsed as a prosodic word.

(61) orth[oʷ] and periodontists (cf. orth[ə]dontist)

(62) mega[ɾ] and gigabytes

The fact that *periodontists* may be pronounced with a schwa in (61) shows that the conjunct part in that word does not have to form a prosodic word. Coordination of parts of words thus requires that the coordinate parts be constituents that can be promoted to the status of a prosodic word, and that the free-standing conjunct actually be promoted to this status (cf. Smith 2000 for a similar observation on German, discussed below).

Promotion to a prosodic word also happens with expletive infixation. Many speakers pronounce *orthobloodydontist* with a schwa as in (63a), showing that (ortho) remains a foot; some speakers, however, find it necessary to tense the final vowel of (ortho) as in (63b), suggesting that they have promoted the constituent to the status of a prosodic word.

(63)   a.   orth[ə]bloodydontist

           b.   orth[oʷ]bloodydontist

There is even a report of a tense [o] before the infix in *absofuckinlutely*, in the following posting to the Linguist list by Geoffrey Russom.

> I wonder whether anyone has observed a feature of expletive infixation as it appears in my dialect: the quite perceptible tensing of a normally unstressed vowel immediately preceding the infixed item. Thus I get "absolutely" as [aebs@lutli], where @ = schwa, but [aebso-EffING-lutli], with tense [o]. This may have something to do with the fact that I don't reduce word-final underlying /o/ in my dialect.

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The choice of vowel, namely [o], is most likely influenced by the orthography, since there do not exist morphologically related forms where the schwa of *abs[ə]lutely* is pronounced as a tense vowel. However, the fact that the speaker wants to pronounce a tense vowel immediately before the infix is indicative of a prosodic word boundary.

To summarize the prosodic conditions on coordinate structures in English: there must minimally be a foot boundary between the coordinate and non-coordinate parts of a word; the free-standing conjunct must form a prosodic word; and coordinate structures are generally dispreferred if primary stress is on the conjuncts. In section 4.3.3 I will try to tie these observations with the grammar of English prosody; the remainder of this section looks at data from Dutch, German and Spanish.

Dutch and German show prosodic restrictions similar to English, except that they do not show a preference against stress on the coordinate parts. Booij (1985) gives many examples of possible and impossible coordinate structures in Dutch; representative examples are reproduced below.

(64)   Coordination possible:

         a.   zicht- en tast**baar** 'visible and tangible'

         b.   ont- en ver**wikkelingen** 'developments and complications'

         c.   **regel**ordening en -toepassing 'rule ordering and [rule] appreciation'

(65)   Coordination impossible:

         a.*blauw- en rod**ig** (blauwig en rodig = 'blueish and reddish')

         b.*absurd- en banal**iteit** (absurditeit en banaliteit = 'absurdity and banality')

         c.***be**varen en -rijden (bevaren en berijden = 'sail and ride')

        d.***ge**hijg en -puf (gehijg en gepuf = 'gasping and puffing')

Booij formulates a rule that states that coordination is allowed when the element outside the coordinate structure, typeset in boldface above, forms a prosodic word (this is formulated in connection with a rule of phonological deletion, see section 4.4, but it can be equally well stated as a condition on surface representations). Prosodic word boundaries are determined in the word formation process: some affixes and all free morphemes are specified to be prosodic words, and this status is retained when they combine to form complex words, resulting in the structure of a prosodic word within a word (a similar intuition underlies the analysis of German in Höhle 1982, which is stated in terms of strong [#] and weak [+] morpheme boundaries: certain affixes and all words are marked by the strong [#] boundaries, and it is only these that allow coordination of parts).

While it may be the case that compound words indeed have the prosodic word within a word structure that Booij proposes, I do not see the coordination facts as supporting evidence. The examples in Booij (1985) where coordination is not allowed either have the coordinate and non-coordinate parts parsed into a single foot, as in (65a)–(65b), or have a non-coordinate part that is smaller than a full foot (65c)–(65d). On the other hand, Booij gives some examples where coordination of parts is allowed with non-compound words, where morphological structure does not lead us to expect an internal prosodic word boundary.

(66)   a. mono- en dia**logen** 'monologues and dialogues'

        b. biblio- en dactylo**grafische** hulp 'bibliographical and dactylographical assistance'

        c. hydro- en aero**statica** 'hydrostatics and aerostatics'

To explain these constructions, Booij has to stipulate that the words in (66) above have the structure of a prosodic word within a word, a stipulation not motivated by any other phonological or morphological consideration. If, however, the requirement on coordination in Dutch is the same as I have suggested for English, namely that there just be a foot boundary between the coordinate and non-coordinate parts, then all the data are accounted for. Since a prosodic word boundary entails a foot boundary, then all words that have internal prosodic word boundaries for independent reasons will also allow coordination of parts.

The situation in German may be more complicated. I know of at least some speakers who refuse to accept *Mono und Dialoge, the German counterpart of Dutch (66a), even though there is a foot boundary between the coordinate and non-coordinate parts; a foot boundary may not be enough for these speakers. Höhle (1982) presents an analysis of the German coordination facts in terms of morphological boundaries. Vowel-initial suffixes in German fall into two classes: "non-cohering" suffixes form their own syllable, whereas "cohering" suffixes syllabify with the preceding stem. This can be shown through a number of tests: non-cohering suffixes trigger obstruent devoicing in the preceding consonant, cohering suffixes do not (67a); non-cohering suffixes retain the schwa of a preceding [ən] or [əl] coda, cohering suffixes force deletion of the schwa (67b)–(67c); and non-cohering suffixes may be preceded by a glottal stop, while cohering suffixes do not allow this (67d).

(67)   NON-COHERING   COHERING

     a. far[p].echt 'colorfast'   far.[b]ig 'colored'

     b. reg[ən].echt 'rainproof'   reg.[n]erisch 'rainy'

     c. seg[əl].echt   Seg.[l]er 'yachtsman'

     d. far[pʔ]echt 'colorfast'   *far[bʔ]ig / *far[pʔ]ig 'colored'

Coordination of parts of words is possible with non-cohering suffixes, but not with cohering ones, which is to be expected if the non-cohering suffixes not only form a separate syllable, but a separate foot. Now Höhle takes the difference in syllabification to be the result of different morphological boundaries: non-cohering suffixes are preceded by strong [#] boundaries, and it is these boundaries that allow coordination. Höhle notes (fn. 8, p. 91) that the phonological distinctions in (67) are absent before consonant-initial suffixes; consequently, determining the morphological boundary in such cases depends solely on data from coordination, and may in some cases lead to speaker variation and underdetermination.

I am not sure that it is necessary to refer to morphological boundaries (rather than prosodic ones) in order to account for the variation among German speakers. An alternative is that in German the minimal boundary for coordination of word parts is that of a prosodic word rather than a foot, and variation stems from different speakers having different prosodic representations for the same words. Variation may also be the result of different speakers requiring different boundaries—some speakers only allow coordination of parts of words with a prosodic word boundary, while others are content with a foot boundary. I leave the matter unresolved, pending further data.

The free-standing conjunct in German must form a prosodic word, the same as in English. This is demonstrated by Smith (2000): the prefix *be-* in *beladen* 'load' normally has a reduced vowel, but it can have a full vowel if it is placed under stress (68); in the coordinate structure *be- und entladen* 'load and unload', where *be-* is the free conjunct, it must have a full vowel (69).

(68) [bə.ˈlɑː.dn̩]; [ˈbeː.ˌlɑː.dn̩]

(69) [ˈbeː.ʔʊnt.ˈʔɛnt.ˌlɑːdn̩]; *[ˈbə.ʔʊnt.ˈʔɛnt.ˌlɑːdn̩]

Another example is the morpheme *farb* 'color' in *farblos* 'colorless', which in standard German forms its own syllable and thus ends in a voiceless [p], but in certain dialects may syllabify with the suffix, resulting in a voiced [b] (70). In the coordinate structure *farb- und ausdruckslos* 'colorless and expressionless' the free conjunct *farb* must end in a voiceless [p] (71).

(70) [ˈfaʁp.loːs]; [ˈfaʁ.bloːs]

(71) [ˈfaʁp.ʔʊnt.ˈaʊs.ˌdʁʊks.loːs]

These facts are explained if the free-standing conjunct has to form a prosodic word, subjecting it to a minimal word requirement (69) and prohibiting it from syllabifying with subsequent material (71).

We see that Dutch and German have prosodic restrictions on coordinate structures that are similar to those found in English. Similar structures are found in other languages too. Spanish, for instance, allows the coordination of word parts that combine with the adverbial suffix *mente*.

(72)   a. decidida y atrevidamente 'decisively and boldly'   (Suñer 1975, p. 604)

       b. queda y lentamente 'softly and slowly'

(73)   a. directa o indirectamente 'directly or indirectly'   (Zagona 1990, p. 5)

       b. inteligente y profundamente 'intelligently and profoundly'

The first conjuncts in the above examples are phonologically identifiable as word parts: in (72b), for instance, the conjuncts cannot both be adverbs, because only *quedo* 'softly' is a free-standing adverb form; *queda* must therefore be a word part of *quedamente* 'softly'. Spanish is consistent with the prosodic restrictions found in the other languages discussed above, since the suffix *mente* which stands outside the coordinate structures forms a trochaic foot.

4.3.3   The source of prosodic restrictions on coordination

The prosodic restrictions on coordination of parts of words are not arbitrary; we expect them to follow from the properties of the phonology and its relation to syntax. Recall our three observations regarding the prosodic restrictions in English (page 71): there must minimally be a foot boundary between the coordinate and non-coordinate parts of a word; the free-standing conjunct must form a prosodic word; and coordinate structures are generally dispreferred if primary stress is on the conjuncts. This section attempts to tie these observations to the grammar of English in general.

