

Conditions on (Dis)Harmony

by

Andrew Ira Nevins

Submitted to the Department of Linguistics and Philosophy
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

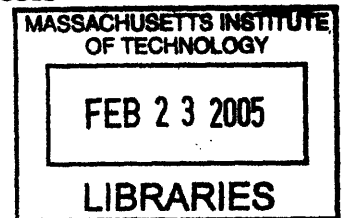
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Abstract

This thesis explores the formal principles and parameters that model the space of *attested*, *unattested*, and *microvarying* patterns of vowel and consonant harmony. The proposal begins with a target-centric theory, in which harmony is the result of a *Search*, initiated by a segment “in need”. Chapter 1 offers comparison with autosegmental, spreading-based models, arguing that the present model provides an explanatory account of locality effects in “non-constituent” copying in Turkish, Barra Gaelic, and Woleaian. It is proposed that harmony and dissimilation are conducted by the same mechanism – because both display intervener-based locality, and parametric bounds on the domain of search – and that they differ formally only in their structural change. Interveners, excluded from the relativized search domain, may stand between target and source, but search inviolably halts at the *closest* element within the domain.

Chapter 2 proposes that the visibility conditions on interveners can be predicted by properties of contrastiveness within the inventory. Nonetheless, within closely-related languages, microparametrization of value-relativization may lead to dramatic differences in surface harmony patterns. Exemplification comes from three case studies: Standard Yoruba and Ife Yoruba; Sibe and Sanjiazi Manchu; and Kyrgyz, Karaim, and Turkish.

Chapter 3 demonstrates that the typology of possible harmony systems has an additional (parametric) determinant: relative sonority. An implicational generalization is proposed: no language has a transparent unpaired vowel of high sonority at the same time it has an opaque unpaired vowel of lower sonority. Exemplification through Hungarian, Wolof, Finnish, and Written Manchu unites seemingly distinct cases of sonority-based harmony asymmetries.

Chapter 4 turns to microvariation within the (dis)harmony system of a single language, examining transparency variation in Hungarian front vowels, and distance-based variation in Hungarian neutral vowel sequences, and in the dissimilative voicing of Embu prefixes. The proposal is that variation results from structural *ambiguity* within analytic possibilities in the hypothesis space developed in Chapters 1-3. When a configuration encountered early in the learning sequence is compatible with multiple (dis)harmony *policies* (i.e. parametric settings of har-

mony grammars), the speaker may choose among these, resulting in variation on those later-learned forms for which the policies *diverge* in their output.

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Acknowledgments

Hopefully¹ this will be the least compelling page of this dissertation.

The first acknowledgements must go to Julio Magaña, who indirectly got me interested in linguistics, and to David Pesetsky, who strongly encouraged me to pursue graduate study in linguistics. My interest in phonology would not have ever grown without the inspiration in my first year from Patrick Winston, Cheryl Zoll, Hubert Truckenbrodt, Noam Chomsky, and (especially) Michael Wagner, all of whom convinced me it was a fascinating field, rich with mysteries and generalizations waiting to be discovered. These people were absolutely instrumental in turning my attention towards phonology.

My committee is one of the best one could ever ask for. Morris, Donca, Michael, and Bert have all served as tremendously encouraging, knowledgeable, and challenging advisors. Morris and Donca's cogent and challenging remarks and counterarguments have caused me to constantly rethink and strengthen my arguments, and will continue to do so for some time.

In the writing of this dissertation, I have benefitted greatly from discussions with the intelligent and warm people with the surnames: Abels, Abrusan, Albright, Anand, Bachrach, Berwick, Boeckx, Calabrese, Fitzpatrick, Hyman, Iba, Kingston, Mailhot, Manfredi, Milligan, Pickard, Poliquin, Poser, Raimy, Reiss, Rodrigues, and Vago. Of course, it is essential to realize how much this work depends on generalizations already established in the insightful and careful dissertations of previous generations of phonologists, particularly the dissertations/books by Bakovic, Calabrese, Casali, Goad, Hannson, Howard, Howe, Ka, Kaun, Kidada, Levi, Li, Parker, Majors, Suzuki, Yang, Zetterstrand and Zhang. Chapter 1 is heavily inspired by the work of Chomsky, Mailhot & Reiss, Piggott, Poser, and Odden. Chapter 2 is heavily inspired by the work of Calabrese and Vaux. Chapter 3 is heavily inspired by the work of Ringen and L. Anderson. Chapter 4 is heavily inspired by the work of Berwick and Yang.

There are many other people to thank for enabling and empowering me during the course of this research: Raphael, Rhoda, and Erica Nevins, Cilene Rodrigues, Assaf Biderman, and Elliot Hess for constant support, Alec Marantz for leading and maintaining a department with numerous resources and countless opportunities, the MIT Libraries Staff for remarkable dependability and efforts, my officemates for their depthless tolerance, the Department of Linguistics Support Staff for all of their assistance, Frank Gehry for designing a place to work that is connected to a swimming pool, Kaldi & Baba Budan for the discovery and export of the coffee bean, and Fela Kuti, the Gang of Four, Segun Bucknor, Alemayehu Eshete, Cartola, Caetano Veloso, Pyaat'-Nizza, Wire, and the traditional guitarists of Indonesia, all of whose music kept me alive and awake while writing.

¹With apologies to William Safire and a tip of the hat to Guglielmo Cinque for my speaker-oriented buletic use of this adverb.

In all honesty, however, it makes the most sense to acknowledge *you*, dear Reader, without whom this dissertation would be but a tree falling in the forest².

²Though Noam Chomsky's constant insistence that 90% of the use of the language faculty is for "inner speech" may detract from the accuracy of this remark.

Note

The Sibe material included in Chapter 2 will also appear, in different form, in:
Nevins, A. & B. Vaux. (under review). "The Transparency of Contrastive Segments in Sibe: Evidence for Relativized Locality".

The Karaim material included in Chapter 2 has already appeared, in different form, in:

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The Zok material included in Chapter 1 has already appeared, in different form, in:

Fitzpatrick, J., Nevins, A. & B. Vaux. (2004). "Exchange Rules and Feature-Value Variables". Paper presented at the Third North American Phonology Conference, Concordia University, May 2004.

Finally, the reader is advised that the current document, in its present form, will be revised, and a section containing a computer simulation of the learning scenario in Chapter 4 will be included. Hence, the reader is directed to MIT Working Papers in Linguistics, as well as the author's website, in order to obtain a more updated copy of this thesis than the present one.

Contents

1	Towards an Intervener-Based Theory of Locality	23
1.1	A User's Guide to <i>Valuation</i> and <i>Checking</i>	33
1.2	The Bundling of Subsegmental Rules into Policies	51
1.3	Search-Based Valuation: Find <i>Closest</i> , Copy Identical/Opposite . . .	62
1.3.1	Dissimilation without the OCP	71
1.3.2	A Note on Iterative Alternating Dissimilation	73
1.3.3	Context-Free Value-Insertion	76
1.3.4	The Necessity of Binary Features in Opposite Valuation	79
1.3.5	Intervention-Based Locality	81
1.3.6	All-Value Relativization: Tangale	83
1.3.7	Asymmetric-Valued Parametrization	85
1.4	"Non-Constituent" Copying	91
1.4.1	Turkish: Valuation from Multiple Sources	97
1.4.2	Barra Gaelic Epenthesis	104
1.4.3	A Comparison with Spreading-Based Formulations	109
1.5	Woleaian Bidirectional Search	110
1.5.1	A discussion of metrical/headed-constituent approaches to harmony	113
1.6	Parasitic Harmony and Defective Interveners	115
1.6.1	Jingulu	119
1.6.2	Bantu "asymmetric" raising harmony	121
1.7	Bounds on the Search Domain: Adjacency Parameters	123

1.8	Conclusions: Impossible Policies and Search Conditions	131
1.9	Appendix: The Elsewhere Condition	133
2	Parametrized Visibility Conditions	137
2.1	All-Values Visible	143
2.1.1	Tangale	143
2.2	Contrastiveness	145
2.3	Ifẹ vs. Standard Yoruba: All vs. Contrastive Visibility	147
2.3.1	Standard Yoruba	147
2.3.2	IfẹYoruba	157
2.4	Sibe vs. Sanjazi Manchu: Marked vs. Contrastive Visibility	161
2.4.1	An Overview of Sibe Segmental Phonology	161
2.4.2	Height-Conditioned Rounding Harmony in Sibe	164
2.4.3	Velar/Uvular Alternations in Sibe Suffixes	168
2.4.4	Crosslinguistic Evidence for Uvularization by [-high] Vowels	171
2.4.5	Towards an Analysis of Non-Locality in Sibe Uvularization .	174
2.4.6	Evaluating Participant-Based Locality: Sibe Low Vowels and Uvulars are Not ‘Similar’	175
2.4.7	Intervener-Based Locality: Relativized to Marked [-high] in Sibe	179
2.4.8	Contrastive Visibility: Examples from Consonant Harmony .	180
2.4.9	Marked Visibility: Sibe Uvularization	181
2.4.10	Sanjazi Manchu: Contrastive Visibility for [high]	187
2.4.11	Tangential Excursus: Phonetic Evidence for Non-Local [RTR] Copying	190
2.5	Contrastive [back] harmony in Turkic	191
2.5.1	Glides versus Palatalized Consonants in Turkish and Kyrgyz	191
2.5.2	Karaim Consonant Harmony: Contrastive Visibility, with Po- sitional Reference	197
2.5.3	Karaim and the Existence of Consonant Harmony	198

2.5.4	The Segmental Phonology of Northwest Karaim	199
2.5.5	Positional Contrastiveness	203
2.6	Conclusions: Non-Contrastive Transparency	209
3	Sonority-Based Asymmetries	211
3.1	Introduction	211
3.2	Sonority-Based Asymmetries in Unpaired Vowels	219
3.2.1	Wolof	219
3.2.2	Hungarian	226
3.3	Sonority-Based Asymmetries in Harmonic Vowels	236
3.3.1	Finnish	236
3.3.2	Manchu	238
3.4	Low Transparent Vowels Imply High Transparent Vowels	247
3.4.1	Lena Bable	248
3.4.2	Londongese	251
3.4.3	Menominee	255
3.5	Closing Considerations: Height as a “Primary Feature”	259
4	Underdetermined Learner Analysis and Variation in Harmony	265
4.1	Finnish Transparent Front-Vowel Variation	269
4.2	Hungarian Doublets	275
4.3	The One-vs.-Many Neutral Vowel Effect in Hungarian	281
4.4	Variation in the Dissimilative Voicing of Embu Prefixes	285
4.5	A Closing Discussion of Approaches to Variation	287

Introduction:

Harmony at the Interfaces

“When two vowels go walking, the first does the talking.”

– Theodore Clymer (1927-2004)

The phenomenon of vowel (and consonant) harmony presents one of the ultimate challenges for the cognitive scientist. The study of vowel harmony provides an occasion to examine this single phenomenon from the perspectives of many of the interfaces between the phonological component and other cognitive subsystems. The most immediate interfaces that impose restrictions on the form of the phonological computation are the articulatory component, the perceptual component, and the lexical-access component.

The goal of this dissertation is to provide a theory of the conditions that govern harmony: that is, the set of principles that limit the space of possible harmony systems, and limit the set of hypotheses that a learner of harmony will consider. An ideal theory of such conditions will have three properties: 1) it will exert wide coverage over empirically attested systems, 2) it will attempt to derive as many principles as possible from substantive and interface conditions, and 3) it will be explicit enough to be implemented on a computer. The reader may decide for him/herself whether these goals have been attained herein, but it is important to agree on them as, indeed, the very goals of linguistic theory writ small.

The “vision” behind the work itself consists of four main ideas:

- (1) a. (Dis)harmony is governed by *policies*, a “macro-rule” or a “mini-grammar”

that consists of all and only the rules related to determination of the featural value for the alternant. Policies have a unique status in grammars in that they have very limited interaction with the internals of other modules. That is, there is no need for rule ordering or constraint ranking between components within the harmony policy and any set of constraints *within* the stress component. The use of policies represents a step towards micromodularization of grammars, with beneficial mathematical consequences for learning

- b. Featural assimilation and dissimilation show great similarity to the *Agree* framework of Chomsky (2001):
 - (i) A newly-introduced item in the derivation needs a value for a feature in order to “converge” at the interfaces
 - (ii) Valuation is initiated by a *search*
 - (iii) This search attempts to *minimize* distance, and find the *closest* source of valuation
 - (iv) This search may be *relativized* to certain values of features
Defective Interveners may cause the search to terminate in failure, resulting in “default” valuation
- c. Two of the most important factors in relativization of (dis)harmony searches are *contrastiveness* and *sonority*. These are arguably *grounded* properties, with roots in the fundamental biases of human attention towards *distinctiveness* and *salience*.
- d. Intra-speaker variation is a consequence of *structural ambiguity* in the language, leading to the maintenance of more than one consistent policy, which are then chosen stochastically during real-time production.

In an attempt to delimit its scope as optimistically as possible, this dissertation may be considered as an attempt to model the real-time morphological production component, whose operations of valuating spell-out and of non-cyclic checking after all affixation yield the eventual instructions to the articulations to execute a set

of gestures that will be categorically perceived. It is important to delimit the empirical phenomenon that this dissertation aims to and does not aim to cover. The empirical existence of coarticulation is, at this point in the history of speech research, factually undeniable. Coarticulation is a gradient phenomenon that, to a large part owes its existence to those motions of the articulators that are a consequence of “how the machines work”. Coarticulatory gestures are, however, not designed for nor employed in the contrastive use of phonological information to yield distinctness in lexical items, or, more familiarly, the linguists’ “minimal pairs”. The point of the departure for the current dissertation is based on (what is perhaps) a truism: *not every language* chooses to categorically execute gestures so as to result in perceived “harmony”. And those languages that do exhibit “consistent” harmony often fulfill a common profile: (a) many of the affixes in the language undergo the harmonic process – that is to say, there are morphological generalizations that may be drawn about where harmony may happen; (b) the morphological combination of lexical word plus affixes yields a consistent percept of harmonic “alternations”, which are not perceived root-internally (i.e. speakers do not seem to store contrasting representations of non-alternating roots, even though they may be clearly subject to coarticulation).

The current research is conducted under the acknowledgement that the existence of coarticulatory, vowel-to-vowel effects as a frequent consequence of the physiology of sequenced articulatory targets is not under any dispute, and constitutes an empirical domain of extremely rich study. The aim here is narrowly defined in its scope, however: to provide a theoretically-informed model of the real-time production steps that are needed in establishing full lexical content as the result of a morphological affixation process. How does the phonological component accomplish this, in a derivational model; i.e. in a characterization of real-time production steps in the mapping between morphologically productive outputs and phonetically ready-to-go instructions, designed to yield a perceptible lexical contrast, for whatever reason harmony inevitably does³.

³The use of “whatever” here is not a “careless” free relative, it is a “free-choice” free relative, to

In a sense, this thesis is an extended study of allomorphy – but avoiding the ‘arbitrary’ connotations of the term. It is contextual allomorphy – and determined by a phonological context. “Harmony” languages are thus those in which phonologically-determined contextual allomorphy falls into classes of morphemes undergoing a consistent type of alternation based on subsegmental feature-values.

Desiderata for a Theory of (Dis)Harmony

In this thesis, I consider data from Turkish, Chumash, Barra Gaelic, Jingulu, Embu, Sibe, Sanjazi Manchu, Standard Yoruba, Ifẹ Yoruba, Written Manchu, Karaim, Kirghiz, Menominee, Lena Bable, Londongese, Finnish, and Hungarian. A finite number of facts can be described in a myriad of ways, at a wide range of levels of description. Thus, theory-construction is often best aided by external desiderata. There are three such considerations that have guided the particular theoretical formulations chosen here, where the demand of descriptive adequacy alone could not arbitrate between remaining alternatives.

The first aim is one I have tried to make evident in the title of the dissertation: it may be fruitful to explore, and make explicit as much as possible, the similar formal mechanisms underlying harmony and disharmony, as both phenomena may operate on successive foci, at long-distance, and subject to relativized conditions. At this point it is important to turn to a summary of the larger research program in which the current study is situated. The reader that is skeptical of the unification of harmony and disharmony will hopefully see how nonetheless it may be a useful research heuristic if our ultimate goal is to seek unification, and understand to what extent individual phonological processes represent highly specialized phenomena, and to what extent they show evidence of general cognitive processes that may not be phonology- (or even language-) specific.

Recent years have seen an emergence of the question, how language-specific is everything inside Universal Grammar? Some of this research (crystallizing most

be filled in by one’s answer to why languages should have harmony; my own prejudices lie with the word-segmentation cue effect of Kaye (1989); Suomi et al. (1997); Vroomen et al. (1998).

recently in Hauser et al. (2002)) has been driven by questions of evolutionary uniqueness and comparative behavioral psychology. In a recent paper concerned with the phylogeny of the language faculty, Marcus (2004) argues, "The innate endowment for linguistic computation is likely to build heavily on the modification of ancestral cognitive systems, combining (modifications of?) a large number of old systems with a relatively small number of wholly new systems. This argues for an approach to linguistics that makes closer contact with cognition yet does not abandon the notion that the capacity for language arises from a firm human-specific endowment". Marcus' approach emphasizes a search for formal similarity between linguistic computations and non-linguistic computations, and his own particular area of comparison is the computation of identity in generalizing over structures of the form *AAB* and *ABB*. Marcus' research program began with the observation that the *ABB* vs. *AAB* distinction plays a crucial role in linguistic computation (i.e., in the wellformedness of Semitic root structure), and subsequently examined the ability of both young infants and tamarin monkeys to extract generalizations of this form over linguistic and non-linguistic stimuli. It is an exciting research program that is still underway, and bears the potential to answer questions about how language-specific (and even species-specific) is the use of variables.

What I would like to point out here is that if Marcus had dwelt on the fact that there are some nuances and counterexamples to the generalization about Semitic root structure, and waited for a perfectly complete theory of trilateral root well-formedness that did not predict any of the unattested forms, he would still be waiting to do his experiments on infants. Similarly, if Marcus had assumed that the formal computation underlying trilateral root well-formedness necessarily needed to be understood in terms of the specific data structures of association lines and conditions on left-to-right association, he never would have been able to construct formally similar configurations of three sequenced stimuli from the domain of musical notes, looming visual shapes, or animal sounds. Thus, within the comparative cognition research program of pursuing cross-domain (and indeed, cross-species) comparison, it is a useful heuristic to emphasize configurational similar-

ity and shared formal properties, rather than giving up the prospect of unification because doing so might engender a theory that overgenerates with respect to actually-attested structures, or that departs from the strictures of technical apparatus that are extremely field-specific (and turn out to impede, to a certain extent, cross-disciplinary crosstalk).

My own goals in unifying assimilation and dissimilation must thus be understood in the context of such research-programmatic heuristics. The unification of assimilation and dissimilation in Chapter 1 allows two important shared formal properties to emerge: parametrized visibility and intervener-based locality. The unification comes at an apparent cost, however: the resulting theory predicts the possibility of iterative dissimilation – that is, a structures like those of vowel harmony, in which there is iterative valuation from one element to the next, but that would result in a necessarily alternating pattern of values. Such configurations are indeed attested, although are somewhat rare in the dissimilation patterns of the world revealed by typological and theoretical inspection. It is my own view, however, that while this remains an important problem, there are important benefits from the unification that has been afforded by modeling harmony and dissimilation as governed by the same principles of structural description (and differing only in structural change). In particular, the view of feature-relativized, closest-based search developed in Chapter 1 brings aspects of phonological and syntactic computation closer together, to the point where a number of biologically relevant questions can now be asked, such as: do infants master the cognitive ability to perform computations of dissimilation, assimilation, and syntactic agreement at the same age, and with the same ability? Are intelligent primates able to perform computations of partial identity and partial non-identity with the same proficiency? Of course, empirical adequacy remains as the overriding and logically prior goal. But where a reduction in data structures, that retains empirical adequacy (as I hope to demonstrate) allows for the framing of questions outside the highly specific vocabulary of current phonological representations, it seems a worthwhile enterprise to pursue.

To take another recent and influential example from the recent literature, Fitch and Hauser (2004) have examined the question of whether tamarins can generalize over the result of a context-sensitive grammar, when that generalization requires a level of formal complexity that requires recursive computation. Fitch & Hauser conclude that tamarins lack the ability to perform the recursive computation needed to discriminate well-formed tokens of this context-sensitive language. This is an important result for the study of comparative cognition, because it suggests that one of the defining properties of syntax (according to Hauser et al. (2002)) may not be shared across species. Such a study now joins the ranks of many important experiments that ask whether other linguistically-relevant computations, such as categorial perception (Kuhl and Miller, 1975), are language- or species-specific. Again, such a result could not have been achieved if it was concluded that context-sensitivity is not exactly the right property of human grammars (because, say, it makes the wrong prediction for uses of the *respectively*-construction in English when there is quantification in subject position). The result emerged because the research heuristic leading up to the comparative test was one of unification of formal properties, and emphasis on characterizing the requisite computations in as domain-general terms as possible.

While the above research-programmatic goals are at the heart of the proposal that harmony and dissimilation share a great deal of commonality in computation, in the end it is also crucial to demonstrate parsimonious and accurate modeling in empirically challenging cases. In Chapter 1, I demonstrate that (the typologically rather rare) alternating dissimilative pattern (of the form [+F] [-F] [+F]) which characterize the fully-fledged “dual” of iterative vowel harmony, are indeed attested (in the case of Dahl’s Law in Embu), thus providing solid evidence that the predictions made here are accurate in their full extent.

The second aim is driven by the goal of providing insight into *the range of attested and unattested variation across and within individuals*. Variation is not simply due to the stochastic nature of the world and arbitrary noise in the collective E-language; the fact is that, in Hungarian, for example, the “vacillators” that allow

either harmonic alternant in their affixes are those that have a very particular shape that leads to ambiguous grammatical analysis, as described in Chapter 4. This aim is also related to the goal of delimiting a set of dimensions along which *microparametric variation* might be exhibited in closely related languages; thus, in Chapter 2, the two closely related languages, Sibe and Sanjiazi Manchu are contrasted, as are Standard and Ifẹ Yoruba. The conclusion reached is that the difference between these respective related harmony systems is attributed to the setting of a single visibility parameter.

Every theory of vowel harmony has to characterize a set of “interveners”, or opaque segments. For example, in the Wolof system of [ATR] harmony, the class of interveners consists of (i) all vowels contrastive for [ATR], plus (ii) the low vowel *a*:. Now, a large class of analytic models can put these five vowels into the relevant category of determining the value of vowel harmony, whether the label for these five vowels is that they are “opaque”, or “lexically pre-associated to an autosegment” or constitute “Left-Aligned Edges of Harmony Domains”. However, one of the central foci of this study is the aim at a characterization of interveners based on *falsifiable* principles. Thus, Chapter 3 offers the clear prediction that no language will have two unpaired (i.e. non-alternating/noncontrastive) vowels ϕ and ψ , such that ϕ is transparent, ψ is opaque, and ϕ is of a higher sonority than ψ . More broadly, this final desideratum may be understood as the requirement that the theory explicitly delimit (by means of constraints on the vocabulary of structural descriptions) the classes of impossible dis(harmony) rules.

Before concluding, I should add (as Bert Vaux has repeatedly reminded me) that “impossible” must be understood with some care, and perhaps qualification. Ideally speaking, Universal Grammar is a delimitation of the set of unlearnable languages. On this view, the function of what is called Universal Grammar, is not really to *provide* a grammar, but rather to provide a set of constraints on what can and can’t be a possible grammar. Thus, the function of Universal Grammar in aiding the learner of harmony does not consist of giving him or her the answer magically from scratch (in fact, as we will see in Chapter 4, the learner may *never* learn

a uniquely correct answer). What Universal Grammar can do is *prevent* the learner from ever considering a host of irrelevant answers. And I do mean prevent. On this view, the closest analog to Universal Grammar in another species would be in the songbirds. W.H. Thorpe's study of trying to teach chaffinches the songs of the tree pipit and seeing their failure to learn it (although it was sensorily perceptible and motorally executable) led him to conclude that "the chaffinch has the inborn blueprint conferring on it a tendency to learn to pay attention to certain kinds of sounds and certain types of phrase only" Thorpe (1958, p.84). Thorpe's quote, and indeed his views, emphasize that the defining feature of songbird learning is what they cannot and do not try to learn, because they simply exclude attention to certain kinds of sound patterns. This constitutes a strong view of the chaffinch's "blueprint", and Universal Grammar: the languages that it excludes are simply unlearnable; they are grammatical hypotheses that are excluded from the search.

The ease with which humans learn language games that seem to violate or exceed the expectations of formal simplicity (reviewed extensively in Bagemihl (1988)) is at odds, to a certain extent, to the findings of experiments in artificial language learning that find humans quite limited in their ability to formalize grammatical generalizations over phonological data; Guest et al. (2000) find, for example, that subjects could not deduce, by transitivity, that if constraint A outranks constraint B, and B outranks constraint C, then it is expected that A outranks C. The hope is of course that experimental methodologies will improve with continued attempts, and that, through psycholinguistic or neurolinguistic means, we may discover "learning biases" in generalizations over phonological data, and also whether the negative biases represent statistical tendencies, learning preferences, or biologically impossibilities. Of course, our desire as theoreticians to know if we are right or not is curtailed by the ethical limitations of conducting a "natural" experiment in exposing a child to a "non-UG-compatible" L1. However, the prediction of this dissertation is that, if an excluded harmony system (in which, say, the only opaque segments were the least sonorous vowels were to arise), either through pidginization or laboratorization, learners would reshape the system in

order to be consistent with principles given by UG, and that we would observe a scenario similar to the regularization of non-UG-compatible grammars attested in the Nicaraguan Sign Language scenario as described by Senghas (1995): learners would regularize this type of harmony system to one allowed within the parametric space developed here. Or, we might indeed observe an all-out failure to learn this non-contrastive-only grammar, in a scenario parallel to that observed by Smith and Tsimpli (1995), who attempted to teach Christopher, a linguistic idiot savant (i.e a person with lower-than-average general intelligence, but phenomenal ability for learning languages) a non-UG-compatible language ("Epun", in which the sentential-focus-marker always appeared on the third word), and observed failure to generalize. The point is that the predictions are clear, and they are predictions that bear on the nature of what is biologically possible.

Chapter 1

Towards an Intervener-Based Theory of Locality

An Overview of this Chapter

The “Conditions on (dis)harmony” postulated in this thesis can be decomposed into *principles* and *parameters*, as can any predictive model of the space of UG-constrained grammatical systems. Everyone working on phonology acknowledges that it is the study of representations that must satisfy a set of constraints and conditions (some phonology-internal, and some interface-related), and that there are well-formedness conditions on the results of operations. These conditions and constraints are of two types. One set applies to all languages and therefore constitutes a guiding principle of computation and hypothesis formation in Universal Grammar. Another set has variable effects in languages. There are two main ways in phonological research for accounting for this latter variability. In one approach (well-represented by Chomsky (1981)), some conditions may or may not be imposed or hypothesized by the learner, on a language-particular basis; these are *parameters of variation*. More recently, Prince and Smolensky (1993) introduce the framework of *Optimality Theory*, which allows each language to impose an arbitrary ordering on a universal set of conditions. Variation in languages is thereby an emergent result of differences in constraint ranking. I will largely adopt the

principles-and-parameters approach herein, but this is not to be construed as a rejection of the optimality-theoretic framework. Rather, my focus is on representations and the operations on them, rather than on the interaction of constraints. Nonetheless, it seems that the intervener-based locality defined here, and the important inviolable role of *closest* demonstrated here, cannot be studied in a way that is fully independent of the question of violable constraints vs. parametric conditions. We will return to this issue at various points in the chapter.

This first chapter focuses mostly on the “principles” component of (dis)harmony: a search procedure for identifying a “goal” with which to establish a representational relation (in current terms, a *source* for *values*). Such relations may occur between vowels that are across morpheme-boundaries, or between vowels within a morpheme. Section 1 offers a principled distinction between these types of harmony relations, with the cyclically initiated, cross-morphemic relation modeled as *valuation*, and the within-domain validation of identical values modeled as *checking*. While the primary difference between these two is mainly a consequence of their lexical representation, it is posited that their mode of application differs as well, in a few details. Importantly, however, both include a principle that, once the search domain for initiating a valuation or checking relation is delimited, that relation will be established with *closest* segment in that domain; that is, there are no possible harmony systems in which the value of an affix vowel is determined by the *farthest* potential source. It is worth noting that the pattern of agreement with the farthest potential source can be easily stated in an alignment-based theory of harmony; suppose that ALIGN-L(+F) and ALIGN-R(+F) both highly outranked IDENT(F). The consequence would be that the leftmost and rightmost vowels would have to agree in order accommodate harmonic alignment with the edges, while all medial vowels would retain their underlying values, due to IDENT. The CLOSEST-based theory clearly excludes such patterns. In any harmony system with, for example, noncontrastive vowels (i.e., due to harmonically unpaired segments in the inventory), there will be more than one process within the repertoire of featural operations; for example, Hungarian has one rule by which vowels un-

dergo harmony due to a contrastive source, and another ‘default’ rule for the scenario in which there are no contrastive vowels in the domain of search (i.e., in a root composed entirely of neutral vowels). However, it is rare that any more than one of these harmonic operations will apply at once; that is, there is *disjunctive application*, if valuation is formalized in rule-based terms. This sort of disjunctive application requires rule-ordering, but of an extremely limited type, analogous to the restricted repertoire of ordered rules in minimalist models of syntax (e.g., MERGE is ordered before MOVE when satisfying a head with uninterpretable features in Chomsky (2001), and downward AGREE is executed before MERGE in Rezac (2003)). When there is set of rules that are in crucial ordering relations, and are to be applied at the same locus for the same purpose (valuing or checking the lexically-deficient feature of a segment), this set is referred to as a *policy*. Policies are an architectural structure within the grammar, described in Section 2.

In Section 3, the key distinctive points of the current model are introduced: locality is intervener-based and relativized, and feature-copying is done algebraically: after identifying a source for copying, the affixal vowel undergoing harmony for a feature F sets its value for F as identical to that of the source in the case of harmony, and to the opposite value of that of the source in the case of disharmony. Comparisons are made with locality theories based on the Line-Crossing Constraint, and it is demonstrated that such theories fail to unify the identical set of locality conditions found in assimilation and dissimilation (or, more broadly, *harmony* and *disharmony*).

In Section 4, a key distinction is drawn between target-centric models of assimilation, such as the one developed here (in which the search for a value *originates with the segment “in need”*), and those within “spreading” theories, in which the initiation of the feature-sharing relation *begins with the source* of the value. Empirical arguments, based on non-constituent copying and multiple-source valuation, are offered in favor of the target-centric model. In addition, remarks about the continued importance of feature-geometry are offered. Section 5 furnishes a further argument from bidirectional search, and demonstrates the problem that this

phenomenon poses for metrical-grid models of harmony.

Section 6 is on *Defective Intervention*: a property of Closest-based search in which, if the closest segment encountered within the search domain is deficient with respect to some Source Condition, search terminates in failure, even if a potentially non-deficient source lies further along in the domain. This constraint on the way that searching operates allows for exclusion of a wide class of patterns, and provides a formal foundation for expressing the conditions found in “parasitic harmony” (Cole and Trigo, 1988).

After concluding the discussion of closest as the defining characteristic of search, Section 7 turns to the boundedness property of Search: that there are certain distance-based bounds that may be placed on the domain. The search operation must thus include an adjacency parameter (Odden, 1994; Suzuki, 1998), and four values are proposed and illustrated. Extrinsically-defined conditions on boundedness appear to be necessary inclusions in the theory of locality. The consequences of this parametric-approach within a theory of learning and parameter-setting are illustrated for distance-based variation in Hungarian vowel harmony, anticipating a broader discussion in Chapter 4.

Section 8 concludes with a brief summary of the class of impossible harmony systems.

Throughout the discussion, and with the addition of each principle to the model, I will emphasize which aspects of the proposals are independent of each other, and which encode intuitions that may easily be translated into a variety of architectural frameworks. I feel that this is an important task, largely because it seems to be all too common these days to dismiss the insights of a particular proposal because of the framework it has been cast in. Many of the insights that I have adopted and attempted to synthesize throughout this discussion emerge out of research programs with vastly different assumptions and emphases from each other and from mine. And in turn, the reader who wishes to implement proposals developed here within the context of a different theoretical vocabulary is not only welcomed but encouraged to do so.

Before proceeding, however, it is worth answering a direct question: is the model of conditions on harmony developed here, which is derivational in its exposition, fundamentally untranslatable into a theory framed in terms of *repairs* to ensure *compliance with surface conditions on harmonic agreement*?

The answer is not a direct ‘yes’ or ‘no’ without elaboration of what theoretical assumptions the terms *surface conditions on agreement* incorporate, because many of these may be independent from one another.

First, we may note that the notion of “surface” here has a questionable status, and is probably better referred to as “output conditions” (in the sense of output of a particular stage of computation), since there are at least three phenomena that come to mind in which harmony is made opaque by another process. The first is the result of medial vowel deletion in Yoruba (Pulleyblank, 1988): the harmony-compliant form *odíde* ‘Grey parrot’ becomes *o:de*, violating the surface generalization that adjacent mid vowels cannot have different [ATR] values; this is described more fully in the section on Yoruba in Chapter 2.2. The second is the result of palatal umlaut in Turkish (Göksel, 2004) (further described in Chapter 2.3), in which [+back] harmony applies across a non-contrastive glide, yielding *yap-ma-yaca-m* ‘do-neg-future-1sg’, followed by the process of pre-palatal umlaut, resulting in surface-disharmonic *yapmiyacam* (further described in Chapter 2.4). The third example of non-surface-true-harmony is due to the result of prefricative tensing in Canadian French (Poliquin, 2005). The [-ATR] harmonic *fri.tuB* undergoes subsequent prefricative tensing, becoming surface-disharmonic *fri.tuB¹*.

What all of these cases reveal is that while one can maintain a coherent theory of harmony as a set of repairs to ensure conditions on an *output* (i.e., the output

¹As this case will not be subsequently discussed, I will present the full range of representative data here. According to Poliquin (2005), there are three (independently motivated) processes that affect high vowels in Canadian French, that are ordered as follows: 1) closed-syllable laxing; 2) regressive [-ATR] vowel harmony; 3) Pre-fricative tensing.

(i)

Underlying form	mi.siv ‘letter’	su.miz ‘submissive’	li.t ^h i ₃ ‘litigation’	tu.ʒuB ‘always’
Closed-σ Laxing	mi.siv	su.miz	li.t ^h i ₃	tu.ʒuB
Vowel harmony	mi.siv	su.miz	li.t ^h i ₃	tu.ʒuB
Prefricative Tensing	mi.siv	su.miz	li.t ^h i ₃	tu.ʒuB

of a policy of rule application, or the output of a stratum of constraint evaluation, or the output of the computation for a “flower” candidate), it is untenable to insist that harmony can be fully reduced to conditions on *the surface*.

However, this is really a point of clarification about terminology (and an acknowledgement of the existence of opacity, which is by no means unique to vowel harmony). There are more substantive issues to consider, such as the ontological status of disharmonic roots and disharmonic suffixes in a theory of output conditions on agreement. Every theory needs to characterize the difference between harmonic and disharmonic roots in terms of a difference in their lexical representation. But in a theory centered around output conditions on agreement, disharmonic roots and suffixes are understood as *exceptions* – aberrations that break the rules. By contrast, in the exposition of the derivational model developed here, disharmonic affixes do not violate any surface conditions, as there are none. “Disharmonic” affixes are simply *non-alternating* affixes, that, in contrast to alternating affixes, do not have their values established by search-based computation of valuation, because their values are *already* listed in the lexical representation of the morpheme. In other words, “disharmonic affixes” are like affixes in English: their featural representation does not crucially depend on another segment. In a model in which constraints on agreement evaluate the well-formedness of outputs, disharmonic affixes need to be marked as exceptions. In a model in which harmony arises as the result of a satisfying a “needy” segment, disharmonic affixes are simply “not in need”. This distinction is largely one of emphasis, and pivots more upon one’s fundamental assumptions about what drives the computation of harmony: whether it is the featural needs of particular morphemes, or a language-wide desire for agreement-in-the-output. In the world of surface-repairs, in particular in monostratal OT, the processes of assimilation and of dissimilation are due to separate markedness constraints: one sort bans adjacent *non-agreeing* elements (thus requiring vowel harmony in Finnish), while another set of markedness constraints ban adjacent *agreeing* elements (thus requiring voice dissimilation in Kikuyu). In the present theory, there is only one type of “markedness”: featural deficiency.

There is no separate set of statements to the effect that agreeing vowels constitute a marked configuration, and non-agreeing vowels constitute another type of marked configuration. In the present theory, harmony and dissimilation are two parametric options in the *solution* to the same type of marked configuration: featural deficiency due to the input representation.

