# Sign-Based Morphology and Phonology
## with special attention to Optimality Theory

by

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M.A. (University of California, Berkeley) 1993

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Linguistics

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA, BERKELEY

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Fall 1996

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Abstract

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In this dissertation, I develop Sign-Based Morphology, a novel, comprehensive, declarative theory of the phonology-morphology interface. Theories of morphology are traditionally assigned one of the following classifications: Item-and-Arrangement, Item-and-Process, and Word-and-Paradigm. Sign-Based Morphology shares properties of all three approaches. It combines insights from constituent structure-based views of morphology on the one hand and realizational views on the other, thus building on ideas in both item-and-arrangement and item-and-process approaches to morphology. It also has a plausible paradigmatic interpretation, thus incorporating insights of the Word-and-Paradigm approach as well. By using insights from these approaches to morphology, which are usually assumed to be mutually incompatible, Sign-Based Morphology manages not only to capture all their advantages, but also to avoid their pitfalls.

Sign-Based Morphology offers principled accounts of cyclic as well as noncyclic phonological effects. Furthermore, it relates the cyclic-noncyclic contrast to independently motivated morphological properties of forms. Bracket Erasure effects follow in a straightforward way from the basic architecture without any brackets or any erasure. I also show how challenges to Bracket Erasure can be dealt with. The explicit sign-based architecture of Sign-Based Morphology, and its use of lexical type hierarchies allows it to capitalize on a new generalization regarding Bracket Erasure effects that I propose in this thesis: phonology has no access to the internal morphological structure of its input constituents, whereas morphology may (indirectly, through referring to lexical types) identify the outermost morphological construction in an input constituent. Previously, it was thought that morphology and phonology had access to exactly the same type and amount of information. Counterexamples to this were taken to motivate a complete abandonment of Bracket Erasure. Sign-Based Morphology can maintain a strict position regarding Bracket Erasure effects, thanks to its sign-based architecture.

Sign-Based Morphology is a declarative theory that derives cyclic phonological effects from static constituent structure configurations. Its existence is proof that, contrary to commonly expressed beliefs, there is nothing intrinsically or irreducibly derivational about cyclic phonology.

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**List of Abbreviations**

**1. Glosses**

| | |
|---|---|
| 1 | First person |
| 1du | First person dual |
| 1pl | First person plural |
| 1pl.poss | First person plural possessor |
| 1pl.sbj | First person plural subject |
| 1sg.poss | First person singular possessor |
| 2du | Second person dual |
| 2pl | Second person plural |
| 2pl.poss | Second person plural possessor |
| 2pl.sbj | Second person plural subject |
| 2sg | Second person singular |
| 2sg.poss | Second person singular possessor |
| 2sg.sbj | Second person singular subject |
| 3pl.pret | Third person plural, preterite (portmanteau morph) |
| 3sg.poss | Third person singular possessive |
| 3sg.sbj | Third person singular subject |
| abil | Abilitative (possibility or ability) |
| abl | Ablative |
| abs.pl | Absolute plural |
| abs.sg | Absolute singular |
| acc | Accusative |
| adj | Adjective |
| adv | Adverb |
| agt | Agentive noun |
| caus | Causative |
| cond | Conditional |
| dat | Dative |
| dim | Diminutive |
| du.sbj | Dual subject |
| dur | Durative |
| erg | Ergative |
| evid | Evidential |
| fut | Future |
| gen | Genitive |
| imprf | Imperfective |
| inc.du.sbj | Inclusive dual subject |
| iter | Iterative |
| loc | Locative |
| m.obj | Masculine object |
| mnr | Manner adverb |
| neg | Negative |
| neg.imrpf | Negative imperfective |

| | |
|---|---|
| noml | Nominal |
| part | Partitive |
| pass | Passive |
| perf | Perfective |
| pl | Plural |
| pl.obj | Plural object |
| pl.sbj | Plural subject |
| poss | Possessed |
| ppl | Participle |
| pres | Present |
| prog | Progressive |
| rel | Relative |
| sbj.pers | Subject person (agreement) |
| sg | Singular |
| sub | Subordinate |

**2. Attribute names**

| | |
|---|---|
| AGR | Agreement |
| CAT | Syntactic category |
| cont | Continuant |
| DTRS | Daughters |
| hi | High |
| lo | Low |
| MORPH | Morphological structure |
| nas | Nasal |
| PERS | Person |
| PHON | Phonology |
| PL | Plural |
| PRES | Present |
| SEM | Semantics |
| SL | Supralaryngeal |
| SYN | Syntax |
| SYNSEM | Syntax and semantics |

**3. Optimality Theoretic Constraints and terms**

| | |
|---|---|
| ACC-LOC | A syllable that is accented in the input must be accented in the output |
| ALIGN(X, {L,R}, Y, {L,R}) | For all X, there is a Y such that the {left, right} edge of X coincides with the {left, right} edge of Y |
| DEP | Dependence (no insertion) |
| EVAL | Evaluation with respect to grammatical constraint system |
| HEAD-IDENT | A syllable that is stressed in the input must be stressed in the output |
| LEX≈PR | A lexical word must be a prosodic word (must contain a |

| | |
|---|---|
| | foot) |
| MAX | Maximality (no deletion) |
| MPARSE | Morphological parsing (requires a phonological output) |
| NLV | No long vowel |
| OCP | Obligatory Contour Principle |

**4. Miscellaneous**

| | |
|---|---|
| CG | Construction Grammar |
| GB | Government and Binding |
| GPSG | Generalized Phrase Structure Grammar |
| HPSG | Head-Driven Phrase Structure Grammar |
| LFG | Lexical Functional Grammar |
| min | Minimum (prosodic size condition) |
| SR | Surface representation |
| SSN | Stress shifting nominalization; stress-shifted nominal |
| UR | Underlying representation |

## Acknowledgments

I thank my committee members Larry Hyman, Jaye Padgett, Andreas Kathol, and Thomas Shannon for all the incredible help and attention they have given me. I hope this dissertation does justice to their superhuman efforts.

I especially want to thank my advisor Larry Hyman, who has always helped and guided me in not just work related to my dissertation, but in everything I needed help with.

I am grateful to other people in the department who have given me so much valuable input that they too could very easily have been members of my thesis committee. Foremost among those are Paul Kay and Chuck Fillmore. Thanks to both for showing me the delights of unification-based grammar. I also thank Rich Rhodes and Karl Zimmer for giving me many crucial insights in their quiet and understated way. Sharon has also been a great advisor, a great colleague, and a great student.

My work has also benefited greatly from my interaction with Farrell Ackerman, David Perlmutter, and Adele Goldberg during the very short and very busy period we spent together at UCSD. I am proud to have been their colleague.