The requirement of a foot boundary between the coordinate and non-coordinate parts comes from the grammar of phonological decomposition itself. This requirement is not particular to coordinate structures, since the same holds of focus below the word level. In chapter 2, section 2.5.1, I reached the conclusion that phonological decomposition assigns meaning to the prosodic constituents that make up a word, rather than to arbitrary stretches of the linear segmental representation (see discussion on page 28). This immediately explains the observation that the split between the coordinate and non-coordinate parts of a word has to occur between two prosodic constituents. Furthermore, these constituents must be at least the size of a foot, because the free-standing conjunct must have the potential to form a prosodic word so it must minimally be a foot (the minimal size of a word in English); the element outside the coordinate structure must therefore be a prosodic constituent that can concatenate with a foot to form an expression of English, so a foot boundary also ensues between it and the adjacent conjunct.

As for the requirement that the free-standing conjunct should be a prosodic word, this is most likely a reflex of the English requirement that every morphological or syntactic word should form a prosodic word (Liberman and Prince 1977; Prince and Smolensky 1993, and references therein). This requirement holds only of lexical words, corresponding roughly to the open-class lexical items, not function words (Selkirk 1995a, and references therein); Selkirk defines lexical words as morphosyntactic

units, dominated by the categories N^0, V^0 or A^0 (fn. 2, p. 440). Do the word parts in a coordinate structure constitute lexical words that are subject to the prosodic word requirement? Well, they are definitely not function words, nor are they closed-class items. The question remains whether they are of the (morpho)syntactic category level of word, or of a lower level. The semantics does not give an answer one way or another: I have argued that for the correct semantic interpretation, coordination has to be at surface level, that is with a structure [A and B]C; but all that matters for the semantics is the geometry of the structure, not the category level labels.

We are seeking an explanation for the difference between the free standing word-part conjunct and the conjunct adjacent to the word part outside the coordinate structure, why the former has to be a prosodic word while the latter does not. The difference can arise from a number of sources. One possibility is that the two conjuncts are of different sytactic status, e.g. different category levels, and this would entail their different prosodic status. Alternatively—assuming that coordinated constituents must be of the same syntactic category level—coordinate word parts would either be of a category level word, or of a lower level (category levels below the word are proposed by Selkirk 1982 for the internal structure of words, but unlike that model, coordinate structures require that these levels interact with higher level syntax). If coordinate word parts are not syntactic words then we have to derive the prosodic word status of the free-standing conjunct from other aspects of the syntactic configuration, whereas if they are syntactic words we need to explain the failure of the other conjunct to get realized as a prosodic word.

At the moment I do not have a reason to choose in favor of one of the three approaches sketched above, so I leave the matter unresolved. If the coordinate parts are indeed syntactic nodes of the level word, then we have evidence for the violability of the requirement that lexical words should form syntactic words. This requirement is satisfied in all the English data presented in Selkirk (1995a). Selkirk considers three configurations of lexical and function words: function words that precede a lexical word (*to London*), function words at the end of a phrase (*more than Sara can*), and object clitics (*feed us*). Each category of function words is prosodified differently, but in all cases the lexical word forms a prosodic word, as demonstrated by aspiration at the beginning (*in T^horonto*) and [ɹ] intrusion at the end (*more scary than a subpoena-r is*; *withdraw-r it*). The grammar enforces prosodification of a lexical word as a prosodic word by means of two Optimality Theory alignment constraints which align the left and right edges of a lexical word with the respective edges of a prosodic word; these constraints are never violated in English (they are violated in one dialect of Serbo-Croatian). If *perio* in *ortho and periodontists* is indeed a lexical word, then violation of these constraints would have to be forced by a higher-ranking constraint.

Finally, the preference against stress on the coordinate parts could either be a purely phonological phenomenon, or a consequence of the relation between syntax and phonology. A possibly related observation is that "right node raising" constructions also resist prominence on the coordinate parts. The following example, due to Roger Schwarzschild, is rather marginal.

(74) [What happened to the whiskey?]

   —?John drank and Mary spilled the whiskey.

However, it is not clear to me that the unacceptability of (74) has the same origins as that of ?*micro and telescopes*, because the origin of the prominence relations is different—in (74) the coordinate parts are expected to be prominent because of their discourse status (the rest of the sentence is given), while in ?*micro and telescopes* prominence on the coordinate parts is a consequence of default word stress.

What is the phonological force working against structures that have stress on the coordinate parts? This restriction is similar to the preference against expletive infixation following the main stress of a word, so we expect the two restrictions to have a similar source. McCarthy (1982, p. 588) suggests that in the case of expletive infixation, the preference is due to the fact that inserting a foot between the main stress and a following foot makes the main stress two feet removed from the end of the word, a pattern not found in ordinary English vocabulary. This does not explain the preference against stress on the coordinate parts: in a structure like ?*micro and telescopes* the first conjunct *micro* forms a prosodic word, so we do not get the atypical stress pattern of ?ˈmicro fuckinˌscope. Our conclusion is that either the two phenomena are not closely related, or that another explanation is needed for the expletive infixation case.

We should not be too quick to dismiss the connection between the restrictions on expletive infixation and coordination of parts of words. There are additional restrictions that appear to be common to both. The word *infixation* itself, for instance, appears to have the ideal prosodic structure for expletive infixation—two trochaic feet, with main stress on the second: (ˌinfik)(ˈsation). But expletive infixation is not allowed, and neither is coordination of parts of words.

(75)   a. ?infikfuckinsation   ?infik and prefixation
        b. ?infixfuckin(s)ation   ?infix and prefixation
        c. ?infifuckinxation   ?infi and prefixation

The structures in (75a) are the ones predicted to be grammatical, the rest are shown just for the sake of completeness. One possible reason for the ungrammaticality of (75a) is that there is some sort of morphological interference, caused either by the proximity of the foot and morpheme boundaries or by the existing word *infix*, where the final [s] is part of the first and only foot. The restrictions on both expletive infixation and coordination of parts of words still require further study, in order to precisely map out the territory of the structures that are on the margins of grammaticality. All of these cases, however, are markedly better than constructions that break the foot structure. We also expect a correlation between the availability of expletive infixation and coordination of parts of words, even when we are not certain about the exact reason why a certain example is allowed or not (a possible exception to this last generalization: the word *infiltration* appears to allow expletive infixation, *infilfuckintration*, more readily than coordination, as in ?*the border suffered from various infil and penetrations in the last year*).

Our account of coordination of parts of words now consists of two parts: a semantic theory that assigns denotations to arbitrary word parts and interprets coordination at surface level, and a phonological component with restrictions on structures that can be coordinated. The final section of this chapter compares this account to existing analyses that derive coordination of parts of words from the corresponding coordination of whole words through a deletion rule.

4.4 Surface coordination vs. deletion

The phonological observations from section 4.3.2 draw on previous analyses of similar constructions in Dutch and German, which preferred to view these constructions as resulting from a process of phonological deletion, rather than coordination at surface level (Höhle 1982; Booij 1983, 1985; Wiese 1992, 1996; Kleinhenz 1997; Smith 2000). Our motivation for an analysis of surface coordination was the difference in meaning between NPs with coordinate word parts (*ortho and periodontists*) and coordinations of full NPs (*orthodontists and periodontists*). In this section I look at additional arguments that compare surface coordination with phonological deletion.

The rule of deletion, as it is put forward in Booij (1985) and Kleinhenz (1997), includes a syntactic component as well as a phonological component. Deletion itself is phonological—the deleted element is a prosodic word. But prosodic restrictions alone do not predict the following contrasts, since in each pair the two structures are identical in terms of prosodic structure.

(76)   a. de land- en de tuinbouw   (Dutch, Booij 1985)
          'the agriculture and the horticulture'

      b.*de land- met de tuinbouw
          'the agriculture with the horticulture'

(77)   a. eine elf-   und eine zwölfjährige   (German, Kleinhenz 1997)
          an   eleven and a   twelve-year-old

      b.*eine elf-   bewundert eine zwölfjährige
          an   eleven admires   a   twelve-year-old

These examples lead Booij and Kleinhenz to conclude that the context for deletion must be syntactic: the deleted element has to be adjacent to a conjunction. Booij explicitly takes this to be evidence for the existence of rules that refer to both syntactic structure and prosodic structure, and thus go against a model like that of Selkirk (1980), which strictly separates the syntactic and prosodic domains.

A question which is not addressed is why this particular deletion rule should exist and not, say, a rule that allowed phonological deletion, under identity, subject to adjacency to a preposition. Indeed, if the deletion rule has nothing to do with the meaning of conjunction, then we should expect that a language should be possible where constructions like (76a) are bad, but constructions like (76b) are grammatical!

Surface coordination, as argued for in this chapter, gives a straightforward answer to the above question, which follows from the meanings of parts of words. Phonological decomposition states that coordinate parts of words denote strings of sounds, which are individual objects (type *e*). These denotations are suitable arguments for the function denoted by *and*: when applied to two strings of sound it yields a plural object which is the join of the individual strings. However, strings of sound are not in the domain of the denotation of the preposition *with*, nor are they in the domain of the denotation of *admire*. It follows that parts of words are licensed in coordinate structures like (76a) and (77a), but not as the objects of *with* (76b) or *admire* (77b).

The above explanation is semantic, just like the explanation for the following contrast, which does not involve parts of words.