The next point of comparison with such theories is rather straightforward, and will be mentioned quickly here: any statement of surface conditions on agreement will end up (implicitly or explicitly) incorporating many of the same conditions that are discussed and developed here; for example, the treatment of transparent segments. Most existing formulations of output constraints on agreement use statements such as “Adjacent Vowels must Agree in F”. However, as we will see in Section 4 of this chapter, consonants often participate in “vowel” harmony². This, however, requires a refinement of constraints on surface agreement to now require that “Adjacent *Relevant* Segments must Agree in F”, and this invites a formulation of relevance that must (for empirical coverage) incorporate many of the conditions developed here: (a) parametrization to all, contrastive, or asymmetric values of F, (b) sonority-based opacity in the cases discussed in Chapter 3, (c) bounding of the “adjacency window” to certain prosodic distances. Finally, it is not obvious how the defective intervention phenomena of Section 6 are to be translated into a pure notion of output conditions on agreement (though more research may reveal possibilities) since the defective intervention situations constitute cases in which the computation of harmony seems to proceed in a very “dumb” and local manner: terminating in failure (and thus yielding an output *violation* of adjacent agreement) because an additional morphological or featural requirement on the source is not met.

The final point concerns the underlying lexical representation that is assumed

²And in fact, few researchers to date have dealt with these kinds of facts using a model of conditions on output agreement between adjacent segments. Padgett (2002), working on the Turkish case in Section 4, retains the asymmetric and relativized notion of spreading with the constraint SPREAD. Rose and Walker (2004) state that agreement and spreading are different mechanisms, and that agreement is “marked by the comparative similarity of participant segments and the absence of blocking by intervening segments” – thus excluding the cases of Section 4 from an output-agreement mechanism.

for harmonically-alternating affixes: that they have one that is featurally needy, and that this fact is in the input to the computation. To be concrete: the Turkish accusative suffix alternates between *i,ü,i,u*, and in current model, this is a consequence of an input that is only [+high], and lacks a determinate value for the features [back] and [round]. This assumption differs from the Richness-of-the-Base hypothesis espoused in some forms of Optimality Theory, in which the correct output is guaranteed by constraint interaction, regardless of whether the input to the computation is *i,ü,i,u*, or simply [+high]. It is not my goal here to review the arguments for and against richness-of-the-base, but it is important to point out that the emphasis here is fundamentally different: it is precisely on the idea that it is the nature of the representation that speakers store when memorizing the form of morphemes that drives harmony, and that harmony reflects a necessary computation that straddles the interfaces between the lexicon and the phonetics. We will return to the issue for further discussion at the end of the next section.

Finally, I will turn to a summary of an assumption that guides the proposal that harmonically-alternating affixes are underspecified for the harmonic value, and thus require a feature-copying process due to their lexical representation. The assumption that these affixes exhibit a special behavior, which we call “harmony”, is due to the fact that they have exceptional lexical representations: ones which are missing a value for the harmonic feature. Note that by modeling harmonizing affixes in this way, a logical consequence is that nothing special, indeed nothing at all, needs to be said about disharmonic affixes. In an agreement / output-condition based theory (as implemented in OT, for the sake of concreteness), disharmonic suffixes (such as Finnish *-kko*) must be taken care of by lexically-indexed faithfulness constraints.

In other words, these models must update their grammars (and constraint-rankings) every time a disharmonic suffix is learned. This would seem to make the prediction that if a new suffix enters the language, it should become *harmonic* by default. But the loanword evidence points towards the opposite conclusion: new suffixes that enter Hungarian, for example, remain disharmonic, as in the

case of the diminutive *-uzka*, borrowed from Russian influence, which should presumably alternate as *üzke* and the suffix *-izmus*, which has an initial neutral vowel, so should be potentially susceptible to harmony, yielding an alternant *-izmius*. In actual fact, neither of these suffixes alternate. In the present theory, this is because (upon introduction to the learner) these affixes have no special lexical representations: the default is to be fully specified. In the competing hypothesis described above, these would require the learner to update the grammar of harmony, introducing new IDENT[back](*uska*) constraints, to be ranked appropriately above the agreement constraints – a learning procedure that does not seem to model the “default” nature of disharmonic suffixes, and in fact seems to bias against them, counter to fact.

One research tradition, led by Lightner (1965); Zimmer (1967) and Ringen (1975), supposes that the alternating affixes in Finnish (for example) are underlyingly underspecified for [back], the *harmonic* feature. Their proposals are essentially based on an “economy of storage” model of lexical representations, in which harmonically alternating vowels have an underspecified representation because their values are predictable, and thus need not be listed. However, in this dissertation, I adopt an alternative explanation for underspecified lexical representations, when they are found in harmonically-alternating suffixes. It is not that they are underspecified because they are predictable, but rather because an underlying value for the harmonic feature is *unlearnable*. In the words of Steriade (1995), “They are unlearnable because they will never be in a position to manifest their existence.” (p.165)³. Thus, we may suppose that the alternating Finnish case suffixes lack a value for [back] in their underlying representation, because such a value can never be deduced⁴. Thus, as Crothers and Shibatani (1980) point out, “it is inappropriate

³It is a consequence of the theory, then, that in a given language, if harmonically-alternating suffixes are derivationally related to free-standing prepositions, this *would* allow a learner to infer an underlying representation. Vago (1975) has argued that Hungarian manifests such a case, but the evidence will not be reviewed here.

⁴It is important to address those readers who feel that a red flag of “circularity” has been raised here, in the following sense: my claim is that due to observed alternations, the learner will postulate underlying deficient representations at Stage 1, and that due to these lexical representations, the learner will perform a valuating-search at Stage 2, fixing a value for the affixal vowel in a given

to extend [Stanley's] requirement of full specification of phonological matrices to lexical items that *do* alternate" (p.72).

A very brief remark is in order about "underspecified representations". The claim here is that harmonically alternating morphemes are underspecified because their alternations are phonologically determined by the environment in which they are spelled out. Thus, the claim is that, for example, Turkish suffixes are lexically stored with only a value for [\pm low]. This is a wholly distinct claim from what is elsewhere also referred to as underspecification: that, e.g., all sonorant consonants do not bear a lexical value for [voice], because it is predictable given the other features *within that segment*. This sort of underspecification ("radical" or "contrastive") is concerned with the lexical representation of *segments*, not morphemes, and it is fair to say that these representations are most often pursued in practice for the purpose of circumventing violations of the line-crossing constraint in assimilation processes⁵. However, as discussed in detail in Chapter 2 (especially in regards to Sibe), making certain values of features literally absent from the representation, in an attempt to prevent line-crossing violations faces empirical problems with long-distance assimilation, which cannot be handled this way. Thus, while maintaining a strong stance about the lexical representation of alternating morphemes,

environment. But this is not tantamount to saying: "Learners hear harmony, so they postulate underspecified vowels, which then result in harmony". But in fact, underspecified vowels do not "result in alternations" on any given single computation. Thus, the crucial difference that breaks full circularity here is that these two effects are chronologically ordered: in learning, speakers consider the full range of alternations of an affix, but in production, there is only a single output in any given derivation. In other words, the nondeterministic nature of the mapping from e-language-observations to an i-language lexical entry leads to a deterministic mapping from the i-language lexical entry to an i-language surface form within a given derivation. Putting it another way, it is not the case that "because there is underspecification, there is harmony, and because there is harmony, there is underspecification", because the existence of e-language "harmony" may ultimately arise from phonologization or from demorphologization. In fact what arises here is thus a diachronic source for the synchronic postulation of underspecified lexical entries, resulting in a computation that, when taken *in toto* demonstrates harmonic alternation.

⁵There are some exceptions to this statement. Keating (1992) distinguishes between arguments from variability and arguments from transparency, noting that the literature is overwhelmingly characterized by the latter (with its proponents often rejecting arguments from variability). However, the arguments from variability (e.g., in the phonetic realization of glottal consonants) certainly demand further scrutiny, especially as pertaining the right way to capture them within a theory of full specification. The other major use of underspecification (as determined by the inventory) to predict the quality of epenthetic vowels; this has been shown to be problematic by Hualde (1991) among many others, and it seems fair to say that it has essentially been abandoned.

the claim of underspecified features *within all tokens* of a segment is not adopted at all in this dissertation, and will be amply discussed in Chapter 2. Rather, as mentioned above, featural underspecification is a consequence of the (un)learnability of an underlying representation.

When the underlying form of alternating suffixes, then, such as the Finnish adessive, essive, and partitive, is deficient (by virtue of the fact that it is missing a value for [back], and such a value is needed for transfer to the articulators, as a simple fact of interface conditions), the Finnish speaker is posed with an immediate task once he or she wants to form, say, the essive of a particular noun. We will refer to *valuation* as the model of the speaker's procedure of supplying featural content to a morpheme whose underlying representation lacks a value for that feature. We now turn to an exposition of the mechanism.

1.1. A User's Guide to *Valuation* and *Checking*

As the phenomenon of (dis)harmony consists of a number of components, it may be best to begin an illustration of the theory with a well-known and relatively simple case: vowel harmony for the feature [back] in the suffixes of Finnish, which has the following vowel inventory for both long and short vowels.

(1)	[-back,-rd]	[-back, +rd]	[+back, +rd]	[+back,-rd]	
	i	ü	u		[+high, -low]
	e	ö	o		[-high, -low]
	ä			a	[-high,+low]

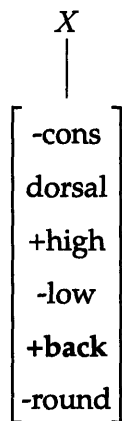
Finnish is a purely suffixing language, and many of the suffixes have two allomorphs; for example, the essive alternates between *na~nä*, the adessive between *lla~llä*, and the partitive between *ta~tä*. Which allomorph is chosen is entirely predictable based on the form of the stem to which the suffix attaches, in a way to be made precise below. Essentially, for these alternating suffixes, if any [+back] vowel precedes them, their [+back] variant will surface, and if they are immediately preceded by *ü,ö,ä*, their [-back] variant will surface. However, for other suffixes, such

as the collective suffix *-kko* (Skousen, 1973, 123), there is never alternation. We may suppose, therefore, the lexical representation of the essive suffix somehow encodes the fact that it may alternate, but that the representation of *-kko* includes the information that it does not alternate.

When the underlying form of alternating suffixes, then, such as the Finnish adessive, essive, and partitive, is deficient, the Finnish speaker is posed with an immediate task once he or she wants to form, say, the essive of a particular noun. Thus, consider the affixation of this “deficient” essive suffix *lla~llä* to the word for “home”, *koti*. Each vowel of *koti* has a value for the feature [back]: the first one has a positive value, and the second has a negative value. But the suffixal vowel has no feature for the value [back].

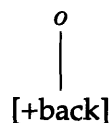
For the sake of clarity, a brief notational convention must be introduced. The representations of segments in this dissertation consist of timing slots that dominate sets of features, as in (2). (Even this diagram is a shorthand, as some features may be grouped into constituent-like sets; we return to the issue of feature geometries in Section 5). Importantly, precedence relations are only defined among timing slots. The contrastive instances of [back] are indicated in boldface:

(2) Underlying Representation for Finnish *o*:



However, for ease of space and typing, representations such as the above will be abbreviated as in (3):

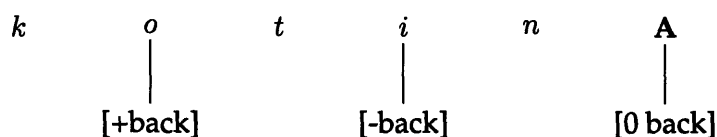
(3) Underlying Representation for Finnish *o*:



Diagrams such as (3), however, should be interpreted purely as shorthand; there is full specification for all features, which is dominated by a timing slot.

Let us turn to the representation of the essive for 'home', immediately upon affixation:

(4) Underlying Representation:

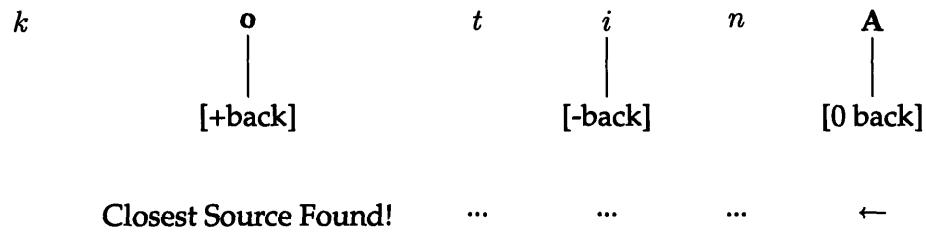


The model developed for these cases is one of valuation in a search for the closest *source* of a value for [back]. Valuation always halts with the *closest* source of the value that is needed. What varies across languages is the delimitation of the *domain* of search; this idea follows closely Calabrese (1995). In Finnish, the search only includes *contrastive* values for [back], given the definition in (5) (defended extensively in Chapter 2).

(5) A segment *S* with specification αF is *contrastive* for *F* if there is another segment *S'* in the inventory that is featurally identical to *S*, except that it is $-\alpha F$

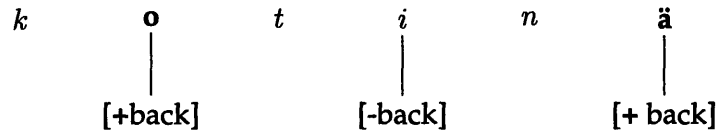
Given this definition, it is apparent that *i, e* are not contrastive for [back], as there are no vowels *i, e* in the Finnish inventory (1) that would correspond to their [+back] counterparts. Thus, with the search for a source for [back] relativized only to *contrastive* values, the closest source encountered in a leftward search in (4) will be the vowel of the initial syllable:

(6) Search Procedure (Contrastive Values Only):



Once the closest source has been identified, if the process is a *harmony* process, the *identical value* of the source will be copied. Thus, while there is *full specification* for [back] on all root vowels in Finnish, the search for a copying source specifically looks for *contrastive* values of [back]:

(7) Copying Procedure:



To be sure, there are many additional aspects of the valuation procedure, and these will be added throughout the course of this chapter. First, however, let us complete this brief excursus of valuation as it applies in Finnish suffixes. A list of representative environments that condition alternations is shown in (8) (Note that *y* in Finnish orthography corresponds to *ü*.):

- (8)
- a. pöytä-nä table-essive
 - b. pouta-na 'fine weather-essive'
 - c. hämärä-nä 'dusk-essive'
 - d. käsi-llä 'hand-adess'
 - e. koti-na 'home-essive'
 - f. kesy-llä 'tame'
 - g. vero-lla 'tax-adess'

The valuation procedure outlined above for *koti-na* demonstrated a leftward search for the closest contrastive value of [back]. Henceforth, we will represent this type of valuation-based search as a rule, in the following format:

(9) *Rule Type: Contrastive Vowel Harmony (CVH):*

Structural Description: $V_{[\text{contrastive: } \alpha \text{ F}]} \cdots V_{\text{target}}$

Structural Change: V_{target} becomes $[\alpha \text{ F}]$

The ... represents the fact that search may be unbounded until the closest potential source is found⁶. Boundness of the search is a parametric property, discussed in Section 7, and its value in most harmony systems is set to unbounded.

(10) *Finnish Contrastive [back] Harmony (CVH):*

Structural Description: $V_{[\text{contrastive: } \alpha \text{ back}]} \cdots V_{\text{target}}$

Structural Change: V_{target} becomes $[\alpha \text{ back}]$

The central principle developed in this search-based model is that harmony is crucially a computation that involves the closest potential source of valuation. As a principle, its status is inviolable. Thus, there is an immediate prediction of an impossible language: one in which an affixal vowel, say, agrees in its value of [back] with the farthest potential source of valuation, or the second farthest, or the second closest. This prediction is not trivial, and in fact excludes a large class of logically possible languages.

However, it may turn out to be the case that the search never finds a contrastive value for [back], if the stem contains only instances of *i* and/or *e*:

(11) tie 'road' tie-llä
 veli 'brother' velje-llä

The rule of Contrastive Vowel Harmony, formalized as a leftward search, will find nothing. However, as we have discussed, the suffixal vowel *requires* a value for [back]. In this case, a value is inserted in a context-free fashion. In Finnish, there is a context-free valuation rule that provides a [-back] value to all vowels that lack a value. This rule will be abbreviated as follows:

⁶I follow Schein and Steriade (1986, p.696) in specifying adjacency-boundedness only where it is a special condition; unbounded '...' are assumed to be the default.

- (12) *Rule 2: Vowel Fronting (VF):*
 Structural Description: V_{target}
 Structural Change: V_{target} becomes [-back]

This rule only applies when contrastive vowel harmony has failed to find a source for copying⁷. The relationship between these two rules thus demonstrates a preference for “copying over insertion”, which is due to the Elsewhere condition (see the Appendix to this Chapter for a formalization that is more flexible than Kiparsky’s original (1973) definition, which is only defined for linear SPE-type structural descriptions).

- (13) CVH: Structural Description: $V_{[\text{contrastive: } \alpha \text{ back}]} \cdots V_{\text{target}}$
 VF: Structural Description: V_{target}

These two rules in an Elsewhere relation compose the learners’ *policy* for ensuring a convergent realization of the affix, with full specification for alternating vowels.

Recall that the hypothesis here is that the computation of harmony sits at the interface between the output of morphology and the input to phonetics, and when the morphology does not deliver a fully-specified representation, the job of the phonological component is to prepare a phonetically-interpretable representation. We might suppose that in executing this task of preparing a representation for the interfaces, the steps of the phonological component will be minimized. That is, we may explore the consequences and properties of a featural component of phonology that has as few intrinsic and idiosyncratic properties of its own, one in which we might observe an effort to minimize computational steps.

The computation of harmony does not proceed globally in the current model. For a Turkish word consisting of a stem and two affixes, such as *pul-lar-in* ‘stamp-PL-GEN’, the view here is that each affix is added one at a time:

⁷It is important to note that the fact that the context-free insertion value for [back] is identical to the value for [back] in noncontrastive vowels is *not* logically necessary; in Uyghur, which also has noncontrastive *i,e*, the context-free insertion value is [+back], resulting in e.g. *til-lar*. We return to this point in Section 3.3. and throughout the dissertation.

- (14) Plural morpheme is spelled-out: *pul+lAr*
 Valuation for [back] occurs for [+low] affix vowel: *pullar*
 Possessive morpheme is spelled out: *pullar+In*
 Valuation for [back] and [round] occur for [-low] affix vowel: *pullarɪn*

The reason for assuming this cyclic model is that it requires no extra machinery to account for the generalization that “all disharmonic suffixes propagate harmony to their right”. In the above example, *-lar*, a [-round] suffix, “blocks” [round] harmony between *pul* and *-In*. This fact is captured naturally if cyclic valuation is indeed, cyclic: for a morpheme sequence $M_1 \dots M_n$, once M_k is added, valuation occurs with the closest source, and M_k becomes part of the prosodic word. M_{k+1} is now added, and its closest source may indeed be the vowel in M_k that underwent valuation on a previous cycle. In classical models of vowel harmony, such as Lightner (1965), harmony is viewed as a property of a root that is copied to all suffixes within the word, essentially simultaneously. The fact that the “surface disagreeing” suffix (i.e., the [-round] *-lAr* that follows the [+round] *pul*) is the one whose value is propagated is not due to any designation as being “disharmonic” with respect to the root; it is simply the value that is chosen due to locality to the target in the following morpheme. Thus, in the current model, upon addition of the suffix *-In*, harmony is not determined by any reference to a root-affix distinction; rather, following cyclic application, there is “bracket erasure” (i.e., opaqueness of internal morphological structure; Mascaró (1976)), resulting in a single phonological word to which an underspecified affix has been added. When *-In* is added, it performs a leftward search for the closest contrastive values of [back] and [round], and it is due to the cyclic character of morpheme affixation that the previous-most-recently-added suffix is the closest leftward source to a new morpheme.

However, it turns out to be the case that cyclic addition of harmonizing affixes is not the only process that yields the phenomenon of “harmony”, which is essentially a set of co-occurrence conditions on values of adjacent tokens of a feature. Root-internal harmony is a case in point. It would be rather difficult to defend the

hypothesis that non-initial vowels in Finnish roots are underspecified for the harmonic feature because its value is *unlearnable*, as freestanding and non-alternating roots occur all the time. However, the fact is that there are generalizations over the lexicon of Finnish roots that include the fact that elements from the two sets {u,o,a} and {ü,ö,ä} do not co-occur. Such generalizations are subject to many exceptions, largely due to the effects of borrowing, which is now largely inevitable under “globalization”; thus, the word for “juggler” in Finnish is a borrowed word, and is disharmonic: *jonglööri*. Moreover, contingent facts about language-contact are such that while roots are often borrowed into languages with harmony, affixes are borrowed with a drastically lower frequency.

In fact, in the case of “static” harmony, it is reasonable to pose the general question whether it constitutes a psychologically real generalization. This stands in sharp contrast to cases of harmony resulting in alternations: every time a speaker wants to put any word in Finnish in the partitive, he or she must make a decision as to the form of the affix, and so must have a policy in hand. The active selection of the correct policy can easily be achieved by comparing the output of certain policies with the attested output, thus constituting a kind of internally-generated negative evidence: if policy number 42 generates the output *-ta* for the Finnish word *pöytä*, and the attested output is *-tä*, then it is time to get rid of policy number 42, as it fails in generating the correct suffixal alternant. However, such evidence is not as easily available for root-internal harmony; as roots do not alternate, there will not be as much confirming or disconfirming evidence for the right analysis. In fact, as far as alternations are concerned, it is not a logical consequence that speakers will bother to construct a harmony policy for roots. It is certainly a true fact about Finnish that very little of the native vocabulary mixes two contrastive specifications for [back] within the same root, but we might wonder if speakers ever notice this fact. There are thousands, if not more, true generalizations about Finnish roots: perhaps none of them have the segment *t* in more than one odd-numbered segment, and so forth. Nonetheless, as it has been found by Suomi et al. (1997); Vroomen et al. (1998), speakers of harmony languages do employ harmony

as a cue in word segmentation, so perhaps there is a benefit to explicitly encoding the generalization about root-internal harmony.

The fact that harmony happens in such a persistent and noticeable way throughout *affixation* in the language might lead speakers to notice harmonic consistency *within the static root*. Thus, I would like to propose that in languages with (dis)harmonic *valuation* as a cyclic process in affixation, affecting all underspecified morphemes, speakers may subsequently extend the observed generalization throughout the lexicon (following Harrison and Kaun (2000)), resulting in a second type of process: *checking*, a non-cyclic procedure for evaluating the harmonic agreement in a phonological domain. However, this is at present, only a hypothesis, and reflects my own hunch that root-internal harmony is only learnable if harmonic alternations exist: in other words, valuation implies checking, but not vice versa.

Checking differs from *valuation* in two respects. First, checking is a noncyclic procedure, that happens only once, after all morphemic concatenation has taken place. This stands in contrast to valuation, which applies immediately upon the affixation of a deficient/underspecified morpheme. Second, checking requires that speakers may alter their initial representations of static morphemes, such that after they have observed alternation-based harmony, they will attempt to extend the generalization of harmony to static roots, by updating their lexical representations such that certain instances of features are subject to checking.

We may summarize the difference as follows:

(15)

Valuation	Checking
Cyclic	Non-Cyclic
Feature-Filling	Feature-Changing

Suggestive evidence that speakers might be applying the harmony policy as a dynamic process within roots can be found in that great source of external evidence in phonology, language games. In Finnish, there is a language game called *kontti kieli*, “the knapsack language” (Campbell, 1980). Kontti Kieli consists of the following three steps:

- (16) a. Move the initial syllable to the end, forming a new Word 2. (*nä.kö* → *kö#nä*)
 b. Prefix *ko-* to Word 1 (*ko-kö#nä*)
 c. Suffix *-ntti* to Word 2 (*ko-kö#nä-ntti*)

Interestingly, the knapsack language applies after all suffixation has occurred; thus, morphologically complex words may undergo it: *kylpylöissä* ‘in the baths’ becomes *kopuloissa kyntti*. We must therefore categorize Knapsack as applying *noncyclically*, on the assumption that noncyclic rules follow all cyclic rules. What is striking about Knapsack, however, is that it applies *prior* to noncyclic harmony-checking. Thus, roots that have undergone alternation and affixation due to Knapsack may *re-harmonize*:

- (17) Front-harmonic *näkö* ‘appearance’ becomes *ko-ko nä-ntti*
 Front harmonic *nälässänsäkö* ‘in his hunger?’ becomes *ko-lassansako nä-ntti*.

As can be observed, the addition of *ko-* to the first syllable induces [+back] harmony in all following vowels. We will thus entertain the consequences of the hypothesis that speakers always apply harmony to root-internal forms in Finnish, when possible⁸.

From the point of view of the lexical representation of morphemes, valuation is a simple concept: a morpheme lacks a value for a given feature F, and needs to find a value, so it looks for one, and copies it. Checking is a bit more nuanced; the idea is that a segment *does* bear a value for the feature in question, but that this value must be “checked” to see if it matches that of a determining segment. If not,

⁸However, there is an important restriction, one that I have adopted from my interpretation of Harrison and Kaun (2000): speakers that observe harmonic alternations may subsequently generalize the policy governing the alternations to static forms. Importantly, however, the prediction is that in a language that does not have alternations, speakers might not make any generalizations about vowel-cooccurrences within roots. This could be tested for languages such as Marash, a dialect of Armenian described by Vaux (1998), that has root-internal [back] harmony, but apparently no harmonizing suffixes. The prediction would be that if Marash speakers had a knapsack-like game, they would not reharmonize roots.

it must be changed.

- (18) All segments within a root that are contrastive for the harmonic feature may be *marked as needing to be checked*.

Being marked for checking, then, will be resolved by the same mechanism as in the valuation-based account: search for the closest possible source of checking (contrastive in the case of Finnish), and if the values match, do nothing; otherwise, change the affixal value to that of the determining checker. Nothing will change in the statement of locality conditions within the structural descriptions of the harmony policies; only a reformulation of the structural change is needed.

- (19) a. *Valuation*: When a morpheme contains a segment *T* that lacks a value for *F*, search for the closest source, *S*, of a value. Copy either the *identical* or *opposite* value of *S* on *F* to *T*.
b. *Checking*: When a morpheme contains a segment *T* that is *marked for checking* its value of *F*, search for the closest source, *S*, of a value. Change the value of *F* on *T* if it is distinct from the value of *F* on *S*.

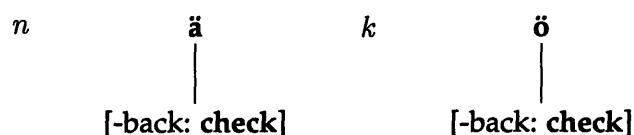
With this in mind, let us proceed to consider the representation of Finnish roots, exemplified by *näkö*. As I am adopting the Harrison-Kaun-inspired hypothesis that speakers actually change the representation of non-alternating roots in response to patterns actively observed in alternations, let us assume that speakers create a representation in roots consistent with the general pattern in the language (although ultimately due to its morphologically-agglutinative structure): harmony is left-to-right.

- (20) Adding Checking-Requirements to the Lexical Representation of Morphemes:
- a. If affixes in the language consistently require valuation for the feature *F*, then:

- b. Add [check] to the representation of F for all segments on which F is contrastive

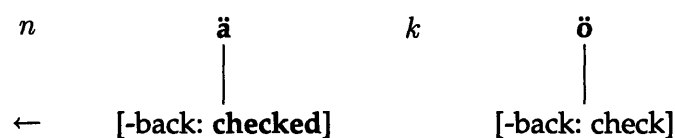
The addition of [check] to a feature yields a representation that is “ill-formed” in the sense that the phonological computation cannot complete until all instances of [check] are changed to [checked] within a given derivation. This will yield representations in Finnish that I will argue are Neo-Zimmerian, as they instantiate Karl Zimmer’s hypothesis that the first contrastively specified segment determines harmony⁹

(21) Lexical Representation:



Iterative application of the checking procedure will operate left-to-right on potential foci. The first vowel, ä will search for a checker to its left. We may suppose that non-contradiction entails successful checking; thus as nothing is found to the left, the feature value specification of the initial vowel is vacuously checked: [-back: checked].

(22) Iterative Checking, Step 1:

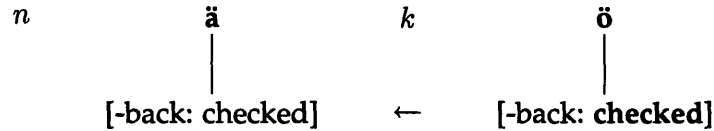


Next, the second vowel, ö, will search for a checker to its left, and encounter the first contrastive [back] specification, ä, with which it may check its value, and since it is identical, it may keep this value, so that “check” becomes “checked”. (As I

⁹“Consonant harmony can be handled by the same rule if the first segment for which gravity (AIN: [± back]) is relevant, be it vowel or consonant, is specified distinctively (AIN: i.e. contrastively) for harmony”, p.167: Note that Lees (1961) contained a proposal in which the first segment was specified, but that in Turkish, lacking neutral vowels, the contrastiveness/relevant clause was not necessary.

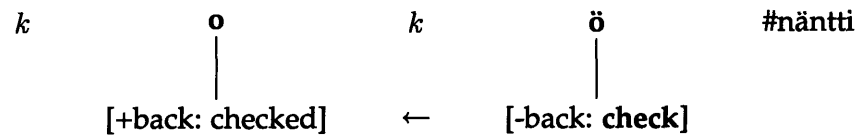
realize, this a relatively unexciting demonstration.)

(23) Iterative Checking, Step 2:



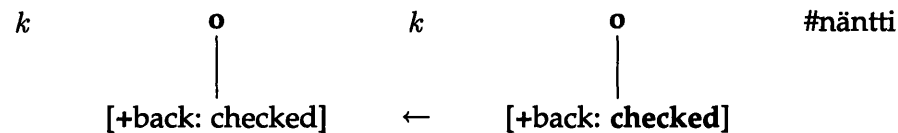
However, recall that *checking* is a non-cyclic process occurring after all morphemic concatenation. We thus expect it to apply after application of the knapsack language. Given *näkö*, the input to the cyclic harmony-checking policy will be two separate words: *ko-kö* and *nä-ntti*. In the first case, *ko-* bears the feature [+back: check], which is trivially satisfied (again, we may suppose that noncontradiction entails successful checking). The next syllable, however, *kö*, bears [-back: check]. Upon a leftward search, it will encounter the [+back] feature of its neighbor.

(24) Iterative Checking in Konti Kielli's First Word:



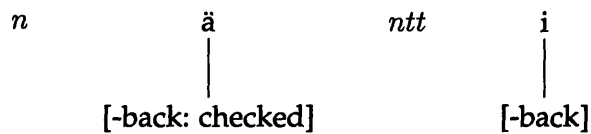
This mismatch in checking requires feature-changing the value of the checking locus to match, and the result becomes *ko*:

(25) Iterative Checking in Konti Kielli's First Word, Continued (Feature-Changing):



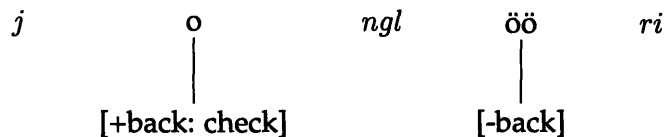
Finally, in the second word (*näntti*), there is nothing to the left of *nä* to check against, so it remains, and in the case of *-ntti*, the vowel is not contrastive for [back], and so does not bear a specification that requires checking.

(26) Checking in Konti Kielli's Second Word:



What is most interesting to consider now is the representation of disharmonic words such as *jonglööri* and their behavior in kontti kieli: they do not re-harmonize, according to Campbell (1986). We may suppose that, by virtue of their surface disharmonicity, these roots are stored *without* a checking specification on their second vowel:

(27) Underlying representation:



Thus, disharmonic roots are distinguished from harmonic roots by the absence of a mark-for-checking on the former. This representation makes the prediction that when prefixed by *ko-*, the piece *-nglööri* will not undergo checking. The lack of a checking-mark on the second, disharmonic vowel allows it to surface with its lexical value in its static form, as well as remaining unaffected in kontti kieli:

(28) Application of Konti Kieli to Disharmonic Word:



No Checking Occurs

Having presented this initial description of the lexical representations that underlie valuation and checking, we may turn to a formal comparison of the two, and their similarities.

(29)

Valuation	Checking
Cyclic	Non-Cyclic
Feature-Filling	Feature-Changing

That checking must occur at the non-cyclic level, and indeed, at a completely post-lexical level, comes from phenomena in which *word edges* are unavoidably referred to. Consider the behavior of another Finnish language game described in Campbell (1980); Harrikari (1999), in which the initial open syllables of two adjacent words are switched:

- (30) saksalaisia hätyytettiin becomes häksäläisiä satuutettiin “the Germans were attacked”
ruotsalaisia hätyytettiin becomes hätsäläisiä ruotuutettiin “the Swedes were attacked”
tykkään urheilusta becomes ukkaan tyrheilystä “I like sports”
otsansa hiessä becomes hitsansa oessa “in the sweat of his brow”
tule sisään becomes sile tusaan “come in”
pitää kalasta becomes kataa pilasta “likes fish”

The reader will notice that the output of the game results in “re-harmony” (i.e. checking) of the roots. What is happening in (30) is akin to a “spoonerism” (i.e. *wave the sails* → *save the whales*): there is switching of the initial constituent (in this case, a syllable) between the first and second words. Clearly, to know where to switch to and from, there need to be word boundaries. The fact that reharmonization (i.e. *urheilusta* becoming *türheilüstä*) occurs after word boundaries have been delimited in a phrase indicates that the reharmonization covered by checking must be a postlexical process.

Before concluding, a brief series of remarks are in order on apparent “duplication” in the two valuation and checking. For example, it is often proposed that the feature-filling/feature-changing distinction ought to be dispensed with, as it in-

volves two “kinds” of rule. So, one could attempt to replicate the effects of feature-changing checking in the root by saying that, within roots, all contrastive feature specifications except the first are deleted by rule, only to be followed by iterative valuation of each now-incomplete root vowel. Let us call this the ‘feature-filling only hypothesis’. We now turn to arguments against this hypothesis. While it might seem like a reduction, it has traded one system with two kinds of rule for another: now, there are *feature-filling rules* and *feature-removing* rules.

Moreover, we might question the point at the derivation at which such a putative feature-removing rule would apply. First, it would need to apply before any affixation, so that the Closest-based valuation of the first affix vowel would continue to maintain the generalization that “the rightmost contrastive root vowel determines the harmonic value”. Thus, we would establish the rule ordering *Feature-Removing* > *Affixation* (where > denotes ‘is ordered before’), so that cyclic valuation in the root would establish harmony within the root before valuation of any cyclically-added suffixes.

However, consider now the ordering statements required by Kontti Kieli (Knapsack). As Knapsack applies to a word after all affixes have been added, we add the ordering *Affixation* > *Knapsack*. Finally, as Knapsack induces re-harmonization of root vowels (and in fact, all vowels in the word), then under the ‘feature-filling only hypothesis’, it would need to be the case that the root-internal specifications are removed again, as well as all following suffixal specifications; in other words, a single postcyclic pass of feature-removing. We thus establish the total ordering in (31):

- (31)
- a. Root-internal *Feature-Removing*
 - b. Cyclic: Root internal cycle of *Feature-Filling*
 - c. Cyclic: Affixation and cyclic feature-filling
 - d. Kontti Kieli
 - e. Postcyclic Root-internal *Feature-Removing*
 - f. Kontti Kieli-based postcyclic pass of *Feature-Filling*

In other words, on the “no feature-changing, only feature-filling” hypothesis, there need to be two distinct cycles of root-internal feature-removing: once, before all affixation, to ensure correct harmonization of the suffixes, and once, after all affixation, to allow re-harmonization by Knapsack. Thus, spelling out all of the details of this counterproposal results in two cyclic operations (Removing and Filling) and two postcyclic operations (Removing and Filling). This is hardly a more economical theory than the one proposed here, in which there is a single cyclic operation (valuation) and a single postcyclic operation (checking). Moreover, the “feature-filling only” hypothesis essentially includes an operation to render roots and affixes lexically identical; however, the present theory offers “duplication” (i.e. distinct mechanisms) precisely because roots and affixes have *distinct lexical representations*: Finnish roots have full specification, which simply needs to be checked within the general process of verifying the well-formedness of a morphologically-complex word, and affixes have unlearnable, hence missing specification, which requires that a value be supplied. A theory that must remove this distinction, prior to the addition of all affixes, and then remove it again, after the application of all affixes, all for the sake of avoiding the postulation of two distinct operations that bear formal similarity to each other, seems to be misguided.

Finally, we may consider the feasibility of a theory that has *only* feature-changing rules, across the board. The putative advantage of such a theory would be that it would allow for a kind of richness-of-the-base, in which the underlying form of affixes did not matter: whatever the input is, if it results in adjacent disagreement, it must be repaired by feature-changing. The assumption that motivates feature-filling in this dissertation, however, is incompatible with richness of the base, because my assumption is that the underlying form of affixes is the locus of whether a language has harmony or not, as opposed to whether placing this within constraints. The reason is precisely because of the presence of disharmonic affixes. If *all* harmony is driven by across-the-board requirements for feature-changing in the case of adjacent disagreement, then disharmonic affixes must be exempted by morpheme-indexed constraints of the form “X is exempt from feature-changing”.