I also thank Mark Ellison, Jim Scobbie, Steve Anderson, Greg Stump, Ivan Sag and John Goldsmith for discussing my work with me. I owe many of the insights in this thesis to them. I have also benefited from discussions with András Kornai, Chris Manning and Susanne Riehemann. I thank them, and all the countless other people who have influenced my work.

I am truly grateful to John McCarthy for writing his LI paper on nonconcatenative morphology. The day I read that paper, I decided to become a formal phonologist and morphologist—I was so struck by its beauty.

I thank the Volaré for everything it's done for me. I thank Aylin Küntay and Hans-Robert Cram for getting me interested in linguistics, Nina Lübbren and Anindo Banerjea for giving me the determination, Ayfer Bartu for giving me the courage to do it, and Vic van Niekerk for not letting me feel bad about quitting engineering. I am grateful to Eve Sweetser for telling me exactly what it would be like to be a linguistics student.

I am grateful to my fellow students for putting up with me, and listening to even my strangest ideas. I am especially grateful to Dan Jurafsky and Jean-Pierre Koenig, both for their amazing dedication to their work, and for all they've done for me. Their devotion to linguistics and their relentless attention to rigor, and their love of sushi made me the linguist I am. I thank Cheryl Zoll for being a great friend and for never failing to encourage me, even at my most depressive moments. I am also proud to be a coworker of Andy Dolbey and Ron Sprouse. Andy's interest in Sign-Based Morphology is my best assurance that it is a worthwhile enterprise. And Ron, thank you for teaching me to relax, not worry, have a homebrew.

Thank you, Jem Bebek, for being so sweet and cute, and for making me get up early everyday. Thank you Gügü for not making me live in Ithaca instead of Berkeley. Thank you Ana and Gün for being Gün and Ana. Dümtek dümtek dümtek yasasin.

## Chapter 1. Introduction

In this study, I develop the theory of Sign-Based Morphology, a novel, declarative approach to the phonology-morphology interface, following up on Orgun 1994b,c, 1995a,b,c, 1996b.[1] Theories of morphology are traditionally assigned one of the following classifications: Item-and-Arrangement, Item-and-Process, and Word-and-Paradigm. Sign-Based Morphology shares properties of all these three approaches. It combines insights from constituent structure-based views of morphology on the one hand and realizational views on the other, thus building on ideas in both item-and-arrangement and item-and-process approaches to morphology. It also has a plausible paradigmatic interpretation, thus incorporating insights of the Word-and-Paradigm approach as well. By using insights from these approaches to morphology, which are usually assumed to be mutually incompatible, Sign-Based Morphology manages not only to capture all their advantages, but also to avoid their pitfalls.

A number of basic properties of the phonology-morphology interaction must be handled by a satisfactory theory. These are summarized in (1):

(1)
- a) Account for cyclic phonological effects
- b) Account for noncyclic phonological effects
- c) Relate the cyclic-noncyclic contrast to independently motivated morphological properties of words
- d) Predict the inside-out nature of cyclic effects
- e) Account for Bracket Erasure effects (do not allow unlimited reference to the internal structure of words by the grammar)
- f) Handle challenges to Bracket Erasure
- g) Account for “level economy” effects (the exemption of forms from the phonology of levels where they do not undergo morphology)
- h) Use only independently motivated analytical tools

Past approaches to the phonology-morphology interface have aimed to capture various subsets of these desiderata, but none have targeted the whole range. Sign-Based Morphology achieves all of the desiderata in (1). Moreover, it does so with minimal, independently motivated machinery; the generalizations they correspond to follow from the basic sign-based architecture of the model without additional, ad-hoc stipulations.

Sign-Based Morphology is thus the only existing approach to the phonology-morphology interface that provides principled accounts of all the desiderata in (1).

### 1.1 Goals

In this section, I briefly discuss the desiderata in (1), and provide a road map to the rest of the study based on these desiderata.

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1 A number of researchers have used the framework of Sign-Based Morphology in their work. These include Dolbey 1996, Dolbey and Orgun 1996, Inkelas 1996, Inkelas and Orgun 1996, Moddeé 1996 and Koenig et al. 1996.

Cyclic phonological effects are those in which a morphological subconstituent of a word seems to undergo phonology on its own. A good example is Mandarin Third Tone Sandhi (Shih 1986, Sproat 1992), which changes a sequence of two third tones (*ǎCǎ*) into a second tone followed by a third tone (*áCǎ*) within compounds and phrases. As Sproat note, in morphologically complex forms such as the compounds in (2), the tonal outcome depends on the direction of branching in the constituent structure:

(2) Sensitivity to direction of branching in Mandarin Third Tone Sandhi.

a) Right branching

| | | | | |
|---|---|---|---|---|
| [ rǔɑn | [ zǐ | cǎo ] ] | → | rǔɑnzícǎo |
| soft | purple | grass | | Arnebia euchroma |

b) Left branching

| | | | | |
|---|---|---|---|---|
| [ [ mɑ̌ | wěi ] | zǎo ] | → | mɑ́wéizǎo |
| horse | tail | algae | | kelp |

Why does Tone Sandhi apply differently to these two forms, both of which contain a sequence of three third tones? Sproat points out that the answer must have something to do with the morphological structure of these forms. As a first step, note that, in both forms in (2), the inner morphological constituent is itself an independent word (3):

(3) [ zǐ cǎo ] → zícǎo ‘Lithospermum Erythrorrhizon’

[ mɑ̌ wěi ] → mɑ́wěi ‘horse tail’

If the compounds in (2) are built out of the words in (3) instead of directly from their constituent roots, then the desired result is obtained simply by applying Third Tone Sandhi in the expected manner (4):

(4) a) Right branching

| | | | |
|---|---|---|---|
| [ rǔɑn | zícǎo ] | → | rǔɑnzícǎo |
| soft | Lithospermum Erythrorrhizon | | Arnebia euchroma |

b) Left branching

| | | | |
|---|---|---|---|
| [ mɑ́wěi | zǎo ] | → | mɑ́wéizǎo |
| horse tail | algae | | kelp |

We see that the inner two member compounds in (2) appear to be subject to phonology on their own. It is this kind of effect of morphological structure on phonology that is referred to as a cyclic phonological effect. Past theories of the phonology-morphology interface differ greatly in their handling of such effects. Accounts range from outright denial of the existence of cyclic effects (e.g., Bochner 1993, Karttunen 1993) to successive cyclic application of phonological rules from the inside out to fully built morphological (or even syntactic) structures (e.g., Chomsky and Halle 1968, Odden 1993) to a bottom-up derivational model of morphology in which phonology applies to the output of each morphological operation (e.g., Kiparsky 1982, Mohanan 1982, and also Anderson 1992), to edge alignment constraints applying to fully formed morphological structures (e.g., McCarthy and Prince 1993), to paradigmatic approaches to morphology that attempt to reduce cyclic effects to paradigm uniformity (e.g., Burzio 1994, Buckley 1995), to essentially syntagmatic approaches enriched with transderivational identity constraints (e.g., Kenstowicz 1995, Benua 1996, McCarthy 1996a). Sign-Based Morphology borrows insights from many of these approaches.