(78) big and small monkeys

(79)*big with small monkeys (cf. big monkeys with small monkeys)

(80)*big admire small monkeys (cf. big monkeys admire small monkeys)

The adjectives *big* and *small* can be coordinated to form a constituent with a coherent meaning, which can then modify *monkeys*. But *big* and *small* cannot combine with *with* and *admire* to form the constituents **big with small* and **big admire small*; also, *big* cannot be modified by the PP *with small monkeys*, nor is it a suitable subject for the VP *admire small monkeys*. These are all consequences of the respective meanings of *and*, *with* and *admire*. Indeed, it would seem odd to have an analysis that derived (78) from *big monkeys and small monkeys* through deletion of *monkeys*, and then stipulated somehow that this is not possible in (79) and (80). Phonological decomposition allows the same explanation for constructions above and below the word level. (Note that a higher order meaning could make sentences (79) and (80) work, for instance if the verb in (80) had the meaning $\lambda\alpha\lambda\beta\lambda\gamma.[\![admire]\!](\beta(\gamma),\alpha(\gamma))$, with $[\![admire]\!]$ the familiar verb denotation and α, β and γ of appropriate types. But the observation is that the expression *admire* is not associated with such a meaning, nor are verbs in general.)

Wiese (1992, 1996) also notes an empirical problem with a deletion rule phrased in syntactic terms: it does not cover the full range of data. The following examples from German show how parts of words appear as independent syntactic elements in structures that do not involve coordination (Wiese 1996, p. 72).

(81)   a. Sachsen entwickelte sich vom Herzog- zum Kurfürstentum.
           'Saxony developed from a dukedom to an electorate.'

        b. Formen wir den Aktiv- in einen Passivsatz um.
           'We form the passive sentence from the active sentence.'

        c. ... übernahm zum Fraktions- auch noch den Landesvorsitz
           '... taking over both the faction chair and the state chair.'

        d. Weil Leitungs- von Mineralwasser unterschieden werden muß, ...
           'since tap water must be distinguished from mineral water, ...'

Wiese proposes that these structures are the product of a purely phonological deletion rule: not only is the deleted element a prosodic word (ω), but the context is also phonological. A prosodic word may be deleted at the edge of a phonological phrase (ϕ), if an identical prosodic word is contained in an adjacent phonological phrase within the same intonational phrase (I). The environment for deletion can be summarized graphically as follows, where the underlined prosodic word is the one to be deleted.

(82)   a. $[_I\,[_\phi \cdots \underline{\omega_i}\,_\phi][_\phi \cdots \omega_i \cdots\,_\phi]\,_I]$
        b. $[_I\,[_\phi \cdots \omega_i \cdots\,_\phi][_\phi\, \underline{\omega_i} \cdots\,_\phi]\,_I]$

Unfortunately, the above proposal fails to distinguish between the pairs of examples in (76) and (77) above. An additional weakness is pointed out by Kleinhenz (1997): since either the first part or the second part of a word may be coordinated, a deletion rule as formulated in (82) would require arbitrary association of the conjunction itself, in

order to ensure that the deleted element is adjacent to a phonological phrase boundary. The conjunction *und* would have to form a phonological phrase with the material that follows it in (83) but with the preceding material in (84).

(83) $[_\phi$Apfel~~saft~~$_\phi]$ $[_\phi$und Orangensaft$_\phi]$
　　　apple　　　and orange-juice

(84) $[_\phi$Ostersonntag　und$_\phi]$ $[_\phi$~~Oster~~Montag$_\phi]$
　　　Easter-Sunday and　　Monday

However, the only natural place for a pause is before the conjunction, so a prosodic structure as in (84) is highly unlikely.

　　To summarize our findings so far: a proposed deletion rule which syntactically specifies a conjunction environment cannot work because it prohibits the grammatical structures in (81), while a proposed deletion rule that only looks at prosody won't work because it allows the ungrammatical structures (76b) and (77b). Our surface coordination account is superior because it captures number contrasts that a deletion account misses (our original motivation), and it explains why parts of words occur in coordinate structures but not as objects of *with* or transitive verbs. We still need an explanation how a surface interpretation is possible for the non-coordinate structures in (81). I do not have an answer at the moment, but we should note that these structures have parallels at the phrasal level: parts of words are allowed where parts of NPs are allowed.

(85)　　a. Parliament developed from a unicameral to a bicameral institution.

　　　　b. We transform the active into the passive sentence.

　　　　c. . . . taking over both the faction and the state chair.

It appears, then, that however the above sentences are interpreted, this should generalize to the constructions with word parts.

　　So, if surface coordination is a better explanation than deletion, how come deletion was proposed in the first place? It turns out that most of the arguments in favor of a deletion account rest on assumptions about the rigidity of syntax and semantics, and are no longer valid when we consider a syntax and semantics capable of manipulating and interpreting parts of words.

　　One argument for deletion is syntactic. Sentences (86) and (87) contain apparent instances of coordination of non-constituents: *een derde* and *een zesde* in (86), and *ein Dreigang* and *ein Sechsgang* in (87).

(86) het verschil　tussen　een derde- en　een　zesdeklasser　　(Dutch, Booij 1985)
　　　the difference between a　third　and a　　sixth-former

(87) ein Dreigang-　und ein　Sechsgangfahrrad　　　　(German, Kleinhenz 1997)
　　　a　three-speed and a　six-speed-bicycle

The proposed deletion rule saves the syntax from having to allow some non-traditional constituents that would be required in order to generate the above examples with surface coordination. But this argument is orthogonal to the issue of coordinating word

parts. The word parts in (86) and (87) have their own meanings which combine in a compositional manner, so as far as the semantics is concerned there is no difference between these structures and phrasal coordination—phonological decomposition is not involved here. Syntactic theories that allow non-traditional constituent coordination have been developed both at the phrase level ("Right Node Raising": Ades and Steedman 1982; Steedman 1985, 1987) and for the internal structure of words (Moortgat 1987). But even if we reject these syntactic theories, concluding that (86) and (87) must involve deletion, it still doesn't follow that all cases of coordination of parts of words are instances of deletion, just like a syntactic theory that does not allow surface coordination for the NP *a yellow and a red cabinet* should not automatically rule out surface coordination in the NP *yellow and red cabinets*.

Another argument for deletion has to do with the semantics of number. Booij (1985) notes that the preposition *tussen* 'between' in (86) requires a plural complement, but on a surface interpretation its complement would be interpreted as singular because of the singular head *klasser*. I suggest that the reason (86) has a plural interpretation for an NP headed by a singular noun has to do with the fact that 'third former' and 'sixth former' in this construction do not refer to individuals, but rather to concepts. We observe the same in the phrasal domain: sentence (88) is much more readily understood as choosing between two concepts—kinds of cabinets rather than actual ones; sentence (89), where a concept interpretation is unlikely, is severely degraded.

(88) I must choose between a yellow and a red cabinet.

(89)*I am standing between a yellow and a red cabinet.

I do not have a full explanation for why concept terms allow an NP headed by a singular noun to receive a plural interpretation. This may have to do with concepts being one-of-a-kind, in the sense that there is only one concept 'a third-former' or 'a yellow cabinet'. Concept terms can even be syntactically plural while being morphologically singular.

(90) Concatenative and autosegmental phonology *are* interesting fields.

Sentences (88) and (90) show that the argument for deletion, like the previous one, is not particular to coordination of parts of words, but rather applies specifically to (86), and to (88) and (90) as well. Whatever analysis we give to the latter should generalize to the former; deletion of word parts due to their morphological status has not been motivated.

The next argument says that coordination of parts of words cannot be generated by the mechanism of syntactic composition because the conjuncts do not have to be free morphemes (91)–(93) or because they can be lexical items of different categories (94)–(95).

(91) schei- en natuurkunde 'chemistry and physics'   (Dutch, Booij 1985)
      (literally: 'analysis and nature knowledge').

(92) wis- en sterrenkunde 'mathematics and astronomy'   (Dutch, Booij 1985)
      (literally: 'sure and stars knowledge').

(93) Him- und Brombeeren 'raspberries and blackberries' (German, Kleinhenz 1997)

(94) leer- en handboeken 'textbooks and handbooks' (Dutch, Booij 1985)
(literally: 'learn and hand books').

(95) Verband Geburts- und andere-r Behinderte-r (German, Kleinhenz 1997)
society birth and other-GEN handicapped-GEN

This is a matter of syntax, then—how are such structures generated at surface level. Moortgat (1987) offers a syntax that generates these structures, through a family of rules that convert stems of various syntactic categories into modifier bound morphemes: for instance, both *leer* 'learn (V)' and *hand* 'hand (N)' are converted to the category N/N; this way they can be conjoined. The semantics that Moortgat offers only works for transparent modifiers, and does not deal with the opaque cases (91)–(93); these cases can be handled by phonological decomposition as developed in this thesis.

One last argument for deletion comes from Dutch "linking phonemes". When *wesp* 'wasp' forms a compound with *steek* 'sting', an additional schwa [ə] appears between the two morphemes: *wespesteek*; similarly, *zonsverduistering* 'sun-eclipse' contains a linking [s]. The linking phonemes are retained when such morphemes are coordinated.