But such a constraint is not enough: it will not tell us what form X actually surfaces with. If the empirical fact is that X is disharmonically [+back] even within a span of [-back] preceding vowels, this result will not follow from “X is exempt” alone: we need to know *what value* X has when it is exempt, and this requires X to have a determinate underlying form. In fact, it is not enough to simply say that X surfaces with whatever the default value for [back] is in the language, because a single language can have both disharmonic [+back] affixes and disharmonic [-back] affixes. For example, Hungarian has the disharmonic [+back] diminutive suffix *-us*, and the disharmonic [-back] suffix *-ert*. At present, I see no obvious way to encode this difference without making reference to the underlying form of morphemes, and if this is the case, then richness-of-the-base cannot be adopted, and the locus of the difference between harmonically alternating morphemes and disharmonic morphemes can be characterized as it is done here: by the fact that the former require feature-filling, and the latter require nothing. As mentioned in the introduction to this chapter, moreover, the fact that newly-introduced morphemes (i.e. Hungarian *-uzska*) are “by default” disharmonic suggests that disharmonic affixes are not “exceptional” and should not be characterized in terms of a special constraint, but in terms of their underlying form, which, unlike that of harmonic suffixes, is fully specified, and hence not subject to valuation.

Having offered this comparison, it remains the case that valuation and checking do share a great deal of formal properties:

- (32)
- a. For a given target of a valuation/checking rule for feature [F],
 - b. Search for a determinant that meets the criteria specified in the structural description
 - c. If the search finds a determinant that matches all of the conditions in the structural description, then let this determinant be the *source*
 - d. Provide the target with the (identical or opposite) value of [F] as that of the source

It should be clear that the range of possible structural changes is extremely limited on this formulation: once a source is identified, either the opposite or identical value of that same feature is copied to the target. Thus, closest-search of this sort is only applicable for searching for a value of feature *F* on the source and providing that value for the same feature *F* on the target; the theory does not include long-distance “mutation”, in which a subsegmental change to a feature *F* on a focus is due to any features *other than F* on the determinant. Thus, as I will discuss in Section 3, assimilation and dissimilation are formally identical in the entire search procedure for a valuation/checking source, and differ only in the polarity of whether the identical or opposite value is copied from the source.

I will conclude this section, however, by reiterating that models that wish to adopt the richness of the base hypothesis (provided that they can somehow distinguish alternating and disharmonic affixes without reference to their input representations) and wish to maintain the assumption that disharmonic affixes are exceptions, may safely model all harmony as *checking* as it has been developed here, importing the formalization of contrastive visibility and closest, with no valuation component.

1.2. The Bundling of Subsegmental Rules into Policies

In this section, we turn our focus to architectural concerns: what is the interaction between separate rules, all of which achieve harmonic valuation in some form or other? We start by reviewing the Finnish case above. There were two rules that were considered in the case of affixation: a search-based value-copying, and a context-free value-insertion. These two rules were crucially ordered with respect to each other (in this case, by the Elsewhere condition). Moreover, they both had the same *function*: to establish a value, in one way or the other, for the feature [back]. We may say that two such rules comprise a *policy*.

A policy represents a kind of “macro-rule”: it represents a complete set of instructions for handling inputs of a given sort. What a policy represents is a “black box”, or macro-function: for any input, it will deliver an output, but its internal

contents may consist of more than one rule or constraint. In essence, a policy defines a “mini-grammar”: it represents a speaker’s entire “policy” for how to handle harmonic alternations in affixes.

This notion of policy has two useful consequences beyond those for describing a set of rules with the same purpose: in Chapter 4, it is posited that *the unit of competing hypotheses* in acquisition is the policy, and that what learners update, compare, and maintain are policies, not individual rules. Thus, variation in the output of harmonic affixation for vacillating stems such as *ágnés* in Hungarian will be seen to be the result of differences in two distinct harmony policies, and not in two distinct harmony rules. Policies, then, represent a “micromodule” of the phonological grammar, and one that in fact has limited interaction with other micromodules of the grammar.

Thus, the ordering of contrastive vowel harmony comes before context-free vowel fronting, but there is no need for the learner to order contrastive vowel harmony as an individual process with respect to, say, the rule of leftmost edgemarking in the stress component. The stress policy may be ordered with respect to the harmony policy, and indeed, the inputs and outputs of these policies may interact, but at present, there is little evidence that the internal constituent rules of these policies interact in any direct way; indeed, to a learner who observes affixal alternations, he or she may develop a policy to deal with these that is completely independent of the policy developed for stress assignment.

Virtually all current theories of phonology, however, do not modularize computations to this extent, and in fact predict grammatical possibilities based on ordering or ranking relations between these individual cross-module rules. Such interactions are ruled out in the current theory, with positive mathematical consequences for learning. For instance, suppose that a grammar consists of n constraints or parameters, but that in fact, these n constraints may be grouped into m micromodules of k constraints each. If none of the micromodule- (or policy-) internal constraints need to be ranked or ordered with respect to those in other micromodules, then the space of grammars to explore is much smaller: it represents,

in an idealized scenario, the difference between $m*(k!)$ and $(m*k)!$ if done in terms of ordering possibilities, or between $m*k^2$ and $(mk)^2$ in terms of parameters. Both of these inequalities are highly significant, and so I believe the idea of encapsulated policies, whose internal contents do not interact with the internal contents of other parts of the grammar, is worth pursuing.

The hypothesis that I will adopt here is that a given rule may only belong to one policy, and that the construction of policies by learners is driven by isolating a phenomenon of interest, where multiple rules seem to be crucially ordered with respect to each other and their structural changes have similar effects (i.e., in the case of harmony, determining the featural value for a needy affix).

The notion of encapsulating the interaction of certain types of rules / constraints / processes from others has received recent attention within the OT literature as well. For example, deLacy (2003) notices some “too many solutions” problems within OT, where a given markedness constraint could potentially be satisfied by many different kinds of repair, but the set of repairs is very restricted. His observation is that “feature conditions cannot affect string structure or prosody”, and subsequently proposes that “All String Structure Faithfulness constraints [i.e. everything related to epenthesis and deletion] outrank all assimilation constraints¹⁰ and all tone-related markedness constraints”, and that “All Markedness constraints that refer to prosodic elements outrank all faithfulness constraints that relate to features”. Clearly this involves delimiting which constraints belong to the class of prosodic-markedness, which belong to featural-faithfulness, and which belong to tonal-markedness, and proposing that there is *no interaction of individual constraints within these modules with individual constraints from other modules*. This is exactly the nature of the architectural proposal I am offering here: individual rules within a featural policy are never crucially ordered with respect to individual rules within the metrical grid algorithm, and so forth. As Wilson (2003) points out, we never observe deletion or epenthesis interactions (“string-changing rules”, in De Lacy’s

¹⁰See also Pater (2003) for a related proposal: “all constraints on segmental correspondence universally dominate all constraints on vowel assimilation”.

parlance) occurring in a particular winning candidate in order to avoid a violation of an output-oriented harmony constraint. Wilson points out that there is no way within standard OT to avoid constraint-evaluation scenarios such as the following. Take as an example nasal spreading in Malay, in which [nasal] copies from the left to all vowels and glides, yielding *mākan* ‘to eat’ *pənəŋəh̃h̃ən* ‘central focus’. Wilson shows that problems arise given a constraint such as (33):

- (33) SPREAD-R,([+nasal],PrWd). For every [+nasal] autosegment n, assign one violation for every segment in the same prosodic word that is to the right of n’s domain (where the domain of an autosegment is the sequence of segments that are associated to it).

The problem arises in the interaction with other processes of the language. Consider epenthesis in the final cluster of the hypothetical form /nawakast/. If SPREAD-R-NASAL is ranked above the constraint demanding epenthesis, the outcome would be that epenthesis is blocked, because it will yield a vowel in the domain of nasal harmony that does not harmonize:

	/nawakast/	SPREAD-R,[+nasal], PrWd	*CC#
(34)	a. [nãwãkasət]	*****!	
	b. [nãwãkast]	****	*

Wilson demonstrates that this problematic interaction could potentially hold for reduplicant size and allomorph selection as well: smaller reduplicants would be chosen, for example, on the basis of the fact that they yielded less lapses of nasal harmony, hence less violations¹¹. The point of these examples is that there are

¹¹The source of this problem is *global evaluation*: nasal harmony should not be evaluated as a property of entire words, but rather, as an iterative process, applying at each potential locus of application, without interference from global counting of harmony violations. Wilson’s examples provide a clear demonstration of the need for each structural description to have a *locus of evaluation*. The standard way to accomplish this is through Howard (1972)’s model, which uses a “pointer” a placeholder that advances throughout the X-tier.

- (i) a. Current-pointer = j
 b. If structural change applies at j, apply structural change

“non-conspiracies”: certain structural descriptions *only* have one repair. This is exactly because there is *non*-interaction of other modules with the harmony policy. This non-interaction can also be illustrated for rule based interactions. Suppose that a [back] harmony policy was interspersed with a rule of posttonic syncope (i.e. second-syllable if there is initial stress) that affected a disharmonic affix:

(35) Hypothetical input output mapping: /pél-ka-rIn/ → péI-ka-rIn] → péIk.rIn
→ [pélkrin]

If valuation is cyclic (i.e. affix-by-affix) and syncope may apply in between, we could expect it to destroy the relationship between the disharmonic affix and the affix following it. To my knowledge, such processes are not attested. Thus, the architectural claim of non-interaction is that policy-external rules cannot apply anywhere inside of a policy — they cannot apply between ordered rules of a policy, of the sort that will be demonstrated here for Chumash, and they cannot affect the optimization of an output constraint, as discussed by Wilson and De Lacy.

In effect, this should not be a surprising proposal: what we call “phonology” is really a vast domain of knowledge over many interacting modules, and we should not necessarily expect the full range of potential interaction between every single individual rule/constraint and every other. What is more difficult, for the theorist, is isolating exactly what the submodules of phonology are, and modelling how the learner knows that a group of rules constitute constituents of the same module. I will not have anything original to offer here as far as how this should be done, but I do hope that models of parameter-setting/constraint-ranking will take into account this more realistic assumption: that cross-module interaction is extremely limited, and that learning a phonology does not necessarily involve establishing a total ordering among each individual statement of the grammar.

These remarks have more force, however, when we consider a policy as the unit of competing hypothesis in learners’ grammars. In Chapter 4, it will become

c. Advance pointer to $j + 1$.

clear that we can better characterize variation across individuals for harmony and dissimilation if we suppose that these speakers are employing different *policies* (as opposed to placing the locus of variation in the individual rules). The reason is that two speakers that differ in whether, to take an example, they treat Hungarian [ɛ] as transparent or not, can be productively modeled as differing in the parametrization and ordering of two rules, not one. Since rules interact due to ordering, there is no such thing as placing the locus of variation in a single rule: modified versions of that single rule will then interact differently with other rules in the same policy, and one can develop a model with clearer predictions if the competing unit of hypothesis is a competing “grammar of harmony”: the entire policy, and not the individual rule.

Before anticipating the role that the architectural construct of a policy plays in modeling variation and learning, however, we can turn to a more direct application of this notion within the modeling of harmony when it interacts with other subsegmental rules. This is because the other area in which policies play a role is in *the mode of application of rules within it*. This becomes important when we consider Chumash, which shows alternations between [+/- anterior] values on sibilants, due to both harmony *and* a rule of precoronal palatalization that applies only in derived environments. Speakers may include both of these processes in a single policy, with functional unity: this policy determines how all sibilants will be handled with respect to their value for [anterior]. Thus, as will be presently illustrated, the rule of precoronal palatalization and rightward [anterior] valuation apply in sequence at each input to the “sibilant policy”.

In his analysis of Chumash, Poser (1982) provides an interesting argument for modeling feature-changing rules (where sibilants alternate in anteriority due to harmony) in the two autosegmental steps of (i) delinking of [α F] on the assimilating segment, followed by (ii) free association of [$-\alpha$ F] to that same segment. Briefly, what happens in Chumash is that the value of [anterior] for the last sibilant in the word determines the value of [anterior] for every other sibilant in the word, thus constituting a case of sibilant harmony. This process is clearly non-

cyclic in character (as it applies in a single pass from rightmost to leftmost edge of a morphologically complex word); moreover, since sibilant-containing suffixes and stems may surface in forms without any other sibilants, learners may deduce the underlying forms of each of these morphemes¹². Thus, the Chumash sibilant harmony policy involves a single-pass instance of iterative *checking*.

(36) Chumash sibilant harmony (Poser 1982: 132)

- | | | | |
|----|--------------------|----------------|---------------------|
| a. | /k+sunon+us/ | [ksunonus] | 'I obey him' |
| b. | /k+sunon+š/ | [kšunotš] | 'I am obedient' |
| c. | /su+wayan/ | [suwayan] | 'cause to hang' |
| d. | /k+su+šoyin/ | [kšušoyin] | 'I darken it' |
| e. | /s+ixut/ | [sixut] | 'it burns' |
| f. | /s+ilakš/ | [šilakš] | 'it is soft' |
| g. | /s+kuti+waš/ | [škutiwaš] | 'he saw' |
| h. | /s+iš+tiši+yep+us/ | [sistisiyepus] | 'they two show him' |

At the outset, one might imagine a *simultaneous* process of checking, in which sibilant harmony is accomplished by a unbounded feature-changing rule that sets the value of every sibilant equal to that of the final one. I will provide a schematic outline of what such a rule would look like in its formal essentials, even though this will not be the solution that I ultimately adopt.

- (37) $\forall x$, sibilant(x), if there $\exists y$, sibilant(y) & last(y):
 let Val(anterior,x) = Val(anterior,y)

What (37) expresses is the fact that all anterior segments in a Chumash word copy the value of the last anterior segment in the word. This copying operation may apply *simultaneously*, and the defining features of (37) are that (a) the source of

¹²This in fact demonstrates a fundamental difference between many instances of vowel and consonant harmony: for a consonantal feature, such as [strident] or [lateral], it is often the case that an affix may attach to a stem that has *no* instance of that feature. However, for a vocalic feature, such as [back] or [high], an affix will always attach to a stem that contains at least one instance of this feature – unless of course we are dealing with purely consonantal stems (which do exist in some cases).

copying for each sibilant is identical: the final sibilant in the word and (b) there is no separation between the step of a sibilant losing its lexically-specified value and the step of it becoming assigned a new value.

However, Poser provides an argument that the final value of the [anterior] feature of all sibilants in the word should *not* be established by a single simultaneous feature-changing operation, but rather by the two ordered steps of 1) delinking all values of [anterior] except the last one, followed by 2) association of the remaining [anterior] value to all sibilants.

Poser points out that, if a dissimilation rule is separated into two distinct rules, one of delinking, and one of reassociation, then there is the possibility that a *third* rule might intervene between these two steps. And he provides a likely candidate for just such a rule: precoronal palatalization (38), with examples in (39).

(38) Precoronal palatalization:

Structural Description: Strident_{target} immediately-precedes C_[Coronal]

Structural Change: Strident_{target} becomes [-anterior]

(39) Chumash Precoronal Palatalization (Poser 1982:152):

- a. /s+nit^hoy/ [šnit^hoy] 'he goes'
- b. /s+tumun/ [štumun] 'it's egg'
- c. /s+lok'in/ [šlok'in] 'he cuts it'

Clearly, Precoronal Palatalization (PCP) is a rule that the Chumash learner will add to his/her [anterior] policy¹³. The interesting interaction is that derived š is opaque to leftward sibilant harmony:

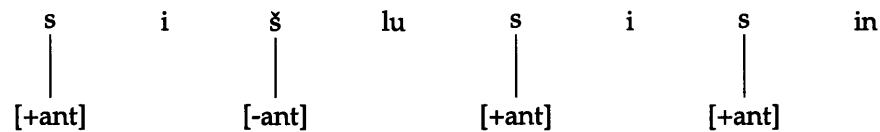
(40) Opacity of PreCoronal Stridents to Sibilant Harmony:

¹³Bert Vaux has proposed the interesting constraint that all constituent rules within a policy are either cyclic or non-cyclic. The consequence would be that PCP is a non-cyclic rule, as it is bundled with [anterior] checking. This seems correct in the range of cases I have considered, and is clearly an idea that should be investigated, but will not be pursued here.

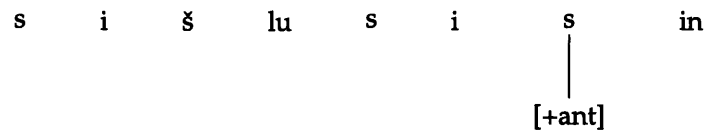
- a. /s+is+ti?/ [šišti?i] 'he finds it'
- b. /s+iš+lu+sisin/ [šišlusisin] 'they two are gone awry'
- c. /s+ti+yep+us/ [štiyepus] 'he tells him'

Poser's argument is thus that, if precoronal palatalization is allowed to apply precisely at the point in the derivation in between (1) delinking all [anterior] specifications except the last one and (2) performing leftwards autosegmental association of [anterior], then forms like *šišlusisin* can be derived:

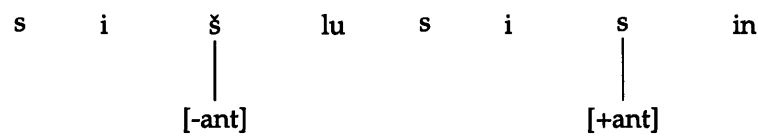
(41) a. Lexical Representations:



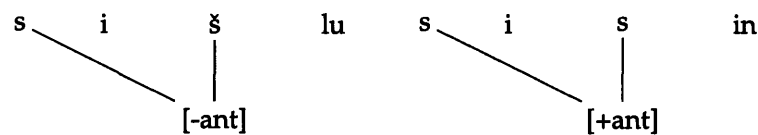
b. Delink all except final:



c. Precoronal Palatalization:



d. Leftward Association:



Poser's argument provides a theoretical motivation for modelling feature-valuation as two steps, each a simultaneous rule: delinking + association. By contrast, in the model here, there is no separation between delinking and reassociation: when a value changes in checking, the new value simply immediately replaces the old one. There thus seems to be at first blush, a problem: if checking does not consist of the two steps of delinking and reassociation, then how can the rule of precoronal palatalization apply "in between"? It is thus incumbent on me to provide a reanal-

ysis of Chumash in terms of checking, and the proposal is as follows. Chumash contains the following two disjunctively ordered rules within the sibilant policy:

- (42) Chumash sibilant policy:
- a. Precoronal Palatalization (PCP):
Structural Description: Strident_{target} immediately-precedes C_[Coronal]
Structural Change: Strident_{target} becomes [-anterior]
 - b. Rightward Anterior Checking (RAC):
Structural Description: Strident_{target} ... C_[contrastive: α anterior]
Structural Change: Strident_{target} becomes [α anterior]

That is, since both rules have the same function (establishing the final value of [anterior] for all sibilants in the word, they are bundled in a policy, with the extrinsic ordering that RAC precedes PCP. What this means is that these rules are only applied when the Sibilant Policy is employed, and that, by hypothesis, these rules do not belong anywhere else in the grammar. Importantly, when a policy is being applied (which is itself ordered with respect to other policies), all constituent rules within that policy may apply to a single focus during the non-cyclic pass through a word. Thus, we will presently turn to cases in which both RAC and PCP may fire, under ordered application, to a single focus within a word.

The learner must thus extrinsically order RAC before PCP within the policy, but the claim is that there can be no policy-*external* rule that is crucially ordered, say, between RAC and PCP¹⁴.

¹⁴Both Morris Halle and Donca Steriade have encouraged me to consider whether a disjunctive ordering between RAC and PCP is possible for the Chumash case at hand. That is, in the current formulation, PCP applies after RAC, thus potentially undoing its effects on precoronal sibilants, and an alternative policy is simply to disjunctively order the two rules, with PCP taking preference over RAC. This is a feasible and intriguing proposal, but the interesting question would be whether this disjunctive ordering follows from any intrinsic similarity between the two rules. Certainly, any formulation of the Elsewhere condition (either in Kiparsky's (1973) version, or the one more flexible one I offer in Appendix One) will not predict disjunctive ordering here, as the structural environments of immediately-preceding a coronal and preceding, unboundedly, a sibilant, are not in any subset relation. Both Morris and Donca have offered the intriguing suggestion that precedence follows in this case from the coronal being closer to the focus. This represents the possibility for a great deal of further research.

As a noncyclic policy, the Chumash sibilant policy applies in a single pass, leftwards, from the rightmost potential focus in the string (in the manner of iterative application outlined by Howard (1972)). Importantly, at each focus, *the policy applies* (and whichever of its constituent rules is chosen will then be applied). Each focus will be considered in turn in the derivation, as shown in boldface:

- (43) a. /s+iš+lu+sisin/ → [šišlusisin]
 b. Focus RAC PCP Output
 sišlusisin n/a n/a sišlusisin
 sišlusisin sišlusisin n/a sišlusisin
 sišlusisin sislusisin sišlusisin sišlusisin
 sišlusisin šišlusisin n/a šišlusisin

Thus, the correct output, [šišlusisin], may be derived *without* separating checking into two steps, one of delinking and one of reassociation. The key is simply to order the rules of PCP and RAC within the policy, such that PCP may apply at a focus k , which then provides a determinant for the application of RAC at focus $k + 1$.

Before proceeding, it is important to emphasize the role of *directional application* of the policy as crucial in ensuring the correct result. For instance, by way of theory comparison, we might wonder whether the rules of RAC and PCP could be translated into a constraint-based approach with parallel evaluation. On such a theory, PCP would be the result of a constraint demanding [-anterior] before coronals, and RAC would be replaced by a rule demanding that adjacent sibilants bear identical values for [anterior]. Clearly, the constraint inducing PCP would have to outrank the constraint ensuring adjacent agreement. There is a problem, however, with such a theory: it provides no way to arbitrate between *šišlusisin*, which has one violation of adjacent agreement, from *šišlušisin*, which has also has one violation.

- (44) a. *sislusisin: violates PALATALIZE PRECORONALLY
 b. *sišlusisin: contains two violations of adjacent [anterior] agreement

- c. šišlusisin: contains one violation of adjacent [anterior] agreement
- d. *šišlušisin: also contains one violation of adjacent [anterior] agreement

It is only by incorporating an iterative and directional mode of evaluation, from right-to-left, that one can capture the generalization that a pre-coronal sibilant will cause surface disharmony *only to its left*.

To conclude, we have motivated policies as providing a learning-theoretic construct for bundling rules of similar function that, crucially, do not interact with other modules of the grammar (i.e., cross-policy rules do not interact, only the output of the policy does). However, it also turns out that the architectural construct of policies play a useful role in non-cyclic iterative passes through foci, in determining the mode of application of individual rules. Rather than passing through the entire word once, and applying Rule 1 of the policy at each potential focus, and then passing through the entire word again, and applying Rule 2 of the policy at each potential focus, Rules 1 and 2 are applied together (disjunctively, in the case above) *as a policy*.

Having outlined the mode of application of valuation and checking rules, we turn to theoretical and empirical motivation for modeling (dis)harmony in this way, as opposed to others which have precedent in the literature.

1.3. Search-Based Valuation: Find *Closest*, Copy Identical/Opposite

Valuation has the following four properties:

- (45) a. It explicitly connects the structural description and structural change of a subsegmental rule
- b. It gives content to the notion of furnishing values for underspecified affix vowels
- c. It is iterative, in that each target of valuation may seek a potentially different source, some of which are themselves the result of valuation operations

- d. It allows assimilation and dissimilation to be expressed in formally identical terms

However, the search conducted in valuation may vary in four ways:

- (46) a. Relativization of the search to certain values of [F]
- b. Limitation of the search to a bounded adjacency domain
- c. Specification of source preconditions for features/properties other than [F]
- d. Reference to positional landmarks in the prosodic word

All four of these factors will be explored throughout this thesis. Let us return to (45-a), however. This point has a significant benefit: it limits the range of feature-valuing operations to a very constrained set. That is, in formulations such as (47), there is no explicit connection between the structural description and the structural change, where crucially, both involve the feature-value [+back], and the intention is clearly one of a) finding a local determinant with the value [+] for [back] and b) copying that value to the target of the rule.

(47) Vowel → [+back] / [+back] _

The same remarks apply to formulations of (47) in terms of OT constraints. The OT equivalent of a structural description is a markedness constraint, that specifies a particular configuration that must undergo a structural change. There is no direct OT equivalent of a structural change, however: what there is instead is a series of ranked faithfulness constraints that specify what structural changes *cannot* be carried out. This turns out to be useful for “conspiracies” related to syllabification, where there often is no dedicated structural change, or where the structural description has to be duplicated in many places in rule-based formulations. However, harmony is not subject to “conspiracies”¹⁵ – there is always exactly one struc-

¹⁵This fact has recently been noticed by Wilson (2003), who introduces the notion of dedicated structural changes into OT to remove instances of adjacent non-agreement. Note that the con-

tural change associated with harmony, namely copying the harmonic value to the target.

Autosegmental formulations had the advantage that, unlike (47), they *were* able to explicitly connect the structural description and structural change of assimilation rules, because, in many cases, the feature value to be copied was *literally* the same token, and thus, copying became automatic, as the determinant and target *shared* the same instance of the feature (at least until the point of “transfer to phonetics”, at which point, a “mitosis” operation took place, yielding two distinct tokens of the original shared feature-value)¹⁶. However, autosegmental formulations remain completely unable to explicitly connect the structural description and structural change in a *dissimilation* rule. Consider the following autosegmental formulation of the Latin liquid dissimilation rule that yields the affixal alternant *-aris* instead of *-alis* when a lateral precedes:

(48) Latin Liquid Dissimilation (Gildersleeve and Lodge, 1895):

spiracy issue is particularly troublesome for alignment-based theories of harmony, which require features to be aligned to edges of domains – as feature-transfer, segmental deletion, and metathesis are all potential but non-attested structural changes in a theory of unfettered GEN.

¹⁶This inspired the intuition of autosegmental phonology (and alignment theory) that assimilation really was just an “extension” of the articulatory instruction to a further timing slot, which held great promise, but as many long-distance cases of harmony require “twin peaks” structures, as Pulleyblank (1996) calls them, in which there are tokens of the assimilating [+F] on source and target, and separated by an intervening [-F]. These representations, which are in some cases forced, compromise the vision of a assimilation as extension of single, shared instruction.

- a. nav-**alis** naval
- b. mort-**alis** mortal
- c. ven-**alis** venal
- d. caud-**alis** caudal

- e. milit-**aris** military
- f. lun-**aris** lunar
- g. consul-**aris** consular
- h. vulg-**aris** common
- i. flor-**alis** floral
- j. sepulchr-**alis** funereal
- k. litor-**alis** of the shore

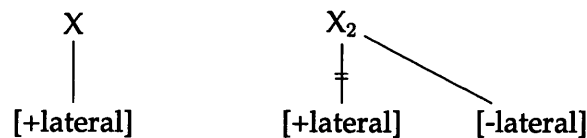
(49) Structural description



(50) Structural change, Part 1:



(51) Structural change, Part 2:



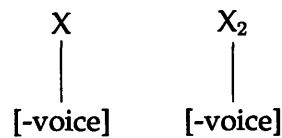
It is part 2 of the structural change that is most problematic. The association of a new autosegment, with precisely the *opposite* value from the one that was delinked, is not forced by the formalism; in fact, any new floating autosegment could be presumably linked. In the present formulation, however, the behavior of the liquid can be simply characterized: it bears the opposite value for [lateral] from the most

immediately adjacent liquid¹⁷

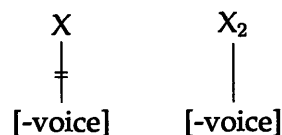
- (52) Latin Liquid Dissimilation: Structural Description: Liquid_[αlateral] ... C_[target]
Structural Change: C_[target] becomes [-αlateral]

Without recourse to a calculus for opposite values, however, researchers have attempted to circumvent the problem of specifying the value of the floating autosegment in (51) by assuming that the new autosegment to be reassigned is always the “default” value of the feature, so that it may be linked to any segment that can host it. For example, it might be proposed that the “+” value that arises in the case when there are no liquids in the stem represents the default value of [lateral]. The generality of this solution is limited. Consider Dahl’s Law in Kikuyu and Embu (Davy and Nurse, 1982), which has the following formulation in the autosegmental account:

- (53) k → γ dissimilative voicing occurs before the voiceless segments *s, t, k*:
- a. yo-siara ‘GERUND-giving birth’
 - b. yo-tɛya ‘GERUND-trapping’
 - c. yo-kama ‘GERUND-milking’
- (54) Current formulation (discussed in Ch. 4): cyclic *valuation* (set to *opposite*) of asymmetric [-voice]
- (55) Autosegmental Account, Structural description

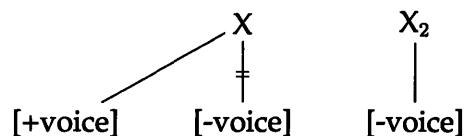


- (56) Autosegmental Account, Structural change, Part 1:



¹⁷In fact, as will be developed in Chapter 2, “liquid” will not be referred to, and the most immediately adjacent segment that is *contrastive* for [lateral] will be the goal of the valuation-search.

(57) Autosegmental Account, Structural change, Part 2:



There is no Kikuyu- or Embu-internal evidence that the newly-linked [+voice] represents the “default” value for this feature, and hence, autosegmental treatments must stipulate that there is a [+voice] association rule, that applies only to the output of a [-voice] delinking rule (see Poser (1987) for discussion of this sort of model). The fact that the delinking of [α F] and subsequent reassociation of value [- α F] have all been triggered by the presence of a local determinant [α F] remains implicit¹⁸. Compare the formulation in terms of opposite-valuation.

(58) Dahl’s Law [Voice] Dissimilation:

Structural Description: $\text{Velar}_{\text{target}} \cdots C_{[-\text{voice}]}$

Structural Change: $C_{[\text{target}]}$ becomes [+voice]

In the suite of operations developed in this dissertation, once a valuation source has been identified for a (dis)harmony rule, the *only* options are to copy its value, or copy the opposite of its value, onto the target. In a restricted set of functions, this is accomplished by limiting the vocabulary to

- (59) a. Set $\text{Val}(F,x) = \text{Val}(F,y)$
b. Set $\text{Val}(F,x) = \neg\text{Val}(F,y)$

In (59), Val is a function that returns the Value of a feature F on a timing slot X. Its output is boolean; the values may be only + or -. What is important is that a

¹⁸Lombardi (1995) provides an account in terms of privative [voice], with the following elements: 1) [voice] is default-inserted on all velar consonants only in prefixes 2) this “default” insertion is blocked when it would violate the OCP, i.e. when a root-initial segment bears [voice] 3) However, [voice] elements can be fused into a single, non-OCP violating element, though only within prefixes. The use of the OCP to block a “default rule” strikes me as problematic in its notion of what default rules are, the fact that [+voice]-insertion is a default rule strikes me as implausible, and the concept of featural-fusion to avoid the OCP is an operation that is difficult to motivate in graph-theoretic terms.

valuation-based search has only these two possible structural changes, and that structural changes such as the following are excluded:

- (60) Excluded valuation operations (where $F \neq G$):
- a. (i) Set $\text{Val}(F,x) = \text{Val}(G,y)$
 - (ii) Set $\text{Val}(F,x) = \neg\text{Val}(G,y)$

In other words, while there is abstraction over values of the same feature, no search that is initiated in order to fix the value of a feature F can depend on the value of a wholly different feature G from the source. Thus, what harmony and dissimilation share in common is that they may only compute identity within the scope of the same feature: there cannot be a rule that says that a suffix vowel becomes [+back] if the nearest adjacent vowel is, say, [+high] and [-back] if the nearest adjacent vowel is [-high]. Assimilation and dissimilation, therefore, share a formal restriction that makes them distinct from “mutation”: the operations of identical-copying and opposite-copying are limited to variables within the same feature¹⁹.

As emphasized in the Introduction to the thesis, however, the research developed here attempts the unification of assimilation and dissimilation for considerations beyond the computational simplicity of reducing two wholly distinct op-

¹⁹There are few, if any, cases of harmony or root-structure constraints that would empirically require expressive power across features. One example that does exist in the literature is the root cooccurrence restriction on voicing and aspiration in Indo-European roots discussed in *SPE*, p. 386:

- | | | | |
|-----|---------|------|-------|
| (i) | tek | teg | *tegh |
| | dek | *deg | degh |
| | *dhek * | dheg | dhegh |

This restriction may be expressed as follows:

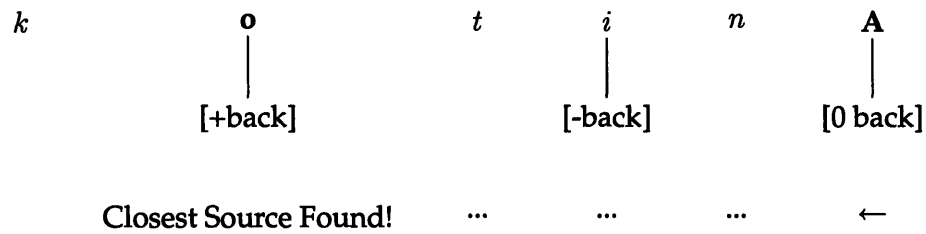
- (ii) $*[\alpha \text{ voice}, \beta \text{ asp}]$ before $[-\beta \text{ voice}, -\alpha \text{ asp}]$

Should this example withstand scrutiny, the claim made by the text remains: statements such as (ii) require a level of computational expressiveness that is formally more complex than that of harmony and dissimilation, and the prediction is that the learning, processing, and distribution of statements of this sort will be of a different (and more marked) nature. Nonetheless, it is worth pointing out that even this example bears a more restricted nature than a random sampling might reveal: both features referred to in (ii) are grouped under the feature-geometric node LARYNGEAL, and perhaps the ban may be understood in terms of complexity underneath this node.

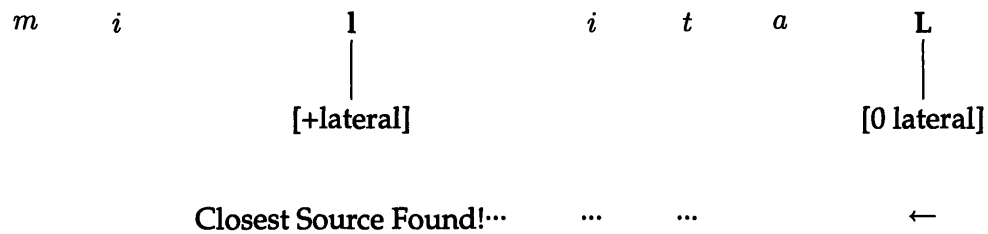
erations to one operation with a parametric option for the polarity of the sign of the structural change. As will be emphasized throughout this dissertation, assimilation and dissimilation rules have the same locality conditions: relativized to (all, contrastive, or asymmetric values of a feature²⁰. This shared formal condition of value-relativized locality becomes most easily apparent when we consider contrastive-value cases. Consider Finnish [back] harmony, which is modeled as a search for the closest contrastive value of [back]. The notion of “vowel” harmony is purely emergent here: it just happens to be the case that only vowels are contrastive for [back], and that is why harmony is vowel-to-vowel. Nothing needs to be said about skipping the intermediate consonants, because they simply are not contrastive for [back]. Now consider Latin liquid *dissimilation*. An unbounded number of intervening segments may stand between the valuation source (the stem-internal liquid) and the target (the liquid in the affix *-a:lis*), as long as none of the interveners are **contrastive** for the disharmonic feature [lateral]. Again, nothing needs to be said about skipping the intermediate vowels and non-lateral consonants, because they are simply not contrastive for [lateral]. Or, turning to Chumash sibilant harmony, as has been discussed in Section 2: an unbounded number of intervening segments may stand between the valuation source (the word-final sibilant) and the target (a preceding sibilant), as long as none of the interveners are **contrastive** for the harmonic feature [strident]. Thus, what harmony and dissimilation crucially share is that a statement of the possible interveners in the structural description can be completely factored out, once the locality conditions for source-target relations are relativized to contrastive values for the harmonic feature.

(61) Finnish Search Procedure (Contrastive Values Only):

²⁰Calabrese’s (1995) conception of value-relativized parametrization employs the term “marked” values of a feature, but I remain hesitant that *all* cases in which only one value of a feature is visible for search represent the marked value of that feature, and so stick to the more neutral formal term “asymmetric” herein.