This study is devoted to exploring the types and properties of cyclic phonological effects found in natural languages. Chapter 2 investigates cyclic phonological effects of the kind just described, as well as *noncyclic* phonological effects. These are cases where intermediate constituents seem to be ignored by the phonology of the word in question, rather than being subject to phonology on their own as in (2). In chapter 2, I propose that such effects result from flat (that is, *n*-ary branching where *n*>2) constituent structures. I then proceed to show how the same flat versus binary branching structures are motivated by independent morphological and phonological considerations in Turkish. This match between phonologically and morphologically motivated structures provides one of the strongest arguments in favor of Sign-Based Morphology. To my knowledge, no other theory of the phonology-morphology interface predicts such a correlation between morphologically motivated structures on the one hand and cyclic versus noncyclic phonological effects on the other.

Chapter 3 is devoted to exploring the relationship between Sign-Based Morphology and other approaches to morphology. In this chapter, I explicate the intellectual debt Sign-Based Morphology owes to past theories of morphology, and discuss how in incorporates their insights, and goes beyond them in both unifying those insights and avoiding possible pitfalls.

Chapter 4 investigates the status of level ordering in morphology. In this chapter, I focus on the empirical motivation for lexical strata and on the question of whether or not cophonologies are extrinsically ordered, as is claimed in Lexical Phonology. In Sign-Based Morphology, level ordering is not the expected case, as I show in this chapter (see also Inkelas and Orgun 1996), though it can be stipulated if necessary in any particular case, as in Orgun 1994c. The expectation in Sign-Based Morphology is for lexical levels (cophonologies) to be extrinsically unordered. This is consistent with the observations of various researchers cited in chapter 4 that level ordering is not supported empirically.

Chapter 5 investigates the status of Bracket Erasure effects in Sign-Based Morphology. The main insight behind Bracket Erasure (Pesetsky 1979) is that the internal morphological structure of forms is in general not available to the phonology or morphology. I show how Bracket Erasure effects follow directly from the local nature of feature percolation in constituent structures. In the rest of the chapter, I deal with challenges to Bracket Erasure effects. The investigation uncovers a previously unknown asymmetry between the amount of morphological and phonological information available to the grammar. The identity of the outermost morpheme in a form (in terms of constituent structure) is available to the grammar, but its location within the phonological string is not. This new generalization follows automatically from the architecture of Sign-Based Morphology by reference to lexical types that must independently be part of an independently needed inheritance hierarchy. As far as I can tell, this generalization is beyond even the descriptive capacity of any other approach to the phonology-morphology interface. Past approaches such as Lexical Phonology must give up Bracket Erasure completely in order to deal with data that require only a minor relaxation of the principle. Only Sign-Based Morphology makes just the right amount of information available. This generalization, handled straightforwardly in Sign-Based Morphology, is not even accessible in an approach that does not use type hierarchies (or similar devices for expressing lexical patterns, such as the paradigmatic rules in Bochner's (1993) Lexical Relatedness Morphology).

Chapter 6 contains a discussion of phonology intended for the formally or computationally oriented linguist. Although I use Optimality Theory (Prince and Smolensky 1993) throughout this study, I devote this chapter to formal approaches to phonology such as those proposed by Bird 1990 and Scobbie 1991. I discuss the issue of one-level phonology (Bird and Ellison 1994, Bird and Klein 1994), often believed to be the only approach to phonology that is in the spirit of a declarative approach to grammar. I challenge this position by pointing out that two-level phonology is consistent with nonderivational approaches. The crucial observation is that percolation of information from daughter to mother nodes, which defines a two-level system, is already assumed in existing nonderivational theories of *syntax*. I argue that there is no principled reason to impose restrictions on the percolation of phonological information that are stricter than those imposed on other types of information. Furthermore, there are data that pose serious problems for one-level approaches to phonology. I present an illustrative example from Bengali.

I grant that, these points aside, there are independent, mostly computational, reasons to favor a one-level approach to phonology, and I provide a brief demonstration that most, if not all, of the insights developed in this study are available even if a one level theory of phonology is used.

The study ends in chapter 7 with a review of the desiderata for a theory of the phonology-morphology interface, all of which are satisfied by Sign-Based Morphology, but no other theory. I also offer a summary of the new empirical generalizations that Sign-Based Morphology has allowed to surface.

## 1.2 Sign-based linguistics

The theory of the phonology-morphology interface developed in this study, Sign-Based Morphology, is a constituent structure-based theory. It shares its basic tools with all constituent structure-based approaches to linguistics. In particular, Sign-Based Morphology, like all constituent structure theories, assumes that both terminal and nonterminal nodes bear features. In all theories, for example, category features are assigned to nonterminal nodes. The relationship between a mother node's features and its immediate constituents' features plays a central role in Sign-Based Morphology. Due to this emphasis on nonterminal node features, the constituent structures might at first appear somewhat crowded. However, such constituent structures with significant amounts of information included in nonterminal nodes will be familiar from the work of Lieber (1980), to which Sign-Based Morphology owes many crucial insights.

The main innovation in Sign-Based Morphology is to include phonological information in nonterminal nodes as well as the usual syntactic and semantic information.[2] This move makes the theory internally more coherent by treating all kinds of information alike (compare with theories such as Lieber's where phonology is singled out as the only kind of information that is borne exclusively by terminal nodes, while syntactic and semantic features are found on nonterminal as well as terminal nodes). It turns out that this natural move has a number of desirable empirical consequences. This work will be devoted to exploring these, as well as working out the formalism in some detail.

The inclusion of phonology in the types of information that nonterminal nodes bear is standard in unification-based grammar frameworks. Partly to acknowledge this debt, and partly to take advantage of the well-developed notational and formal apparatus developed in such frameworks, Sign-Based Morphology is couched in the unification-based grammar tradition. This school of thought includes frameworks such as Head-Driven Phrase Structure Grammar (HPSG; Pollard and Sag 1987, Pollard and Sag 1994), Construction Grammar (CG; Fillmore et al. 1988, Fillmore and Kay 1994, Fillmore and Kay 1996), and Lexical Functional Grammar (LFG; Kaplan and Bresnan 1982). The approach to morphology developed in this study is meant to be compatible with any of these frameworks (and, in fact, even with other grammatical frameworks that are not explicitly unification-based, including, perhaps surprisingly at first, approaches to morphology that reject constituent structures such as that of Anderson 1992; see section 3.2.2 for a discussion). I will, however, use a simplified HPSG-like notation in this work for the sake of concreteness.