(96) wespe- en bijesteken 'wasp and bee stings' (Booij 1985)

(97) zons- en maansverduisteringen 'solar and lunar eclipses' (Booij 1985)

Booij (1985) argues that deletion is the only possible source for the linking phoneme in the first conjunct, since coordinated words are inaccessible to morphological rules: the ordinal derived from the cardinal number *drie-en-zestig* 'sixty three' is *drie-en-zestigste* 'sixty third', where the first conjunct retains its cardinal form, rather than **derde-en-zestigste* (cf. *derde* 'third'). Indeed, this argument shows that the coordinate structures in (96) and (97) cannot be derived from the bare noun coordinations *wesp en bij* and *zon en maan* through a morphological operation like the one that derives the ordinal numbers from cardinal numbers. However, there is no reason to believe that coordination should be similar to this sort of morphological derivation. Coordination can simply operate on bound forms: Moortgat (1987, p. 47) incorporates the linking phoneme into his category-changing rules, noting that it "makes the left members formally recognizable as bound forms"; this is to be expected for the opaque cases in particular, because under the semantics proposed here only the bound morphemes have the right meaning (that is, the right sound) to combine with the meaning of the head.

This concludes the review of the arguments given in favor of the deletion analysis. As long as we have a syntax capable of manipulating word parts and the semantics developed above, a surface interpretation is possible. I have argued that coordination of parts of words is interpreted at the surface level, through the semantic process of phonological decomposition which assigns denotations to arbitrary word parts. Conjunction retains its ordinary meaning without additional machinery. Coordination of parts of words is subject to prosodic restrictions, which mandate a minimum size for constituents that can be coordinated. The analysis is superior to deletion proposals, both in its empirical coverage and in its explanation of why parts of words function as independent elements in coordinate structures but not in other grammatical constructions.

Chapter 5

Echo questions

5.1 Introduction

This chapter develops a semantics for echo questions. My proposal is that the pitch accent in echo questions is an instance of focus, and echo questions are interpreted through focus semantics (cf. Hockey 1994). The alternative set $\llbracket \cdot \rrbracket^f$ of an echo question is the set of possible answers, which constitutes the meaning of the question. The focus strategy exempts echo questions from locality restrictions ("islands"), allows echo questions on parts of words, and allows second-order echo questions which denote sets of questions. A focus strategy is available for echo questions precisely because they "echo" a preceding statement—the entire echo question is given, so none of its parts needs to be marked with focus; therefore focus can serve the purpose of indicating disputed (rather than new) material.

The particular syntax of echo questions has made them resistant to linguistic treatment, since echo questions often constitute exceptions to otherwise valid generalizations about the syntax of questions. One of the difficulties in giving an analysis of echo questions has been the fact that echo questions can appear on arbitrary word parts.

(1) She believes in WHAT-jacency? (Janda 1985)

(2) John witnessed a great reve-WHAT-tion? (Janda 1985)

(3) Cha-WHAT-as? (Janda 1985)

(4) He's un-WHAT-able? (Hockey 1994)

Without an adequate theory of syntactic and semantic representations for word parts, the examples above give an impression that echo questions are fundamentally different from other grammatical constructions (see Janda 1985, who proposes that echo questions are derived by substituting question words for arbitrary syllable strings in the surface structure of a sentence). The theory of phonological decomposition as developed throughout this dissertation allows us to account for data like (1)–(4) within the familiar system of syntax and semantics. Echo questions on parts of words are

expected if the semantics of echo questions is that of focus, since focus can be marked below the word level (see chapter 2).

Echo questions have the following typical characteristics: they relate to a previous utterance, and are similar to it in form and meaning (hence the term "echo"); they inform the interlocutor that the speaker has misperceived part of the previous utterance or refuses to accept it; and they have a particular intonation, consisting of a rising pitch accent (L+H* in the terms of Pierrehumbert 1980) and a high-rising boundary (HH%). We can classify echo utterances according to two parameters—whether they contain a *wh*-phrase, and whether they have the syntax typical of direct questions (Parker and Pickeral 1985 attempt a more refined classification, but the above two parameters are sufficient for our purposes). The echo questions that are the most prominent in the linguistic literature are those that have a *wh*-phrase, but do not display the familiar syntax of questions.

(5)   A: I gave flowers to George.

              L+H*   HH%
       B: You gave WHAT to George?

Along with these, we also find utterances that display the same intonation pattern but with a fronted *wh*-phrase—the typical syntax of direct questions.

(6)   A: I gave flowers to George.

           L+H*   HH%
       B: WHAT did you give to George?

Both types of questions serve the same function, that is questioning or objecting to part of the interlocutor's utterance, and as far as I can tell they are pretty much interchangeable: they are pragmatically appropriate in the same contexts.

(A note on the transcription of pitch in the above examples: Hockey (1994) transcribes the pitch accent on echo *wh*-phrases as high (H*) rather than rising (L+H*); however I believe it is in fact rising, based on the description in Pope (1976) and the pitch tracks reproduced in Hockey (1994). Additional evidence that the pitch accent is indeed rising comes from questions with multiple echo *wh*-phrases.

(7)   A: Bill gave flowers to George.

           L+H*   L+H*   HH%
       B: WHO gave WHAT to George?

There is a discernible drop in pitch before the second echo *wh*-phrase *what* in B's response; this is expected if the word is marked with a rising pitch accent (L+H*), but would be surprising if it were marked with a high accent (H*), in which case we would expect the pitch to remain high between the two accents. In the remainder of the chapter I will suppress the actual pitch notations, and simply set accent-bearing words in SMALL CAPS; all echo questions are to be read with a L+H*HH% intonation.)

Echo utterances are also possible without a *wh*-phrase; the echo intonation is imposed on a declarative sentence, and the rising (L+H*) pitch accent is placed on the word or phrase that is being questioned.

(8)   A: I gave flowers to George.

       B: You gave FLOWERS to George?

The function of such an utterance is similar to that of questions of the type in (5) and (6)—it too questions part of the interlocutor's utterance or objects to it (this similarity is noted by Hockey 1994, who calls such utterances "echo declaratives"). The difference between echo questions with *wh*-phrases and utterances like (8) is that the former may indicate that the speaker hasn't heard or perceived part of the interlocutor's utterance, while the latter obviously cannot.

    What's missing from the paradigm are echo questions with the characteristic syntax of questions but without a *wh*-phrase. Fronting of a non-*wh* constituent is ungrammatical in English (except in certain Yiddish-influenced dialects).

(9)   A: I gave flowers to George.

       B:*FLOWERS you gave to George?

It is also impossible to have echo utterances with the syntax of direct yes/no question as a response to declarative sentences (such echoes are acceptable as responses to yes/no questions (11), in which case they are interpreted as second order questions; see section 5.5).

(10)   A: I gave flowers to George.

        B:*Did you give FLOWERS to George?

(11)   A: Did Mary give flowers to George?

        B: Did Mary give FLOWERS to George? That's not important. The question is whether she gave him candy.

Based on a survey that checked the suitability of various sentence types as echo-responses to a number of different constructions, Parker and Pickeral (1985) report that structures like (10) are marginal at best (that is, they report that such structures are completely unacceptable in some contexts, and marginally acceptable in others). In a response to this article, Moulton (1987) attempts a different classification of interrogative utterances, and he too notes the absence of echo yes/no questions (for reasons that are obscure to me he proposes that the missing slot in the paradigm is filled by questions such as the last one in the following sequence, pronounced with a falling pitch: *Is it a vegetable? Is it an animal? Is it a mineral?*).

    In this chapter I will consider questions like (5) and (8), that is utterances with echo intonation but without the syntactic properties of direct questions, whether they have a *wh*-phrase or not. Bolinger (1987, p. 263) considers utterances like (5) to be echo *wh*-questions, as opposed to ones like (8), which are echo yes/no questions; he bases this distinction on the observation that the latter can be answered with *yes* or *no*, while the former need an answer that replaces the *wh*-phrase, e.g. *flowers*. I disagree with this characterization: while *yes* is an appropriate response to a non-*wh* echo, just plain *no* is rather odd—the speaker is expected to clarify what she had originally intended to say. This is in contrast to a direct question like *did you give flowers to George?*, to which a *no* response is perfectly acceptable. I believe this shows that a non-*wh* echo is more

than an inquiry about a particular proposition—it is an inquiry about alternatives to it. Consequently I propose that both *wh* and non-*wh* echo questions have the same kind of denotation, a set of alternatives arrived at by focus semantics. *Yes* is a possible response to a non-*wh* echo because the echo offers a proposition that can be responded to. *Wh*-echo questions do not offer such a proposition so they can not be answered with *yes*, but still, if the speaker assumes that her original utterance had been fully perceived and the echo expresses surprise or objection, she can respond to the echo with something like *you heard me right*.

Questions with echo intonation and fronted *wh*-phrases (6) are excluded from the discussion in this chapter. Such questions can be interpreted either with the familiar semantics of questions or through the focus semantics for echo questions, and since at the moment I do not have a reason to decide one way or the other, I prefer to put these constructions aside. The focus semantics for echo questions is developed in the next two sections: section 5.2 argues for identifying the pitch accent in non-*wh* echoes as focus, and section 5.3 shows how the same assumption for *wh*-echo questions explains their insensitivity to locality restrictions. The following sections show how the theory applies to echo questions below the word level (section 5.4), second-order echo questions which denote sets of questions (section 5.5), and echo questions on prepositions, quantifiers and question words (section 5.6).

5.2   Focus

Focus in ordinary, direct questions serves the same function it does in declarative sentences. Schwarzschild (1999, p. 162) demonstrates how focus marking on questions satisfies the requirement that all constituents must be given.

(12)   A: I bought a watch for my younger sister.

         B: What did you buy for your OLDER$_F$ sister?

According to Schwarzschild, a constituent is given if after replacing its focused sub-constituents by variables and existentially binding all the unsaturated arguments, the resulting proposition is entailed by previous discourse. Schwarzschild takes the denotation of a question to be the set of true answers (Karttunen 1977); the proposition derived from B's utterance in (12) for the purpose of determining givenness turns out to be the one in (13), and indeed it is entailed by A's utterance.