(62) Latin Search Procedure (Contrastive Values Only):



This reduction of locality conditions of harmony and dissimilation to the same basic principle, *closest within a value-relativized domain of a feature*, may not have been amply appreciated in recent generative treatments of phonology. In the 1980s, spreading did assimilation, while the Obligatory Contour Principle (OCP) did dissimilation. In the 1990s, alignment and correspondence did assimilation, while the OCP did dissimilation. However, there are formal benefits to seeking unification of these two processes, and even suggestive results that language users do not treat assimilation and dissimilation with these wholly different computational mechanisms. Pycha et al. (2003) report a preliminary experimental finding: speakers who are taught an artificial language can learn harmony as well as disharmony, but there is a significant difference between their ability to learn harmony/disharmony and a completely “random” segmental mutation²¹. This constitutes evidence that assimilation and dissimilation might be handled by the same formal mechanism (although, as Donca Steriade (pers. comm.) has pointed out, one might want a wider range of formal rule types in the control condition).

²¹Wilson (2003) also finds assimilation and dissimilation to be easier to learn than a random alteration; though the two are not compared directly, he does interpret the results as “suggesting a cognitive bias for dissimilation that is at least as strong as the one for assimilation” (p.543).

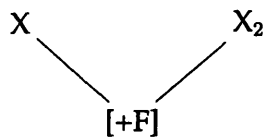
1.3.1. Dissimilation without the OCP

The primary mechanism for triggering dissimilation in autosegmental phonology is the OCP (see Yip (1988) for a representative example). Thus, there is the restriction that (63) is not well-formed, but (64) is; this results from purely-theory internal considerations:

(63) OCP violator/ fake geminate



(64) OCP respecting/ real geminate



In fact, the distinction above ends up creating a host of theory-internal problems, especially since structures such as (64) are sometimes claimed to be “converted” or mitosis-ized into (63) before the transfer to phonetics. As much as possible, we would like to cut out this “middleman” condition on intermediate representations. The theory of locality, as independently developed for assimilation phenomena, can do just what the OCP does: force one of two elements to bear the **opposite** value of a local source. What all of this is to say is **not** that the OCP does not represent a “true generalization” – it of course does²². But its implementation, in terms of “obligatory *contour*”, creates the illusory restriction that it can only happen on “adjacent elements”. And we know that this is not true – long-distance CC and VV interactions are some of the most widespread in dissimilation. However, as has been extensively discussed, two dissimilating consonants are **not** adjacent, except on a theory-internally-postulated *consonantal plane*.

²²Though subject to some well-known qualifications; see Odden 1988 and below.

Such a plane is plausible for Semitic, where morphemic representations already require a level of representation at which consonants and vowels are separated. However, McCarthy's mechanism of "tier conflation" is not the only imaginable implementation. Subcategorization of the affixation site of the vocalic *binyan* can be accomplished in terms of affixal additions to the precedence and syllable structure of a representation; Ussishkin (2003); Margalioth (2003); Raimy (2000), among others, contain proposals on how to do so, without tier-based separation. Moreover, tier conflation in its original formulation (McCarthy, 1986) is identified with bracket erasure in removing morphemic distinctions. However, Bat-El (1988) provides arguments against morphologically-based tier conflation, as the metathesis rule in the *hitpa'el* binyan needs to refer to heteromorphemic status of participating segments. Thus, even in Semitic, C/V separation is not without problems. Tier separation of vowels and consonants becomes much more dubious in languages without morphemic plausibility. What results, therefore, is a situation where, in order to make two segments local, they are put on a separate plane, solely for the purpose of the OCP to operate, and mark that sequence as subject to a rule that changes the value of one of them. The alternative implementation is as follows: rather than stating the OCP as a principle, and specifying a repair on one of the violating elements, it can rather be stated that dissimilative affixes have an instruction to copy the *opposite* value from a local determinant. Exemplifying cases, such as Latin and Dahl's Law, were schematically discussed above. The claim is thus as follows:

- (65) Locality of dissimilation [i.e. opposite valuation] processes can be achieved by value-based relativization, which are independently necessary and implicit in every theory of vowel harmony

Thus, given the formalism which is independently developed for vowel and consonant harmony in this dissertation, a mechanism for vowel and consonant *disharmony* follow from one parametric difference in the structural change.

1.3.2. A Note on Iterative Alternating Dissimilation

The proposed unification between assimilation and dissimilation might lead one to wonder why, since iterative harmony often results in identical adjacent values of a feature (66), iterative dissimilation doesn't always lead to an "alternating" pattern, as in (67):

(66) + + + + +

(67) + - + - + - +

Strictly alternating patterns such as (67), that iterate indefinitely, have not been abundant in the literature to date (and Poser (1987) in fact tries to explicitly rule out patterns of this type). However, recall that value-relativization may be set to the "asymmetric" or marked value of a feature. That is, a search domain will only pick out *one* of the binary values of a feature. In dissimilation, this turns out to be one of the more frequent settings, and in particular, in combination with the unbounded setting of the adjacency parameter. Consider first a schematic example from Mandarin tone sandhi²³: 3rd tone dissimilates to 2nd tone when it precedes, at an unbounded distance, another 3rd tone. We may approximate the process by supposing that both 2nd and 3rd tone share the feature [+rise], and that 3rd tone bears the marked value [+contour], while the 2nd tone bears [-contour].

(68) Approximation of Mandarin contour tone dissimilation:

Structural Description: [Rise]_{target} . . . [Rise]_[+contour]

Structural Change: [Rise]_[target] becomes [-contour]

The formalism of (68) expresses that any tone with the feature [+rise] will change to [-contour] if it precedes a [+contour] segment at any distance. Consider now the underlying utterance in (69), which, as a result of (68), becomes (70):

²³The exposition here will remain schematic, and quite likely, requires greater detail to characterize the full range of facts (especially factors such as speech rate; see Shih (1997)), but nonetheless serves to demonstrate the logical character of unbounded, marked-value dissimilation.

(69) Lao₃ Li₃ mai₃ hao₃ jiu₃
Old Li buys good wine

(70) Lao₂ Li₂ mai₂ hao₂ jiu₃

The rule in (68) does result in iterative dissimilation, but not iterative *alternating* dissimilation (which would be of the form 32323). This is a consequence of the fact that dissimilation has been encoded as a search for the marked value of [contour], and thus only [+contour] is visible as a source for dissimilation. Formally, both options are possible, but the Mandarin rule chooses to employ marked visibility. Patterns like 2323 (or ++++, more generally), however, are predicted by the theory. Their apparent absence from many attested systems could have to do with the fact that perceptual origin of phonologized dissimilation (Ohala, 1981) may be asymmetric in its effects. Ohala proposed that a common source of dissimilation is the consequence of “compensation for misperception”: a speaker thinks they have mistakenly perceived αF on a segment S (near another instance of αF on a segment Y), and hence applies a correction whereby S is subsequently represented as $-\alpha F$. The relevance of this model to marked dissimilation is that it may be the case that it is more common for speakers to “think-they-misperceive” for value α of feature F, but not for $-\alpha$ of F.

Nonetheless, I will point out that alternating patterns may be found to a limited extent in dialects of Embu (Davy and Nurse, 1982), as discussed more fully in Chapter 4. Embu possesses the dissimilative voicing characteristic of Dahl’s Law, that is characterized, like Mandarin contour sandhi above, as asymmetric-value harmony: the search is relativized to [-voice] only²⁴. Thus, many speakers exhibit what is formally identical to the Mandarin pattern: a sequence [+voice] [+voice] [-voice], where both dissimilating segments find the same rightward source with a marked value:

²⁴It is worth noting that Bennett (1967) suggests the diachronic origins of Dahl’s law involve dissimilation for [+aspiration], in which case this rule did undergo phonologization as dissimilation of the marked value. The subsequent loss of aspiration on voiceless stops, however, transformed this into a rule of [-voice] dissimilation, and it no longer seems appropriate to call this “marked” value harmony, so I will use the neutral terminology of *asymmetric value* relativization.

- (71) Unbounded, asymmetric-value dissimilation in Embu: /a.kaa.kii.kia/ →
[a.ɣaa.yii.kia]

Nonetheless, there are some speakers who have internalized a different version of the dissimilation rule: one that is *bounded* by syllable-adjacency. For these speakers, the search for a [-voice] source is limited to looking within the next syllable. Even if a [-voice] source exists two syllables away rightward, this is too far away for the bounded character of the search. The result of this parametric option is that the syllable immediately preceding a [-voice] source undergoes dissimilative voicing, but that the syllable preceding these two is now too far away to undergo dissimilative voicing, resulting in what is, on the surface, an alternating pattern:

- (72) Syllable-bounded, asymmetric-value dissimilation in Embu: [a.kaa.yii.kia]

Interestingly, if another prefix is added, the voiceless segment that failed to undergo dissimilative voicing in (72) may now act as a source for asymmetric [-voice] for the preceding syllable:

- (73) Syllable-bounded, asymmetric-value dissimilation in Embu: /ka.kaa.kii.kia/
→ [ɣa.kaa.yii.kia]

Thus, one dialect of Embu in fact does possess a strictly alternating, iterative dissimilation pattern, fulfilling the “missing” typological profile. However, it is worth acknowledging the rarity of this Embu example, and at the same time, pointing out that it follows as the result of a very specific set of conditions in the present theory: dissimilation must be asymmetric-valued, and it must be *bounded* in character. This is a rarer combination than dissimilation that is asymmetric-valued and unbounded in character. What is crucial about the bounded character of the alternating Embu dialect is the following: due to the fact that the search is bounded, dissimilation on a target *k* from a source in syllable *k+2* **fails**. By failing to dissimilate, however, *k* *retains* its asymmetric value, and can in turn, act as a source for

dissimilation for syllable *k-1*²⁵.

In closing, I would like to conclude that the relative typological rarity of alternating iterative dissimilation is not a reason to dismiss the attempted unification of harmony and dissimilation: such a pattern does exist in Dahl's Law, and its typological rarity may be due to the rarity of combination of the parameters of syllable-bounded adjacency and asymmetric-value dissimilation. Contrastive-value dissimilation would certainly allow for many more cases of alternating patterns. My tentative suggestion at this point is that the relative rarity of contrastive-value dissimilation, and the predominance of asymmetric-value dissimilation, has its origins in the asymmetric character of misperception that provides one of the diachronic sources of dissimilation.

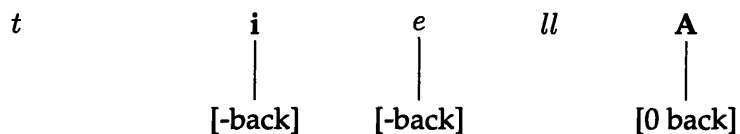
1.3.3. Context-Free Value-Insertion

Given the existence of phenomena such as Dahl's Law (Davy and Nurse, 1982), we have reviewed why it becomes difficult to say that dissimilation is the result of OCP-trigger delinking of [-voice], followed by insertion of [+voice] by a "redundancy rule", since [+voice] is the marked value of the feature in anyone's book.

However, on the view of affixal segments seeking valuation that is developed here, there will be configurations in which a segment does not find a valuation source in the course of its search. For example, in Finnish vowel harmony, when all-neutral vowels precede, the affix is valued as [-back]. However, given the operation of Value-Closest developed here, the fact that neutral vowels are transparent in searches in which they are preceded by [+back] vowels leads to the conclusion that neutral vowels simply cannot provide a [back] value in harmonic valuation. We modeled this as contrastive-value relativization. The Finnish vowels *i,e* are not contrastive for [back], and hence not included in the domain of search.

(74) Search Procedure (Contrastive Values in Boldface):

²⁵And logically, this can continue: syllable *k-2* is too far away from *k* to dissimilate, retains its [-voice] value, and acts as a source for dissimilation in syllable *k-3*. Unfortunately, three prefixes with velar segments seems to be the maximum allowed by the morphology of the Thagicū group of Eastern Bantu in which Dahl's Law is found.



No Source Found! ←

In the representative case of an all-neutral root such as *tie* ‘brother’, no contrastive [back] source is found, the search terminates, and a subsequently-ordered context-free valuation rule may apply. There is strong motivation for modeling the process by which affixes receive values when attached to all-neutral stems (i.e. an empty search domain for contrastive values) with context-free rules in this way. Consider the comparison between Finnish and Uyghur. In Finnish, the non-contrastive vowels are *i, e*, and the context-free insertion rule provides the value [-back]. However, in Uyghur, which has the same surface inventory, the noncontrastive vowels are also *i, e*:

(75) Uyghur Surface Vowel Inventory (Lindblad, 1990; Hahn, 1991):

(76)	[-back,-rd]	[-back, +rd]	[+back, +rd]	[+back,-rd]	
	<i>i</i>	<i>ü</i>	<i>u</i>		[+high, -low]
	<i>e</i>	<i>ö</i>	<i>o</i>		[-high, -low]
	<i>ä</i>			<i>a</i>	[-high,+low]

Nonetheless, the default value of [back] in suffixes attached to all-neutral stems is [+back] (Lindblad, 1990, 23): e.g. *siz-maq* ‘draw-GER.’, *deŋiz-ğa* ‘sea-DAT.’, *til-lar* ‘tongue-PL.’²⁶. There is thus no necessary formal connection between the value

²⁶Donca Steriade points out that all of these suffixes are [+low], and indeed, a thorough inspection of Lindblad (1990) reveals that all cases of default [+back] insertion he discusses are for [+low] suffix vowels. I do not know what to make of this – whether it reflects a morphological accident, or whether it shows that the preference for default [+back] assignment is inherently connected with the [+low] specification of these vowels. What it does show, however, is that in an otherwise contrastive-value harmony pattern, an all-neutral stem still *does not participate in harmony*. Should the choice of default value in context-free insertion turn out to be governed by extra-harmonic featural preferences (e.g. [+low] → [+back]), this actually might support further the independence of context-free insertion and harmony, since stems with contrastive values allow no such preference

of noncontrastive vowels in the inventory and the value assigned to affixes by context-free insertion. A similar comparison can be made for Wolof and Manchu [ATR] harmony, which will be extensively discussed in Chapter 3. In both languages, the [+ATR] vowel *i* is transparent. However, in Manchu, when the only stem vowel is *i*, affixes show a [-ATR] default value, while in Wolof, they show a [+ATR] default value. As nothing in the grammar or inventory of Wolof or Manchu predicts this difference, I suggest that learners posit context-free valuation rules in certain cases. Importantly, since they are context-free, they will always be disjunctively ordered after VALUE-CLOSEST rules by the Elsewhere condition.

(77) Uyghur [back] harmony policy

a. *Uyghur Contrastive [back] Harmony (CVH):*

Structural Description: $V_{[\text{contrastive}: \alpha \text{ back}]} \cdots V_{\text{target}}$

Structural Change: V_{target} becomes $[\alpha \text{ back}]$

b. *Uyghur Context-Free Vowel-Backing:*

Structural Description: $V \cdots V_{\text{target}}$

Structural Change: V_{target} becomes $[+ \text{ back}]$

In addition, as we will see in Chapter 4, context-free insertion rules prove to be insightful components in the grammar of Finnish and Hungarian, as they “emerge” to yield surface variation in certain affixes in a way that cannot be described if they are folded into the harmony rule. Thus, while there are many ways to write grammars that do not contain context-free feature-changing rules, the fact that rules of this sort emerge and determine the form of variation in adult grammars (discussed in Chapter 4) provides empirical motivation for their inclusion. Before closing, it is interesting to consider how recent markedness-based formulations of dissimilation can model cases like dissimilative voicing in Dahl’s Law. For example, Ito and Mester (2003) employ a constraint-conjunction logic to formulate the OCP for dissimilative devoicing in Japanese. The intuition is that [+voice] is marked, but

for backness to succeed.

can be tolerated. However, *two* instances of [+voice] are doubly bad, and if the constraint *VOICE² is highly-ranked, it will penalize all outputs that have two instances of [+voice]. It is a puzzle how this approach can handle Dahl's Law at all, since it is a case of dissimilation that does not seem to be markedness-driven. Would it involve a *-VOICE² formulation of self-conjoined markedness? In other words, is the analytic option to say that *VOICELESS² is high-ranked, and triggers repair in Kikuyu/Embu? Quite likely not, as this will render vacuous any intuition of "markedness" of a particular value of [voice]. Thus, if Dahl's Law requires a separate machinery from dissimilative devoicing in Japanese in the theory of self-conjoined constraints (i.e., if Ito & Mester need to posit *VOICE² for Lyman's Law, but a wholly different mechanism for Dahl's Law), then perhaps we should seek an alternative, such as the present theory, in which these two formally identical dissimilation processes receive a unified explanation.

1.3.4. The Necessity of Binary Features in Opposite Valuation

We have considered the operation VALUE-OPPOSITE, active in dissimilation rules, which provides the target with the opposite value of the source. Clearly, for this rule to yield an output every time it is applied, all features that participate in valuation relations must be binary. There are often objections to binary features in the literature, in particular for features such as height, when there are three degrees of height, and it seems "wasteful" to posit two binary features in order to classify three categories.

Nonetheless, binarity within a three-category allows for the formalization of two principles: grouping and opposition. That is, suppose that instead of the two binary features [\pm high], [\pm low], height was expressed via a single ternary feature, ranging over the values [height 1], [height 2], [height 3]. The *grouping* problem would be that such a feature system could not express generalizations in which high and mid vowels behave as a natural class, to the exclusion of low vowels. We find many empirical cases in which this is necessary; one that will receive extensive attention in Chapter 3 is the asymmetry between low and non-low vowels.

The principle of opposition is necessary to express polar reversals in the value of a feature. Such operations, where the value of a feature changes from [α F] to [$-\alpha$ F], are called exchange rules, such as the ones attested in Brussels Flemish and Zok, as shown in Appendix Two.

One (not necessarily unique, but certainly among the most compact) solution to a formulation of rules governing exchange-rule alternations involves the operation of a polarity rule that inverts the value of mid and high vowels. This operation cannot be expressed in any elegant (or perhaps more tendentiously, cognitively plausible) ternary-valued model, as there is no way to separate the values [1] and [2] from [3] and define a (non-disjunctive) function that, given one as input, will yield the other. I thus take the existence of exchange rules to be strong evidence for binary values in grammar²⁷.

Many exchange rules are relegated to the “morpholexical” wastebasket (e.g. Anderson and Browne (1973); Moreton (1999)). This position seems to adopt the view that some uses of phonological features (e.g., to express oppositions in word-formation) fall outside the domain of study of researchers interested in the set of operations that occur on phonological feature-values. Such a view is diametrically opposed to the claim made throughout this dissertation: that the contrastive use of features to signal distinctions in meaning (i.e. “to form minimal pairs”) forms the cornerstone of *inventory oppositions* relevant for participation in harmony and dissimilation.

Thus, the conclusion to be drawn here is that, despite their apparently cumbersome use in describing three-category universes of distinction, binary-valued features allow expression of “a natural class” and of an opposition that make them indispensable in an explicit repertoire of minimal computational operations that learners may posit in the formation of generalizations about subsegmental processes.

²⁷And of course, not only vowel height shows polarity; as we have mentioned, gender polarity, represented by a morphological binary feature, is well-attested in adjectival concord systems (and perhaps pronominal systems, though see Lecarme (2002) for cautionary remarks on Somali).

1.3.5. Intervention-Based Locality

We turn to the core of the locality component envisioned here. It is instructive to start with one of the more general statements of locality within harmony, due to Steriade (1995:121):

- (78) *The Locality Condition:*
 The elements related by a phonological rule or constraint must
 be adjacent on some tier

In the present model, (78) is all (essentially) that needs to be said. Association lines and underspecification are irrelevant, once the *tiers* are properly defined. And, of course, another difference is that tiers, in the present model, have no independent ontological status outside of phonological rules: that is, tiers are better understood as *relativized domains of search for the current computation*. Once these domains are bounded and are relativized for a feature F (to all, contrastive, or an asymmetric value of F), the Locality condition as stated in (78) (restricted in its formulation here only to copying of subsegmental values: VALUE-CLOSEST) really is all that holds.

In contrast, the consequence of the autosegmental formalism is that locality conditions are enforced by the ban on crossing association lines. Of course, the ban on “crossing lines” is somewhat of a metaphor²⁸. In graph-theoretic terms, association lines are *edges*, and the autosegments and timing slots that they connect are *vertices*. Thus, the vertices represent elements in featural representations, and the edges represent the association relation. Now, there is nothing in the representational characterization of the relations between autosegments and timing slots that requires that the lines be drawn as straight lines. And there are plenty of ways to circumvent pictorial line-crossing by allowing the lines to be curvy (see Coleman and Local (1991) for additional discussion of this point). So the metaphor in terms of crossed lines may be somewhat of a red herring. What it boils down to,

²⁸A notable exception is the proposal of Sagey (1988), discussed in the next footnote.

rather, is the following:

- (79) Given segments $X1 > X2 > X3$, and the association relations $R(F1,X1)$ and $R(F2,X2)$, where $F1$ and $F2$ are tokens of the feature $[F]$, there can be no association relation $R(F1,X3)$.

No researcher within the autosegmental paradigm would quibble with (79) as an interpretation of the line-crossing constraint²⁹. Yet it is clear that (79) does not require association lines at all. Rather, what it states can be recast as follows:

- (80) Given segments $X1 > X2 > X3$, and the association relations $R(F1,X1)$ and $R(F2,X2)$, where $F1$ and $F2$ are tokens of the feature $[F]$, there can be no sharing of the value of $[F]$ between $X1$ and $X3$.

However, even (80) is insufficient, for as we have seen, *dissimilation* relations cannot be characterized in terms of (80). The following amendment takes care of this:

- (81) Given segments $X1 > X2 > X3$, and the association relations $R(F1,X1)$ and $R(F2,X2)$, where $F1$ and $F2$ are tokens of the feature $[F]$, there can be *no direct valuation relation* (i.e. identical or opposite) for $[F]$ between $X1$ and $X3$.

In effect, (81) is the first step of the theory of locality developed in this dissertation. However, as we will see, the formulation above is too strong. There are a number of cases of valuation relations for $[F]$ between $X1$ and $X3$, with an intervening $[F]$ associated to $X2$. One such case is Sibe, to which we return in detail in Chapter 2,

²⁹Although the proposal of Sagey (1988) seems to insist that the features themselves are in an ordered relation, independent of the ordering relation among the timing slots (perhaps akin to claiming that there are c-command relations among individual features on syntactic terminals, which has never been claimed). This assumption does not seem to be completely motivated, and so is omitted here (although the existence of “tonal melodies”, if they exist (though cf. Zoll (2003)) would require ordering among features, independent of timing slots). In short, it seems redundant to order both features *and* timing slots. (Alternatively, one might maintain that *only* features are in precedence relations, and that the associated timing slots are not. However, Raimy (2000) provides extensive motivation for ordering relations among timing slots, so it would be difficult to maintain this alternative.)

but for which a brief outline follows.

In the preceding discussion, the emphasis has been on relativization of search to particular values of the harmonic feature: namely, the contrastive values of that feature. However, the proposal of Calabrese (1995) contains two other value-types that search may be relativized to: *all* values of a feature F, and the *asymmetric* (in some cases, coinciding with *marked*) value of F. We turn presently to a brief exemplification of *all-value* relativization.

1.3.6. All-Value Relativization: Tangale

Tangale is a Chadic language, and in fact, the only one known to possess a vowel harmony system. It has a suffixing [ATR] harmony, and the following 9-vowel inventory:

(82) Tangale Inventory (Kidida 1985:18)

i	u	[+high,+ATR, -low]
ɨ	ʊ	[+high, -ATR, -low]
e	o	[-high, +ATR, -low]
ɛ	ɔ	[-high, -ATR, -low]
a		[-high, -ATR, +low]

As can be seen, the feature [ATR] is contrastive for all vowels except /a/. Examples of stem-affix combinations yielding harmony may be observed in (83):

(83) Examples of Harmony (Kidida 1985:20)

- a. wudo-no my tooth
- b. wudɔ-nɔ my farming
- c. sórii-nì his height
- d. s'ɔr-n`i his age
- e. rii-go multiplied
- f. ri:i-gɔ satisfied
- g. d`ukà salt
- h. kanj-wu their deleb-palm

Importantly, /a/ values suffixes as [-ATR], as seen in, e.g. (83-h). Thus, it may be said that Tangale has non-contrastive vowels that are visible within the search for valuation. More precisely, all values of [ATR] appear to be visible sources for valuation in Tangale:

- (84) Structural Description: $V_{[\alpha \text{ ATR}]} \cdots V_{\text{target}}$
 Structural Change: V_{target} becomes $[\alpha \text{ ATR}]$

To verify the harmonic behavior of /a/, the noncontrastive vowel, we may observe that it is non-alternating (and disharmonic) when in suffixes (85) and that it is a visible local source that, when the closest vowel to a suffix, is the one whose value is copied in disharmonic roots (86).

- (85) The vowel /a/ cooccurs with tense vowels if in an affix:
- a. peer-na compelled
 - b. pɛd-na untied
 - c. dob-na called
 - d. laŋɔld`ed`e small frog
 - e. la-pídò small tree
 - f. ana-wólò singers
 - g. ànà-w`ut`en workers

- (86) The vowel /a/ intercepts [+ATR] harmony from the stem to an affix, be-

cause it is the closest value of [ATR] in the affix's leftward search.

- a. ped-nà-n-g'ò untied me
- b. peer-ná-n-g'ò compelled me
- c. dob-nà-g-g`ù called you (pl.)
- d. dib-nà-m-g`ù cooked for us
- e. wee-nà-m-g`ù saw us

The analysis of Tangale is completely straightforward: all values of [ATR] are visible. Thus, the parametric setting for the structural description of this harmony rule is that the domain of search for valuation includes all values of the harmonic feature.

We return to a further cases of ALL-VALUE VISIBILITY in Chapter 2, focusing on rounding harmony in 3- and 5-vowel languages³⁰.

As for the second parametric option of value-relativization, we have reviewed already contrastive visibility at some length above (in the cases of Finnish, Chumash, and Latin). We thus turn our immediate attention to asymmetric-value parametrization.

1.3.7. Asymmetric-Valued Parametrization

Sibe, a Tungusic language discussed at length in Chapter 2, provides evidence for a value-relativized search that only includes asymmetric values of a feature. Briefly, what happens in Sibe is that search is relativized to marked values of [high], which are [-] in Sibe. Thus, the presence of a [-high] vowel anywhere in the stem is sufficient to trigger uvularization of a suffix-initial Dorsal consonant. What is

³⁰One of the important points about the parametric system developed here is that it is couched within a theory that does not appeal to redundant values (largely because, as outlined in Chapter 2, there is no logically foolproof algorithm for arriving at an optimization of redundancy). Thus, in 3-/ 5- vowel systems with the high vowels *i* and *u*, these are specified as [-back,-round] and [+back, +round], respectively. The consequence of assuming this featural representation is that, under the definition of contrastiveness offered in (5), neither [round] nor [back] has a contrastive value on either of these segments. Thus, cases of alternating *i~u* harmony necessarily involve *all* value harmony (usually of [round], in the cases where (due to looking at other heights) it is determinate). Under these limited parametric options, it is an automatic consequence that there will be no language with the three high vowels *i,ü,u*, in which *u* and *i* alternate to the exclusion of *ü*.

In the form *ku.du.mu.ki.si.na*, the source is in the third syllable and the target is in the sixth syllable. I will assume that the underlying form of the suffixal consonant is //, which is [+sonorant], and I will assume a redundancy rule: [+nasal] → [-lateral].

(90) Kikongo nasal harmony:

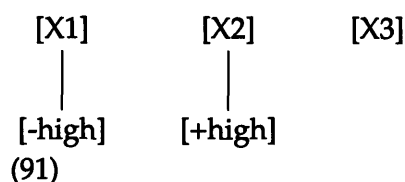
Structural Description: $C_{[+nasal]} \cdots C_{target}$

Structural Change: C_{target} becomes [+nasal]

Kikongo nasal harmony is oblivious to intervening consonants: its search domain includes only the marked [+] values of nasal³¹, and the unbounded character of search will continue until an instance of [+nasal] is met. It is important to realize that relativization to an asymmetric value still imposes an important locality restriction: search will terminate with the closest leftward [+nasal] segment. In the case of Kikongo, this will ensure [+nasal] copying every time. But in a language with an additional condition on copying from the source (such as that it be a *coronal* nasal), bearing the marked value [+nasal] alone will not be enough, and if the first [+nasal] element is labial, the search will terminate right there in failure. We will turn to such cases of “defective intervention” in Section 8. For now it suffices to point out that asymmetric value harmony ensures that Kikongo nasal valuation can look at an unbounded distance until a value of this sort is found (and no further).

³¹There is an interesting complication in the Kikongo data, which I will not definitively analyze here, because I am not convinced of the correct solution. Briefly, prenasalized stops are transparent to nasal harmony. There are three analytic solutions to this problem, none of which are completely satisfactory. One is to assume that prenasalized stops are featurally distinct from nasal consonants (in Rose and Walker (2004) this is tied to the lack of a “release”, though no feature is proposed). The second is to assume that the heterosyllabic status of prenasalized stops exempts them from harmonic domains (in Piggott (1996) it is claimed that they are “unfootable” and harmony is foot-sensitive). The third is to assume context-sensitive visibility of the feature [+nasal] on prenasalized stops; this is the approach of Ao (1991), and the one that I will adapt here, as follows. Suppose we enrich our parametrization of contrastive and asymmetric/marked visibility to be context-sensitive (I show how such an amendment is in fact necessary for Karaim non-initial syllables in [back] harmony in Chapter 2). As the only [+consonantal] segment that can occur preconsonantly is *always* [+nasal], and it is a fact about markedness that it can only be defined in the presence of an opposition, it can be said that the nasal component of prenasalized stops is *positionally unmarked*, and hence excluded from the search domain.

Returning to the case of Sibe, the relativization restriction is that only [-] values of [high] are interveners for (90). Importantly, this type of relativization is cumbersome to translate back in to the autosegmental formalism. One would have to state that intervening [+high] features, even though they are present, are “invisible” for the purposes of the line-crossing constraint. However, once the line-crossing constraint is dispensed with, there is no need to appeal to invisibility of this sort. Rather, what the representation contains is the following: an affixal consonant, X3, that requires a value for [high]:



- (92)
- a. X3 performs a leftward **search** for the closest instance of a [-high] feature.
 - b. X3 locates a [-high] feature on X1, and initiates a **valuation relation** with X1.
 - c. X3 copies the *identical* value of [-high] to itself

The formulation of long-distance assimilation in Sibe, as given in (92), bears close resemblance to the formulation of the *Agree* operation, as defined in Chomsky (2001). Consider the establishment of agreement between the Agr-node on Tense and the nominative object in Hindi sentences such as (93), which have an intervening ergative subject:

(93) Raam-ne rotii khaayii
 Raam.masc-ERG bread.fem-NOM ate.fem
 'Raam ate bread'

(94) [_{TP} khaa-T [_{vP} Raam-ne [_{VP} t_{khaa} rotii]]]

At the derivational point in (94), the Agr node c-commands the subject (*Raamne*), which in turn c-commands the object. Nonetheless, an agreement relation is established between Agr-on-Tense and the object, *across the intervening subject*.

The analysis presented in Anand and Nevins (2004) of (94) is that the search domain for agreement is relativized to noun phrases with *structural case*. As the subject bears inherent case (ergative), it is not within the search domain, and does not constitute an opaque intervener for agreement. Few, if any, syntacticians, would propose that the subject position is underspecified at the point of long-distance agreement, and added in by a later redundancy rule.

It is important to realize that the formulation of (dis)harmony rules as valuation according to a relativized locality is formally exactly parallel to the establishment of agreement in syntax. (And perhaps *dis-agreement* as well; Halle (1990) draws attention to the well-known case of “opposite agreement” in gender between numerals and head nouns in Hebrew, which are of course subject to the same locality restrictions as “agreeing” concord.) The essential difference (aside, of course, from the nature of the features that are involved) is that locality in syntax is defined in terms of *dominance* relations, while locality in phonology is defined in terms of *precedence* relations. Of course, no syntactician has proposed a line-crossing constraint to account for why locality-violating sentences such as **A book was given John* are ungrammatical. Rather, what they have appealed to is a definition of locality in terms of *interveners*:

(95) Relativized Locality: No relation (Merge, Agree, Disagree) may occur between elements X and Y if Z intervenes, where Z is of the relevant type

Given the elevation of (95) to a principle of human cognition, all of the work that remains to be done is define precisely what constitutes a “relevant type” of intervener. This constitutes exactly the goal of Chapters 1-2 of this dissertation. Relativized locality seems to be a principle that runs throughout the linguistic system, and perhaps more broadly in cognition. Grammar seems to disallow movement of

“like across like”:

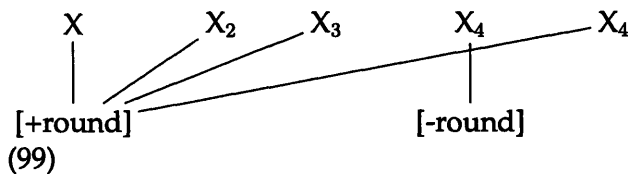
(96) I told [John] [a lie]

(97) *A lie was told John

Similarly, Turkish [+round] harmony cannot go from the stem to a suffix, across a [-round] suffix:

(98) pul-lar-in, *pul-lar-un ‘stamp-PL-GEN’

As we just have reviewed, these Locality constraints in phonology are often implemented with the **Line Crossing Constraint**, which disallows one [round] feature from crossing another. It is important to realize that the aspect of the autosegmental model that is most tightly caught up with the association-line approach to locality is the common idea that there is an imperative for [round] to Spread from the stem, rightwards, as far as possible, but that it may be occasionally blocked when it crosses a line:



That is, the predominant view of harmony sees it as “an imperative for the trigger to spread”. In contrast, as has been outlined above, the Valuation operations of assimilation and dissimilation are viewed from a target-centric point of view, with the target *seeking* a source for variation.

This distinction, between (a) the trigger spreading the feature *to* the target, and (b) the target seeking to copy the feature *from* the trigger, may seem like a completely symmetrical way of describing the world, somewhat like characterizing a human’s growth as towards the ceiling versus away from the floor. However, in this next subsection, I will argue that one of the most insightful criticisms of the

autosegmental model (and indeed, a much wider class of models, namely all of those that assume that the target of an assimilation receives *all* its values from the *same* source), that of Padgett (2002) (though essentially anticipated in Sagey (1987)), may be fruitfully re-understood and solved when looking at assimilation from a “target-centric” perspective³².

1.4. “Non-Constituent” Copying

The epitome of the predictive promise of a spreading-based approach to assimilation can be observed in the following quotation:

“Since the hierarchical representation of the distinctive features is fixed and universal, the only simple [spreading] operations will be operations either on individual features or the class nodes that dominate them.” (McCarthy, 1988, 87)

That is, the hope of feature-geometry in the trigger-centric perspective is that, when more than one feature spreads together, these features will all be part of a constituent. Indeed, this was the inspiration behind the introduction of the notion “feature-tree” by Clements (1985).

Again, a useful parallel may be found in the representational use of constituency in syntax:

- (100) a. John bought [a book about metathesis] on Monday
b. [A book about metathesis] was bought on Monday
c. *[A book about] was bought metathesis on Monday

Thus, the phrase “a book about metathesis” must move together to form a passive subject, and an only-partial movement of this constituent yields an ill-formed operation. Syntactic constituency is formally captured by grouping constituents

³²Padgett’s solution, following his observation that the spreading model makes incorrect predictions for assimilation, is to retain the spreading model, but make it violable, and allow for constituent-spreading to spread only partial constituents when necessary. Our solution, as will be discussed, differs greatly from this.

under the same **nodes** in a tree. Similarly, phonological constituency is captured in the feature-geometric model by grouping constituents under the same nodes in a tree. However, both of these representations are based on the assumption that the trigger (i.e., “the mover”) is the element on which the operation is defined. There are, nonetheless, dependency relations in both syntax and phonology in which the “movers” do not comprise a constituent. One example from syntax is “portman-teau” agreement, as is found in Kiowa-Tanoan languages. In these cases, the form of a single agreement morpheme is determined by the phi-features on two (sometimes three) arguments of the verb. Importantly, there is no motivation (and in fact, evidence to the contrary) that the two arguments that determine the form of the Agr morpheme “move together as one constituent”. Rather, a more insightful analysis is achieved by a “target-centric” perspective: the Agr morpheme has *needs for valuation* by subject and object phi-features, and will seek valuation for those two features in independent searches, when necessary. We may find immediate parallels in the behavior of underspecified affix vowels seeking featural valuation in phonology. We turn to a straightforward example.