The basic object of grammatical description in a unification-based theory is a Saussurean sign, a pairing of form (phonology) and meaning (semantics). Signs are modeled by feature structures. A feature structure is a collection of attribute-value pairs.

---

2 Although Lieber excluded phonological information from nonterminal nodes, inclusion of such information in nonterminal nodes is a standard feature of unification-based grammar formalisms such as Head-Driven Phrase Structure Grammar (HPSG; Pollard and Sag 1987, Pollard and Sag 1994), Construction Grammar (CG; Fillmore et al. 1988, Fillmore and Kay 1994, Fillmore and Kay 1996), and Lexical Functional Grammar (LFG; Kaplan and Bresnan 1982). However, the implications of this aspect of unification-based formalisms for cyclic phonological effects has not been addressed in the unification-based literature. Sign-Based Morphology remedies this deficiency.

An attribute value pair consists of an attribute name (written in small capitals on the left hand side) and a value (written on the right hand side). Values that are unspecified are indicated by writing the name of the attribute in lower case italics in place of a value.[3] Values are themselves feature structures, except for atomic values, which have no internal structure. Atomic values are written in lower case italic letters. Examples of feature structures are shown in (5):

(5) a) [CAT *noun*]

b)

$$\left[\begin{array}{ll} \text{SYNSEM} & \left[\begin{array}{ll} \text{CAT} & \textit{noun} \\ \text{AGR} & \left[\begin{array}{ll}\text{PERSON} & \textit{third}\\ \text{NUMBER} & \textit{plural}\end{array}\right] \\ \text{SEM} & \text{‘they’}\end{array}\right] \\ \text{PHON} & \textit{ðeɪ}\end{array}\right]$$

c) Generic sign:[4]

$$\left[\begin{array}{ll} \text{SYNSEM} & \textit{synsem} \\ \text{PHON} & \textit{phon}\end{array}\right]$$

The examples in (5b,c) illustrate some of the structure of the basic sign, which consists of a SYNSEM attribute (syntactic and semantic information) and a PHON attribute (phonological information). The notation SYNSEM|AGR|PERSON *third* is a useful abbreviation for [ SYNSEM [ AGR [ PERSON *third* ] ] ]. I will use this abbreviatory notation quite extensively.

The syntactic and semantic features will be highly abbreviated and informal in this study for the sake of conciseness. In particular, English glosses will generally be used to represent the value of the attribute SYNSEM|SEM.

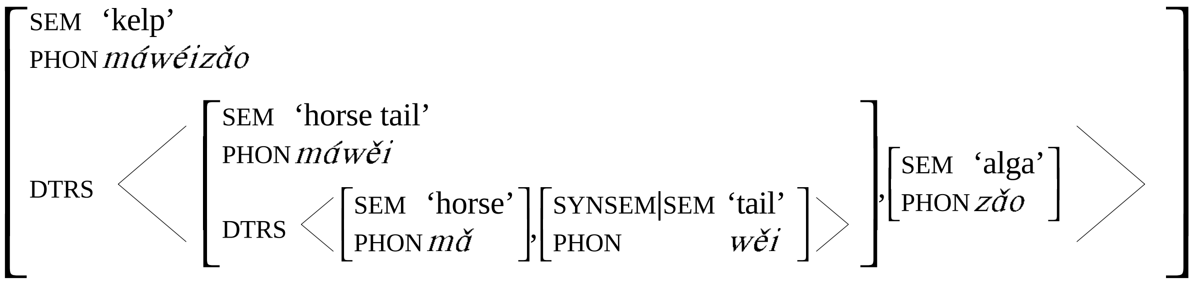
Constituent structures are a statement of relations between signs. In HPSG work, constituent structures are notated within a feature structure by using a list-valued attribute called DTRS (daughters), whose value consists of a feature structure with attributes representing the daughter nodes. An example is given in (6a), where the path SYNSEM|SEM is abbreviated further to SEM, and where the value of the DTRS attribute is represented as a

3 We will see in section 5.2.3 that this notation refers to a type in an inheritance hierarchy.

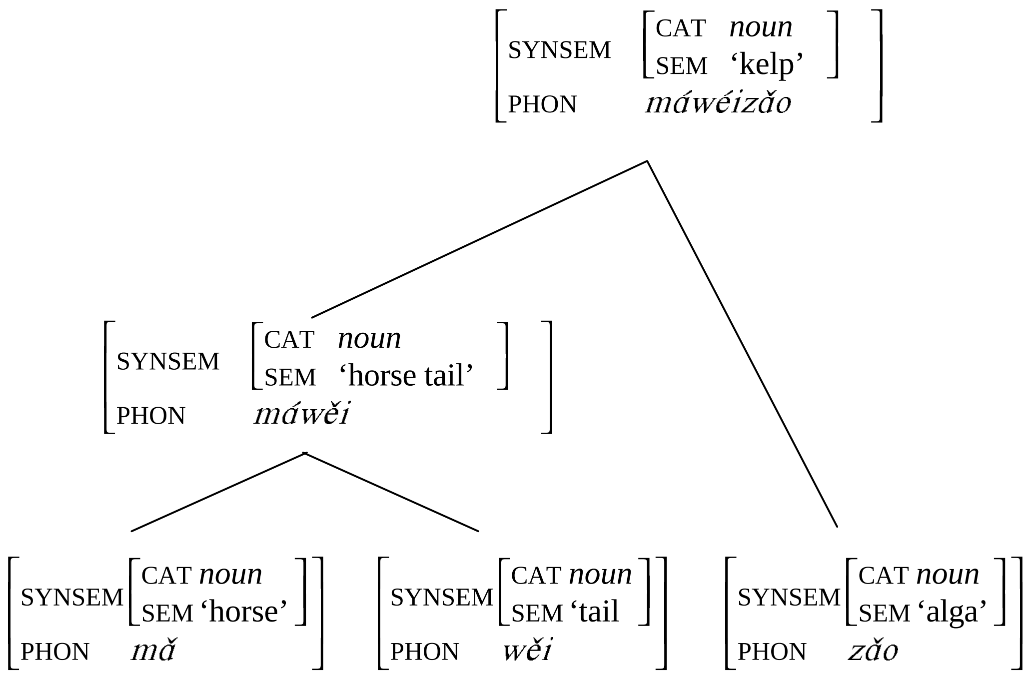
4 In HPSG, the usual assumption is that the value of the phon attribute is a list of phonological units. Following Bird and Klein 1994, we may assume that lists can be parameterized and that the type phon is an abbreviation for list(segment), that is, a list of segments. See Bird and Klein 1994 and Walther 1995 for a discussion of how metrical structure and autosegmental representations can be incorporated into such a system.

list of the immediate constituents of the node that bears this attribute. In this study, I will use the equivalent, but visually more attractive, tree notation (6b):[5]

(6) a) HPSG notation




b) Tree notation




Other attributes will be introduced as they are needed. For a more detailed and formal discussion of HPSG, refer to Pollard and Sag 1994.