(13) $\exists X \exists y$ [speaker A bought y for her X sister]

Focus is necessary on the adjective *older* in (12) in order to get an existentially bound variable in (13). The *wh*-phrase *what* is not focused—this follows if it is an existentially quantified indefinite to begin with. *Wh*-phrases are generally not focused in direct questions.

In some instances, a *wh*-phrase may be marked with a pitch accent because a larger constituent needs to satisfy the givenness requirement. This can be seen in embedded questions where focus marking on a *wh*-phrase is possible (14), though not obligatory (15).

(14) Mary knows that George ate breakfast, and Jane knows WHAT he ate.

(15) Mary knows that George ate breakfast, and Jane knows what he ATE.

The embedded question *what he ate* is given even without focus marking—the proposition that John ate something is entailed by the first part of the sentence; each part of the embedded question is also given. However, the constituent *knows what he ate* is not given, since nothing in the first part of the sentence entails the proposition that someone knows what John ate. The entire constituent must be marked with focus, though none of its parts has to be. What determines where accent is placed within the constituent is something other than the givenness requirement, and as we see, there is more than one possibility (the factors that determine pitch assignment in the above examples remain to be determined; pitch on *ate* in (15) may be the result of the Nuclear stress rule, see Halle and Vergnaud 1987).

Turning over to echo questions, we notice that an echo question in its entirety is always given, and so is each part of the echo. This leads us to expect that no part of an echo question should be focused. But echo questions characteristically do have a pitch accent. We start by looking at echo questions without a *wh*-phrase: the echo in (8), repeated below, is identical to the preceding utterance except for its intonational contour (rising pitch and high-rising boundary).

(8)   A: I gave flowers to George.

      B: You gave FLOWERS to George?

The echo intonation indicates that the speaker believes she has misperceived part of the interlocutor's utterance or wishes to dispute it, and the disputed constituent is marked with a pitch accent.

Of course, the disputed part of the echo question in (8) is in fact given. Furthermore, givenness is a requirement on echo questions—the disputed part of an echo question must be entailed by the preceding utterance: the echo in (16) is felicitous because giving Jill a chihuahua entails giving her a dog; the echo in (17) sounds odd because the entailment doesn't go through in the other direction.

(16)   A: I gave Jill a chihuahua for her birthday.

       B: You gave her a DOG for her birthday?

(17)   A: I gave Jill a dog for her birthday.

       B:#You gave her a CHIHUAHUA for her birthday?

The sensitivity to entailment relations shows that the givenness requirement on echo questions is semantic—what is disputed in the echo question is not some part of a linguistic expression, but rather some aspect of its meaning. Furthermore, the entailment relations that determine givenness are sensitive to context: the echo question in (17) is felicitous if the speakers assume that if speaker A gave Jill a dog, it was a chihuahua. This shows that the relation between the echo and the preceding utterance has to be one of "pragmatic" or contextual entailment (see Karttunen 1973).

Non-*wh* echo questions are therefore distinct from direct yes/no questions. The difference in intonation is subtle but clear: the pitch accent in an echo question (18) is rising (L+H*), while a direct yes/no question (19) carries a high (H*) pitch accent.

L+H* HH%
(18) You gave Jill a CHIHUAHUA?

H*   HH%
(19) You gave Jill a CHIHUAHUA?

The difference in the requirement on context is that the echo question (18) takes it for granted that the interlocutor has implied she had given Jill a chihuahua, whereas no such implication is present in the direct question (19). The echo question expresses surprise (and a bias as to what the expected answer is), while the direct question is a genuine question.

So the propositional content of a non-*wh* echo question has to be given, and the utterance expresses surprise or disbelief directed at that particular aspect of the proposition corresponding to the pitch-marked constituent. In what sense, then, does the echo utterance constitute a question? It is here that focus comes into play. The speaker who uses an echo question informs her interlocutor that she refuses to accept part of the interlocutor's utterance: the disputed part is marked as focus, as if it were not given in prior discourse, and the part that the speaker accepts is deaccented. The question meaning is then arrived at through a Gricean inference: the proposition expressed by the echo offers no new information and the echo itself signals that the speaker considers part of it not to be given, so the interlocutor infers that the speaker intends to question this information. An argument along this line is given in Hockey (1994).

The semantics of non-*wh* echoes can be formalized through the use of alternative semantics for focus (Rooth 1985, 1992b): the question denotation of an echo utterance will be its alternative set $[\![\cdot]\!]^f$. Groenendijk and Stokhof (1984) show that the notion relevant to characterizing question-answer relations is the set of all possible answers (Hamblin 1973), rather than the set of true answers (Karttunen 1977) or the full semantic answer (Groenendijk and Stokhof 1982) which are important for embedded questions. The alternative set of a non-*wh* echo question is the set of all propositions derived by substituting alternatives to the denotation of the focused constituent—precisely the set of possible answers to the question; the echo is used to ask the interlocutor which of these propositions was asserted, or intended.

Wh-echo questions too have an obligatory pitch accent, which must be located on the *wh*-phrase. This is not due to a givenness requirement: as we have seen in the beginning of this section, *wh*-phrases are already given and need not be focused. Rather, I suggest that the reason the *wh*-phrase of an echo question is marked with focus is that this is a strategy to arrive at the meaning of the echo question itself, the same way as for non-*wh* echoes. This sounds superfluous—after all, shouldn't the meaning of the echo question follow from the semantics of questions? The familiar treatment of questions runs into problems because it is sensitive to locality restrictions, while echo questions are not; an additional strategy is necessary in order to escape these locality restrictions.

5.3 Locality

Echo questions appear to be exempt from any locality requirements. This is not to be confused with another property of echo questions in English, which has received much

attention in the literature—the fact that echo *wh*-phrases need not be fronted, as in (5), repeated below.

(5)   A: I gave flowers to George.

        B: You gave WHAT to George?

Sentence (5) is an obvious exception to the generalization that *wh*-expressions in English necessarily appear in front of their clauses. In itself, this property does not seem to be of great significance to the semantics of echoes, since the option exists to use a question with echo intonation and the syntax of a direct question, as seen in (6).

(6)   A: I gave flowers to George.

        B: WHAT did you give to George?

Some speakers of English find the fronted versions more acceptable than the unfronted ones; in other languages, fronting of echo *wh*-phrases may be obligatory (Romanian, see Comorovski 1996) or highly preferred (Hebrew, my personal judgment). Furthermore, English itself has unfronted non-echo *wh*-phrases in multiple question constructions.

(20) Mary knows who ate what.

Finally, unfronted *wh*-expressions are the norm in languages other than English for all questions (e.g. Chinese). The existence of echo *wh*-phrases in unfronted positions in English is therefore not a very remarkable property.

   A much more striking fact is that echo *wh*-phrases which do not appear in a fronted position are exempt from locality restrictions. This is not directly attributable to the fact that they are not fronted. Unfronted non-echo questions are still subject to locality requirements: sentence (21) is ungrammatical—it does not have a pair-list reading, because the *wh*-phrase *what* is inside a coordinate structure.

(21)*Mary knows who ate beans and what.

        (cannot be used to report, for instance, that she knows that Mike ate beans and fish, and that Bill ate beans and squid; cf. (20).)

Echo questions are not subject to this locality requirement: echo *wh*-phrases can appear in a coordinate structure, both as the only echo *wh*-phrase in a sentence (22) and when there are multiple ones (23).

(22)   A: John knows who ate beans and squid.

        B: John knows who ate beans and WHAT?

(23)   A: Jane knows Bill ate beans and squid.

        B: Jane knows WHO ate beans and WHAT?

The exemption from locality constraints is also valid crosslinguistically. Fronting of echo *wh*-phrases is obligatory in Romanian, except when fronting would result in an island violation, in which case echo *wh*-phrases remain unfronted (Comorovski 1996;

unfronted *wh*-phrases also occur in second order questions, see section 5.5). In Hebrew too I feel that the fronting of echo *wh*-phrases is preferred, but when fronting is ungrammatical, unfronted echo *wh*-phrases are perfectly acceptable. And in Chinese, where *wh*-phrases are not normally fronted, some dependencies between *wh*-phrases are still excluded—for instance, there is no grammatical counterpart to (21) with *wh*-dependencies across a coordinate structure (thanks to Lian-Hee Wee and Liping Chen for their judgments; see also Nishigauchi 1990, p. 32, fn. 13 for the possibility that *wh*-dependencies are also impossible across a *wh*-clause). Nevertheless, Dayal (1996, p. 228) reports that echo questions are possible in Chinese in certain configurations where direct questions are not allowed. The fact that all the above languages allow echo *wh*-phrases in positions that other *wh*-phrases are excluded (due to locality violations) suggests that this property is not accidental.

Before developing an explicit semantics for *wh*-echo questions we will look at the contextual requirements on their use. Recall that the propositional content of a non-*wh* echo has to be entailed by preceding discourse. A similar requirement on *wh*-echo questions is what makes the following discourse odd.

(24)   A: I saw a kangaroo in the cafeteria today.

       B:#You saw WHO?

The echo in (24) is appropriate only in contexts that entail that speaker A saw a person; the echo therefore implies that speaker B thinks that this is what speaker A had said, presumably because she has misperceived A's utterance. What the context must entail in order for a *wh*-echo to be appropriate is the proposition derived by treating the *wh*-phrase as an indefinite with its normal content (e.g. *who* must refer to a person) but without *wh* properties (for the separation of *wh* properties from the content of a *wh*-phrase in echo questions see Reis 1992). The contextual requirements are the same for non-*wh* and *wh*-echo questions—the *wh* properties of an echo *wh*-phrase are simply ignored for this purpose.