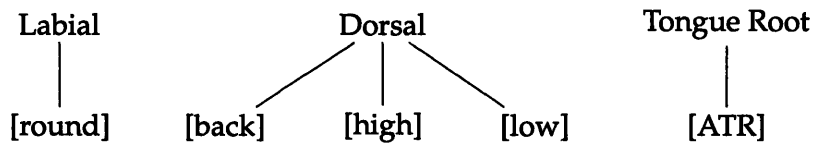
Dagaare: Copy everything but [-high]

Dagaare is a language of Ghana, studied by Bodom (1997). Dagaare is a 9-vowel system, with [ATR] contrasts among the [-low] vowels, as shown in the inventory:

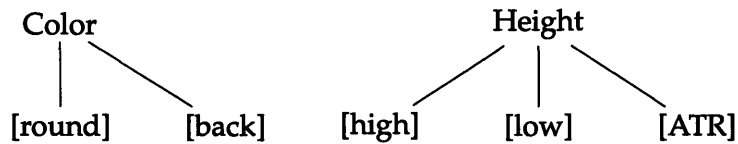
(101) Dagaare Vowel inventory

-back,-round	+back,+round	
i, ɪ	u, ʊ	[+high,-low]
e,ɛ	o,ɔ	[-high,-low]
	a	[-high,+low]
	+back,-round	

Consider the (articulatorily-motivated) constituent-based grouping of vocalic features adopted by Sagey (1986) (and many subsequent researchers):



This constituency was challenged by Odden (1991), who proposed instead the following groupings:



In Dagaare, we find [round] and [ATR] spreading together. These do not form a constituent in either of the models proposed above. The imperfective suffix in Dagaare copies the features [ATR] and [round] from a preceding source:

(102) Imperfective suffix always [-high]: Bodomo 1997:25)

Verb	Impf	Gloss
do	duo-ro	climbing
tu	tuu-ro	digging
bɔ	bʊɔ-rɔ	looking for
mɔ	mʊɔ-rɔ	wrestling
bʊ	bʊʊ-rɔ	discussing
mi	mii-re	raining
piiri	pii-re	discovering
siri	sii-re	touching
ɲme	ɲmie-re	beating
kp̂e	kp̂e-re	entering
ĝpe	ĝpie-re	grinding roughly
kpa	kpa-a-ra	boiling
la	laa-ra	laughing

The situation in Dagaare is by no means unique; the 9V Bantu language Kàlòŋ (Hyman, 2003) demonstrates identical behavior for the class 6 prefix /mA-/, which has the alternants *ma*, *me*, *mo*, *mɛ*, *mɔ*, copying [ATR] and [round] from the nearest

vowel.

We may formalize the representation of the Dagaare imperfective suffix as follows. The affix is lexically stored with *only* a height specification: [-high]. Immediately upon phonological spell-out, the affix seeks values for the features [ATR] and [round]³³. This search for valuation proceeds leftward (as there is nothing to the right of the cyclically-introduced suffix), and immediately upon finding a valuation source, copies the values to itself.

On the surface, the distribution of the imperfective alternants in Dagaare exhibits apparent “non-constituent” copying, since [low] and [ATR] and [round] don’t form a constituent, to the exclusion of [high].

However, consider this set of operations from the perspective of a target-centric theory of valuation³⁴. It is not the case that there are a set of spreading rules in Dagaare that spread the nonconstituent set of features above. There is no “spreading” in this process³⁵. Rather, the imperfective suffix is entered in the lexicon with *only* [-high]. Immediately upon suffixation, IMPERF seeks **valuation** for all remaining features. Valuation is achieved with the **closest segment**³⁶ that can provide a con-

³³ And perhaps [back] and [low] as well, though these are predictable.

³⁴ The current work resonates with (and indeed, draws inspiration from) the discussion of target-centric assimilation in Maillhot and Reiss (2004), who motivate such a view based on possible learnability considerations. Such considerations, assuming they prove accurate, provide complementary evidence to the empirical motivations developed here.

³⁵ Here and throughout, the term *valuation* is thus **not** interchangeable with *spreading*, as valuation is target-centric, and spreading is trigger-centric.

³⁶ The notion of ‘closest segment’ has certain precedents in the literature, many of them within a series of articles in the journal *Linguistic Analysis*. The *Minimum Distance Constraint* of Battistella (1982, 110) states that “No segment S may intervene in a variable X of some rule R, if S can itself condition application of the rule.”, though is stated as a binary parameter on rules, whereas it is adopted as an invariant *principle* here. Yamada (1983) formulates *The Class Complement Constraint*, which is limited to assimilation and dissimilation rules, and states that “In a phonological rule the intervening material may be constituted only by those segments belonging to the complement of the class that consists of the focus and the determinant.” However, Yamada’s paper also includes additional subconditions such as “If a complement defined in the Class Complement Constraint contains a neutral vowel, then no other vowel than this may intervene between focus and determinant.” (p.56) One primary goal of this dissertation is to eliminate “neutral vowel” as an a priori category, particularly since, in some cases, what is transparent for one rule may be visible for another (e.g., Hungarian non-low vowels that are non-contrastive for [back] are invisible for [back] harmony, but they *are* visible for the [round]-harmony rule affecting mid vowels.). In addition, Yamada assumes abstract vowels such as *i* (which later undergo absolute neutralization rules), purely for the purpose of upholding the constraint as formulated: “In fact, in accounting for many apparent counterexamples to the Class Complement Constraint I have depended on the abstract analyses including absolute neutralization rules” (p.70). As discussed in Chapter 2, absolute neutralization

trastive specification for the relevant feature:

- (103) VALUE-CLOSEST: Given a segment X that needs valuation for a feature F,
- a. Y is the closest source of valuation if Y bears a value for F,
 - b. and there is no Z that bears a value for F, such that either
 - (i) Z precedes X, and Y precedes Z [Y Z ... X]
 - (ii) X precedes Z, and Z precedes Y [X Z ... Y]

We have thus eliminated the need to posit non-constituent spreading in Dagaare. In fact, the very object of study has shifted on this target-centric view. Rather than developing a catalogue of “which features spread together” in assimilation, the research question now shifts to “which features are already included in an underspecified affix?”. What is evident from the Dagaare case (and indeed, many others) is that underspecified affixes sometimes only carry a specification for *height*, leaving other features to be filled in by valuation. Thus, a study of the typology of underspecified affixes reveals that it is often the case in “non-constituent copying” that a vowel seeks valuation for all contrastive features except a height feature that it already bears. We will return to an exploration of the substantive basis for this tendency in Chapter 3.

While we have thus avoided non-constituent spreading (e.g., from both Color and Height (but without [high] in Odden’s theory, or from Labial, Tongue Root, and Dorsal (but without [high]) in Sagey’s theory) we have not seen any argument yet that VALUE-CLOSEST is a **necessary** way to look at harmony. For example, the terminal-spreading model of Halle (1995) could perhaps handle Dagaare as well. On Halle’s revised autosegmental theory, structural descriptions identify the nodes to be spread in an assimilation rule. However, once a node is identi-

rules result from a failure to identify the importance of contrastiveness in syntagmatic visibility. Jensen (1974) proposes the *Relevancy Condition*, which is based on shared major class features between the determinant and focus. As Odden (1980) points out, this leads to “overspecification” of the features in certain rules; moreover, all VC interactions (such as Sibe uvularization) are counterexamples; clearly “major class” is the wrong grain size for features of the intervener.

fied for spreading, all of its terminal nodes are each “on their own”, given the instruction to spread. Since the Dagaare imperfective already bears a feature for [high], it could be said that all non-terminal nodes dominating vocalic features (i.e. those features that are contrastive in [-consonantal] segments in Dagaare) are activated for spreading, and the [high] terminal simply fails to spread because it is already specified on the imperfective. It is worth pointing out, however, that this version of terminal spreading is essentially similar in insights to the violable theory of constituent-spreading of Padgett (2002). The target-centric theory differs considerably: the target seeks whatever it needs to become a fully contrastive segment in the language, and since there is no “spreading”, there is no constraint on constituent-based spreading.

Before proceeding, I would like to offer a few remarks on the role of feature geometry within phonological theory, under the shift of emphasis onto target-centric models of harmony. There is nothing inherent in a target-centric model of harmony that precludes the continued development of feature-geometry as a theory of the internal organization of segments, and as a theory of which features constitute subdistinctions among which others. The only point objected to here is that feature-geometry does not provide a correctly restrictive theory of which features may occur together in harmonic valuation from one segment to another, and that a shift in emphasis on to which features are *needed* by the target in a newly-added morpheme is likely to provide a better understanding of which features occur together in harmonic valuation. However, feature-geometry continues to be an insightful exploration of the internal structure of segments with respect to the articulatory organization of speech sounds, and the results of Sagey (1986) and Padgett (1991), with respect to the internal organization of contour segments and complex segments such as affricates, prenasalized stops, and labiovelars, continue to be the most restrictive models of possible segments of these sort. There is no need to throw out all of feature geometry as a theory of *possible segments* just because it is not a good theory of possible harmony patterns. Insightful work within the feature-geometry program continues to emerge; Levi (2004) is a recent example of

how investigating the Dorsal subcomponent of glides allows for an insightful understanding of the behavior of glides in syllabification, “sonority reversals”, and unexpected alternations such as the *y/g* alternation in Fula consonant gradation.

Nonetheless, within the theory of harmony, arguments for the target-centric view become even more compelling when the *sources* of valuation for an affix vowel are distributed across *two different segments*. These are the subject of the next subsection.

1.4.1. Turkish: Valuation from Multiple Sources

The first case to be discussed is in Turkish in which “vowel harmony” (so-called because it *usually* involves only vowels) is intercepted by consonants, which influence harmonic alternations in the suffixes. In particular, the three consonants with palatalized versions in Turkish involve themselves in harmony. Put slightly differently: the three consonants with palatalization *used to yield lexically contrastive sounds* in Turkish involve themselves in harmony.

Clements and Sezer (1982) provide a thorough study of vowel and consonant (dis)harmony in Turkish, which has the following 8-vowel system

(104) Vowel Inventory:

-back	+back	
i, ü	ı, u	[-low]
e, ö	a o	[+low]

Note that the Turkish vowel system is thus an exemplar for the use of binary features; [\pm low] [\pm round] and [\pm back] cross-classify the entire system.

Turkish has [back] and [round] harmony. An initial formulation is that all suffixes copy [back] from the immediately preceding vowel, and that, in addition, all [-low] suffix vowels copy [round] from the immediately preceding vowel.

(105) “Well Behaved” Turkish Vowel Harmony

stem	ACC.SG	GEN.SG	NOM.PL	gloss
ip	ip-i	ip-in	ip-ler	rope
kiz	kiz-i	kiz-in	kiz-lar	girl
yüz	yüz-ü	yüz-ün	yüz-ler	face
pul	pul-u	pul-un	pul-lar	stamp
el	el-i	el-in	el-ler	hand
sap	sap-i	sap-in	sap-lar	stalk
köy	köy-ü	köy-ün	köy-ler	villa
son	son-u	son-un	son-lar	end

Thus, one formulation under a spreading-based account (not ultimately adopted here) might be:

- (106) The final root vowel:
- a. Spreads the non-terminal Color node to [-low] vowels, and
 - b. Spreads the terminal feature [back] to [+low] vowels

The question of which features are copied in Turkish, however, is far from the most interesting of concerns. The interaction of *consonants* in the vowel harmony of Turkish, as we will presently discuss, definitively weighs in favor of a subsegmental (as opposed to prosodically-defined) view of locality. In prosodically defined views of locality, e.g., Archangeli and Pulleyblank (1994), locality holds at the syllable-internal level of moraic positions (essentially, the syllable nucleus). The participation of *consonants* within the locality of harmony requires such a theory to be augmented in disjunctive ways, whereas in the current subsegmental relativization to contrastive values of [back], the participation of consonants in “vowel” harmony requires no additional statement about the locality of the process.

In the Turkish consonant inventory, k, g, l have [-back] counterparts (Clements & Sezer 1982: 233); thus, in $k \sim k^y$, $g \sim g^y$, $l \sim l^y$, the feature [back] is contrastive (and cannot be predicted allophonically):

- (107) Contrastive [back] in Turkish *k,g,l*:
- | | | | |
|------|-------------|---------------------|----------|
| bol | abundant | bol ^y | cocktail |
| kalp | counterfeit | kal ^y p | heart |
| kar | snow | k ^y ar | profit |
| gaz | gas | g ^y avur | infidel |

What is interesting is that these consonants, with contrastive [back] specification, “participate” in vowel harmony. *k,g,l* are contrastively [+back], and hence vowels added after them will find these consonants as the closest source, and copy [+back]. Thus, even in a word whose last vowel is [+back], if the last *segment* is contrastively [-back], then the suffixal alternant will be [-back]. Conversely, in a word whose last vowel is [-back], where we would expect the suffix vowel to be [-back], if an intervening consonant is contrastively [+back], this consonant will determine the harmonic alternant instead³⁷:

- (108) Effects of (Non-)Palatalized Liquid on Harmony of Following Vowels
(Clements and Sezer, 1982; Levi, 2004)

usul ^y	usul ^y -ü	system-acc.sg
petrol ^y	petrol ^y -ü	petrol-acc.sg
sual ^y	sual ^y -i	question-acc.sg
okul	okul-u	school-acc.sg
karakol	karakol-u	police station-acc.sg
tʃatal	tʃatal-i	fork-acc.sg
petrol ^y	petrol ^y -de	petrol-loc.sg
meʃgul ^y	meʃgul ^y -düm	busy-past-1.sg

Importantly, we can see in the last two examples of (108) that the vowel undergoing valuation and the palatalized liquid need not be strictly adjacent for [-back]

³⁷Examples shown involve only the palatalized liquid. Similar effects may be observed with the [+back] velar, that yields [+back] suffix vowels in an otherwise [-back] harmonic sequence:

ʃevk	ʃevki	desire
ha:l ^y ik	ha:l ^y iki	creator

valuation to “unexpectedly” occur.

What is most challenging theoretically about the examples in (108) is the fact that both [back] and [round] harmony are operative in high-vowelled suffixes. In a form such as meʃgulʲ-düm, therefore, the *ü* of the suffix receives its [+round] value from the preceding root vowel *u*, while it receives its [-back] value from the preceding root consonant *ʃ*. The Spreading rule, therefore, as formulated in (106) fails, because the constituent-based spreading of Color is blocked by an intervener which itself spreads [-back].

The intuition to be captured in these Turkish cases is that there are *two sources* of valuation for the underspecified affix in meʃgulʲ-düm. However, rather than writing (or positing) two distinct Spreading rules, one spreading [back] from vowels, and one spreading [back] from contrastively palatalized consonants, the Turkish affixal alternations may be governed by a single statement:

- (109) Immediately upon affixation of a [-low] suffix, copy the values of [round] and [back] from the *closest* contrastive source

Clearly, in meʃgulʲ-düm, the *ʃ* is a closer potential source for [back] valuation than the preceding *u*. Hence, in the leftward search for a valuation source, once *ʃ* is encountered, [-back] is copied to the suffix, and the search for [back] is terminated. However, the search for [round] continues, until *u* is encountered. This is schematized in (110):

- (110) meʃgulʲ-dIm (Suffix needs: [round], [back])
Search initiated:
meʃgulʲ-dIm (Source for contrastive [back] found)
meʃgulʲ-dIm (Suffix needs: [round])
Search continued:
meʃgulʲ-dIm (Source for contrastive [round] found)
meʃgulʲ-düm

We now begin to see an argument for VALUE-CLOSEST: when inflectional suffixes are added in Turkish, they take their specification for [back] from, indeed, the **closest** source of valuation, which is, in these cases, a consonant!

These facts are, no doubt, expressible in a traditional Spreading theory: there could be both the normal vowel harmony rule of spreading [back] rightwards from vowels, plus another rule of spreading [back] rightwards from contrastive consonants. This would be redundant, and miss the generalization that is simply captured in VALUE-CLOSEST.

A comparison with Segmental Formulations

Consider how the Turkish consonant-interception phenomenon would be handled in a segmental theory, without any notion of relativization of visibility. In such a theory, the interveners must be explicitly mentioned within the structural description:

(111) [-cons] → [α back] / [-cons, αback] (C₀) -

This formulation of vowel harmony means that any number of consonants may intervene. However, we have just seen that this is not the case; k/kʷ, g/gʷ, l/lʷ may not intervene:

(112) [-cons] → [α back] / [-cons, α back] ([+cons, -lateral, -velar]₀) -

Moreover, we must encode the fact that these consonants spread backness as well. This can only be collapsed into the same rule by using {}-bracket disjunction:

(113) [-cons] → [α back] / { [-cons, α back] XOR [+cons, +velar, α back] XOR [+cons, +lateral, α back] } ([+cons, -lateral, -velar]₀) -

The problem with (113) is that it must mention both the set of consonants that may potentially provide a source for [back] copying, and the complement class of such consonants (since the complement class can indeed intervene, cf. meʃgulʷ-

düm³⁸. One of the major advantages of the intervener-based approach to locality developed here is that, given the correct relativization of search, interveners *never* need to be explicitly mentioned in the formulation of a structural description³⁹.

Turning briefly to autosegmental formulations, in Clements and Sezer (1982) (one of the original data sources), the behavior of “consonant-induced vowel harmony” is represented as follows. The [-back] instance of *l^y* is designated as 1) a P-bearing unit (meaning, a site to which an autosegment of type P can associate, 2) opaque and 3) underlyingly associated with the autosegment [-back]. However, there is no explicit connection between the fact that *l^y* is *contrastive* for [-back] and the fact that it is designated as opaque. That is, there is nothing in Clements & Sezer’s typology of P-bearing units that would rule out the following inventory (or indeed, its opposite):

- (114) All contrastively [back] vowels: transparent
All contrastively [back] consonants (or liquids): opaque

In the intervener-based account developed here, there is a direct source for the diacritic “opaque”: being the closest potential source within the search domain (as we have illustrated all along). Opaque only makes sense in a source-centric theory, where the imperative to spread has been blocked. From the target’s perspective, however, nothing is “blocked”; the closest determinant is simply what is chosen within the parametric options of value-relativization. The window of “scansion” includes only the first and closest item within the search domain. “Blocking”, by its very nature, implies that there are two elements that such a model must recognize: the blocker and the blockee. But there simply is no blockee in the current theory; in a sense, *all* non-closest items in the domain are “blockees”, if one likes, because

³⁸This problem is not unique to Turkish, however. Kenstowicz and Kisseberth (1977, chap.5) illustrate that rule application of this sort in Yawelmani, based on infinite schemata, must place *undergoers* of harmony within parenthesis-notation.

³⁹Note that the Relevancy condition of Jensen (1974) does not achieve this result, as it is only allows omission of explicit mention of interveners when trigger and target share major class features (such as [+cons]), which is not the case for Turkish CV-interaction. The Minimum Distance Constraint of Battistella (1982), similar in spirit to the “closest potential determinant” logic developed here, would attain the correct result.

none of them are ever considered once the first is encountered. Inclusion within the search domain (i.e., being designated among the class of P-bearing units to begin with) is not a matter of arbitrary membership within an extensionally-defined set⁴⁰; rather, an intensional characterization of the domain is provided by relativization to certain feature-values, in this case, all and only the contrastive ones.

Thus, there is a large class of harmony patterns that are excluded from the learner's hypothesis space in the current model: harmony systems in which an affixal vowel agrees in value with the closest *noncontrastive* value of a feature:

(115) (Excluded) Hypothetical Harmony Pattern:

- a. Contrastively [back] consonants: m/m', t/t', l/l'
 Noncontrastively [+back] consonants: g, d
 Noncontrastively [-back] consonants: k',n'
 Contrastively [back] vowels: all
- b. *jedil'-u*
 metk'öm-ü
 n'ömomumu-tü

Such a system, however, is easy to generate if the noncontrastive segments are lexically associated with the corresponding values of autosegments and "designated" within the class of opaque P-bearing units. Moreover, the prediction of the feature-relativized account here is that if a new segment was added to the inventory, it would behave accordingly based on whether its value was contrastive within the inventory or not. Thus, many of the corollary predictions of are falsifiable. For example, in a system with a unique (i.e. unpaired) short vowel or a unique nasalized vowel (i.e. Mohawk) the prediction of (115-a) is that if the search is relativized to contrastive values, these vowels will not participate in harmony. Set-based groupings of "like-behaving" segments (i.e. those that represent natural classes as atoms in a set, without feature-based inclusion, such as Flemming

⁴⁰As is the case in Odden (1980); Clements and Sezer (1982); Hulst and Smith (1986) and, on Hungarian, Steriade (1987, p.347), as representative examples throughout frameworks.

(2004)) fail to explain how newly introduced segments would be added to such sets, except based on “analogy” (which, when formalized, merits to adopting features anyway, as sub-atomic units of similarity). Segmental formulations thus miss the shared subsegmental character of harmony participants.

We concluded this subsection by showing the surprising consequences of multiple-source valuation, where the two potential sources come from distinct classes of segments. Relativization of search to contrastive values of the harmonic feature, coupled with the closest-based locality principle, allow for modeling of this process that is much more straightforward than theories without relativization.

1.4.2. Barra Gaelic Epenthesis

We have just considered the participation of contrastive [back] consonants in vowel harmony to illustrate multiple-source valuation. In some configurations in which multiple sources value multiple features, the set of outcomes is even more restricted than we might expect, and provide an argument for an ordered derivation of the feature-valuing steps. We consider next Barra Gaelic, in which a scenario quite similar to that of Turkish obtains: palatalized consonants “intercept” featural valuation that is otherwise entirely determined by a vocalic source. In Barra, as discussed by Sagey (1987), the problem of “non-constituent” copying poses a problem for almost every theory of feature geometry (i.e. whether it groups [back] with [round] to the exclusion of [high] and [low], or vice versa). The reason is this: usually, Barra epenthesis results in a full copy of *all* vocalic features of the preceding vowel (which, on a spreading view, involves transfer of full constituents). However, when a consonant with contrastive [back] intervenes, what is actually copied from the vowel must be characterized as a “deficient” constituent: all features *except* [back].

A distinguishing feature of the consonantal inventory in Barra is that ***all* consonants in the inventory are contrastive for [back] except Labials and /n/**. The vowel system of Barra is as follows:

(116) Barra Vowel system:

-back +back

i i,u

e ʌ,o

æ a,ɔ

It is important to note here that, while Barra Gaelic distinguishes contrastive [back] extensively among the consonants, it lacks front rounded vowels such as *ii*. This will become extremely important later. Nonetheless, [round] is contrastive for /u/, as it distinguishes /u/ from /i/, and hence [round] will be copied to an epenthetic vowel from /u/, as we will presently observe.

The process that creates a vowel in need of featural values is sonority-driven epenthesis. Barra Gaelic exhibits the phenomenon of leftward *multiple-source valuation* for epenthetic vowels that arise in order to break up sonorant+consonant clusters.

(117)	Underlying form	Surface form	Gloss
a.	tʲimxʲal	tʲimixʲal	round about
b.	æmsʲirʲ	æmæ sʲirʲ	time
c.	alpə	alapə	Scotland
d.	sʲærv	sʲærav	bitter
e.	urpel	urupel	tail
f.	ɔrm	ɔrɔm	on me
g.	færk	færak	anger
h.	mʌrʲv	mʌrʲev	the dead
i.	bulʲkʲ	bulʲikʲ	bellows (gen.sg.)
j.	merʲkʲ	merʲekʲ	rust

As can be seen in (117-a-b), when the intervening consonant between the epenthetic

vowel and the preceding vowel is noncontrastive for the feature [back], a full copy of the vowel results, as all vocalic features are copied, furnishing the epenthetic timing slot with values that yield an identical vowel. In (117-c-f), the intervening consonant has the same [back] value as the preceding vowel. Hence, the epenthetic vowel is surface-identical to the preceding vowel, even though, on the account developed here, its [back] value is furnished by the consonant. This divergence in valuation sources is most apparent in (117-g-j), in which the epenthetic vowel and the preceding vowel are identical for all features *except* back. The intervening consonant bears a different value for [back] than the preceding vowel, and since the consonant is a *closer* valuation source, it is encountered immediately in the leftward search⁴¹.

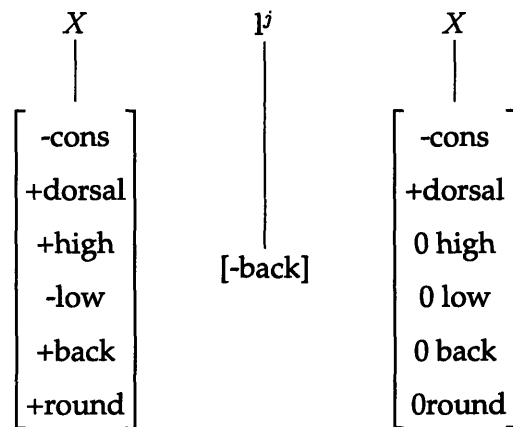
The steps involved are the same as those outlined above for Turkish me[ɟul^y-düm, except there are more features to be valued. In Barra, a vowel must bear specifications for [back], [round], [high], and [low], in order to be lexically distinct. On the view that the epenthesis process furnishes only a timing slot with the feature [-consonantal], the vowel must conduct a dynamic search in order to find values for its four vocalic features.

However, illustration of one representative case, bu^lik^j, reveals an important aspect of the computation: that the closest source is immediately copied from, *without look-ahead*. Recall that the inventory lacks front rounded vowels, such as /ü/. As in the Turkish example immediately discussed above, the epenthetic vowel copies [back] from a preceding consonant, and the remainder of its feature-values from a preceding vowel. Consider bu^lik^j: if there *were* full vowel copy, we would expect an *u* in the second syllable. Let us examine, however, how the directional

⁴¹Thus far, we have considered the valuation behavior of affixes, which copy the closest source. For suffixes, this will be obviously to the left, since there is nothing to the right. For prefixes, this will be to the right, since there is nothing to the left. In the case of epenthesis, however, it looks like the direction of search must be stipulated. However, one possibility within the derivational character of the current model is that in the case of sonority-driven epenthesis, given an iterative left-to-right syllabification algorithm, the closest source of visible valuation will be leftwards. A review of the handful of cases in Kawahara (2003) reveals that Kolami copy-epenthesis is from the left, whereas Winnebago and Fula loanwords resulting from word-initial onset-liquid clusters copy from the right. In short, these data are consistent with the possibility that leftward copying is a universal default, except when there is nothing to the left.

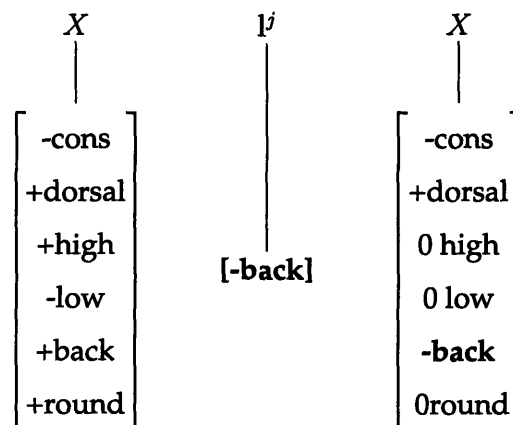
search proceeds. Barra vowels require full specification for [high], [low], [round], and [back]. However, as mentioned, the feature combination [-back,+round] is banned from the inventory; we may understand this either in terms of an inviolable constraint, or an implicational statement: [-back] → [-round]. For concreteness of illustration, I will adopt the latter (though its implementation is a secondary-level assumption). Consider now the steps involved in valuation of the epenthetic vowel:

(118) Valuation of epenthetic vowel in bulⁱikⁱ, Step 1:



←

(119) Valuation of epenthetic vowel in bulⁱikⁱ, [-back] Copying:



(120) Persistent Application of [-back] → [-round]:

sis, and a highly-ranked DEP would require that all features on the epenthetic vowel be copied, rather than inserted. Moreover, we might suppose that copying of features contravenes a low-ranked INTEGRITY constraint, which penalizes a segment that shares its features with another. In addition, we might suppose that constraints such as CORRESPOND-WITH-CLOSEST and CORRESPOND-WITH-CONTRASTIVE guarantee that the potential sources of copying are the palatalized liquid and the preceding vowel. However, these constraints alone will not choose between the attested and unattested output. What is required is a statement to the effect that the first closest contrastive value that is copied is etched in stone, and must be kept, regardless of what might ultimately lead to a better choice from a “global” perspective. Even though in some possible grammars, copying all features from the *same* source might lead to less violations of INTEGRITY (or, intuitively, a less polygamous set of correspondence relationships), this never seems to happen. Regardless of its ultimate implementation in terms of rules or constraints, it seems that all research into multiple-source harmony must reckon with the fact that valuation is a “greedy” operation, and will copy the first value that it can, and that this seems to be an irrevocable fact about the way the computation works.

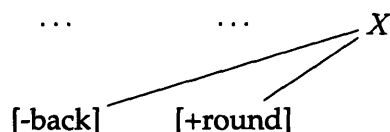
In the *valuation* model developed here, this search is initiated *by the target*, and upon each match with a contrastive source for the feature in question, valuation occurs. Thus, when a contrastively (non)-palatalized consonant is the first segment to the left of the epenthetic vowel, the vowel will copy its value for [back], and proceed to conduct the search for the remaining unvalued features.

1.4.3. A Comparison with Spreading-Based Formulations

Importantly, in the cases where a consonant determines the specification for [back], what is spreading from the previous vowel is [high], [low], and [round], and these are **not** a constituent. In a spreading-based theory, one must resort to two distinct [-back] spreading rules (as Halle (1995) does): one from vowels, and one from consonants, with the latter blocking the effects of the former (and essentially resulting in a “violated” preference for full transfer from the vowel). The VALUE-CLOSEST

operation is framed in different terms: it is not the case that two potential triggers of assimilation must “fight it out”, rather, the target has a set of needs, and seeks the quickest satisfaction of them in a dynamic search. However, even with Line-Crossing dictating the preference for operation of the closer spreading rule, the “*bul^huk^h problem” remains. Suppose that [+round] spreads from the vowel, and [-back] spreads from the consonant. The result can be ruled out by a filter:

(122) Autosegmental filter on [-back,+round] illicit structure:



But there are two possible delinking rules that could resolve this structure: delinking [round] *or* delinking [back]. Importantly, only the rule delinking [round] is chosen as a repair operation on this filter. However, there is nothing in its structural description that would lead us to expect its preference. What is being missed is that, in the case of conflicting feature specifications as the result of subsegmental “sharing”, the closer one always wins out.

1.5. Woleaian Bidirectional Search

We have just observed a class of cases that are insightfully modeled in a target-centric search. In this section, we will turn to a case of assimilation that is also readily stated in the target-centric view of dynamic search for valuation sources, but is extremely cumbersome to state in an imperative-to-spread theory. The data source is Howard (1972), who discusses the Woleaian height harmony rule based on Sohn (1971)⁴².

The valuation operation is a dynamic search, guided by considerations providing full lexical content for an underspecified affix. All cases we have considered thus far are either cyclic-affixes, in which case the directionality of search is pre-

⁴²I have not been able to get a hold of Sohn’s article (“a-raising in Woleaian”, Working Papers in Linguistics 3.8:15-36. Department of Linguistics, University of Hawaii.) , but I have obtained his grammar of Woleaian (Sohn, 1975), which confirms the phenomenon.

dictable, or epenthetic. The prediction of the VALUE-CLOSEST account is that when a target vowel is **equidistant** from two vowels, the **closest** source is **both** of them, and hence successful valuation may only occur when both bear the needed feature.

Woleaian has the following vowel inventory:

- (123) i(:) ü(:) u(:)
 e(:) ö(:) o(:)
 a(:) ɔ:

In Woleaian, there is a formative between the verbal stem and the agreement suffixes that varies between /a/ and /e/. The conditions on the distribution of /e/ are as follows: it occurs when both adjacent vowels are [+high]. We may suppose that this vowel is a “theme vowel” of sorts: a morphological formative that is cyclically introduced at the same time as the spell-out of the following agreement affix, and specified only for [-round, -high]. In its dynamic search for [low] valuation, which is determined by the closest valuation source, it turns out that *both* flanking vowels are equidistant. Thus, only when both of them are [-low] will /a/ be raised to /e/:

- (124) Woleaian /a/-raising: when both adjacent vowels are [+high]
- | UR | SR | gloss |
|-------------|---------------------|-------------------------------|
| ülüm | ü:l | drinking object (indp't form) |
| ülüm-a-ji | ülümej | 1st.sg |
| úlüm-a-mu | ülümem ^w | 2nd.sg |
| ülüm-a-la | ülümal | 3rd.sg |
| ülüm-a-ca | ülümaf | 1st-incl.pl |
| ülüm-a-mii | ülümemi | 2nd.pl |
| ülüm-a-jire | ülüme:r | 3rd.pl |

Importantly, the determinants for this process may be *deleted on the surface*, as may be seen in, for example, the 1st.sg form in (124). Thus, the “two-sided” nature

of the determining environment cannot be attributed to surface coarticulation⁴³. Moreover, as shown in the following examples, a high vowel on the right is not sufficient to trigger raising.

(125)	UR	SR	
	mata-ji	metaj	eye, 1.sg
	mata-mu	metam ^w	eye, 2.sg
	mata-mii	metami	eye, 2.pl
	mata-la	metal	eye, 3.sg
	mata-ca	metaf	eye, 1pl.incl

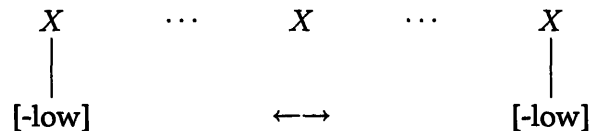
The raising rule may be formalized as follows:

- (126) Woleaian raising rule: the stem formative is [-high] and can be valued for [-low] if **both** closest segments bear [-low]:

Structural Description: $V_{[-low]} \cdots V_{[target]} \cdots V_{[-low]}$

Structural Change: V_{target} becomes [-low]

- (127) Woleaian bidirectional search:



In a spreading theory, there would need to be two rules⁴⁴; one spreading [-low] Left, and one spreading [-low] Right, and the additional condition that *each could only apply if the other did!* VALUE-CLOSEST, on the other hand, provides an effective

⁴³Donca Steriade has suggested that the deleted vowel leaves a surface remnant, which is sufficient to trigger raising. This may be plausible for the 1st.pl form if we assume that the deleted high vowel has coalesced with the palatal stop *j*, that the deleted high vowel in the 2nd.sg form retains its [+high] feature in the secondary articulation on *m^w* (though few representations require [+high] for rounded consonants), and that the deleted high vowel fuses with the raised vowel in the 3rd.pl. However, notice that this alternative posits three unrelated mechanisms to ensure that [+high] remains in the surface representation, while the current analysis unites these phenomena in terms of the underlying featural status of the deleted vowel.

⁴⁴A "non-directional" or mirror-image rule would not be sufficient here, as one would still have to state that its structural description must be met in *two* environments, and that one alone is not sufficient.

way to model *multiple-source valuation* of this sort without any additional stipulations about resolving the application of two-sided spreading rules.

1.5.1. A discussion of metrical/headed-constituent approaches to harmony

The Woleaian data from the last section are instructive in theory-comparison, particularly when considering suprasegmental models of vowel harmony. In considering Woleaian in particular, it seems that the results of relativized locality are not effectively duplicated by relying on metrical constituency. A number of researchers have experimented with using the formalism of the metrical grid in order to provide a mechanism for harmony (Steriade (1979); Halle and Vergnaud (1981), and more recently, Harrison and Raimy (2004)). The metrical grid, as pioneered by Liberman (1975) and refined most radically by Idsardi (1992), defines a notion of *projection*, which allows *grouping relations* to take place among certain elements.

This notion of projection is extremely useful for the construction of metrical feet, and allows for a formal characterization of parametric weight-sensitivity: in some languages, coda consonants or heavy syllables may project onto a tier of representation, allowing the constituent-building operation to include them, but not, for example, onset consonants. We might consider, therefore, the application of grouping domains and head-driven asymmetries in the modelling of harmony.

It is important to point out that the notion of projection does not differ at all, really, from relativization in the sense defined here. But what is rather different about metrical grids is that they define two additional operations: *grouping* (or constituent-building/footing) and *prominence-marking* (or head-projection). As I hope to illustrate, these latter operations are not natural ways of describing harmony or dissimilation. In particular, while it may be obvious enough to state assimilation rules on metrical constituents (i.e., “spread the harmonic feature from the head of the constituent to all dependents in the constituent”), it is really not obvious how dissimilation rules are to be stated. One possibility, of course, is something like: “change the value of all dependents in the constituent to the opposite of that of the head of the constituent”. However, in this case, it is not clear

what using the metrical grid has added. Anderson (1982) offers sage remarks to this effect:

“While one can, of course, construct a metrical ‘tree’ consisting exactly of the vowels of the word, and then perform the dissimilation on the elements of the tree, the fact remains that the rule in question in no way involves a manipulation of metrical structure *per se*: the change remains to be stated after the tree is constructed.” (p.5)

“Once an adequate set of criteria for defining the notion of ‘possible projection relative to a given rule’ is found, there is no reason to believe that it cannot be directly incorporated into the theory of GV [garden variety] rules (as well as others), and thus this theoretical issue does not (so far as we have reason to believe) distinguish metrical and autosegmental facts from others” (p.9)

In addition to the lack of insight provided by prominence-based grouping for dissimilation, the other essential property of metrical grids that makes them ill-suited to the description of (dis)harmony is the very fact that they are *headed* constituents, with the possibility for only one head. As seen above with Woleaian bideterminant *a*-dissimilation, we will observe that this dissimilation rule requires determinants on both sides of the target. Thus, not only would a ternary foot be needed, but a bi-headed one, and this is explicitly excluded in the formalism of metrical grid theory (taking Idsardi (1992) as a representative example):

(128) Metrical Approach to Woleaian Bidirectional Raising:

“All non-heads must bear the same value of [low] as the head(s)”:

* *

(* * *)

[-low] a [-low]

There is no existing theory of metrical grid construction in which a single constituent has two heads, and adding this possibility to the theory for the purpose

of extending the utility of metrical grids to harmony only weakens the predictive power of the formalism for what it was originally intended for.