5 The tree notation is somewhat less precise than the feature structure notation, since in HPSG, different daughters are often represented by different attributes (such as head-dtr, subj-dtr), a distinction that is lost by using the tree notation. Since this loss of precision has no bearing on the issues discussed in this work, using the visually more appealing tree notation will do no harm

## 1.3 Optimality Theory

Phonological analyses in this study will be stated in the framework of Optimality Theory (Prince and Smolensky 1993). In particular, I will use the two-level version of Optimality Theory proposed by McCarthy and Prince 1994a,b. In this section, I present a brief introduction to the basics of Optimality Theory.

An Optimality-theoretic grammar consists of ranked and violable constraints. Violation of a constraint is possible if and only if such violation is necessary in order to better satisfy a higher-ranking constraint. Given an input, the grammatical output is the one that best satisfies the ranked constraint system among an infinite set of candidate output forms. Consider, for example, [ə] epenthesis in English plural forms (*dagz* 'dogs' versus *bædʒə̱z* 'badges').[6] Assume for the sake of demonstration that the underlying form of the plural suffix is /z/. Assume, following Borowsky 1989 that the constraint responsible for [ə] epenthesis is some version of the Obligatory Contour Principle (OCP; Leben 1973, Goldsmith 1976), prohibiting two adjacent stridents. We also need constraints against deletion (MAX) and insertion (DEP)[7] of phonological material. The constraints are summarized in (7):

(7) OCP Two adjacent stridents are prohibited
DEP Do not insert phonological material
MAX Do not delete phonological material

OCP must outrank DEP, since epenthesis applies in order to prevent OCP violations. Similarly, MAX must outrank DEP; otherwise, deletion would have been the chosen repair. We cannot establish a ranking between MAX and the OCP, since the two never conflict in the data we are considering.

(8) MAX, OCP » DEP

The mapping of the input form to the winning candidate is illustrated by using a constraint tableau (9), (10):

---

6 All English data reflect the speech of a native of California.

7 MAX (maximality) and DEP (dependence) are taken from McCarthy and Prince 1995. Unlike the original version of Optimality Theory in Prince and Smolensky 1993 in which only the output phonological string (but not the input string) was visible to the grammatical constraint system Eval, in this version the phonological mapping relates two phonological strings, input and output. Deletion and epenthesis correspond to the absence of an element of one string in the other string. MAX and DEP assign violation marks for this. It may be noticed that MAX and DEP are duals (mirror images) of each other. This point is implicit in McCarthy and Prince's definition of these constraints. In Orgun 1996a I made this point explicit by proposing a family of constraints with the structure CORR(string1, string2, X) requiring for every phonological element X in string 1 to be a corresponding element in string 2. MAX is then CORR(input, output, X), and DEP is CORR(output, input, X).

(9)

| /dɑg-z/ | MAX | OCP | DEP |
|---|---|---|---|
| ☞ dɑgz | | | |
| dɑg | *! | | |
| dɑz | *! | | |
| dɑgəz | | | *! |

(10)

| /bædʒ-z/ | MAX | OCP | DEP |
|---|---|---|---|
| bædʒz | | *! | |
| bædʒ | *! | | |
| bæz | *! | | |
| ☞ bædʒəz | | | * |

The input form is shown in the upper left-hand cell. Below this, the candidate output forms that we are considering are listed (even though the candidate set is infinite—it is the set of all possible phonological strings—relatively few candidates are of interest to the linguist). The winning candidate, which is the actual grammatical output form, is indicated by a pointing hand.[8] The constraints that constitute the grammar are listed along the top. A broken line between columns indicates lack of evidence for crucial ranking between the constraints so separated. A solid line indicates that the left hand constraint outranks the right hand one. An asterisk in a cell indicates a constraint violation. Fatal violations are indicated by an asterisk followed by an exclamation mark. Cells that are irrelevant to determining the grammatical output are shaded. The sole purpose of the pointing hand, exclamation mark, and shading is to make the tableau easier to read. The conventions do not form part of the formalism.

### 1.4 What does "nonderivational" mean?

Current years have witnessed a growing trend towards approaches to grammar that are said to be nonderivational. However, there is little if any explicit discussion in the literature of what makes a theory derivational or nonderivational. One of the main claims of Sign-Based Morphology is that it does away with the myth that cyclic phonology is necessarily derivational. To make it clear what this means, I present an explicit discussion of what exactly it means for a theory to be nonderivational. I include helpful analogies that might make the issue clearer.

#### 1.4.1 Derivational models

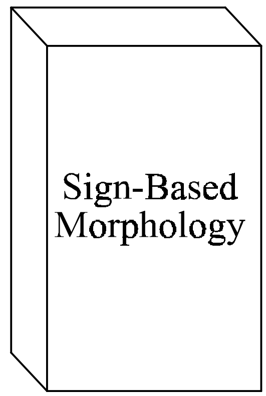
In a derivational model, the order in which operations are carried out has an effect on the ultimate outcome. This property alone is what distinguishes derivational models from nonderivational ones.

---

8 The following notational conventions will be used in later chapters: an ungrammatical form incorrectly predicted by the constraint system to be the optimal output will be indicated by a bomb symbol (💣). The actual grammatical form will then be indicated by a pointing hand in parentheses, following Prince and Smolensky 1993.

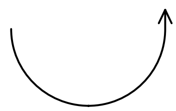
A good example of a derivational model is rotation through ninety degrees around various axes. To illustrate this, imagine a book (11):

(11)



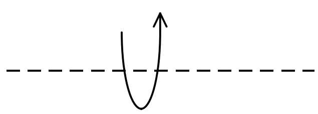

Let us define two rotations. The first is a rotation through ninety degrees around an axis perpendicular to the page (12):

(12) R1:



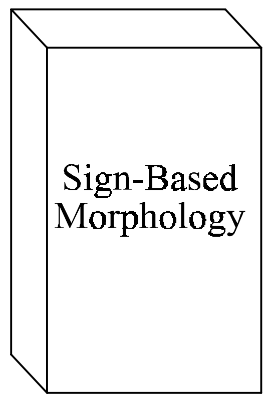
The second function we define is a rotation through ninety degrees around a horizontal axis parallel to the page (13):

(13) R2:

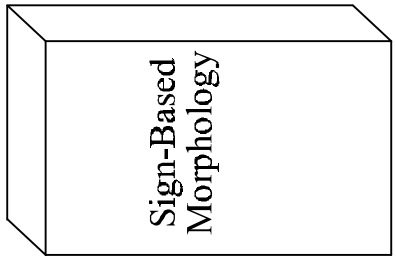


If we apply R1 followed by R2, we obtain the result in (14):

(14) Initial state:



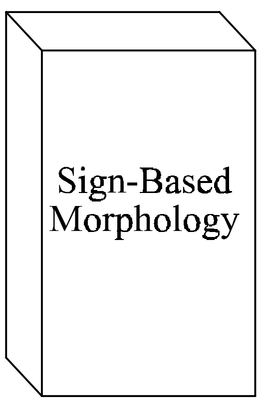
Output of R1:



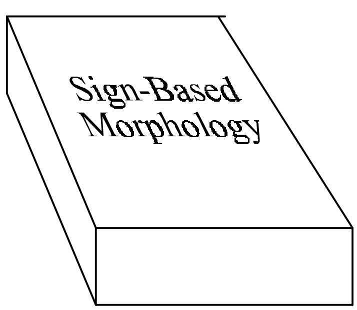

Final state (output of R2):


When we carry out the rotations in the opposite order (R2, then R1), we obtain a different result (15):

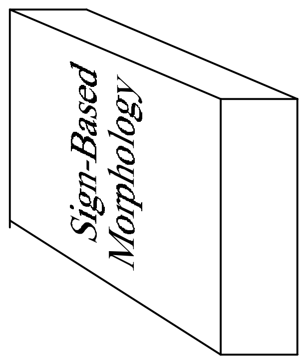
(15) Initial state:




Output of R2:



Final state (output of R1):




Since the order in which the rotation functions are applied has an effect on the ultimate outcome, rotation through ninety degrees around different axes is derivational.

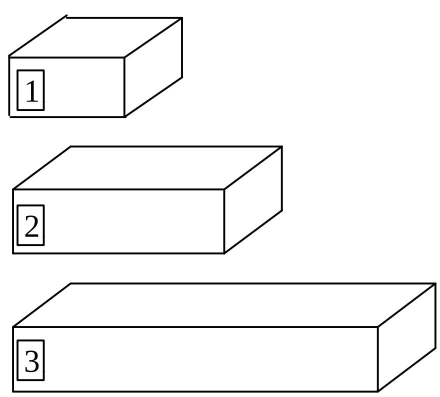
A familiar derivational theory of phonology is the SPE model, where the surface output crucially depends on the order in which rules are applied.

### 1.4.2 Nonderivational models

In nonderivational models, the ultimate outcome is independent of the order in which operations are performed. If desired, an interpretation in which all operations are carried out at the same time, in parallel, is possible. In many models, it is also possible to conceive of the system as imposing constraints on the object being described, rather than as performing operations. Regardless of which of these conceptions is adopted, the crucial property of nonderivational models is that the outcome never depends on the temporal order in which operations are performed.

Building a Lego® or Tinker Toy® model is a nonderivational system. As long as the pieces are connected in the same configuration, it is irrelevant in which order the connections are established. Imagine, for example, that we have three bricks of various lengths, out of which we build a step pyramid. The bricks are shown in (16):

(16)



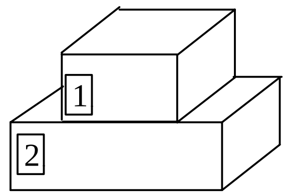
The two operations we define are:

i) Place brick 1 on top of brick 2

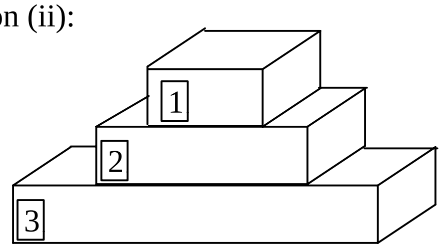
ii) Place brick 2 on top of brick 3.

If we apply operation (i) before operation (ii), we have the derivation in (17):

(17) Output of operation (i):

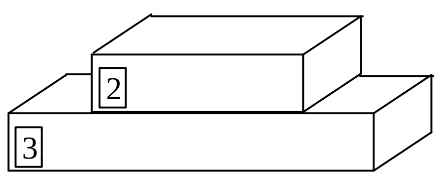



Output of operation (ii):

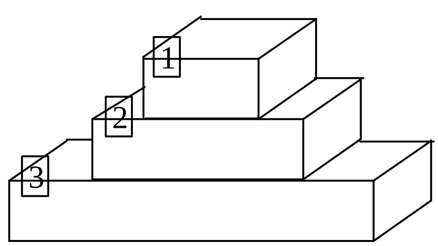



If we apply the operations in the opposite order, we still get the same result, as shown in (18):

(18) Output of operation (ii):




Output of operation (i):



Building Lego models is nonderivational since the surface outcome is independent of the order in which building operations are carried out. Notice that the final outcome could also have been described in terms of static constraints:

i) Brick 1 is on top of brick 2

ii) Brick 2 is on top of brick 3.

It is a general property of nonderivational models that their output can be described in terms of wellformedness constraints instead of in terms of instructions for building the output procedurally.

Another example of a nonderivational model is function composition. Consider, for example, the functions in (19):

(19) $f(\mathrm{x}) = 2\mathrm{x}$

$g(\mathrm{y}) = \mathrm{y} + 1$

Suppose we want to compute $g(\mathrm{f}(47))$. If we apply $f$ to 47 first, then apply $g$ to the result, we obtain the following:

(20) $\mathrm{f}(47) = 94$

$\mathrm{g}(94) = 95$

Now, suppose we compute $g(f(\mathrm{x}))$ analytically first, then apply this new function, which I call $h$, to 47. We then have the following derivation:

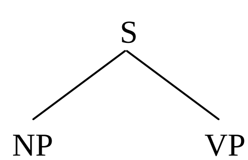
(21) $h(\mathrm{x}) \equiv g(f(\mathrm{x})) = g(2\mathrm{x}) = 2\mathrm{x} + 1$

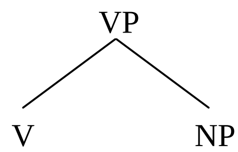
$h(47) = 95$

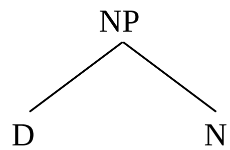
The ultimate outcome of function composition is independent of the order in which composition and variable substitution are performed. The model is therefore nonderivational.