The denotation of a *wh*-echo question cannot be computed through the familiar semantics for direct and indirect questions because the *wh*-phrase in an echo question is in the wrong position—it is not at the front of a clause, nor is it bound by another *wh*-operator at the front of a clause. In formalizing the semantics for echo *wh*-questions we must make sure it is insensitive to locality restrictions: whatever is responsible for locality in direct and indirect questions must be turned off for echoes. Such a solution is offered by Dayal (1996, p. 125): questions are interpreted through LF-movement, which enforces locality restrictions; echo *wh*-phrases are bound by a special operator outside the CP that does not require LF-movement, thus exempting echo questions from any requirements imposed by movement. This proposal captures the insensitivity of echo questions to locality and also links it to the availability of second order questions (see section 5.5), but not to the obligatory pitch accent on echo questions.

My proposal is that *wh*-echo questions are interpreted through the same focus strategy as non-*wh* echoes. Focus is insensitive to locality restrictions.

(25)   Bill $\left\{ \begin{array}{l} \text{even} \\ \text{only} \end{array} \right\}$ knows who ate beans and SQUID.

Indeed, observations about the absence of locality restrictions on association with focus were a major motivation in developing a semantics of focus that does not rely on syntactic movement (Anderson 1972; Rooth 1985; see also von Stechow 1989). Tying the focus on echo *wh*-phrases to the interpretation of echo questions explains why echo questions are not subject to locality restrictions.

The question denotation of a *wh*-echo is its alternative set $[\![\cdot]\!]^f$, just like that of a non-*wh* echo; alternatives to a *wh*-phrase are denotations matching in type. Note that this semantics gives the echo questions *you saw* WHO*?* and *you saw* WHAT*?* the same denotation; the difference between the two is in their contextual appropriateness—the former is only felicitous in response to the an utterance that entails that the interlocutor saw a person. Alternative sets also turn out to be identical for *wh* and non-*wh* echoes: the alternative set, i.e. the question denotation, of (5), (8) and (26) is the set of propositions (27).

(5)   A: I gave flowers to George.

        B: You gave WHAT to George?

(8)   B: You gave FLOWERS to George?

(26)   B: You gave SOMETHING to George?

(27) $\left\{ \begin{array}{l} \text{``speaker A gave flowers to George''} \\ \text{``speaker A gave chocolate to George''} \\ \text{``speaker A gave flowers and chocolate to George''} \\ \ldots \end{array} \right\}$

The set in (27) is a set of propositions—it is the same as the denotation of the question *what did you give to George?* according to the proposal in Hamblin (1973), or the partition of possible worlds induced by the intension of the same question according to Groenendijk and Stokhof (1984). The difference lies in the pragmatics: a direct question asks for a true proposition, while an echo question asks for the proposition that was asserted or intended. Furthermore, a non-*wh* echo also offers a proposition (so it can be answered with *yes*, see section 5.1), and indicates that it is that proposition that the speaker finds hard to accept, rather than the interlocutor's original utterance. Thus, sentence (8) indicates surprise at giving flowers to George, while (26) expresses surprise at giving him anything at all. If a *wh*-echo is understood as expressing surprise or disbelief, this can only be directed at the echoed utterance, since the echo does not offer a proposition by itself (the meaning of its content is not computable, though the alternative set is).

To summarize the proposal so far: focus semantics constitutes an alternative strategy for arriving at a question denotation, one that allows interpreting unfronted *wh*-phrases without locality restrictions. In English this strategy is available for any sentence with a focused *wh*-phrase; in Romanian and Hebrew the strategy is only available when a corresponding sentence with a fronted *wh*-phrase is ungrammatical. The focus strategy is available for echo questions (but not other questions) precisely because they "echo" previous statements, so focus can fall on the question word and there is no need for anything else to be focused. By using focus semantics we capture the similarity

between echo *wh*-questions and echo questions that do not contain a *wh*-phrase. Focus semantics also extends to echoes below the word level and to second order questions, which are discussed in the following two sections.

5.4   Echo questions below the word level

The focus semantics for echo questions immediately accounts for echo questions on parts of words, since focus is generally allowed below the word level (see chapter 2). Focus below the word level is interpreted through phonological decomposition: a focused word part denotes its own sound (so in ORTHO*dontist*, with focus on *ortho*, the word part *ortho* denotes its own sound), and the rest of the word denotes a function from sounds to word meanings (so *dontist* denotes a function that for each sound β yields the meaning of the word β*dontist*). This correctly predicts that the alternative set for ORTHO*dontist* is the set of all meanings of words that end in *dontist*.

   We can see how the semantics of focus below the word level interacts with the interpretation of echo questions by looking at an example of an echo question on a word part.

(28) Bill is a WHAT-dontist?

Since an echo *wh*-phrase is focused, the alternatives to the constituent WHAT-*dontist* in (28) are predicted to be meanings of words ending in *dontist*.

(29) $[\![\text{what}]\!]^f = D_e$

(30) $[\![\text{dontist}]\!]^o =$ the function $h : D_e \to D_{et}$ such that for all $\beta \in D_e$, $h(\beta) = [\![\beta\text{dontist}]\!]^o$ if β*dontist* is a word and $[\![\beta\text{dontist}]\!]^o \in D_{et}$, undefined otherwise.

(31) $[\![\text{what-dontist}]\!]^f = \{\alpha(\beta) | \alpha \in [\![\text{dontist}]\!]^f \land \beta \in [\![\text{what}]\!]^f\}$
$= \{[\![\text{dontist}]\!]^o([\![\text{ortho}]\!]^o), [\![\text{dontist}]\!]^o([\![\text{perio}]\!]^o), \ldots\}$
$= \{[\![\text{orthodontist}]\!]^o, [\![\text{periodontist}]\!]^o, \ldots\}$

So the alternative set for the question (28) is the set of propositions that include "Bill is an orthodontist", "Bill is a periodontist" and so on; the echo question asks which of these propositions was asserted, or intended. The fact that these possible answers have a similar form is a consequence of the meaning of focus below the word level, where the meaning of a word part depends on its form; it does not have to do with the semantics of echo questions.

   It is instructive to compare this approach with proposals to the effect that echo questions differ radically from familiar syntactic and semantic structures. Janda (1985) claims that echo questions are "metalinguistic", derived by substituting question words for syllable strings in the surface structure of a sentence. This is supposed to explain why echo questions allow violations of locality requirements (32)–(33), as well as cases where the question word appears in the place of what looks like a string that is not a syntactic constituent (34)–(35).

(32) They're having a WHAT-party?

(cf. *What are they having a party?; *A what-party are they having?; *Jill knows who's having a what-party.)

(33) He WHAT?

(cf. *What he?; *What did he?; *Jack knows who what.)

(34)   A: He swam across the Monongahela River.

     B: He swam across the Mononga-WHAT River?

(35)   A: The man tore his laissez-passer into pieces.

     B: The man tore WHAT (about) pieces?

Insensitivity to locality requirements (32)–(33) is expected under the focus semantics for echo questions. Echo questions on word parts (34) are also handled by the focus semantics, coupled with phonological decomposition. Finally, it appears that echo *wh*-phrases cannot substitute for non-constituents: the most striking alleged case of this (35) is outright weird in my opinion; McCawley (1987, p. 251) also judges it to be unacceptable, and continues to show that echo questions do have to respect constituent structure.

(36)   a. Smith is the WHAT of the zoology department?

     b.*Smith is WHAT of the zoology department?

Focus semantics thus deals with all the data that motivated a separate "metalinguistic" analysis for echo questions.

    The reason echo questions on parts of words do appear to be "metalinguistic" is that focus below the word level is interpreted through the semantics of phonological decomposition, which makes reference to phonological form. The observation that echo questions can be "metalinguistic" is indeed limited to echo questions on parts of words. The proposal that echo questions as a rule are based on the form of the previous utterance runs into serious problems, which Janda fully acknowledges. The following examples show that echo questions do not copy the form of the statements they echo.

(37)   A: I'm not acrocephalosyndactylic.   (Janda 1985, p. 182)

     B: You're not WHAT?

(38)   A: It really throve.   (Janda 1985, p. 183)

     B: It really did WHAT?

(Note that the question word *what* is of the property type *et* in (37) and (38).)

(39)   A: Jim gave me a present.

     B: You got a present from WHOM?

In (37) speaker B must use the pronoun *you* where speaker A used *I*, and the verb must also match the subject. In (38) speaker B may use a dummy verb *did* that is not present in speaker A's utterance. And (39) shows that an active sentence can be echoed in the

passive. In each of the three cases, the surface forms of the echoed and echo utterances are related in a non-trivial way.

In order to sustain the idea that echo questions are formed by syntactic operations on the interlocutor's utterance, Janda proposes that in (37) "the pronouns and verbs must also be altered appropriately when a former listener becomes a speaker"; as for (38), he suggests that *did what* as a unit can substitute for a verb or VP. The derivation of an echo question from a previous string seems complicated and arbitrary. Under the current analysis, the patterns in (37) and (38) are expected. The pronouns switch between speaker and hearer because they have actual denotations: the denotation of *you* in B's utterance is the same as the denotation of *I* in A's utterance, so the proposition expressed by speaker B is entailed by previous discourse; discourse also entails the echoes in (38) and (39). Echo questions generally allow substitution of coreferential expressions.

(40)   A: Rusty chewed the antique chair you lent us.

        B: Your dog chewed WHAT?