1.6. Parasitic Harmony and Defective Interveners

Having focuses on the target-centric property of search, and the relativization of the search domain, we may direct our scrutiny towards the *Closest* property of search. At the risk of sounding repetitive, I will mention again the defining characteristic of the current theory: *Once the domain of search is identified, search stops with the closest element within that domain*; this is non-negotiable and inviolable.

Suppose, however, that the domain is delimited in such that x,y,z are in it, and z is the rightmost in this domain, which is being searched by a :

(129) [... x ... y ... z ...] $\leftarrow a$

The search will terminate with z . However, suppose that z is “defective” in some way; i.e., that, although it is in the domain of search, and the rightmost element within that domain, it does not satisfy some additional condition C , and by virtue of not satisfying C , z is defective. What is most interesting about these configurations, then, is that both y and z bear the feature F that a needs, but, by dint of failing to meet C , not only does z become excluded as a source for a value, but z also prevents y (which does meet C) from being a source as well. To give a simple example: suppose that a language has [voice] harmony on obstruents in the affix *-ta*, and that the affix will agree in voicing with the closest obstruent⁴⁵. However, suppose that there is the additional phenomenon that, if this obstruent is bilabial, then even if it is voiced, it will not provide a value in valuation.

(130) Hypothetical language:

a. *dotu-ta*

⁴⁵I will remind the reader that long-distance voicing agreement is attested in many languages, both within roots and in affixal alternations; see Odden (1994); Hannson (2001); Rose and Walker (2004) for discussion and references.

- b. togu-**da**
- c. demaki-**ta**
- d. nafaludu-**da**
- e. shodobo-**ta**
- f. chitabu-**ta**

If the *Closest* principle were violable, then we might expect a higher-ranked imperative to perhaps arbitrate, and yield different outcomes in (130-e,f). But, in the present theory, a hypothetical language such as (131), in which the affix skips an instance of [voice] in bilabials, is impossible:

(131) (Excluded) Hypothetical language:

- a. dotu-**ta**
- b. togu-**da**
- c. demaki-**ta**
- d. nafaludu-**da**
- e. shodobo-**da**
- f. chitabu-**ta**

It is important to point out that, although the present theory admits relativization of the search domain, *this relativization is for values of the harmonic feature only*. That is, a statement such as “voice harmony is relativized to voiced non-labials” is impossible in the present theory. The only possibility is relativizing [voice] harmony to all, contrastive, or asymmetric values of [voice].

However, once *Closest* becomes violable, languages such as (131) are easy to generate, and perhaps expected. For example, suppose agreement in voicing is required among all *Corresponding* segments⁴⁶, and that there were four constraints: CORRESPOND-CLOSEST and the similarity-based scale CORRESPOND-ALVEOLARS

⁴⁶This is presented in the parlance of Rose and Walker (2004), because their account is one in which segmental similarity is a prime determinant of long-distance locality, but in fact the point holds for any family of surface-based long-distance AGREE constraints.

>> CORRESPOND-LINGUALS >> CORRESPOND-OBSTRUENTS, where Lingual is a class grouping dorsals and alveolars. Consider ranking CORRESPOND-CLOSEST above CORRESPOND OBSTRUENTS within this scale⁴⁷.

- (132) CORRESPOND-ALVEOLARS >> CORRESPOND-LINGUAL >> CORRESPOND-CLOSEST >> CORRESPOND-OBSTRUENTS
- a. demak_Ci-t_{Ca}, *d_Cemaki-t_{Ca}: CORRESPOND-LINGUAL >> CORRESPOND-CLOSEST
 - b. shod_Cobo-da, *shodob_Co-d_{Ca}: textscCorrespond-Alveolars >> CORRESPOND-CLOSEST >> CORRESPOND-OBSTRUENTS
 - c. chit_Cabu-ta, *chitab_Cu-d_{Ca}: textscCorrespond-Alveolars >> CORRESPOND-CLOSEST >> CORRESPOND-OBSTRUENTS

The ranking in (132) allows Closeness to be violated when the closest potential correspondent does not meet some condition C (in this case, being [+lingual]) and a further-away correspondent does satisfy C. However, in the present theory, no such interaction is possible: *once the domain of search is identified, search stops with the closest element within that domain*, and if the closest element should fail to meet some precondition, then the search terminates in failure: no value will be copied.

- (133) A *Defective Intervener* is a determinant that is encountered in the search for a valuation source, that, due to failing to meet a precondition C on valuation sources, causes the search for valuation sources to terminate in failure. (This precondition will be denoted by an exclamation point: ...!C indicates a search for the closest source, but that if the closest does not satisfy the condition C, terminate in failure).

When the closest segment within the search domain is “defective”, then search terminates, and another rule or constraint, ordered disjunctively or ranked lower, which inserts the “default” or Elsewhere value, will have to step in, as described

⁴⁷We might also add DEP([-voice]) >> DEP([+voice]) to this hierarchy, such that if no correspondent is found within the search, the affix surfaces with voiceless *t*.

in Section 1.3.3. Thus, search-failure due to defective intervention enables default-insertion, as will be illustrated in concrete cases below. The condition C on sources of valuation in presently-investigated cases may be either a morphological condition or a featural condition.

Defective intervention is thus a consequence of the principle of *Closest*⁴⁸. A useful metaphor for defective intervention as due to the failure to meet a precondition can be found in Mailhot and Reiss (2004): if I tell you to find the first man with a parrot, and if it's red, bring back the parrot's name to me, that is very different from telling you to find the first man with a red parrot, and bring the parrot's name back to me. In the latter case, the search will be carried out until any red parrot is found. In the former case, however, the search will be carried out until a parrot is found. If that first parrot found happens not to be red, then the search terminates in failure. Defective intervention, then, is precisely the case in which, once a potential determinant is found, if it does not meet the precondition, the search terminates. This is to be distinguished from (dis)harmonic valuation without preconditions on the determinant, which simply search until the determinant that meets all predicates in the structural description is found⁴⁹. We turn to two cases in which a source precondition holds, that provide empirical justification for this important consequence of the present theory.

⁴⁸Indeed, it is suggestive that certain cases of defective intervention may obtain in syntactic agreement, where an intervener does not meet some precondition, resulting in termination of the search, and insertion of default values. For example, in Icelandic, there is a search for person and number features by the verb+tense complex, which is usually determined by the closest element. However, if that closest element is dative (i.e., failing to meet a precondition on being structurally-cased), then even if it is if has features to value the verb+tense, it will act as a defective intervener, failing to allow agreement either with it, or with a lower, structurally-cased argument. For discussion of relevant cases in Icelandic in terms of defective intervention, see Chomsky (2001); Boeckx (2000); Hiraiwa (2004).

⁴⁹Mailhot & Reiss provide an extremely useful computational formulation for this distinction: in the case of defective intervention, there are nested conditionals: "if a first parrot is found, then, if it's red, find out its name." On the other hand, in the case of persistent search for a determinant, there are conjoined conditionals: "if a red parrot is found, find out its name". A computational implementation of defective intervention as modeled in this dissertation will ultimately have to incorporate Mailhot & Reiss's formulation, or a similar equivalent thereof.

1.6.1. Jingulu

Pensalfini (2002) discusses the intriguing height harmony in Jingulu, a language of North-Central Australia. Jingulu has the three vowels *i,u,a*, which I will assume here are distinguished by the feature [\pm high], as well as [\pm round] and \pm back]. Vowel harmony affects both nominal and verbal words, and importantly, moves from affix-to-stem. One of Pensalfini's major discoveries in the article, however, is that there is a very restricted subclass of suffixes that can do this; in particular, only those suffixes that are first-merged with the root. Suffixes of this type induce copying of [+high] iteratively to the root, but importantly, a [+high] vowel in the root will block the copying process. That is, an underlying high vowel in the root will prevent any *preceding* vowels from raising.

(134) Jingulu [high] harmony (Pensalfini 2002:563). Raised vowels indicated in

boldface:

a.	/warlaku/	/-rni/	[warlakurni]
	dog	+f	'bitch'
b.	/ngamurla/	/-rni/	[ngamurlirni]
	big	+f	'big (fem.)
c.	/ankila/	/-rni/	[ankilirni]
	cross-cousin	+f	'female cross-cousin'
d.	/kunyarrba/	/-rni/	[kunyirrbirni]
	dog	+f	'bitch'
e.	/bardarba/	/-rni/	[birdirbirni]
	younger brother	+f	'younger sister'
f.	/mamambiyaka/	/-mi/	[mamambiyikimi]
	soft	+vegetable (a gender feature)	'soft (veg.)'
g.	/ngaja/	/-mindi-yi/	[ngijimindi-yi]
	see	1.dual.incl-fut.	'we will see'
h.	/ngarrabaja/	/-wurru-nu/	[ngirribijiwurrunu]
	tell	3pl-did	'they told'

The characterization of [high] harmony receives an initial formulation as follows. I will assume that [high] harmony may only apply in the first *phase* of phonological spell-out⁵⁰, in order to capture Pensalfini’s generalizations that 1) only suffixes spelled-out together with the root may trigger [high] harmony, and 2) no suffixes added after the first phase may trigger high harmony.

(135) Jingulu [high] harmony (applies from Left-to-Right, in *First Phase* only)

[To be revised]

Structural Description: $V_{\text{Root}_{\text{target}}} \cdots V_{\text{[+high]}}$

Structural Change: V_{target} becomes [+high]

The ... notation above indicates that the rule is unbounded in character; that is, a root with an arbitrary number of vowels could apply the rule to each one, regardless of its distance from the determinant. However, as we have mentioned, [+high] *root* vowels, although they have the value required of determinants, do not provide a source of [+high] copying. Moreover, not only do [+high] root vowels fail to provide a source of [+high] copying, they also *block* [+high] copying from any further potential determinants. [+high] root vowels thus constitute *defective interveners* in valuation. It is possible, of course, to analyze the Jingulu case as a derived environment restriction: the harmony rule can only be triggered by “derived contexts”, and two root-internal vowels do not constitute a derived context. But I will attempt here to assimilate this case of morphological defective intervention to the featural cases because the logic is the same, and because the mechanism of Closest that I employ here would hold even if Jingulu word-formation did not contain derivational stages.

Within the defective intervention rubric, in the Jingulu case, the precondition *C* on determinants is that they be suffixal vowels. Recall that the notation ...|*C* indicates that a valuation rule is subject to a precondition that may potentially lead to defective intervention. The revised version of Jingulu high harmony is as

⁵⁰See Marvin (2002) for a detailed discussion of the role of syntactic structure in a phase-based cyclic model, and how it determines the application of phonological processes.

follows:

(136) Jingulu [high] harmony (applies from Left-to-Right, in *First Phase* only)

[Final version]

Structural Description: $V_{\text{Root}_{\text{target}}} !\text{Non-Root} \cdots V_{[+\text{high}]}$

Structural Change: V_{target} becomes [+high]

It is important to emphasize that the formulation of defective intervention in the search for valuation finds close parallels in other cognitive domains. For example, Boeckx (2000); Anagnostopoulou (2003) explore many cases of dative-nominative constructions in which the following configuration holds:

(137) Agr ... Dat_{3rd.sing} ... Nom_{1st.pl}

(138) *Structural Description:* Agr_{target} ... [+Participant!] ... DP _{α pl}

Structural Change: Agr_{target} becomes [α pl]

Importantly, the intervening 3rd person argument *blocks* agreement between Agr, the target of valuation, and the Nominative, a potential source of variation. The reason is that the intervening 3rd person is within the search domain (bearing a set of ϕ -features), but nonetheless, does not meet a precondition that the source of valuation be 1st or 2nd person ([+Participant], in featural terms). The search for a valuation source thus terminates in failure.

1.6.2. Bantu “asymmetric” raising harmony

In the last section, we examined a case in which the source precondition was morphological. We turn to a case in which the source precondition is featural. This will turn out to constitute a type of defective intervention that covers the subclass of cases known as “parasitic harmony”.

(139) *Parasitic* harmony (Steriade, 1981; Cole and Trigo, 1988): harmony for a feature F between segments X and Y applies only if X and Y share the

same value for a feature G , $G \neq F$.

This is one of the more common Source Conditions that result in defective intervention. A often-researched example, conforming to (139) is the requirement in Yowlumne (Yawelmani) that [round] harmony only applies among same-height vowels. Thus Yowlumne has no “cross-height” harmony. Similar patterns are attested, with varying dimensions of restrictions and tolerances, throughout the Turkic languages (see Korn (1969); Kaun (1995) for an overview). It is a notable generalization about the literature that parasitic harmony only holds when the required shared feature (e.g., G in (139)) is height. We thus turn to a case where it is roundness, in order to show that the height-roundness parasitism can work in either direction: in Yowlumne, [round] harmony is dependent on [high], while in Kisa and other Bantu languages, [high] harmony is dependent on [round].

Hyman (1999) contains an extensive survey of vowel height harmony in the Bantu languages. An overwhelming number of them have what is called “asymmetric” raising harmony: the [-back] vowels lower when preceded by any [-high] vowels, but the [+back,+round] vowels lower only when preceded by [+round] vowels:

- (140) Kisa “asymmetric” lowering (Hyman 1999:238)
- | | | | | |
|----|-------------|--------------------|-------------|----------------|
| a. | -tsom-el-a | ‘pierce-appl.’ | -tsom-ol-a | ‘pull out’ |
| b. | -rek-el-a | ‘set-trap-appl.’ | -rek-ul-a | ‘spring trap’ |
| c. | -βis-il-a | ‘hide-appl.’ | -βis-ul-a | ‘reveal’ |
| d. | -fu:ng-il-a | ‘lock-appl.’ | -fu:ng-ul-a | ‘unlock’ |
| e. | -βa:mb-il-a | ‘spread-out-appl.’ | -βa:mb-ul-a | ‘spread apart’ |

As can be seen, /i/ lowers to /e/ after both o, e , but /u/ lowers to /o/ only after o . Hyman (1999) provides a convincing case that front height-harmony and back height harmony constitute two distinct processes, historically. We will treat them as two separate rules here:

- (141) Bantu contrastive [high] harmony:

- a. Front Height Harmony:
Structural Description: $V_{[\text{contrastive: } \alpha \text{ high}]} \cdots V_{\text{target}}$
Structural Change: V_{target} becomes $[\alpha \text{ high}]$
- b. Back Height Harmony, Source Precondition [+round]:
Structural Description: $V_{[\text{contrastive: } \alpha \text{ high}]} \cdots ![\text{+round}] V_{\text{target}}$
Structural Change: V_{target} becomes $[\alpha \text{ high}]$

Thus, Back Height Harmony is “parasitic” on [+round], which in the system here, means that there is a precondition on licit valuation sources encoded in the specification of the search domain. Intervening vowels that are the right height, but of a different roundness, yield a failed valuation-search, and no further-distance sources are considered.

Defective intervention is an empirical hypothesis about harmony systems, that can be modeled in any target-centric theory of locality. Even within differing representations of harmonic features (Kaye, Lowenstamm & Vergnaud 1985, Archangeli & Pulleyblank 1994, van der Hulst & van der Weijer 1995, Clements 2004) and of the formalization of the relation governing harmony (Mester 1988, Calabrese 1995, Krämer 2003, Rose & Walker 2004), the intuition that search terminates with the closest potential source remains as a useful generalization about phonological locality, one with parallels in other cognitive domains, and with the potential to be falsified.

1.7. Bounds on the Search Domain: Adjacency Parameters

Thus far, the valuation-search has been discussed in terms of relativization to a domain, which, following Calabrese (1995), is stated in terms of *value-types* for the harmonic feature. As we have seen, one of the most important settings of this parameter is visibility to only the contrastive values of a feature. Yet another is visibility only to an asymmetric value of the feature (which is in many cases the marked value of that feature in the language).

However, there are cases of search in which delimitation of the value-types in

the domain is not the only restriction imposed on the domain. Odden (1994) contains an important discussion of the fact that certain assimilation and dissimilation processes have “locality-bounds” that are not solely determined by relativization to a class of interveners: for example, Kikongo and Lamba have identical rules of nasal harmony, but the Lamba version may only occur if the trigger is in an adjacent syllable to the target (Ao, 1991; Odden, 1994; Piggott, 1996).

(142) Kikongo long-distance nasalization:

- a. sakid-ila ‘to congratulate for’
- b. ma-kin-unu ‘it was planted’
- c. wu-mant-unu ‘it was climbed’
- d. kudumuk-is-ina ‘to cause to jump for’
- e. mant-ina ‘to climb for’

(143) Lamba syllable-bounded nasalization:

- a. pat-ile ‘scolded-PERF’
- b. um-ine/*um-ile ‘dry-PERF’
- c. mas-ile/*mas-ine ‘plaster-PERF’

(144) a. Kikongo nasal harmony (search for marked [+nasal]):

Structural Description: $C_{[+nasal]} \dots \text{Sonorant}_{\text{target}}$

Structural Change: $\text{Sonorant}_{\text{target}}$ becomes [+nasal]

b. Lamba nasal harmony:

Structural Description: $C_{[+nasal]} \sigma$ -precedes $\text{Sonorant}_{\text{target}}$

Structural Change: $\text{Sonorant}_{\text{target}}$ becomes [+nasal]

Inspection of (144) reveals that the featural properties of determinant and focus are identical in both rules. Indeed, both languages have identical inventories in the relevant respects. Nonetheless, Bemba imposes a restriction that the search

for valuation may not look beyond one syllable⁵¹. As Yamada (1983) remarks, “In general, the problem of distance should be clearly distinguished from what may intervene in a phonological rule” (p.63). Thus, the fact, for example, that Karok *s*-Palatalization may apply across an intervening coda consonant but not across an intervening syllable is an additional, marked parameter that a rule may specify, independently of featural relativizations in the domain of search.

These sorts of restrictions on the length of the search are formally similar to the role played by “barriers” or “phase boundaries” in syntactic theory: even though valuation (or the establishment of a relation) may not have been found within a relativized domain *D*, and even though an appropriate valuation source may lie just beyond *D*, the search simply terminates at given points.

I take these “adjacency” parameters to be variables within the otherwise singly-principled mechanism of VALUE-CLOSEST. They are an additional way in which conditions on (dis)harmony may vary. Indeed, Suzuki (1998) has developed a theory similar to Odden’s for the adjacency parameters in dissimilation, concluding that dissimilation may vary in fundamentally similar ways. For example, in a tonal dissimilation process discussed by Suzuki, HH tonal sequences change to HL at an *unbounded* distance in Arusa, but only within *adjacent syllables* in Kihehe (Meussen’s Rule).

The inclusion of these adjacency parameters into the theory will play a major role in this dissertation in Chapter 4. The proposal there is that the very possibility of having a (dis)harmony rule set to one of many compatible adjacency-bounds is posited to lead to a structural ambiguity for certain forms. Thus, if there is a

⁵¹An interesting alternative to syllable-based adjacency between segmental participants is proposed by Piggott (1996), who views instead the harmony as occurring between *syllabic* participants. In fact, such a view could be adopted within the general framework here, subject to the following revisions: all discussion of valuation thus far has assumed that in a given morpheme, a certain segment will be featurally deficient and require a value for a given feature. One could easily imagine, however, that in some languages, the syllable was the basic unit of underspecification: that is, in some languages, an entire syllable would need a designation as [+nasal] or not, and this would require valuation for deficiently-specified morphemes. Technically, this solution would work, and would create an interesting flexibility in the nature of where underspecification of a given morpheme may reside. What is still not clear to me, however, is how the specification of an entire *syllable* as [+nasal] should guarantee that nasality to be realized only on a [+sonorant,+consonantal] segment within it.

harmony rule that is always observed to apply in adjacent syllables, and there is no observation of cases at which it fails to apply at greater distances, the observed process is compatible with many possible parameter settings. In the framework of the learning scenario postulated in Chapter 4, the space of grammars/policies generated by these adjacency parameters, when coupled with ambiguous input, forms the basis for variation in the adult grammar.

One brief illustration will be offered here, focusing on variation in Hungarian vowel harmony. Farkas and Beddor (1987) and Ringen and Kontra (1989) note that the rules of [back] harmony are straightforward for cases when the vowels *u, u:, o, o:, e, a* are in the syllable immediately preceding the affixal-target, and when these vowels are in the syllable that is two syllables away from the affixal-target, speakers consistently apply the regular rule for [back] harmony. However, they discovered that when these vowels are *three* syllables away from the affixal-target, and the non-contrastive vowels *i, e* intervene, speakers exhibit variation in their outputs. Thus, while *papi:r-nak* demonstrates a [+back] suffix when the source and target are separated by an intervening noncontrastive vowel, in the form *aszpirin*, speakers shows variation between *-nek* and *-nak*, with some speakers allowing both.

Let us consider possible representations of harmony policies that contain an adjacency parameter. If speakers consider all possible parametric-settings for adjacency when constructing the rule, then there is ambiguity in the interpretation of Hungarian [back] harmony. Upon observation of forms such as *aktiv-nak*, the speaker could either posit an *unbounded* search domain, or a search domain that contains all [-back] values, but is limited to only a two-syllable window. This latter domain-restriction amounts to *intervening-syllable-adjacency*: as, at most one transparent syllable may intervene between source and target. The four settings that I propose for the parameter are in (145); a formal description of search-delimitation is in (146).

(145) Adjacency Parameter (adj):

- a. Unbounded
 - b. Immediate-Adjacency
 - c. Syllable-Adjacency
 - d. Intervening Syllable Adjacency
- (146) In a Valuation Procedure for an Affixal Segment T needing a value for F:
- a. Consider a search domain D, extending {leftwards/rightwards/bidirectionally} from T, with a search-window of size adj that contains {all/contrastive/asymmetric} values of F.
 - b. Choose as a potential source S the closest item to T within D.
 - (i) If S does not meet any condition C that is imposed on potential sources, terminate in failure.
 Otherwise, copy the {identical/opposite} value of F on S to T.
 - c. If no segments are found in D, terminate in failure (allowing a disjunctively-ordered rule in the policy to apply).

Let us briefly discuss the values of the adjacency parameter in (145). The first is unbounded, and this accounts for many of the familiar cases of long-distance featural relations, such as sibilant harmony in Chumash and lateral dissimilation in Latin and Georgian. The second is immediate adjacency, and this accounts for cluster voicing assimilation, place assimilation, and other featural relations that occur between immediately-adjacent segments. The third value of is syllable-adjacency, which states that the domain of search is one syllable. What this means, more precisely, is that the search may look within the current syllable and in one syllable-further. For example, Davy and Nurse (1982), on Dahl's Law in Kikuyu, note that *k*-voicing may occur in *a.geo.ke.ra* 'and he got up', in which the source of [voice] (opposite) copying is in the adjacent syllable, but not in *a.ke.o.ki.nya* 'and he trod on them', in which the source is two syllables away. We have discussed a similar formulation in one dialect of Embu in 1.3.2, to which we return in Chapter 4. Let us note for the moment in our discussion of Kikuyu, that the prefixal velars are allowed rightward search for a [-voice] source of opposite valuation where $ADJ =$

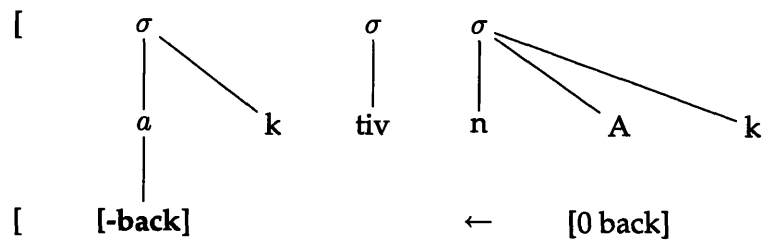
syllable-adjacency.

The final adjacency boundary is one that states that at most one syllable may intervene between the target and the source; in other words, that if the search encounters no source of valuation in the adjacent syllable, it may look one more syllable. This will be called *intervening-syllable-adjacency*. This is, as far as I am aware, a new proposal in the typology of adjacency parameters, and its evidence largely comes from the study of variation.

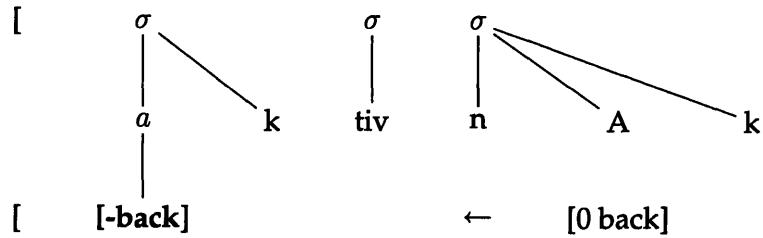
At this point it is worth briefly returning to the picture of the learning sequence that I have adopted in this thesis. Regarding the so-called “distance effect in Hungarian, we note that the vowel *i* is transparent to palatal harmony in Hungarian, due the fact that it is non-contrastive for [back]. Consider now the form *aktiv*, which according to Ringen and Kontra, took [+back] suffixes 100% of the time in their survey. In the vocabulary developed here, the output *aktiv-nak* is **ambiguous** between *intervening-syllable adjacency* and *unbounded adjacency*. The suggestion in Chapter 4 is that speakers cope with this ambiguity by maintaining *both* policies as compatible with the observed output. In fact, if we adopt a model of statistical reinforcement, as developed by Yang (2003), in which every compatible “policy” (or parameter-setting) is rewarded when it produces the correct parse, then both of these policies, differing only in their locality-bounding, will be high among the favorites.

As stated above, observation of *aktiv-nak* is thus compatible with the single-syllable or the unbounded parameter. If each of these is maintained in a separate policy, then when a *longer* distance between focus and potential source is encountered, variant suffixes will result, depending on whether the policy in terms of intervening syllable adjacency is chosen, or the one in terms of unbounded intervener size is chosen.

(147) Unbounded ADJ:

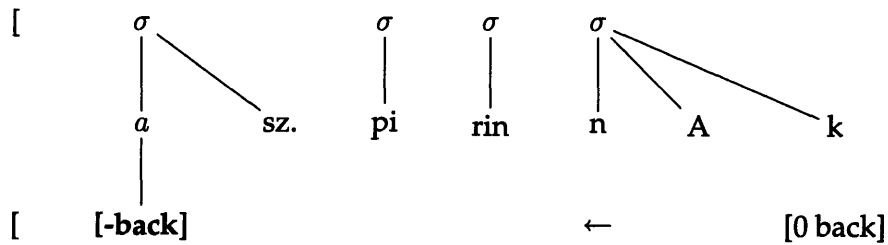


(148) Intervening-syllable ADJ:

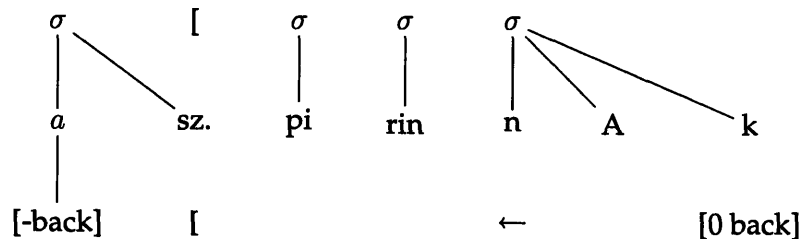


Let us now consider what happens for the input *aszpirin* (a loanword, the computation of whose output seems to give Hungarians a headache). According to Ringen and Kontra, it takes 58% [-back] suffixes, and for many speakers, both *aszpirin-nak* and *aszpirin-nek* are possible. On the model developed here, it is because the intervening-syllable-adjacency policy leads to a search that terminates in failure:

(149) Unbounded ADJ:



(150) Intervening-syllable ADJ:



Thus, on the unbounded setting of the parameter, search successfully finds [-back]

in the initial syllable, and it is copied, yielding *aszpirin-nak*. However, on the intervening-syllable-adjacency setting, no [-back] value is found within the domain, and search terminates in failure. The context-free [-] insertion rule in the policy may now apply, yielding *aszprin-nek*.

The structural property of Hungarian that leads to variation in *back+neutral+neutral* (BNN) words, then, is due to the fact that BN words are *ambiguous* between different parametric settings of locality restrictions. That is, the only “diet” of words that contain transparent vowels that learners encounter early on, and to a large part, throughout the lexicon, contains no more than one transparent vowel in a row. The resultant size-based ambiguity is a rampant fact about any parametrized theory of phonological rules. It is only on longer forms that these parametric options make different predictions, and that is precisely where we see variation emerge: on BNN words, *not* on BN words.

Before closing this section, let me offer the hope that further research may reveal other facts that we might expect to be correlated with this parametric difference in the size of the search domain. At present, such domain-size parameters seem to be a necessary additional point of variation in the delimitation of search domains, and generalizations about what types of features lend themselves to which settings of the parameter are, at best, forthcoming. The fact that a potential source-target relation may be halted not only by minimality considerations (i.e. the like-across-like principle), but also by an additional, extrinsically-imposed boundary on the search domain, raises interesting challenges for attempts at reduction of locality principles. I must note that parallel results keep arising in the study of syntax, despite many valiant attempts to the contrary. For example, it is a fact that A-movement out of a finite clause is impossible in English, so that sentences such as **John₁ seems that t₁ left* are ill-formed. The currently agreed-upon analysis for these is that movement of the embedded subject is moving “too far”: A-movement cannot cross a CP. Another instance of movement that is banned is *wh-* movement from within a subject: so that **Who₁ did [pictures of t₁] fall down from the wall?* is banned. Importantly, these types of movement are difficult to rule out on purely relativized

minimality considerations: in the A-movement cases, it does not seem to be the case that the CP boundary bears the relevant features that would make it a closer attractee⁵². In the *wh*-movement from subject islands example, it is certainly not the case that the containing DP contains *wh*- features that make it a closer intervener⁵³. Thus, it must be stated that the subject position constitutes an extrinsically-defined opaque domain for *wh*-movement, and that CPs constitute an extrinsically-defined opaque domain for A-movement⁵⁴ (whether by virtue of being barriers (Chomsky, 1986), phases (Chomsky, 2001) or spell-out domains (Uriagereka, 1999), and thus, that relativized-minimality alone cannot predict all locality conditions.

Thus, the fact remains that they represent the adjacency parameters extrinsically-delimited restrictions on the locality domain of a long-distance relation, and cannot (at least at present) be understood in terms of the familiar like-across-like rubric of intervener-based locality pursued in this thesis and throughout many studies of syntax. However, the values of the parameter are limited, and as I attempt to show in Chapter 4, the inclusion of adjacency-parameters in the model allows for a natural account of distance-based variation in (dis)harmony.

1.8. Conclusions: Impossible Policies and Search Conditions

This chapter has outlined the mechanisms involved in assimilation and dissimilation, by providing a model of the computational operations that form the elements of the structural descriptions and structural changes of (dis)harmony rules. In the next two chapters, the model, which is purely formal at this point, will be enriched, as it becomes apparent that two substantive properties of segmental inventories

⁵²Though see Abels (2004); McFadden (2004) for some discussion; these authors propose that certain phrasal categories (i.e. CPs) that act as barriers may in fact be doing so because they bear the relevant A-features, but that since they are CPs they constitute a kind of defective intervener.

⁵³We know this is the case because the same extraction is fine when the DP is in object position: *Who_i did you buy [pictures of t₁]?*; thus, it cannot be that the containing DP constitutes a defective intervener, it must be that the movement is illicit specifically when in subject position.

⁵⁴Williams (2003) contains a proposal to rule out the ban on A-movement from CPs due to principles of tree-construction involving simultaneous derivation of matrix and embedded clauses. In this approach, there is no need to explicitly state that CPs represent bounds on a search domain. However, it is fair to say that this model still instantiates the general point of this subsection: that relativized minimality alone is not enough to rule out certain locality violations, and other principles (i.e. of tree-construction and order-of-embedding) must play a role as well.

play crucial roles as determinants of harmony: contrastiveness and relative sonority. I would like to briefly conclude with a sample of what constitute impossible policies:

- (151)
- a. Valuation with only the *non*-contrastive values of a feature (**Excluded by Visibility Parameters**; see Chapter 2 for further discussion)
 - b. Valuation with the *furthest* value in the search domain (**Excluded by Closest Principle**)
 - c. Valuation by a vowel that is not within the feature-relativized domain, and is of *low-sonority* (**Excluded by Sonority Condition**; see Chapter 3 for further discussion)
 - d. Valuation with the second-closest source, when the intervening source is defective (**Excluded by Closest Principle**)
 - e. Valuation within a bounded window of *three* syllables away, but no further (**Excluded by Adjacency Parameters**; see Chapter 3 for further discussion)

Finally, I will note that the exclusions in (151) limit the hypothesis space greatly, in aid to the learner, but emphasize that they still leave open many hypotheses, some of which have intersection and redundancy. In Chapter 4, I argue that this is a benefit of the current model, as it allows for an explanation of variation in terms of *multiple compatible policies*. A model that was so restricted that it allowed only one way to describe some of the basic recurrent configurations of vowel harmony would not be amenable to an analysis of variation in these terms.

Finally, it is important to remind the reader that the development of the current model, and in particular the proposals leading to the corollary predictions of (151), does not show that “parametrized rules triumph over ranked constraints” or that “derivations are more insightful/correct than declarative statements” but rather that certain principles (i.e. target-centric *closest*, value-relativization, parametrized adjacency) are unavoidable generalizations about the grammar of harmony. However, it should be clear that due to the existence of non-surface true harmony (i.e.

Canadian French, Yoruba, Turkish, as discussed in Section 1), a theory of violable constraints will have to introduce stratal evaluation. Due to the existence of “non-conspiracies”, i.e. Wilson’s point discussed in Section 3, a constraint-oriented theory must introduce “dedicated repairs”. Due to the existence of inviolable closeness in Barra Gaelic *bul^jik* discussed in Section 4, and defective intervention, discussed in Section 6, a theory of constraint interaction must introduce the inviolable principle of (relativized) *Closest*. When all of these necessary components of a complete model of harmony are considered together, the result is a serially-evaluated (i.e. derivational) model of configurations with dedicated repairs (i.e. paired structural descriptions and structural changes) and certain inviolable constraints (i.e. Principles). It is a fact that the correct analysis of any particular fragment of a language may be stated in any number of ways. It has also not been definitively resolved how the variation between languages is best characterized in terms of the division of labor between lexical representations, on/off parameters and the ranking of language-specific priorities. Nonetheless, the consideration of the range of attested (*and non-attested*) input-output harmony mappings in this chapter has revealed that the grammar of harmony must include an abstract relativization of locality, an ordering of processes, an extremely restricted set of structural changes, and a core set of universal principles.

1.9. Appendix: The Elsewhere Condition

The Elsewhere Condition (Kiparsky, 1973) will be used extensively to determine the order of application in (dis)harmony systems, when the scenario arises that two structural descriptions are both met on the same determinant-focus pairings. In order to make a evaluation of the Elsewhere condition transparent, two disjunctively ordered rules in Finnish from Chapters 3-4, those of Back vowel harmony (BVH) and Vowel-Fronting (VF) will be converted into a different notation. In the following notation, the potential focus of a rule is introduced by the *lambda* oper-

ator⁵⁵ (λ), while the potential determining context of a rule is introduced by the \exists operator, and is identified in a (directional) search originating at the focus (in the method outlined by Howard (1972) with an advancing “pointer”). The rules are repeated in their earlier format in (152), and then converted into lambda-notation in (153).