A familiar linguistic example of a nonderivational model is constituent structure definition. Suppose for example that we have the following phrase structure constructions:

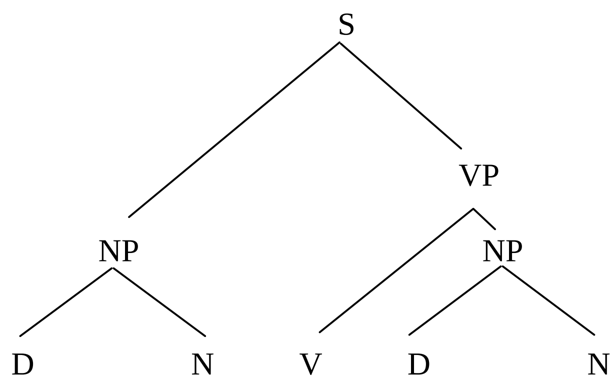
(22) i)



ii) 


iii) 


Regardless of the order in which we combine these constructions, they will license the following constituent structure tree:

(23) 

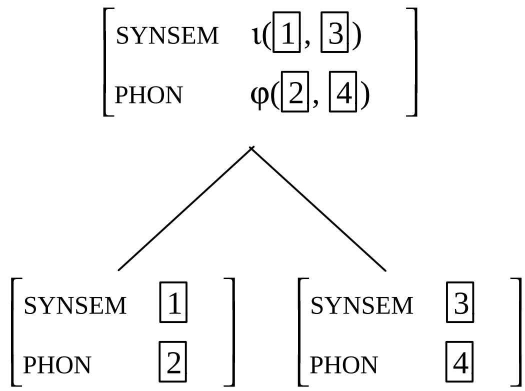

Since the outcome is independent of the order in which we combine our constructions, the model is nonderivational. Not surprisingly, we can, if desired, view our constructions as constraints on wellformed constituent structures rather than as procedural instructions for building one.

### 1.4.3 Why sign-based linguistics is nonderivational

Sign-based linguistics is based on constituent structures. We have just seen that licensing constituent structures is a nonderivational affair. The distinguishing aspect of sign-based theories is that they assume that all nodes in a constituent structure contain semantic and phonological information. The question we must address is whether this fact makes sign-based theories derivational.

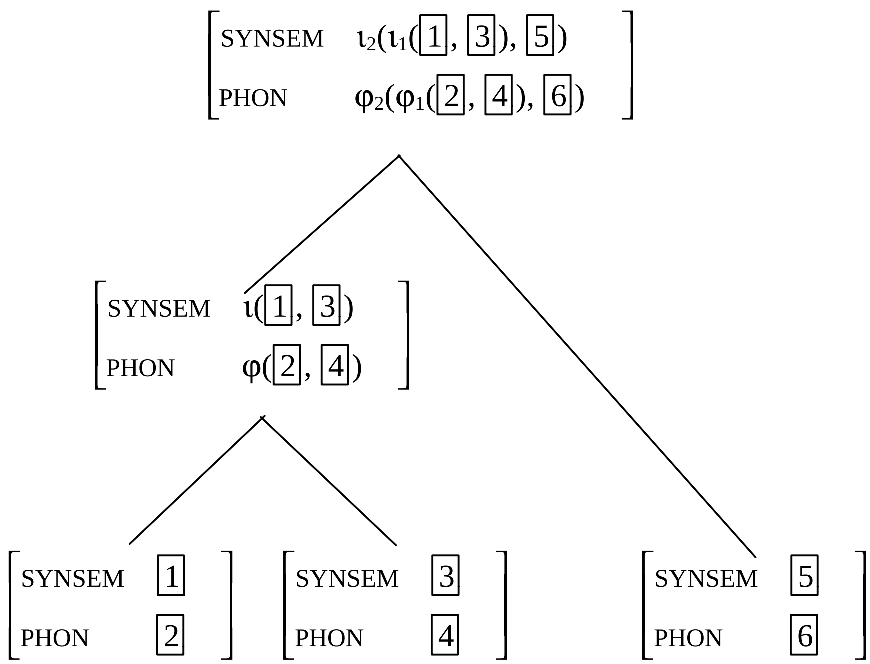
The dependency between mother and daughter node features in a sign-based constituent structure can be represented by using functions as in (24):

(24)




In a hierarchical constituent structure, some function composition will be called for. For example, consider the constituent structure in (25) with three levels of constituents:

(25)




Since constituent structure building is nonderivational and function composition is also nonderivational, we can conclude that sign-based linguistics is also nonderivational (assuming, of course, that the functions ι and φ are defined nonderivationally).

One of the main claims of this work is that sign-based representations such as the one in (25) automatically derive cyclic phonological effects. Since I have just demonstrated that such theories are nonderivational, we can consider the belief that cyclic phonology is necessarily derivational a myth.

### 1.4.4 Advanced formal considerations

One last issue needs to be addressed concerning nonderivationalism. It turns out that any computation that can be done, can be done nonderivationally. This is achieved by reifying each stage of the derivation as a distinct representation. One can then replace derivational operations with statements (constraints) on relationships between these representations. For example, Johnson (1972) has noted that the traditional SPE derivation can be given a nonderivational interpretation in this way. The traditional derivation assumes that a single phonological string is successively deformed by phonological rules that apply in a particular temporal order. After the last rule has applied, the resulting string is submitted to the phonetic interpretation module. This model is depicted in (26):

(26) UR →[rule 1]→[rule 2]→…→[rule *n*]→SR

In the nonderivational interpretation, the temporal stages are replaced by separate levels of representation, and the rules with correspondence constraints holding between those representations (27):

(27)

SR<br>
↑<br>
[correspondence constraints]<br>
↓<br>
intermediate<br>
representation 1<br>
↑<br>
[correspondence constraints]<br>
↓<br>
intermediate<br>
representation 2<br>
↑<br>
[correspondence constraints]<br>
↓<br>
⋮<br>
↑<br>
[correspondence constraints]<br>
↓<br>
SR

Given that every computation can be performed nonderivationally in this trivial and unenlightening manner, one is tempted to ask what significance it has for a theory to be nonderivational. The general answer is that if all the representations used in a nonderivational theory are independently motivated, that theory can be considered satisfactory. If nonderivationalism is achieved only by proliferating levels in an ad-hoc manner, then something is wrong with the theory. A derivational theory might be undesirable, but so is one that uses ad-hoc representations that have no independent motivation.

Let us evaluate Sign-Based Morphology from this perspective. In Sign-Based Morphology, a nonderivational model of phonology-morphology interleaving is achieved by utilizing constraints that relate mother nodes to their immediate constituents. Constituent structures are of course assumed independently of the need to deal with cyclic phonological effects. They are not introduced just to deal with cyclicity. Thus, the only tool used in order to deal with cyclic phonology, namely constituent structures, is amply motivated theory internally.

The intermediate nodes in a Sign-Based Morphological constituent structure are also justified by the fact that they each represent an independent lexical entry. Their existence is thus established beyond doubt. Consider terminal nodes first. These represent morphologically simple lexical forms, that is, roots.[9] Next, consider nonterminal nodes. These represent morphologically complex lexical entries.

Thus, we have seen that:

i) The general mechanism of using constraints relating nodes in a constituent structure does not introduce ad-hoc tools, since constituent structures are motivated independently of phonology-morphology interleaving.

ii) The specific intermediate constituents used in Sign-Based Morphology are not ad-hoc entities, since they all represent lexical entries whose existence cannot be doubted.