The only place where form plays a part in deriving the meaning of echo questions is when the question is on part of a word, and this is because the semantics of phonological decomposition is sensitive to the form of the word. Everywhere else, echo questions have meanings that are indifferent to the actual form of the utterance, just like other questions.

Echo questions are allowed on parts of words because their semantics is the semantics of focus. But phonological decomposition is a more general phenomenon; shouldn't it be possible to apply phonological decomposition in a way that would allow ordinary (non-echo) questions on word parts? If an ordinary question had a constituent like *what-dontist* which received a meaning through phonological decomposition, then we should be able to form a question. But such a question would violate locality constraints. These are not necessarily constraints on fronted *wh*-phrases: questions on parts of words are also ungrammatical with unfronted *wh*-phrases.

(41) *Sue knows who has an appointment with a what-dontist.

     (cf. Sue knows who has an appointment with which specialist.)

The example above is similar to (21), where a *wh*-phrase could not be interpreted inside a coordinate structure. Any semantics for questions has to incorporate a locality mechanism, be it in the syntax or the semantics, that blocks dependencies like (21) and (41). It appears that words are simply islands for interpreting *wh*-dependencies; for this reason phonological decomposition does not apply in non-echo questions.

5.5   Second order questions

Echo questions can be uttered as a response to questions. In such instances they seek to ascertain what question had just been asked or intended, or express surprise at such a question. Echoes that inquire about questions are often referred to as "second order questions", following Karttunen (1977, fn. 7, p. 12).

(42)   A: Who did Mary see?

       B: Who did WHO see?

The expected answer to the echo in (42) is a clarification of the question that speaker A had originally intended. Question denotations are the sets of possible answers (Hamblin 1973; Groenendijk and Stokhof 1984); the denotation of speaker B's utterance is therefore the set of question denotations which can serve as answers to the echo.

(43) {"who did Mary see?", "who did Bill see?", "who did Jane see?", ... }

The two occurrences of the question word *who* in the echo in (42) serve different functions: the first, unaccented *who* is part of the original question that speaker B accepts; the second *who*, with a rising (L+H*) pitch accent, marks the constituent that speaker B wishes to question or dispute. It is the latter *who* which gives rise to alternatives in the denotation of the echo.

The familiar semantics for questions (e.g. Hamblin 1973; Karttunen 1977; Groenendijk and Stokhof 1982) does not yield second order denotations for questions with multiple *wh*-phrases, regardless of the order in which the *wh*-phrases are processed. For this reason Dayal (1996, p. 125) introduces a layer above the CP for computing the meanings of echo questions: the CP level gives an ordinary denotation of a statement (for first-order echoes) or a question (for second-order echoes), with a free variable for each echo *wh*-phrase; an echo operator above the CP binds the free variables and returns a set of statement or question denotations, whichever the case may be, as the denotation of the echo.

Focus semantics for echo questions has the same effect. The alternative set of an expression is a set of ordinary denotations of the same type, so the alternative set of a question is a set of denotations of the same type as the question. Since the only focused constituent in a second-order question is the echo *wh*-phrase (or phrases), the alternative set of the second-order question will be the set of question denotations formed with alternatives to the echo *wh*-phrase(s).

Focus semantics also predicts that second order questions are possible when the echo pitch accent occurs on a non-*wh* constituent in a question. This is correct.

(44)   A: Who gave flowers to George?

       B: Who gave FLOWERS to George? I don't care. What bothers me is who gave him candy.

(11)   A: Did Mary give flowers to George?

       B: Did Mary give FLOWERS to George? That's not important. The question is whether she gave him candy.

The alternative sets for the echoes above are indeed sets of questions. Like other non-*wh* echo questions, the fact that the echo constituent is given explicitly means that second-order non-*wh* questions cannot be used to signify that the speaker has not perceived the original utterance correctly, but they can show an objection to the original utterance.

Fronted second order questions are ungrammatical, because the ordinary semantics for questions cannot compute second-order question denotations.

(45) A: Who gave flowers to George?

  B:*WHAT did who give to George?

    (cf. Who gave WHAT to George?)

Not only is sentence (45) ungrammatical, but to the extent that we can give it an interpretation, it would be a multiple question. Since focus rather than fronting is the only strategy that semantically results in sets of questions, we predict that second order questions will have unfronted echo *wh*-phrases even in languages that require fronting whenever possible; this is correct for Romanian (see Comorovski 1996) and Hebrew.

  By using alternative sets as the denotation of echo questions, focus semantics captures the insight of Dayal (1996), that echo denotations are sets of ordinary denotations of statements and questions. Rather than arriving at these sets through a special operator located in a distinct syntactic position, the current proposal uses the already available semantics of focus. In doing so we not only correctly predict the absence of locality restrictions on echoes and the existence of second-order questions, but also tie together the semantics of *wh* and non-*wh* echoes, and link that to the obligatory pitch accent of echo questions.

5.6 Prepositions, quantifiers and question words

The data so far show a full parallelism between *wh* and non-*wh* echo questions: every non-*wh* echo question corresponds to a *wh*-echo in which the focused constituent is replaced with a *wh*-phrase, and conversely, every *wh*-echo corresponds to a non-*wh* variant. This parallelism does not hold of all echo questions. Any constituent that can be focused can form a non-*wh* echo, for example prepositions and quantifiers.

(46) A: I sleep under my bed.

  B: You sleep UNDER your bed?

(47) A: I gave ice cream to most of the children.

  B: You gave ice cream to MOST of the children?

    (can imply, for instance, "I find it hard to believe you gave it to most of the children, rather than just some or all of them".)

It is impossible, however, to form appropriate *wh*-echoes to the initial utterances in the above two examples.

(48) A: I sleep under my bed.

  B:*You sleep WHAT your bed?

(49) A: I gave ice cream to most of the children.

  B:*You gave ice cream to WHAT of the children?

    (cannot be used to imply "I didn't hear if you gave it to some, most, or all of the children" or "I find it hard to believe you gave it to most but not all of the children".)

The last example improves somewhat if we replace the echo *wh*-phrase *what* with *how many*, but it is still not very good, as the question implies that a specific number had been mentioned. The problem seems to be simply that English has no question words corresponding to prepositions or quantifiers, so *wh*-echoes cannot be formed.

A similar thing happens when an echo response to a question, which normally results in a second-order question, targets the question word itself as the disputed constituent. Here too the only way to ask an echo question is by focusing the original constituent, not by replacing it with another *wh*-phrase.

(50)   A: I found out where Jessie bought the schnapps.

      B: You found out WHERE Jessie bought the schnapps?

      (can imply, for instance, "I find it hard to believe you found out where he bought it rather than when".)

(51)   A: I found out where Jessie bought the schnapps.

      B:*You found out WHAT Jessie bought the schnapps?

      (cannot be used to imply "I didn't hear whether you found out where or when he bought it" or "I find it hard to believe you found out where he bought it rather than when".)

Here too the problem is not with the intended meaning of an echo like that in (51): after all, the echo in (50) is perfectly coherent. Rather, an echo like (51) cannot be formed because English lacks a question word for questioning other question words.

Focus semantics for echo questions broadens the coverage of the theory to echo questions of types that were not dealt with in previous accounts, including non-*wh* echoes that lack a *wh* counterpart. Focus semantics gives *wh* and non-*wh* echoes a uniform treatment; differences lie in the contextual requirements and answerability, not in the question denotation. The absence of *wh*-echo questions of certain types is the result of gaps in the English lexicon, which does not have a suitable question word for every type of constituent that can be echoed.

Chapter 6

Conclusion

In the dissertation I have shown that natural language semantics needs to be able to interpret arbitrary word parts in focus constructions, coordinate structures, and echo questions (the latter follows from focus semantics). In all of these cases, the semantics is sensitive to the form of linguistic expressions, a property not characteristic of semantics in general. My proposal is that interpretation of arbitrary word parts is achieved through a process of phonological decomposition, which encodes the form of an expression in its meaning. In this final section I take a look at phonological decomposition from a number of additional angles: a general discussion of the merits of compositional analyses (section 6.1), expectations regarding syntactic idioms (section 6.2), and an interesting parallel with lexical access (section 6.3).

6.1   Compositionality

Phonological decomposition, as developed in the dissertation, is a process that assigns denotations to expressions that lack independent meanings, allowing them to participate in compositional semantics. The compositional analysis is motivated by the intuition that focus and coordination operate on the meanings of linguistic expressions: focus signals alternative meanings (rather than alternative forms), and conjunction is a function on meanings rather than expressions. Therefore, if a linguistic expression is placed in a focus or coordinate structure, it must have a meaning; constituents that do not have meanings independently need to be given denotations somehow.

Compositionality itself is not a goal of the analysis. A recent debate in *Linguistics and Philosophy* raised the issue of compositionality as a desideratum for semantic theories. The debate is over a claim by Zadrozny (1994) that any semantic system can be made compositional, rendering the whole concept of compositionality formally vacuous. As an illustration, Zadrozny shows how one can construct a compositional semantics for an expression like *high seas*, whose meaning, intuitively, is not composed of the meanings of the words *high* and *seas* (in contrast to an expression like *high wall*).