- (152) a. *Rule H_{1A}: Back Vowel Harmony (BVH):*
 Structural Description: $V_{[+back]} \dots V_{\text{target}}$
 Structural Change: V_{target} becomes [+back]
- b. *Rule H_{1B}: Vowel Fronting (VF):*
 Structural Description: $V \dots V_{\text{target}}$
 Structural Change: V_{target} becomes [-back]
- (153) a. *Rule H_{1A}: Back Vowel Harmony (BVH):*
Structural Description:
 $\lambda x. \text{vowel}(x) \ \& \ \exists y, \text{vowel}(y) \ \& \ \text{back}(y) \ \& \ \text{transitively- precedes}(y,x)$
Structural Change: Set $\text{Val}(\text{back},x)$ equal to $\text{Val}(\text{back},y)$
- b. *Rule H_{1B}: Vowel Fronting (VF):*
Structural Description:
 $\lambda x. \text{vowel}(x) \ \& \ \exists y, \text{vowel}(y), \ \& \ \text{transitively- precedes}(y,x)$
Structural Change: x becomes: $\neg\text{back}(x)$

A few remarks are in order to clarify the notation. All of the predicates are boolean. Thus, the predicate $\text{vowel}(x)$ returns true if x is a vowel. The predicate $\text{transitively- precedes}(y, x)$ is true if y transitively precedes x (that is, y precedes x in the left to right sequence of segments, as determined by precedence relations among the timing slots). The predicate $\text{back}(x)$ is true if x is [+back], and the predicate $\neg\text{back}(x)$ is true if x is [-back]. Finally, $\text{Val}(\text{back}, x)$ is a function that returns the value that the segment x has for the binary feature [back]. A sample translation

⁵⁵Readers familiar with the lambda calculus will note that, strictly speaking, a structural change cannot occur within the scope of a lambda expression. The structural change of each rule, then, may be assumed to be implemented in a modified lambda-calculus that allows “side effects” / mutation, possibly through calling another function.

of (153-a) into conversational English would be as follows:

- (154) a. *Rule H_{1A}: Back Vowel Harmony (BVH):*
Structural Description:
 $\lambda x. \text{vowel}(x) \ \& \ \exists y, \text{vowel}(y) \ \& \ \text{back}(y) \ \& \ \text{transitively-precedes}(y,x)$
Structural Change: Set Val(back,x) equal to Val(back,y)
- b. *In Conversational English:* "Give me as a potential focus a segment x. If x is a vowel, and if there happens to be some potential determinant y, and if y is a vowel, and y is [+back], and y precedes x in the word, then I'll do the following: I'll change x's [back] value to be the same as y's [back] value"

The reader may wonder what the utility of this seemingly obscure notation is. The answer is that the Elsewhere condition may now be simply stated as follows:

- (155) Given rules R₁ and R₂,
- a. R₁ is disjunctively ordered before R₂ if the set of conjoined boolean predicates that form the structural description of R₂ are a subset of the set of conjoined boolean predicates that form the structural description of R₁.

An inspection of (154) will reveal that R₁ is disjunctively ordered before R₂ by this version of the Elsewhere condition, since the predicates that compose SD(R₁) are a superset of those that compose SD(R₂), differing only in the presence of the predicate back(y). To make this visually apparent, the two SDs will be repeated below, with the predicate distinguishing them indicated in boldface:

- (156) a. *Rule H_{1A}: Back Vowel Harmony (BVH):*
SD: $\lambda x. \text{vowel}(x) \ \& \ \exists y, \text{vowel}(y) \ \& \ \text{back}(y) \ \& \ \text{transitively-precedes}(y,x)$
- b. *Rule H_{1B}: Vowel Fronting (VF):*

$SD: \lambda x. \text{vowel}(x) \ \& \ \exists y, \text{vowel}(y), \ \& \ \text{transitively-precedes}(y,x)$

Rules that stand in this subset relation will be applied disjunctively: if the superset rule's structural description is met, the subset rule will not apply. Thus, in later chapters, where it will be remarked that certain pairs of rules posited by the learner will be evaluated and applied in an order dictated by the Elsewhere condition, the reader should keep in mind the implementation in this subsection, in terms of *sub-
sethood of conjoined predicates in the structural description* rather than other potential formulations.

Chapter 2

Parametrized Visibility Conditions

This chapter may be seen as an outgrowth in the steps towards constraints on possible assimilation and dissimilation rules that can be traced in the literature: from the formal constraints on rules of Howard (1972); Jensen (1974); Battistella (1982); Yamada (1983) to the representationally-based constraints on rules of Clements (1985); Sagey (1986); Steriade (1987); Calabrese (1988); McCarthy (1988); Odden (1994); Archangeli and Pulleyblank (1994). The goal of this chapter will be to show that “neutrality”, or transparency, in harmony, follows a very restricted range of variation, due to the activity of a single three-valued parameter.

The previous chapter developed the motivation for the operation of VALUE-CLOSEST, through which a morpheme with allomorphic alternants searches for a featural value to determine its form. The notion of *closest* is to be understood in terms of the *precedence* relation:

- (1) G is the closest goal to P if $\neg\exists H, H \neq P$, such that either:
- a. G precedes H and H precedes P
 - b. P precedes H and H precedes G

However, the study of (dis)harmony systems reveals that, while an important foundation for the determination of a featural source, (1) is too restrictive. What is important is being the closest source of a *relevant* type:

- (2) G is the relativized-closest goal to P if $\neg\exists H, H \neq P$, such that either:
- a. G precedes H and H precedes P
 - b. P precedes H and H precedes G
 - c. The domain of search includes both G and H

It is the last clause which is most important. This clause holds in situations in which the domain of search for a closest-valuator is restricted by the *value* of the feature.

The hypothesis of this chapter is that in addition to all-value and symmetric-value harmony, one of the most important restrictions / relativizations of search is to values of the feature in question [F] that are *contrastive* on that segment.

The idea that contrastiveness should play a role in the restriction of search domains for subsegmental rules has many antecedents in the literature. What all authors agree on is that certain features on certain segments are “invisible” for the purposes of computing the locality of an assimilation relation.

In Kiparsky (1981); Steriade (1987), for example, it is assumed that “predictable” or “redundant” features are simply *not present in the representation* at the point at which locality is computed. Steriade’s formulation can be exemplified by the example of the value of [voice] in sonorants: the inventory allows for true statement of the implication: [+sonorant] \rightarrow [+voice]. Hence, the value of [voice] is *predictable* on the basis of [sonorant]. Steriade’s (1987) application of this concept to locality then dictates that, when the application of redundancy rules *follows* harmony, the redundant features will not be present during the harmony rule – hence their invisibility.

There are two aspects of this solution that have been shown to be problematic: the consistency of a rule-ordering in which redundancy-filling rules are necessarily “late”, and the notion of predictability itself, which runs into problems when there is *mutual* predictability among features.

The first problem, of transitivity paradoxes in rule ordering with underspecification, is addressed in detail in Steriade (1995) but can be briefly illustrated here by

an example from Mohanan (1991) and McCarthy and Taub (1992): coronal assimilation in English across lexical boundaries (e.g. *hot cakes* → *hock cakes*, *sweet bread* → *sweep bread*) would lead one to assign the redundancy rule for coronal specification to the late lexical phonology, but at the same time, many rules of English phonology (e.g. onset structure constraints barring **tl*, *t*-palatalization in *presidential*, the ban on coronals preceding stressed nuclei composed of *ju* and others) need to refer to coronal specification early in the phonology. Thus, late-ordering of specification has no support from (and is often contradicted by) other behavior of the “invisible” feature.

The second problem, indeterminate predictability of underspecification, is raised most incisively by Dresher (2003). Consider the following inventory, characterized by [\pm white] and [\pm triangular]:

		A	B	C
(3)		○	◁	◄
	White	+	+	-
	Triangular	-	+	+

Since, in the inventory above, A is the only [-triangular] item, one could say that this feature alone can characterize A, and is all that must be lexically specified; a later rule can fill in the predictable fact that all [-triangular] items are [+white]. Similarly, for C, it is the only [-white] item in the inventory; hence one might argue that its [triangular] feature is predictable once we know the value of [white]. If we get rid of all predictable specifications, then we can have the representations in (4) and the redundancy rules in (5):

		A	B	C
(4)		◇	◁	◄
	White		+	-
	Triangular	-	+	

(5) Redundancy rule 1: [-triangular] → [+white]

Redundancy rule 2: [-white] → [+triangular]

The principle that allows this representation is *logical redundancy*, defined by Drescher (2003:243) as follows:

- (6) If ϕ is the set of feature specifications of a member, M, then the feature specification [F] is *logically redundant* iff it is predictable from the other specifications in ϕ .

Thus, the slogan underlying representations such as that above for A, B, and C may be summarized as: "Don't specify any feature that is logically redundant." Indeed, this is the essence of Steriade's 1987 proposal, which is cast in terms of cooccurrence filters, rather than redundancy rules. To see this dependence on logical redundancy is problematic, consider the following inventory and its features, and consider the co-occurrence restrictions that represent generalizations over the inventory:

- | | A | B |
|------------|---|---|
| | ◀ | ○ |
| (7) White | - | + |
| Triangular | + | - |
| Small | + | - |
- (8) Feature co-occurrence restrictions: *[+triangular,+white], *[-white, -small], *[-triangular, +small]
- (9) Redundant-values with respect to F: the class of segments where a feature co-occurrence constraint blocks a value of F (Steriade 1987: 341)

However, based on the definition of redundant values in Steriade (1987), [+triangular] is redundant, since a feature co-occurrence constraint blocks it, while [-triangular] is also redundant, since a feature co-occurrence constraint blocks it,

too. Similarly, both [\pm white] and [\pm small] are redundant, given the inventory of A and B above. Thus, as all values of all features are redundant above; does that mean that the inventory has *no* specifications?

Dresher (2003), after demonstrating the logic of this problem¹, suggests that the solution is a *hierarchy* that determines which features are to have scope over which others in determining successive contrast. For example, in Manchu, which has the [-low] vowels *i, u, v*, once the [back] distinction has cut up the space between *i* and *u, U*, and once the [ATR] distinction has cut up the space between *u* and *v*, then [round] is redundant for these latter segments, and can be predicted by the fact that they are [-low,+back]. Thus, the solution to the problem of *logic redundancy* outlined above is to assume that certain features have “priority” in the directionality of implicational statements. Thus, in the Manchu case, for [-low] vowels, the implication is [-back] \rightarrow [+round], and not the other way around ([+round] \rightarrow [-back]).

While Dresher’s hierarchical/asymmetric approach to implicational redundancy statements may prove sufficient to achieve underspecification without overgeneration, it is worth asking why underspecification of segments in individual segments is a desideratum at all. As was mentioned at the outset of this chapter, the primary use of *paradigmatic* underspecification is to achieve a simpler statement of the *syntagmatic* applicability of, e.g., an assimilation process. But then why not put the locus of “invisibility” within the syntagmatic rule itself?

The most direct source of inspiration for the current work is Calabrese (1995), who argues that “underspecification of feature values becomes an idiosyncratic property of individual rules”. Let us paraphrase this as follows:

- (10) Parametric Visibility: A given valuation rule *R* for the feature [F] may parametrize its search domain to only *contrastive* values for F.

The advantage of (10) is that it allows full specification for all features in segments;

¹Dresher focuses on redundancy rules, and does not discuss that the same outcome arises using co-occurrence constraints, but it is very straightforward to extend the logic, as I have done here.

the motivation for leaving [back] out of [-low,-round] segments in Finnish (which accomplished the harmonic invisibility of neutral segments for Kiparsky, Steriade, etc.) disappears, once we state the valuation rule as limited to contrastive values of [back].

- (11) A segment S with specification αF is *contrastive* for F if there is another segment S' in the inventory that is featurally identical to S , except that it is $-\alpha F$

Or, alternatively (and equivalently):

- (12) An instance of the feature F is contrastive within a set of other features S if both features of F may occur in S

Thus, since there are no [+back,-low,-round] segments in Finnish, the value [back] is not contrastive for the [-low,-round] values. This fact alone has no effect on the phonology of Finnish, nor the representation of *i,e* – but where it does have effect is in the operation of valuation rules that restrict their domain of search to contrastive values. Thus, the learner does not need to learn a redundancy rule or posit a co-occurrence restriction, nor does s/he need to order it after the operation of harmony; rather, the learner must posit the valuation rule yielding assimilation or dissimilation, and set the value of that rule's visibility parameter accordingly.

This will be achieved in shorthand notations in structural descriptions with the notation: $V_{[\text{contrastive: } \alpha F]}$

What is interesting about contrastiveness as a property of features, and the role that it plays in relativization of the search domain, is that not all (dis)harmony systems employ it. Thus, consider the system of Tangale [ATR] harmony, repeated from Chapter 1.

2.1. All-Values Visible

2.1.1. Tangale

Tangale is a Chadic language, and in fact, the only one known to possess a vowel harmony system. It has a suffixing [ATR] harmony, and the following 9-vowel inventory:

(13) Tangale Inventory (Kidida 1985:18)

i	u	[+high,+ATR, -low]
ĩ	ụ	[+high, -ATR, -low]
e	o	[-high, +ATR, -low]
ẹ	ọ	[-high, -ATR, -low]
a		[-high, -ATR, +low]

As can be seen, the feature [ATR] is contrastive for all vowels except /a/. Examples of stem-affix combinations yielding harmony may be observed in (14):

(14) Examples of Harmony (Kidida 1985:20)

- a. wudo-no my tooth
- b. wuḁo-nḁ my farming
- c. sórii-nì his height
- d. s'or-n'ì his age
- e. rii-go multiplied
- f. riḁ-gḁ satisfied
- g. d`ukà salt
- h. kanj-wụ their deleb-palm

Importantly, /a/ values suffixes as [-ATR], as seen in, e.g. (14-h). Thus, it may be said that Tangale has non-contrastive vowels that are visible within the search for valuation. More precisely, all values of [ATR] appear to be visible sources for valuation in Tangale:

- (15) Structural Description: $V_{[\alpha \text{ ATR}]} \dots V_{\text{target}}$
 Structural Change: V_{target} becomes $[\alpha \text{ ATR}]$

To verify the harmonic behavior of /a/, the noncontrastive vowel, we may observe that it is non-alternating (and disharmonic) when in suffixes (16) and that it is a visible local source that, when the closest vowel to a suffix, is the one whose value is copied in disharmonic roots (17).

- (16) The vowel /a/ cooccurs with tense vowels if in an affix:

- a. peer-na compelled
- b. pɛd-na untied
- c. dob-na called
- d. laŋɥld'ed`e small frog
- e. la-pídò small tree
- f. ana-wólò singers
- g. ànà-w`ut`en workers

- (17) The vowel /a/ intercepts [+ATR] harmony from the stem to an affix, providing instead its own [-ATR] value in valuation

- a. ped-nà-n-g`o untied me
- b. peer-ná-n-g`o compelled me
- c. dob-nà-g-g`u called you (pl.)
- d. dib-nà-m-g`u cooked for us
- e. wee-nà-m-g`u saw us

The analysis of Tangale is completely straightforward: all values of [ATR] are visible. Thus, a parametric setting for the structural description of a disharmony rule is that the domain of search for valuation includes all values of the harmonic feature.

By considering Tangale, we have observed that the visibility of all values of a feature vs. only the contrastive values of a feature is a point of variation in the operation of VALUE-CLOSEST.

2.2. Contrastiveness

A number examples of locality as determined by contrastive visibility can be found in the literature; a striking one is Chumash [anterior] harmony (Poser, 1982), which affects /s/ and ʃ across intervening coronals. Only the [+strident] segments are contrastive for [anterior], so intervening [-strident] consonants are not considered in the computation of locality. The third person subject prefix illustrates this case: it assimilates [-anterior] from the nearest contrastive source:

- (18) Chumash [anterior] assimilation (Poser 1982:132-133)
- a. s-aqunimak 'he hides'
 - b. s-ixut 'it burns'
 - c. ʃ-ilakʃ 'it is soft'
 - d. s-kuti 'he sees'
 - e. ʃ-kuti-waʃ 'he saw-past'

The instances intervening /k,t,w,x/ in (18) are not relevant to the computation of locality for [anterior] assimilation, because they are not contrastive for [anterior] by the definition in (18).

The importance of contrastiveness in the computation of motor planning and comparison has been established in interesting ways elsewhere in the study of human cognition. Sedivy et al. (1999) made use of the real-time eye-tracking paradigm in an experiment with spoken language and visual contexts. Given a scene with a pink comb, a yellow comb, and a yellow bowl, subjects were given instructions such as *Pick up the yellow comb*. Importantly, the use of an eye-tracker allowed Sedivy and her colleagues to measure where subjects looked in real-time, as they heard each incoming word. Sedivy *et. al* found that at the onset of the word *yellow*, subjects looked much faster and more frequently at the yellow comb, even before they had heard the head noun.

The only logical explanation is that subjects understood that, given spoken instructions, their interlocutor would be more inclined to use the predicate *yellow*

when it was *contrastive* for the object to be manipulated. That is, even though the predicate *yellow* was true of both the comb and the bowl, the subjects preferred to interpret it in a contrastive use within 300 milliseconds, only looking to the object of which it was noncontrastively true much later (at 450 milliseconds). We take these results as supporting evidence to show that the preferred contrastive use of a predicate (over a set of more than one objects for which it is true) may be a guiding principle in human cognition. Nobody would say that the bowl was “underspecified” for *yellow*, and that is why subjects waited longer to look at it; rather, it seems that when performing a search for something with the relevant feature, contrastive uses of that feature may simply get priority in certain circumstances. The search for a determinant feature in assimilation and dissimilation are, by hypothesis, two such instances in the phonological computation, in which contrastiveness determines the search domain.

Contrastiveness, however, is not a property that can be observed by looking at a spectrogram or a power spectrum or even an electromyographic or ultrasound movie of the articulators in action. Contrastiveness is an extremely abstract property of the speech sound; one that cannot exist anywhere but in an intelligent mind. However, so is “the color red”. Discretization is an essential property of all perception: without it, there is no possibility of perceiving or using a finite set of categories.

Importantly, the notion of contrastiveness as a *parameter* is taken seriously; we should expect to find languages that are closely related (or nearly identical in form) that differ only in the value of this parameter, retaining all other aspects of the structural description of a harmony rule. In the first two sections of this chapter, we will examine two such cases. The first, in Section 2.3, is a microparametric difference in [ATR] harmony between Standard Yoruba and Ife Yoruba. The second, in Section 2.4, is a microparametric difference in Long-Distance Uvularization between two Tungusic languages of China, Sibe and Sanjiazi Manchu.

Having developed the theory of contrastiveness in the case studies of these two language families, we then turn to revisions and consequences of the notion

of contrastiveness as developed here. We begin Section 2.4 with a unified formulation of [back] harmony in three distinct Turkic languages. The single setting of this visibility parameter has radically different surface consequences where the inventories of these languages differ. We examine the phenomenon of Consonant Harmony in Karaim, where the definition of contrastiveness must be augmented to refer to positional factors. The chapter will conclude with a summary of how, indeed, the range of “transparency” is quite limited by the grammatical options made available within an intervener-based approach to valuation rules.

2.3. Ifẹ vs. Standard Yoruba: All vs. Contrastive Visibility

In this section, we explore the [ATR] systems of Standard Yoruba and Ifẹ Yoruba, a central Yoruba dialect, spoken in Ile-Ifẹ, and described by Ọlanikẹ Ọla Oriẹ (2001). The two languages make for very good comparison, because they have identical vowel inventories, and show the same basic harmonic behavior: Right-to-Left [ATR] harmony. Nonetheless, they show a fundamental difference in the transparency of noncontrastive vowels, which we will characterize in terms of relativization of the search domain.

2.3.1. Standard Yoruba

Among the oral vowels², Standard Yoruba has the 7-vowel system in (19).

(19) Oral Vowel Inventory

i	u	[+high,+ATR, -low]
e	o	[-high, +ATR, -low]
ẹ (ɛ)	ọ (ɔ)	[-high, -ATR, -low]
	a	[-high, -ATR, +low]

Bakovic (2000), Adetugbo (1967), and Fresco (1970) suggest that, as the harmony is right-to-left, final vowels should always be treated as (the only) root vowels,

²SY also has nasal /ĩ ũ ỹ/. These will be discussed where relevant.

“despite the apparent paucity of independent synchronic evidence for such morphological structure in some cases” (Bakovic 2000: 129).

The operation of harmony may be first observed in disyllabic forms, which come from two sources: monomorphemic nouns of the form VCV, or deverbal nouns of the form V-CV. Before proceeding, we must note that Standard Yoruba exhibits a positional restriction: nasal vowels and the vowel [u] are systematically absent from the initial syllable in Standard Yoruba. (Thus, the final syllable hosts a wider range of contrasts than the initial syllable.)

Disharmony within disyllabic words is possible in the following cases:

- (20)
- a. [a] may precede [+ATR] vowels (as it cannot alternate, lacking a [-ATR] counterpart)
 - b. [i] may precede [-ATR] vowel (as it cannot alternate, lacking a [-ATR] counterpart)
 - c. There are a limited number of disharmonic stems in which a [-ATR] mid vowel precedes a final high vowel. These are treated as limited in productivity, and stored with a diacritic, yielding a representation similar to that of exceptional Hungarian stems such as *hid*.

Co-occurring combinations of vowels in disyllabic words may be observed in the following examples:

- (21)
- a. èwé 'lip'
 - b. olè 'thief'
 - c. éró 'crowd'
 - d. ód̂zó 'rain'
 - e. égé 'cassava'
 - f. ɔse 'soap'
 - g. èfó 'vegetable'
 - h. ɔwó 'hand'
 - i. εja 'fish'
 - j. òdá 'drought'
 - k. ajé 'world'
 - l. abo 'female'
 - m. alé 'night'
 - n. ako 'male'
 - o. ilé 'house'
 - p. iĝbó 'forest'
 - q. ide 'brass'
 - r. ikó 'cough'
 - s. ebi 'hunger'
 - t. órí 'shea-butter'
 - u. eku 'rat'
 - v. ówú 'cotton'
 - w. èbi 'guilt'
 - x. ɔtí 'heaven'
 - y. εtu 'deer'
 - z. órũ 'heaven'
 - za. ilá 'okra'
 - zb. àfi 'except'
 - zc. atú 'type of dress'
 - zd. igi 'tree'
 - ze. ikú 'death'
 - zf. aja 'dog'

A preliminary formulation of harmony may be characterized as follows (where *mid* abbreviates [-high,-low]):

- (22) Structural Description: $V_{\text{midtarget}} \cdots V_{[\alpha \text{ ATR}]}$
 Structural Change: $V_{\text{midtarget}}$ becomes $[\alpha \text{ ATR}]$

Thus, all values of [ATR] will be visible in the search, yielding èwé, olè, 'eró, ódžó, égé, ɔse, èfó, ɔwó, eja,ðdá, ebi, órí, eku, ówú.

As noted above, disharmonic forms with a [-ATR] mid vowel, such as èbi are limited, but of interest to our study here. Archangeli and Pulleyblank (1994) adduce additional examples of such roots (p.149):

- (23) a. èkú 'a costume worn by the Egúngún'
 b. èrí 'evidence'
 c. ewù 'a pleasurable feeling'

In addition, Bakovic notes minimal pairs in deverbal nouns, where behavior is more clear:

- (24) a. rú 'to disrupt' takes [+ATR] prefixes
 b. rú 'to haft' takes [-ATR] prefixes (cf. A& P 1989:fn 18)
- (25) a. ò-kú 'corpse' (root: die); e-rú 'dishonesty'
 b. ò-mu 'drink-er' ; è-rí 'evidence'

The representation of the (b) forms is that they bear a diacritic on the high vowel that indicates the value to be copied is [-ATR]. This solution is preferable to pre-specifying the initial vowel as [-ATR], because, in the case of deverbal nouns that may take more than one prefix, all such prefixes will be [-ATR]. Thus, speakers of Yoruba must record the representation of the final vowel in case such as èbi as [-ATR]³.

³Krämer (2003) describes such cases as "Trojan vowels", recalling Odysseus' horse filled with a hidden group of Greek warriors. Readers who find this mnemonic useful are welcome to use it, as

It is worth briefly considering alternatives to the diacritic analysis. Mohanan (1991) casts a condition on final high non-nasal⁴ vowels: that they are extraprosodic⁵. Thus, by virtue of being extraprosodic, they are outside the domain of harmony. Interestingly, Ola Orié's proposal, based on tonal and distributional properties, is that final vowels in all Yoruba dialects are the prosodic head, which is clearly incompatible with Mohanan's suggestion. Another problematic fact is that neighboring dialects of Yoruba lack disharmonic roots like èbi entirely, and it is perhaps a stretch of the imagination to suppose that these dialects differ on a radical property such as whether final high vowels are extraprosodic. On the other hand, a diacritic on certain lexical items, as assumed here, is more likely to be the kind of representational element subject to loss and variation

Thus far, we have not encountered any instances of transparency (or opacity), as at least three elements are required to diagnose this property. We immediately turn to trisyllabic forms.

it characterizes the diacritic treatment of èbi assumed here.

⁴Mohanan cites a personal communication from D. Pulleyblank to the effect that there are no disharmonic mid [-ATR] followed by final high vowels when the final high vowel is *nasal*. D. Pulleyblank (personal communication, May 2004) asserts that this was an unfortunate misquotation, and indeed, Ola Orié (2003:7, fn.10) cites examples such as ení 'mat'.

⁵Calabrese (2003) adopts this suggestion as well.

- (26)
- a. akisa 'rag'
 - b. ìkparí 'end'
 - c. ògèdè 'incantation'
 - d. ògèdè 'plantain'
 - e. eméwá 'chief's messenger'
 - f. ebora 'type of egungun'
 - g. àjèré 'name of a Yoruba town'
 - h. abéré 'needle'
 - i. ìjèrè 'a kind of seed'
 - j. ìjéré 'name of a Yoruba town'
 - k. ofòdì 'name of a ward in Lagos'
 - l. ógbèrì 'uninitiated'
 - m. erákpó 'type of plant'
 - n. ìgàkè 'tickling'
 - o. íkparí 'end'
 - p. àkùrò 'dry-season marshy-farm'

As may be observed, both medial and initial mid vowels are consistent with our initial formulation of [ATR] harmony:

- (27) Structural Description: $V_{\text{midtarget}} \cdots V_{[\alpha \text{ ATR}]}$
 Structural Change: $V_{\text{midtarget}}$ becomes $[\alpha \text{ ATR}]$

Finally, the set of forms below represent one of the most important points about Standard Yoruba [ATR] harmony: *all mid vowels that precede medial high vowels are [+ATR].* Thus, high vowels, even though they are not contrastive for [ATR], are not transparent, and provide a local source of valuation to preceding vowels.

- (28) a. òkígbe 'magical drug'
 a. èdžìkà 'shoulder'
 a. òjìbó 'any European'
 a. orúkṣò 'mudbench serving as a bed'
 a. èsúró 'Redflanked Duiker'
 a. èlùbó 'yam flour'

There are a handful of disharmonic trisyllabic forms. Bakovic (2000) analyzes these all as the result of hiatal vowel deletion (on which see, for example, Oyelaran (1971)). Usually in hiatus, the second vowel is deleted⁶:

- (29) òmutí 'drunkard' = òmu + tì; first member of compound is known to be disharmonic; second hiatal vowel deletes.

However, the purely compound-based analysis loses a bit of explanatory merit when disharmonic forms with the instrumental prefix o-/o- before [a] (examples from A&P 1989, based on R.C. Abraham's (1958) dictionary):

- (30) a. odár'o 'dyer' (from d'ar'o 'to dye')
 b. órayé 'fool' (from ra + (ní) iyé 'render stupid')

These forms are not amenable to a compound analysis, and hence, it cannot be that all disharmonic trisyllabic forms are attributed to compounding-plus-hiatus. On the current analysis, these forms, limited in number, also must be analyzed in terms of a diacritic [+ATR] copy-value on the medial low vowel.

A few other remarks on Standard Yoruba are in order. [ATR] harmony does not apply across clitic boundaries (Bamgboṣe, 1967):

⁶However, in some cases (usually adjudicated by sonority; cf. Casali (1998)), it may be the first vowel

- (31) a. mo lo 'I went'
 b. mo jó 'I danced'
 c. o fè 'you (sg.) want'
 d. o dé 'you (sg.) arrived'
 e. ó wá 'he came'
 f. ó kú 'he died'

However, in the dialects of Oyo and Egbado (Bamgboṣe, 1967; Fresco, 1970) assimilation does occur for these clitics. Archangeli and Pulleyblank (1994) situate the variation in terms of postlexical linking of [-ATR] to high vowels. However, Bamgboṣe notes that 2nd person plural /ɛ/ does not harmonize, even in these dialects. In the present analysis, the variation is characterized simply in terms of the lexical specification of these clitics. If a learner observes alternation, then s/he will store the alternating clitics as requiring valuation (i.e, unspecified for [ATR]), and apply the general harmony rule proposed earlier.

At this point, a remark is in order on the status of morpheme-structure-constraints as opposed to harmony rules as I have developed them here. One might suppose that all of Yoruba [ATR] harmony may be characterized in terms of surface constraints on intra- and inter-morphemic vowel sequences. However, this analysis would face difficulties with certain classes of forms that exhibit derivational opacity. In Standard Yoruba, there is a rule of consonant deletion, which is then followed by what is described left-to-right vowel assimilation (Pulleyblank, 1988).

- (32) a. oóde (from odíde) 'Grey Parrot'
 b. eèpè (from erùpè) 'earth'
 c. yoòbá (from yorùbá) 'Yoruba'

Thus, one analysis of these facts is that, following consonant deletion, the remaining medial vowel assimilates completely to the preceding vowel. Importantly, the surface forms that result from this process are disharmonic. Thus, a Standard Yoruba speaker will hear the varying outputs odíde, which is fully consis-

tent with surface morpheme structure constraints, and *oóde*, which violates surface morpheme structure constraints. Thus, the statement of [ATR] distribution in terms of purely surface MSCs must face counterexamples (or violability). However, consider an alternative analysis, which requires no modification to the existing harmony rule developed in (27). The essence of the proposal is that [ATR] valuation is ordered prior to consonant-deletion. All vowels bear specification for [ATR], and no further valuation will occur. Consonant deletion then brings into syllable-adjacency two vowels that violate [ATR] harmony on the surface, but are consistent with the order of computation given here.

The consonant-deletion-plus-assimilation analysis will be abandoned here, and instead, I propose a syllable-deletion-plus-compensatory-lengthening analysis, in order to preserve the tone on the medial vowel: *e.rù.pè*, to which harmony becomes *e.∅.pè*, which lengthens the initial vowel to *eè.pè*. The reason for motivating a syllable-deletion analysis is that it appears elsewhere in natural language, whereas a consonant deletion rule in Yoruba is more cumbersome to state: “delete the onset consonant of the second syllable”. To motivate the syllable-deletion analysis, we make a brief tangent into Turkana.

Turkana (Dimmendaal, 1983) has a haplology-driven syllable-deletion process, in which, if there are two adjacent non-initial syllables, the first one will delete. The deleted syllable leaves a floating tone, and the preceding vowel lengthens.

(33) Turkana haplological syllable-deletion (Dimmendaal 1983:48)

- a. /lu-ka-bob-ò-k/ → lu.ka.bo.boq → lu.ka.∅.boq → [lúqáábòq]
- b. /e-cùc-ut/ → e.cù.cut → e.∅.cut → [éécút]

Omitting rules for [ATR] harmony, uvularization, and tone-shift in Turkana, we may characterize the syllable deletion rule as follows:

- (34) Structural description: σ_1, σ_2 , where $\text{precedes}(\sigma_1, \sigma_2)$
 & $\text{Onset}(\sigma_1) = \text{Onset}(\sigma_2)$ & $\text{Nucleus}(\sigma_1) = \text{Nucleus}(\sigma_2)$
 Structural Change: Delete $\text{Onset}(\sigma_1)$ and $\text{Nucleus}(\sigma_1)$

A few comments are in order regarding (34). First of all, any evaluation of haplology, whether rule- or constraint- based, will need to have the identity predicate (=) that evaluates the segmental identity of two segments⁷. Second, deletion of the Onset and Nucleus of σ_1 does not destroy σ_1 . Rather, σ_1 now must engage in a valuation search for a nucleus (as this is required by the interfaces for convergence in any syllable):

(35) Turkana Closest-Nucleus-Valuation

Structural description: $\sigma_{\text{closest}} \cdots \sigma_{1\text{target}}$

Structural Change: $\text{Set Nucleus}(\sigma_{1\text{target}}) = \text{Nucleus}(\sigma_{\text{closest}})$

Importantly, the exact same rule in (35) may be applied in Yoruba, following medial-syllable deletion.

(36) Yoruba medial syllable deletion:

Structural description: σ_1, σ_2 , where $\text{precedes}(\sigma_1, \sigma_2)$ & $\neg \exists \sigma_0$, such that $\text{precedes}(\sigma_0, \sigma_1)$

Structural Change: Delete $\text{Onset}(\sigma_1)$ and $\text{Nucleus}(\sigma_1)$

(37) Yoruba Closest-Nucleus-Valuation

Structural description: $\sigma_{\text{closest}} \cdots \sigma_{1\text{target}}$

Structural Change: $\text{Set Nucleus}(\sigma_{1\text{target}}) = \text{Nucleus}(\sigma_{\text{closest}})$

Thus, valuation may be understood as a *dynamic* operation that may apply during intermediate stages of the phonological computation, whenever valuation is needed. The Turkana and Yoruba syllable-deletion rules, however, have revealed an interesting consequence of valuation: the difference between valuation initiated by a syllable and valuation initiated by a segment. Valuation initiated by a syllable seems to have no access to internal featural content (and indeed, does not need this access), and copies entire segments. Thus, the output of medial syllable deletion in

⁷The identity predicate between segments may be further decomposed into universal quantification over all feature values in each segment and an identity comparison over them; this is the proposal of Reiss (2003b), which is crucial if there is no atomistic definition of segments.

Yoruba will leave a syllable seeking valuation (here, leftward) for nuclear segment. Once this valuation is accomplished, the result may be a surface violation of what seem to be otherwise regular generalizations about [ATR] sequences. Importantly, we may understand this result as following from the steps of sequenced computation developed here. Thus, the failure of the final [-ATR] to “spread” leftwards in *eè.pè* shows that harmony precedes consonant-deletion. A purely surface AGREE constraint will flounder on these data.

In concluding this section, we may emphasize its central point: all values of [ATR], even noncontrastive ones, are visible in the search for featural valuation in Standard Yoruba (yielding a harmony policy quite similar to that of the 9-vowel system of Tangale). In the next section, we turn to Ifẹ Yoruba, in which noncontrastive values of [ATR] are transparent, or, more properly, excluded from the domain of search.

2.3.2. Ifẹ Yoruba

Ifẹ Yoruba has the same vowel inventory as standard Yoruba. According to Olanikẹ Olorie (2001), high vowels are transparent in Ifẹ. We verify this difference with Standard Yoruba in the following table. Transparent medial vowels are shown on the left, and the corresponding harmonic medial vowel behavior in SY is shown on the right.

(38)	Ifẹ	SY	
a.	orúkò	orúko	‘name’
b.	èlùbó	èlùbó	‘yam flour’
c.	eúré	ewúré	‘goat’
d.	òsùpá	òsùpá	‘moon’
e.	òruka	òrùka	‘ring’
f.	òrìsà	òrìjà	‘primordial deity’
g.	òkuta	òkuta	‘stone’

Thus, learners that encounter èlùbó will not formulate the harmony rule as in (27), but rather, as follows⁸:

(39) Ifẹ[ATR] Valuation:

Structural Description: $V_{\text{midtarget}} \dots V_{[\text{contrastive}: \alpha \text{ ATR}]}$

Structural Change: $V_{\text{midtarget}}$ becomes $[\alpha \text{ ATR}]$

Let us consider the consequences of this formulation for an input such as /èlùbó/. Valuation for the initial vowel will perform a rightward search for the closest contrastive value of [ATR]. The consonants and the high vowel /u/ will be skipped, as these are not contrastive for [ATR]. Search encounters ə, which is contrastively [-ATR], and this value is copied to the initial vowel, yielding èlùbó.

However, at this point, it becomes apparent that the harmony rule in (39) does not constitute a complete harmony *policy* for

. The reason is, there are of course disyllabic forms, in which the final vowel is a noncontrastive high vowel, such as the following:

- (40) a. etí 'ear'
 b. eku 'rat'
 c. èrígì 'molar'
 d. ògiri 'wall'

As Ifẹ makes only use of contrastive values in its search, the forms in (40) clearly cannot be assimilated under the rubric of (39). Thus, Ifẹ learners must add a context-free advancement rule to their grammars:

(41) Ifẹ context-free advancement:

Structural Description: $V_{\text{midtarget}} \dots V$

Structural Change: $V_{\text{midtarget}}$ becomes [+ ATR]

⁸Readers curious about the behavior of [a] in harmony are asked to refer to Chapter 3, where the analysis of Wolof long vowels is entirely parallel to that of Ifẹ.

This rule will clearly be superseded by the contrastive ATR harmony rule, due to the Elsewhere condition (as formulated in Chapter 1). Thus, high vowels behave transparently in medial position in trisyllabic forms, and only yield the appearance of participating in harmony in disyllabic forms. There is an immediate positive consequence of framing the analysis in this way. In Standard Yoruba, *all* values of [ATR] were visible in the search for valuation, including values of [-ATR] that were diacritically-based on high vowels. Given the formulation of searching for contrastive values only, however, these diacritics, should they exist, will never be encountered in a relativized search.

According to Ọla Orié (2003), those disyllabic forms that were disharmonic in SY⁹ are “harmonic” in Ifẹ:

- (42)
- a. èbi ‘guilt’ (cf. SY èbi)
 - b. ewírì ‘bellows’ (cf. SY ewírì)
 - c. ebi ‘hunger’ (cf. SY ebi)
 - d. ékuru ‘food made of beans’ (cf. SY èkuru)
 - e. etu ‘antelope’ (cf. SY etu)

We may understand (42) if Ifẹ has an automatic consequence of a harmony policy that only includes the following two rules:

- (43) Ifẹ[ATR] Valuation:
 Structural Description: $V_{\text{midtarget}} \dots V_{[\text{contrastive: } \alpha \text{ ATR}]}$
 Structural Change: $V_{\text{midtarget}}$ becomes $[\alpha \text{ ATR}]$
- (44) Ifẹ context-free advancement:
 Structural Description: $V_{\text{midtarget}} \dots V$
 Structural Change: $V_{\text{midtarget}}$ becomes $[+ \text{ ATR}]$

⁹Even though forms like ebi are, as we have discussed, quite common in SY, Adetugbo (1967) notes that there is only one dialectal occurrence of /ɔ̄si/: ɔ̄ti, ‘foreign wine’.