Thus, unlike the unnatural and ad-hoc nonderivational interpretation of SPE, which reifies a large number of phonological representations that have no empirical, theoretical, or cognitive justification, the nonderivational interpretation of Sign-Based Morphology given in section 1.4.3 is the natural and principled interpretation.

As I have remarked earlier, the overall theory will be nonderivational provided that the functions that describe feature percolation are nonderivational. Although Optimality Theory, which is only one of the many nonderivational theories of phonology available today, is used in phonological analyses throughout this study, the theory of the morphology-phonology interface which is developed here is meant to be independent of the phonological theory assumed. Any nonderivational two-level theory of phonology may be used. As I discuss in chapter 6, even one-level theories of phonology permit most, if not all, of the desirable consequences of Sign-Based Morphology to emerge.

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9 Here, I am assuming that affixes are not represented as terminal constituents. See section 3.2.2 for a discussion of this point.

## Chapter 2. Cyclic and noncyclic phonological effects

A proper theory of the phonology-morphology interface must account for apparent cyclic phonological effects as well as noncyclic phonological effects. Cyclic phonological effects are those in which a morphological subconstituent of a word seems to be an exclusive domain for some phonological rule or constraint. In this chapter, I show how Sign-Based Morphology can handle noncyclic as well as cyclic phonological effects. Furthermore, Sign-Based Morphology, unlike other theories of the phonology-morphology interface, relates the cyclic-noncyclic contrast to independently motivatable morphological structures.

### 2.1 Turkish prosodic minimality

The example in this section is a disyllabic minimal size condition that some speakers of Standard Istanbul Turkish impose on affixed forms (Itô and Hankamer 1989, Inkelas and Orgun 1995). The examples in (28b) show that affixed monosyllabic forms are ungrammatical for these speakers (unaffixed monosyllabic forms are accepted (28a), as are semantically similar polysyllabic affixed forms (29b).

| | | | | | | |
|---|---|---|---|---|---|---|
| (28) | a) | doː | 'musical note C' | b) | *doː-m | 'C-1sg.poss' |
| | | je | 'eat' | | *je-n | 'eat-pass' |

| | | | | | | |
|---|---|---|---|---|---|---|
| (29) | a) | $\text{sol}^j$ | 'musical note G' | b) | $\text{sol}^j$-ym | 'G-1sg.poss' |
| | | kɑzɑː | 'accident' | | kɑzɑː-m | 'accident-1sg.poss' |
| | | jut | 'swallow' | | jut-ul | 'swallow-pass' |
| | | $\text{tek}^j\text{mel}^j\text{e}$ | 'kick' | | $\text{tek}^j\text{mel}^j\text{e}$-n | 'kick-pass' |

What happens when more suffixes are added to the forms in (28b) to bring the total size to two syllables? It turns out that nominal forms with additional affixes are still ungrammatical regardless of the total size, as shown by the data in (30).

| | | | | |
|---|---|---|---|---|
| (30) | *doː-m | 'C-1sg.poss' | *doː-m-u | 'C-1sg.poss' |
| | *reː-n | 'D-2sg.poss' | *reː-n-den | 'D-2sg.poss-abl' |
| | *fɑː-m | 'F-1sg.poss' | *fɑː-m-sɑ | 'F-1sg.poss-cond' |

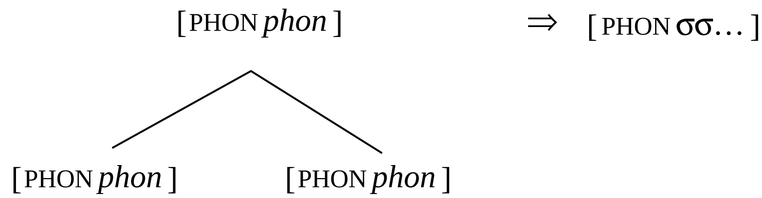
These forms suggest that the disyllabic minimal size condition is enforced cyclically. That is, assuming a binary left-branching structure for suffixed forms, each suffixed subconstituent must satisfy the minimal size condition.

(31) $[\ [\ [\text{root}]\ \text{suffix}\ ]_{\text{min}\ \sigma\sigma}\ \text{suffix}\ ]_{\text{min}\ \sigma\sigma}$

As we have seen in section 1.2, cyclic phonological effects result from the enforcement of phonological constraints on each constituent. If we assume that every nonterminal node is subject to the disyllabic condition, the rest follows simply from the constituent structure.

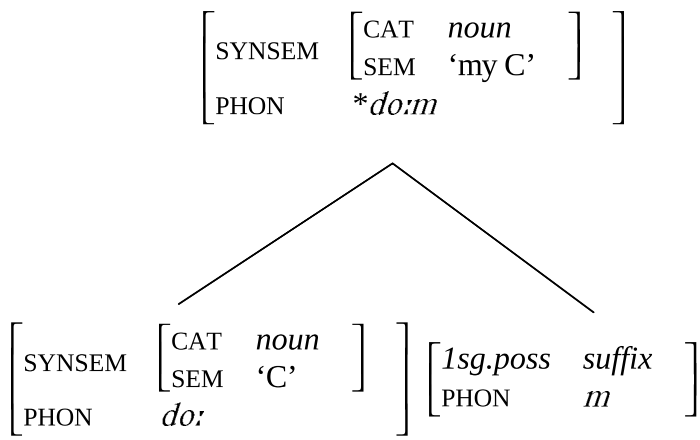
Example (32) schematically shows the disyllabic minimal size constraint.[10] The intended interpretation of this construction is that any node that is morphologically complex must contain at least two syllables.[11]

(32)




The structure for the ungrammatical subminimal form *doː-m* ‘my C’ is shown in (33):

(33)




This form is ungrammatical because the mother node contains only one syllable, and therefore violates the requirement that all nonterminal nodes contain at least two syllables. This violation is indicated by an asterisk preceding the phonological string of the mother node.

Example (34) shows the structure for the supraminimal form **doː-m-u* ‘my C (acc.)’, which is ungrammatical even though it contains two syllables.[12]

---

10 The constraint can be stated more formally if type hierarchies are used (see section 5.2.3 for discussion). We can then simply define a type nonterminal node (we independently need this to distinguish terminal nodes, which have immediate constituents from nonterminal nodes, which do not). Then, the disyllabic minimal size condition can be part of the definition of the type nonterminal node: nonterminal node ⇒ phon /σσ…/. I abstract away here from the issue of representing metrical structure in a feature-based formalism such as HPSG. See Bird and Ellison 1994 and Walther 1995 for some discussion.

11 I assume here that affixes are represented as terminal constituents. This assumption is not crucial, but makes the presentation more transparent.

12 I am using the synsem|sem attribute to provide English glosses, not to make claims concerning semantic representation. I am not claiming, for example, that “accusative” is part of the semantic representation of the accusative suffix.