Let *high*, *wall* and *seas* be basic expressions of the language; let *high wall* and *high seas* be complex expressions; and let $[\![\cdot]\!]$ designate an intuitive meaning function such

that the following hold.

$$\llbracket \text{high wall} \rrbracket = \llbracket \text{high} \rrbracket (\llbracket \text{wall} \rrbracket)$$
$$\llbracket \text{high seas} \rrbracket \neq \llbracket \text{high} \rrbracket (\llbracket \text{seas} \rrbracket)$$

We now define a function μ, whose domain is expressions of the language and whose range is (partial) functions. The expressions *wall*, *seas*, *high wall* and *high seas* are mapped by μ to functions from expressions to their meanings.

$$
\begin{aligned}
\mu(\text{wall}) &= f_1 : \text{wall} \mapsto \llbracket \text{wall} \rrbracket \\
\mu(\text{seas}) &= f_2 : \text{seas} \mapsto \llbracket \text{seas} \rrbracket \\
\mu(\text{high wall}) &= f_3 : \text{high wall} \mapsto \llbracket \text{high wall} \rrbracket \\
\mu(\text{high seas}) &= f_4 : \text{high seas} \mapsto \llbracket \text{high seas} \rrbracket
\end{aligned}
$$

The action happens in the definition of $\mu(\text{high})$: this is a function that not only maps the expression *high* to its meaning, but also maps elements from the range of μ to one another.

$$
\begin{aligned}
\mu(\text{high}) \quad = \quad f_5 : \quad &\text{high} \mapsto \llbracket \text{high} \rrbracket \\
&\mu(\text{wall}) \mapsto \mu(\text{high wall}) \\
&\mu(\text{seas}) \mapsto \mu(\text{high seas})
\end{aligned}
$$

The function μ is compositional by definition: $\mu(\text{high wall}) = \mu(\text{high})(\mu(\text{wall}))$ and $\mu(\text{high seas}) = \mu(\text{high})(\mu(\text{seas}))$. Furthermore, the standard meaning function is fully recoverable from μ, since for any expression A, $\llbracket A \rrbracket = \mu(A)(A)$. Zadrozny thus claims that the function μ is a compositional interpretation function for the language.

Zadrozny shows that a similar construction can be made for any semantics; therefore any semantics can be emulated by a compositional construction, from which standard meanings are fully recoverable. This leads Zadrozny to conclude that the notion of compositionality is formally vacuous, and instead he argues for a notion of systematicity that should constrain possible semantic systems.

In reply to the above argument, Kazmi and Pelletier (1998) claim that Zadrozny's construction μ is not a meaning function at all, because the output of μ is the functions f_1–f_5, which are not meanings. So while the μ of an expression is a function of the μ of its parts, the meanings are still not compositional. Dever (1999) points out that the function μ violates a basic intuition about meaning, since it does not preserve synonymy: two distinct expressions that have an identical meaning will be assigned different values by the above construction, because the function μ maps each expression to a distinct function:

$$
\begin{aligned}
\llbracket A \rrbracket &= \llbracket B \rrbracket \\
\mu(A) &= f_A : A \mapsto \llbracket A \rrbracket \\
\mu(B) &= f_B : B \mapsto \llbracket A \rrbracket \\
\mu(A) &\neq \mu(B)
\end{aligned}
$$

Therefore the construction μ does not agree with our intuitions about meanings. And Westerståhl (1998) notes that Zadrozny's construction does not offer an explanation why synonymous lexical items get different meanings under the μ-calculus.

Dever (1999) points to a crucial aspect of Zadrozny's emulation of compositionality which explains why it fails to capture anything interesting about meanings. The

functions that form the output of μ are made of two distinct components: one maps expressions to their meanings, and the other maps μ-outputs to other μ-outputs. The first component is responsible for connecting the μ-calculus to what we ordinarily think of as meanings; the second component forms the μ-calculus itself. Dever correctly points out that the two components are completely independent of one another—a change to one would not affect the other.

The lesson from the above discussion is that achieving compositionality through formal construction is only interesting to the extent that the new construct is a meaning in some intuitive sense. The constructs of phonological decomposition are the representation of sounds as the meanings for focused and coordinate word parts, and functions from sounds to word meanings as meanings for the rest of the word. That sound can be a meaning of a linguistic expression is hardly controversial (cf. *ortho is disyllabic*); proposing such meanings for word parts in focus and coordinate structures captures an important insight about focus and coordination: below the word level, these processes are sensitive to the form of the expressions they combine with—the alternatives to a word with a focused part are meanings of words similar in form, and word parts can only be coordinated if the words they are part of share a common prosodic constituent.

The functional denotations for the unfocused and non-coordinate parts retain the compositionality of focus and coordination. The reason we want to model focus below the word level and coordination of parts of words in a compositional system is that focus and coordination are compositional themselves: the effects of focusing a constituent are a function of the meaning of the constituent in focus, and the meaning of a coordinate structure is a function of the meanings of its parts. The new constructs thus capture the intuition that the meanings of focus and coordination, when applied to word parts, are the same as the meanings that apply to phrasal constituents. Compositionality of the resulting system is not the goal of the analysis—it is a necessary consequence of the meanings of focus and coordination.

6.2   Idioms

Phonological decomposition gives meanings to parts of words that do not have an independent meaning. But units that lack an independent meaning do not have to be word parts, they may be whole words or even larger syntactic constituents. This is the case with idioms, which are complex syntactic expressions that receive meanings which are not predictable from the meanings of their parts, and thus serve as terminal nodes for semantic interpretation (see for example Di Sciullo and Williams 1987; Marantz 1997). From the point of view of compositional semantics, then, idioms are non-terminal syntactic nodes that receive a basic meaning. Should we expect phonological decomposition to apply to parts of idioms?

Not all idioms are semantic primitives. In chapter 4, section 4.2.4 we looked at Nunberg *et al.*'s (1994) analysis of idiomatically combining expressions, where an idiom's meaning is split between its syntactic constituents. These are expressions like *pull strings*. The examples that show that the meanings of the parts are available independently are repeated below.

(1)   a. pull high-ranking strings

        b. Pat got the job by pulling strings that weren't available to anyone else.

                                                  (Nunberg *et al.* 1994, p. 500)

        c. Those strings, he wouldn't pull for you.   (Nunberg *et al.* 1994, p. 501)

        d. Kim's family pulled some strings on her behalf, but they weren't enough to get her the job.   (Nunberg *et al.* 1994, p. 502)

The expression *pull strings* is idiomatic (it does not involve the ordinary meanings of *pull* and *strings*), but the special meanings are assigned to the constituent parts, and the expression as a whole is compositional—its idiomatic meaning is computed from the special meanings of the parts through ordinary compositional semantics. We do not expect phonological decomposition to apply to such an expression, since the process does not apply to expressions that are already compositional (cf. chapter 4, section 4.2.5).

Other idiomatic expressions, like *kick the bucket* meaning 'die', cannot be analyzed as idiomatically combining expressions—the special meaning of the idiom is not distributed among the parts, and we cannot identify special meanings for the parts themselves. We therefore expect that phonological decomposition should be available for such idioms (Nunberg *et al.* 1994 call them *idiomatic phrases*).

The difference in compositionality between idiomatically combining expressions and idiomatic phrases is used by Nunberg *et al.* to explain why the former can be put in the passive (*some strings were pulled by my friends in City Hall*) while the latter cannot be passivized (**the bucket was kicked by Bill*): Nunberg *et al.* explain that passivization is a relation between two lexical forms of a verb. In idiomatically combining expressions the verb has its own meaning, so it is lexically related to a passive form, while in idiomatic phrases the verb has no independent meaning. If this explanation is correct, we expect it to survive even if phonological decomposition can simulate a meaning for the word part *kick* in *kick the bucket*, because the resulting meaning is not expected to stand in any relation to a passive form of the verb.

For the same reason, phonological decomposition also predicts that coordination of parts of an idiom with part of a compositional expression should be impossible.

(2) He kicked the bed and then the bucket.
     (cannot mean: "he kicked the bed and then died")

This follows because the simulated denotation for *kick* in *kick the bucket* is not the same as the lexical meaning of the verb *kick*. Sentence (2) is therefore an instance of zeugma, just like the ungrammatical **black and floorboards* (chapter 4, section 4.2.5).

At the same time, the analysis does predict that coordination of idiom parts should be possible if two idiomatic phrases share a word (provided that the coordinate meaning is sensible). I have not found examples of this, but I haven't found counterexamples either. One reason for the paucity of data may be that the density of the space of syntactic idioms (a measure of lexicalized expressions compared to possible syntactic structures) is much lower than the density of the space of words (see Di Sciullo and Williams 1987).

6.3 Meaning, form, and lexical access

The semantics of arbitrary word parts reflects their phonological form. It is interesting to point out that similar connections are independently noted in the psycholinguistic literature. Language users are able to extract information about meaning from parts of words: word recognition happens in real time, and lexical access begins as soon as the beginning of the word is heard, without waiting for the complete phonological shape. Tanenhaus *et al.* (1995) show, for instance, that as a word like *candle* is being heard, it activates the meaning of a word with a similar onset, such as *candy*; Allopenna *et al.* (1998) show that this is also true of syllables at the end of a word, so as the second syllable of *beaker* is being heard, it activates the meaning of the word *speaker*. This evidence shows that language users are able to give meanings to parts of words—they associate a sound with the set of meanings of words that match it in form. Similar things happen on the production side too: Dell (1995) shows that the number of speech errors ("slips of the tongue") that combine phonological and semantic mistakes is greater than what would be expected based on mistakes that are solely phonological or semantic, suggesting an intimate connection between phonological and semantic processing.

This is not to say that these psycholinguistic observations are the same as the phenomena described in this dissertation. The motivation for choosing denotations for parts of words is entirely semantic, driven by the need to explain focus below the word level and coordination of parts of words as part of the general theories of focus and coordination. And there are observed differences: while phonological decomposition is restricted to apply to prosodic units of a certain minimal size, lexical activation can be triggered by phonetic material as short as a segment. Nevertheless, the similarities between these two kinds of observations beg further study.

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