Given an input such as /Ebi/, or even /Ebi_[copy value: -ATR]/, the output of the harmony policy will be [ebi], as context-free advancement is the only rule that may apply. As we will see, Ifẹ demonstrates a harmony policy that is thus formally identical to Finnish: non-contrastive vowels are fully transparent in medial positions, but when they are the only vowel in the word, a context-free valuation rule may apply, that happens to yield the same harmonic value as that of the neutral vowel. Importantly, this “same” valuation is not universal, it only “happens to” be the same. In Uyghur (Lindblad, 1990), the neutral vowel is *i*, and the result of context-free valuation for suffixes attached to all-neutral stems is [+back] valuation, the opposite value. Thus, the formulation of the Ifẹ policy developed here places no premium on the harmonic value of noncontrastive vowels: they are full invisible to the system.

Finally, we may briefly consider the dialect of Ekiti Yoruba, as described by Olanike Ola Orié (2003). Ekiti has a 9-vowel system, allowing [-ATR] contrast among the high vowels. Ekiti has a harmony rule identical to that of Standard Yoruba, except that both mid and high vowels seek valuation.

- (45) Structural Description: $V_{[-low]_{target}} \cdots V_{[\alpha ATR]}$
 Structural Change: $V_{[-low]_{target}}$ becomes $[\alpha ATR]$

A comparison table of correspondences may be found in (46). What it shows is that in Standard Yoruba, medial high vowels are “blockers”, in Ifẹ Yoruba, they are “transparent”, and in Ekiti, they are “undergoers”. However, none of these terms are primitives in the theory of harmony developed here. The classifications are the phenomenological result of 1) the structure of the segmental inventory and 2) parametrization of valuation to all *vs.* contrastive visibility.

(46)	SY: Blockers	Ifẹ: Transparent	Ekiti: Undergoers	
a.	èbúté	èb'ute	èbúte	harbor
b.	ewúro	eúro	eúro	bitter-leaf
c.	orúkò	ɔrúkò	ɔrúkò	name
d.	odíde	ɔdíde	ɔdíde	parrot
e.	ewúré	eúré	eúré	goat
f.	èlùbó	èlùbò	èlùbò	yam flour
g.	òṣùpá	òṣùpá	òṣùpá	moon
h.	ewùrà	eùrà	eùrà	water-yam

Having demonstrated the powerful changes that a single parametric change in a valuation rule can yield in describing microvariation in dialects of Yoruba, we turn to another case of microvariation: that of the visibility of [low] in VC harmony in Tungusic languages.

2.4. Sibe vs. Sanjiazi Manchu: Marked vs. Contrastive Visibility

In this section, we will explore a further parametric option for the relativization of a search: to an asymmetric set of values for the harmonic feature. In other words, learners may posit that an affixal segment, seeking valuation, only searches for a given value {+,-} of the value of interest, and does so at unbounded distance. This option *asymmetric-value harmony* is limited in natural language, but we will make a strong case for it in Sibe, where the hypothesis will be that asymmetric-value harmony may only be relativized to the **marked** value of a feature. Importantly, determination of the marked value of a feature must come from phenomena external to the harmony rule under consideration.

2.4.1. An Overview of Sibe Segmental Phonology

The crucial data to be discussed come from Sibe (southwest Tungusic), as described by Li (1996). Sibe (also written Xibe or Xibo) is a modern Manchu dialect in the Tungusic family.

As in all Tungusic languages, Sibe is purely suffixing, with no prefixation or infixation. In the vowel system, Sibe has only Rounding Harmony, and no other vowel harmony (e.g. backness). The primary stress is mostly on the initial syllable in Sibe. One of the most important features to note at the outset is that, unlike Classical Manchu, Sibe has no active contrast for the feature retracted tongue root (RTR). As Li notes, "in the disintegrated RTR system of Sibe, [RTR] is systematically absent in the UR." (Li 1996: 286)

The following table illustrates the consonantal inventory. Importantly, along the velar-uvular distinction, the language opposes *k* and *q*, *g* and *ɣ*, *x* and *χ*, and *ɣ* and *ʁ*. By hypothesis, these segments are all specified as [Dorsal], but differ in their specification of [± high]. The [+high] segments /*k g x ɣ*/ will be referred to as *velar*, while the [-high] segments /*q ɣχ ʁ*/ will be referred to as *uvular*.

(47) Sibe Consonant Inventory:

	LAB	COR	DORS	nas.	cont.	liq.	later.	distrib.	anter.	high	voi.	cons.	son.
p	+	-	-	-	-	-	-	-	-	+	-	+	-
b	+	-	-	-	-	-	-	-	-	+	+	+	-
m	+	-	-	+	-	-	-	-	+	-	+	+	+
f	+	-	-	-	+	-	-	-	-	+	-	+	-
v	+	-	-	-	+	-	-	-	-	+	+	+	-
t	-	+	-	-	-	-	-	-	+	+	-	+	-
d	-	+	-	-	-	-	-	-	+	+	+	+	-
s	-	+	-	-	+	-	-	-	+	+	-	+	-
z	-	+	-	-	+	-	-	-	+	+	+	+	-
n	-	+	-	+	-	-	-	-	+	+	+	+	+
l	-	+	-	-	+	+	+	-	+	+	+	+	+
r	-	+	-	-	+	+	-	-	+	+	+	+	+
tʃ	-	+	-	-	-	-	-	+	-	+	-	+	-
ʃ	-	+	-	-	+	-	-	+	-	+	-	+	-
dʒ	-	+	-	-	-	-	-	+	-	-	+	+	-
ʒ	-	+	-	-	+	-	-	+	-	+	+	+	-
tʂ	-	+	-	-	-	-	-	-	-	+	-	+	-
ʂ	-	+	-	-	+	-	-	-	-	+	-	+	-
dʑ	-	+	-	-	-	-	-	-	-	+	+	+	-
ʑ	-	+	-	-	+	-	-	-	-	+	+	+	-
k	-	-	+	-	-	-	-	-	-	+		+	-
g	-	-	+	-	-	-	-	-	-	+	+	+	-
x	-	-	+	-	+	-	-	-	-	+	-	+	-
ɣ	-	-	+	-	+	-	-	-	-	+	+	+	-
q	-	-	+	-	-	-	-	-	-	-	-	+	-
o	-	-	+	-	-	-	-	-	-	-	+	+	-
χ	-	-	+	-	+	-	-	-	-	-	-	+	-
ʁ	-	-	+	-	+	-	-	-	-	-	+	+	-
ŋ	-	-	+	+	-	-	-	-	-	+	+	+	+
j	-	-	+	-	+	-	-	-	-	+	+	+	+

The vowel inventory is composed of three binary distinctions: [\pm back], [\pm round], and [\pm high], resulting in eight vowels. There is ample evidence that there is only one phonologically active height distinction, as will be extensively discussed.

(48) Sibe Vowel Inventory¹⁰:

	LAB	COR	DORS	nasal	voiced	consonantal	sonorant	round	back	high
i	-	-	+	-	+	-	+	-	-	+
ü	-	-	+	-	+	-	+	+	-	+
ɨ	-	-	+	-	+	-	+	-	+	+
u	-	-	+	-	+	-	+	+	+	+
ɛ	-	-	+	-	+	-	+	-	-	-
ö	-	-	+	-	+	-	+	+	-	-
a	-	-	+	-	+	-	+	-	+	-
ɔ	-	-	+	-	+	-	+	+	+	-

In the next subsection, the distinct behavior of [+high] and [-high] vowels in Sibe rounding harmony will provide evidence that i, ü, ɨ, u and ɛ,ö,a,ɔ form distinct natural classes, and that neither can be treated as “underspecified” for [high].

2.4.2. Height-Conditioned Rounding Harmony in Sibe

Sibe has Left-to-Right rounding harmony. Like many languages with rounding harmony (see Kaun (2004) for an overview), Sibe imposes restrictions on [round] agreement between vowels of different heights. Cross-height harmony is only tolerated when there is a [+high] target. Thus, [+high] vowels may undergo rounding harmony triggered by vowels of either height. Nonhigh vowels, on the other hand, may undergo rounding harmony only as long as the trigger is also [-high]¹¹. This

¹⁰Specifications are provided for the major articulators and for [voice] and [nasal] because they will be used in the formation of natural classes throughout the inventory when we return to the predictions of a similarity-based approach to locality.

¹¹In fact, the behavior of [round] harmony in Sibe is more complicated, in that while the language has front rounded vowels, only [+back] vowels alternate in rounding harmony. Sibe thus exhibits an additional [back] restriction on round harmony; see Kaun 2004 for discussion of this preference.

is exemplified for root-internal harmony in (49). In (a), the target is high, and the trigger is high, so rounding agreement takes place. In (b), the target is high, and the trigger is non-high, but rounding agreement can take place. In (c-d), the target is nonhigh, and the trigger is non-high, so rounding harmony may obtain. However, in (e), rounding harmony fails to apply, because it cannot spread from a [+high] to a [-high] target.

- (49)
- a. fulxu root
 - b. ɕögu vegetable
 - c. ɔmɔl grandson
 - d. ölxɔ cowardly
 - e. uva flour

The patterning of [-high] vowels as a natural class with respect to rounding harmony can be further verified by examining co-occurrence restrictions on round vowels when a root contains two [-high] vowels. As (50-d-h) illustrate, after a [-high, -round] vowel, any of the [+high] vowels may follow, while only [-high] vowels which are [-round] may follow. Similarly, after a [-high, +round] vowel, any of the [+high] vowels may follow, but only [-high] vowels which are [+round] may follow. This exemplifies the essential pattern of “labial attraction” among low vowels in Tungusic languages, and confirms the height specifications assumed in (48).

- (50) Roots with /a/ in the initial syllable: no /ö,ɔ/ follow:

- a. aχa rain
- b. mami grandmother
- c. narχun thin, slim
- d. ani year
- e. maχal cap, hat
- f. sarχin wife
- g. dzalu full
- h. madzig little, slightly

(51) Roots with /ε/ in the initial syllable: no /ö,ɔ/ follow:

- a. χεrχa pine tree
- b. tεxa hunting dog
- c. vequ askew, slant
- d. εtχun wild boar
- e. εlin mountain
- f. εdki neighbor
- g. χεti to fasten
- h. tεvilχun a kind of willow

(52) Roots with /ɔ/ in initial syllable: no /a,ε/ follows:

- a. bɔdɔmin plan
- b. ɔlχun dry
- c. ɔdzi to kiss
- d. ɔmɔl grandson
- e. ɔrχu grass
- f. χonin sheep

(53) Roots with /ö/ in initial syllable: no a,ε/ follow¹²:

¹²Except for Uygur loanwords (Li 1996: 196): *çöbe* (*subsidiary*, Uyg. *jöber*); *çöget* (*oleander*, Uyg. *jöget*); *kötär* (*vegetable garden*, Uyg. *kötatliq*).

- a. ölxɔ cowardly
- b. döçü to enter
- c. tɕõki to peck
- d. ömi to drink
- e. ötüvu to be greedy
- f. tɕõru the day after
- g. tömxɔ nipple

Returning to the theoretical question posed by forms such as *uva* (49)[e], it becomes clear that there is a condition blocking the spread of [round] from [+high] to [-high] vowels. This is schematically illustrated in (54):

- (54) Round Harmony Patterns:
- Low → Low OK
 - High → Low BLOCKED
 - High → High OK
 - Low → High OK

The state of affairs in (54) cannot be modeled by assuming that high vowels are underspecified for [high]; if so, there would be no way to state the blocking of rounding harmony from high vowels to non-high vowels. However, full specification of vowels for [high], as in (48), allows for a simple formalization of the conditions on rounding harmony¹³:

- (55) Spread [Round] rightwards except:
- (i) from [+high] to [-high]
 - (ii) from [+back] to [-back]

¹³The particular formulation of these constraints on [round] spreading is not crucial here; for example, see Kaun (2004) for an implementation of (i) and (ii) in terms of perceptual grounding.

The important conclusion of this subsection, then, is that the behavior of the two vowel heights in Rounding harmony provides independent syntagmatic evidence for a natural class of [+high] and [-high] vowels.

2.4.3. Velar/Uvular Alternations in Sibe Suffixes

The central data of interest are exemplified below. The diminutive suffix for adjectives has four variants in Sibe (Li 1996:201). Whether or not there is a round or unround vowel in the suffix is determined by the roundness of the closest root vowel. Since the suffix vowel is a high vowel, its full participation in rounding harmony will follow predictably, as discussed in the previous subsection. Hence, (56-a-h) exhibit an unround high, back vowel when the closest vowel to the left is [-round], while (56-i-p) exhibit a round, high back vowel when the closest vowel to the left is [+round].

The alternation between a velar ([+high]) and uvular ([-high]) consonant in the suffix, on the other hand, is determined by whether there is a [-high] vowel preceding *anywhere in the word*. In (56-a-d) and (56-i-l), no [-high] vowel precedes the suffix, and hence its initial consonant surfaces as [k]. In (56-e-f) and (56-m), when the stem vowel that is closest to the suffix is [-high], the suffix surfaces with [q]. The most surprising and compelling cases are those in (56-g-h) and (56-n-p), in which the suffix surfaces with [q], even though the determining [-high] vowel is two syllables away, and a [+high] vowel intervenes.

- (56)
- | | | |
|----|----------------|--------|
| a. | ildi(n)-kin | bright |
| b. | ɕümi(n)-kin | deep |
| c. | muxuli(n)-kin | round |
| d. | udzi(n)-kin | heavy |
| e. | ɕa(n)-qin | good |
| f. | sula-qin | loose |
| g. | ɕɔlmi(n)-qin | long |
| h. | adzi(g)-qin | small |
| i. | untuxu(n)-kun | empty |
| j. | ulu-kun | soft |
| k. | giltu(xun)-kun | severe |
| l. | irsu(n)-kun | ugly |
| m. | tɔndɔ-qun | honest |
| n. | χɔdu(n)-qun | quick |
| o. | dzalu-qun | full |
| p. | farχu(n)-qun | dark |

This behavior is not limited to this particular suffix. Identical factors govern the alternation of the comparative suffix, which has the variants -kindi / -qindi / -kundi / -qundi (Li 1996: 201). In fact, velar/uvular alternations are not limited to the [-continuant] series of Dorsal consonants. The suffix of the non-self-perceived immediate past tense shows an alternation between the voiceless velar fricative /x/ and the voiceless uvular fricative /χ/ (Li 1996: 202).

- (57)
- a. dʒi-xi to come
 - b. ti-xi to sit
 - c. içi-xi to be enough
 - d. gini-xi to go
 - e. tisu-xu to satisfy
 - f. türü-xu to rent
 - g. utu-xu to dress
 - h. xinu-xu to hate
 - i. tüke-çi to watch
 - j. sav-çi to see
 - k. fɔndʒi-çi to ask
 - l. ömi-çi to drink
 - m. tɔ-çu to curse
 - n. gö-çu to hit (the target)
 - o. bɔdu-çu to consider
 - p. lavdu-çu to become more

As can be seen in (11a-d) and (11i-l), a [-round] rightmost stem vowel yields a [-round] vowel in the suffix, while in (11e-h) and (11m-p), a [+round] rightmost stem vowel yields a [+round] vowel in the suffix. The velar/uvular alternations are conditioned by the same factor as those in (10): whether a [-high] vowel precedes anywhere in the word. Hence, (11i-p) exhibit the uvular suffix, even when the conditioning [-high] vowel is non-local to the suffix, as in (11k-l) and (11o-p).

Finally, the velar/uvular alternation shows long-distance effects even across intervening suffixes. Hence, when the reciprocal suffix /-ndu/ precedes the past tense suffix, the uvular variant of the past tense suffix can be conditioned by a [-high] vowel three syllables away (12a). When there are no [-high] vowels preceding in the word, the suffix is realized as a velar (12b).

- (58) a. qari-ndu-çu to protect-reciprocal-past

- b. niki-ndu-xu to rely on-reciprocal-past

The generalization about Sibe suffixes, then, is that a [-high] vowel is sufficient to trigger an alternation from velar to uvular within the Dorsal consonants. The data in (10)-(12) are of obvious interest to theories of the locality of phonological processes. In particular, the fact that a [-high] vowel can induce a [-high] alternation across an intervening [+high] vowel exemplifies a case in which contrastive segments are transparent to an assimilation process. Before proceeding with a theoretical account, however, it is worth considering uvularization processes induced by [-high] vowels in other languages. Similar alternations in Turkana and Yakut will illustrate that a causal relationship between [-high] vowels and uvular consonants is well-attested cross-linguistically.

2.4.4. Crosslinguistic Evidence for Uvularization by [-high] Vowels

There has been a good deal of attention to the fact that uvular consonants may differ in their featural composition (see Trigo (1991) for a thorough discussion). In Sibe, as we have seen, [-high] seems to be a necessary component of uvulars. In Chomsky and Halle (1968), it was suggested that uvulars are [+back, -high]. While there has been a recent tendency to treat the uvulars of certain languages as [-ATR] (see Shahin 2002 for a proposal on Palestinian Arabic), it is not always the case that [-ATR] vowels are necessary for inducing uvularization¹⁴. In fact, in Turkana, one finds quite the opposite.

Turkana has a nine-vowel system, with a contrast between [+ATR] and [-ATR] in all vowels except /a/:

(59) Turkana vowel inventory (Dimmendaal, 1983):

¹⁴Throughout the discussion, [+ATR] will be used interchangeably with [-RTR], and [-ATR] will be used interchangeably with [+RTR].

	i	ɪ	e	ɛ	a	ɔ	o	u	ʊ
high	+	+	-	-	-	-	-	+	+
low	-	-	-	-	+	-	-	-	-
back	-	-	-	-	+	+	+	+	+
ATR	+	-	+	-	-	-	+	+	-

Dimmendale (1983:9) describes uvularization in Turkana as follows: "The voiceless velar obstruent /k/ obligatorily becomes a uvular obstruent when surrounded by /o/'s, /ɔ/'s, or /a/'s, on the condition that such a vowel belongs to the same phonetic syllable as the velar obstruent. If /k/ is preceded and followed by back vowels, it further changes to [χ],[ʁ], or [ʁ]." In other words, the context is [-high,+back], and the advancement or retraction of the tongue root is, in fact, irrelevant, particularly because both /o/ and /ɔ/ can induce uvularization (60).

(60) Turkana uvularization:

	UR	SR	gloss
a.	a-bokok	a.bo.ɣoq	turtle
b.	na-bəkəbək	na.bəɣəbəq	elephant shrew
c.	a-kamu	a.ɣa.mu	dry season
d.	a-kəkək-aan-ut	a.ɣoo.kyaa.nut	loneliness

In short, there is cross-linguistic support that [-ATR] is not a necessary feature for uvularization in a given language. Trigo (1991) provides independent arguments that "pharyngeality remains orthogonal to uvularization" in Akha, where low vowels from both the "head" (-RTR) and "chest" (+RTR) register trigger lowering of [x] to [χ].

Recall that the proposed generalization about Sibe is that [-high] is sufficient to induce uvular alternations in the suffix. While Turkana uvularization illustrates a case in which uvularization can proceed without the feature [-ATR] on a triggering vowel, it remains to be shown that, in addition, [-back] is not a necessary feature. Yakut, as described by Krueger (1962), illustrates such a case.

Yakut has an eight vowel system¹⁵, as shown in (61). There is active [back] and [round] harmony in the language.

(61) Yakut vowel inventory:

	-back, +rd	-back, -rd	+back, -rd	+back, +rd
high	ü	i	ɨ	u
low	ö	e	a	o

Among the Dorsal consonants, Yakut has velar /k g/ and uvular /q χ ʁ/ , which occur in the following contexts (Krueger 1962: 55):

- (62) a. q after a o e ö ia uo ie üö; k **elsewhere**
 b. χ after a o e ö ia uo ie üö; g **elsewhere**

Yakut Dorsal consonants, therefore, also require [-high] as a necessary feature for uvularization. Importantly, since both /ö/ and /e/ can trigger uvularization, it can be observed that [+back] is not always necessary for uvularization. Consonantal alternations of this sort in suffixes can be illustrated with the 2nd.pl /-git/ (D'jačkovskij 1987; Krueger 1962: 89). In (63), both [+back] (17c-d) and [-back] (17e-f) harmonic vowels may trigger uvularization, as long as they are [-high].

(63) Yakut velar/uvular alternations:

- a. tɨ:-git your-pl. boat
 b. kel-li-git you-pl. came
 c. sa:-ʁit your-pl. gun
 d. oʁo-ʁut your-pl. child
 e. kinige-ʁit your-pl. book
 f. öŋö-ʁüt your-pl. service

On the basis of Yakut, it is possible to conclude that [-high] alone is sufficient to induce uvularization, supporting the generalization that either [-back] or [+back]

¹⁵In addition, there are four diphthongs: ia, ie, uo, üö. The first half is always the determinant of [back] harmony (Krueger 1962:49).

ditions at all on the class of interveners in long-distance agreement phenomena. One formal implementation of the process in which two segments participate in a long-distance agreement without locality conditions may be achieved through Correspondence Theory. Rose and Walker (2004) propose a theory of *Agreement-by-Correspondence*, which is designed for long-distance agreement such as consonant harmony. Rose & Walker's proposal is that only segments which are *highly similar* can participate in non-local agreement. They thus offer a verifiable theory of when and where non-local agreement may obtain. We will return to the details of Rose & Walker's proposal, and the prediction it makes for Sibe (and more generally for vowel-consonant interactions) in the following subsection.

The second class of theories is one in which assimilation processes are indeed governed by locality conditions, but where the locality conditions may be sensitive to varying properties of the interveners. These *Intervener-Based* theories of locality share with the No Line Crossing model the intuition that assimilation processes may be blocked by interveners with certain specifications. However, they may differ in the extent to which the geometry of diagonally crossing lines is employed as a central locality metric. The locality theory of Calabrese (1995) posits that assimilation processes involving a feature *F* may be blocked depending on the *values* of *F* that intervening segments bear. Thus, Calabrese proposes that the locality of an assimilation (or dissimilation) process may be relativized to either *contrastive* or *marked* values of the participating feature. We will return to the details of Calabrese's proposal, and the prediction it makes for Sibe (and more generally for vowel-consonant interactions) after the next subsection.

2.4.6. Evaluating Participant-Based Locality: Sibe Low Vowels and Uvulars are Not 'Similar'

The Correspondence approach to long-distance agreement will be examined for the transparency of Sibe contrastive [+high] segments to the [-high] agreement between low vowels and uvular consonants across them. The Long-Distance Correspondence view has been proposed by Rose & Walker's (to appear), in accounting

for consonant harmony (see also Hannson (2001) for a related proposal). Rose & Walker emphasize the role of *similarity*: “Despite the early promise of the tier-based view of locality, this approach has drawbacks. First, it fails to capture the role of similarity.” (p.47).

The proposal is that long-distance agreement is mediated by Agreement-By-Correspondence (ABC) among similar segments, and that any case of assimilation which is not strictly adjacent will be due to this mechanism. Importantly, Rose & Walker aim to constrain the theory of when two segments can be in an ABC relation, by a mathematical definition of similarity: “We suppose that **correspondence constraints exist only for segment pairs exceeding a certain threshold of similarity**. In this study, we will use the similarity scales resulting from the method of computation proposed by Frisch et al. (2004) - which function as our basis for relative similarity.” (p.22)

The prediction for Sibe is clear. If the low vowels and the uvulars are similar enough, then the case of long-distance [-high] agreement could be due to Correspondence, and thus exempt from the Line-Crossing Constraint¹⁸.

The pairwise similarity values for segments in the Sibe inventory can be computed using the Frisch et. al (2004) algorithm. If ABC is to be constrained in any predictive way, it should be the case that the long-distance agreement between low vowels and uvular segments in Sibe is due to their high degree of similarity.

For ease of exposition, the pairwise similarity values are presented here only for segments that are Dorsal. Since this includes both the velar/uvular consonants and all vowels, an inspection of the highest similarity pairs among these segments can be used to impose an appropriate threshold of what counts as ‘similar’ in the Sibe inventory¹⁹. This is shown in (65). The calculations were performed using full featural specification for the consonants and vowels, with binary values as shown in (1)-(2). The reader is directed to Frisch et. al’s (2004) paper for more thorough

¹⁸Incidentally, the problem that transparent contrastive segments pose for the No Crossing Constraint are similarly posed for syllable-adjacent versions of an output-based AGREE constraint, though we will not address the latter in any detail.

¹⁹Many thanks are due to Adam Albright for assistance in the automation of these computations.

discussion of the algorithm; the point here is that Rose & Walker adopt this specific computation as a predictor of which segments may be eligible for a long-distance agreement relation.

(65) Most Similar Segments Among Dorsals:

Seg1	Seg2	Shared	Total	Similarity	Class
ü	i	462	740	0.624	High Front Vowels
χ	x	164	270	0.607	Voiceless Dorsal Continuants
ö	e	260	430	0.605	Low Front Vowels
u	i	242	414	0.585	High Back Vowels
ɠ	ɣ	278	480	0.579	Voiced Dorsals
o	a	134	241	0.556	Low Back Vowels
q	x	156	283	0.551	Voiceless Dorsals
g	d	460	856	0.537	Voiced Stops
ö	ü	276	520	0.531	Front Round Vowels
e	i	378	718	0.526	Front Unround Vowels
k	t	248	482	0.515	Voiceless Stops

The table in (65) establishes the most similar segments within the Dorsal class, with 0.50 chosen as a threshold for a reasonable degree of similarity. Towards the bottom of the table, it is found that front round vowels /ü/ and /ö/ count as highly related, as do the front unround vowels /e/ and /i/. Importantly, there are no vowel-consonant pairs in this table. Thus, direct inspection reveals that the agreement relation between the low vowel and the uvular in a form such as dzalu-qun is not predicted within a Participant-Based theory of long-distance Correspondence.

The similarity relationship between low vowels and uvular consonants does not exceed a reasonable estimate for the similarity cutoff threshold across the language. However, it could be the case that, due to the particulars of the Sibe inventory, /q/ is as a whole less similar to other segments than might be expected. Hence, an important intuition of the Participant-Based theory of ABC might be

preserved if, among all pairwise segments in the inventory, /q/ is more similar to [-high] vowels than other segments. The table in (66) shows the similarity values for /q/ with all segments in the Sibe inventory, to a cutoff of 0.05. Importantly, the similarity of /q/ to the [-high] vowels is extremely low.

(66) Similarity Values for /q/:

Seg1	Seg2	Shared	Total	Similarity
q	x	156	283	0.551
q	k	174	422	0.412
q	ɣ	139	487	0.285
q	t	96	414	0.232
q	g	149	767	0.194
q	p	63	332	0.19
q	s	84	533	0.158
q	ŋ	67	521	0.129
q	d	86	690	0.125
q	f	48	386	0.124
q	b	53	487	0.109
q	z	78	916	0.085
q	n	40	494	0.081
q	v	43	583	0.074
q	m	24	360	0.067
q	r	48	724	0.066
q	l	24	457	0.053
q	ɑ	160	348	0.46
q	χ	102	269	0.379
q	a	48	362	0.133
q	e	64	522	0.123
q	o	31	310	0.1
q	ö	42	438	0.096
q	ɨ	44	536	0.082
q	i	60	826	0.073
q	u	29	423	0.069
q	ü	40	652	0.061

Thus, Rose & Walker's principled approach to Participant-Based Locality, based on the similarity of the segments undergoing Agreement-by-Correspondence, predicts that the low vowels and the uvular stops should *not* participate in long-distance agreement, contrary to fact. In Sibe, the similarity of the triggering vowel to the target consonant is much lower than that of the triggering vowel to the transparent intervener. Whether or not this highlights a general shortcoming of similarity-based models for all instances of Vowel-Consonant is an open issue. For example, in the case of Ṣanānī Arabic (Watson, 1999), emphatic consonants induce [+round] valuation in high vowels, even at long distances:

(67)

(68) tayuub

Assuming that [+round] is a feature on pharyngealized consonants (Jakobson, 1978, 272), this process may be characterized as X. It is quite unlikely that these segments are "similar".

More immediately to our present concerns, the calculations here are sufficient to demonstrate that this theory of locality makes the wrong predictions for Sibe uvularization.

2.4.7. Intervener-Based Locality: Relativized to Marked [-high] in Sibe

The theory of locality that will ultimately account best for the Sibe data is one that emphasizes the potential role of intervening segments. In an intervener-based theory of locality, a featural relation (such as assimilation) may take place between any two segments within the word domain, as long as no segment of *the relevant type* intervenes.

Assuming full specification for all features, we may continue to adopt the insights of Calabrese (1995), in which, for harmony involving the feature *F*, potential intervening segments can be relativized to three types: all values of *F*, those which are **contrastive** for *F*, and those which bear the **marked** value of *F*. The definitions

of *contrastive* and *marked* are provided below²⁰

- (69) A segment S with specification αF is *contrastive* for F if there is another segment S' in the inventory that is featurally identical to S, except that it is $-\alpha F$
- (70) A segment S with specification αF is *marked* for F if the value α is the marked value of F (with markedness determined by the learner based on paradigmatic & syntagmatic processes)

Since there is full specification of feature values for all segments, the notion of intervention in this approach depends not only on the presence of a feature, but its values as well. The leading idea is that each assimilation or dissimilation process may parametrically vary in its sensitivity to the values of intervening segments.

2.4.8. Contrastive Visibility: Examples from Consonant Harmony

A simple exemplification of contrastive visibility can be found in the familiar process of [lateral] dissimilation in Latin. The adjective-forming suffix is *-alis* (71-a-d), but changes to *-aris* if the stem contains an /l/. This can be seen as a dissimilation of [+lateral] when preceded by another [+lateral]²¹ (71-e-h). This dissimilation process can occur across intervening consonants and vowels, as long as they are not contrastive for [lateral]. However, an intervening /r/, which is contrastive for [lateral], will intervene, blocking application of the dissimilation rule²².

- (71) Latin Liquid Dissimilation (Gildersleeve and Lodge, 1895): Only contrastive [lateral] visible

²⁰The definitions of contrastive and marked depart from those of Calabrese (1995), who makes crucial use of universal filters and deactivation statements.

²¹Long-distance lateral dissimilation is also attested in Kuman, Yidin^y, and Yimas; the reader is referred to Suzuki (1998) for discussion and references.

²²Apparently, the form *fluvi-alis* is an exception to this rule.

- | | | |
|----|---------------|--------------|
| a. | nav-alis | naval |
| b. | mort-alis | mortal |
| c. | ven-alis | venal |
| d. | caud-alis | caudal |
| | | |
| e. | milit-aris | military |
| f. | lun-aris | lunar |
| g. | consul-aris | consular |
| h. | vulg-aris | common |
| i. | flor-alis | floral |
| j. | sepulchr-alis | funereal |
| k. | litor-alis | of the shore |

Intervening consonants such as /t,n,g/ in (71-e-h) do not block the [+lateral] dissimilation, since they are not contrastive for [lateral], but intervening /r/ in (71-i-k) does, because it *is* contrastive for lateral, by the definition in (18).

Having illustrated the effects of contrastive visibility, we turn to marked visibility, which plays a central role in the analysis of Sibe Uvularization.

2.4.9. Marked Visibility: Sibe Uvularization

We may consider a simple case of *marked* visibility in the behavior of rounding harmony in the Karchevan dialect of Armenian (Vaux, 1998). Karchevan shows epenthetic harmony, according to which the [round] and [back] specifications of epenthetic vowels are determined by neighboring segments. Karchevan has the following vowel inventory:

(72) Karchevan Vowel Inventory (Vaux 1998: 166)

[-bk,-rd]	[+bk,-rd]	[-bk,+rd]	[+bk,+rd]
i	ɨ	ü	u
e	ɛ	ö	o
æ	a		

In Karchevan, nouns are followed by the definite article, which has the allomorphs {i i ü}. Importantly, the [+round] variant, [ü], only occurs after the [+round] vowels {ü,ö}, but not after the [+round] vowels {u,o}. Illustrative examples are as follows:

(73) Karchevan epenthetic harmony (Vaux 1998:169)

- a. værd-i rose-def.
- b. béh-i spade-def.
- c. vit^hs-mindzi six-ordinal
- d. hák^h-i foot-def.
- e. t^hʃok^h-mindzi four-ordinal
- f. tisin-mindzi ten-ordinal
- g. jorku-mindzi two-ordinal
- h. mürdzúm-ü ant-def.
- i. bódzür high-def.

Karchevan thus demonstrates a case of [round] valuation that is sensitive not only to the presence of the feature [+round], but to its *value*, which, by universal convention (e.g., Kean (1975)) is only marked in vowels that are [-back]. The fact that only {ü,ö} value roundness on the epenthetic vowel is thus a result of the fact that, for some features in certain processes, potential sources of featural assimilation may be relativized to those bearing particular values. In this case, the values ‘-’ of [round] in [-back] vowels and ‘+’ of [round] in [+back] vowels are simply not visible to determining the quality of the epenthetic vowel.

We may find an even more compelling case of *marked* visibility as we return to the central data at hand. We can now formulate the locality conditions for Sibe

uvularization.

- (74) *Marked Visibility for Sibe Uvularization*: Copy [αhigh] to alternating suffixes²³, with only the **marked** value of [high] (- in Sibe) visible

Under the formulation of (74), the spreading of [-high] from the low vowel to the dorsal consonant of the suffix in lavdu-χu may occur because, as will be discussed below, minus is the marked value of [high] in Sibe. Given a *marked*-only parametrization of visibility, the intervening [+high] vowels will not be relevant interveners, and will not interfere with the locality of long-distance [-high] assimilation.

Any determination of an assimilation rule as being relativized to marked feature values only must rely upon independent evidence for the marked value of the feature under scrutiny. There are three sources of distributional evidence, completely independent from the uvularization process, that [-high] is the marked value for [high] in Sibe. The first comes from cooccurrence restrictions. Li (1996, based on observations over the Sibe lexicon (though without explicit quantification), states that “Sibe has a restriction on low vowel co-occurrence within the domain of a phonological word.” (p.203). Li’s observation is that, by and large, the language disfavors too many low vowels in a word, and this is one often-used diagnostic for markedness of a particular feature, in this case, [-high]. A second source of evidence comes from the distribution of vowels with suffixes. Most suffixes in Sibe contain a single high vowel. In addition to the alternating inflectional suffixes discussed earlier, all of which contain a high vowel, Sibe contains the following suffixes.

- (75) Alternating derivational suffixes: -lu/li -nu/ni -ru/ri -du/di (Li 1996:199-200)

Nonalternating derivational suffixes: -çi -rtan -nɔfi (Li 1996: 201)

²³The lowering rule does not apply root-internally (cf. edki, ‘neighbor’; üχa, ‘to itch’). Thus, the rule must be more specific than a general Left-to-Right spreading from low vowels to Dorsal consonants, hence the formulation here in terms of alternating suffixes.

Nonalternating inflectional suffixes: -kin -tçi -maq -mætçi -ma -ndu -tçivi
-tis (Li 1996: 203)

The relative distributional bias towards [+high] vowels in suffixes suggests that this is the unmarked value for [high] in Sibe, especially in the light of the recent body of research suggesting that affixes tend to draw from the unmarked pool of segments within a given language. For example, English inflectional affixes only draw from the coronal consonants, Lushootseed has glottalized consonants only in roots and lexical suffixes (Urbanczyk, 1995), and Cuzco Quechua does not have aspirated stops in suffixes (Beckman, 1998). These cases illustrate that affixal inventories tend to be reduced in favor of the unmarked values of segmental contrast, and support the view that the relative dearth of [-high] vowels in Sibe suffixes is due to their marked status.

Next, vocalic epenthesis in Sibe is always a [+high] vowel (either the high back rounded [u] or high back unrounded [ɨ], due to harmony from the value of [round] in the immediately preceding vowel). Examples are shown in (76) and (77).

(76) Epenthesis with accusative ending /-v/:

- a. εχ-ɨ-v large.bead-acc.
- b. tasχ-ɨ-v tiger-acc.
- c. döv-u-v fox-acc.
- d. mul-u-v beam-acc.

(77) Epenthesis between causative /-v/ and present-future tense /-m/:

- a. ömi-v-ɨ-m to drink
- b. va-v-ɨ-m to kill
- c. çöndzü-v-u-m to elect
- d. bu-v-u-m to give

Finally, there is some diachronic evidence that low vowels are marked in Sibe. Zhang (1996) provides a comparison of Sibe and its predecessor, Written Manchu. Written Manchu had stress on the final syllable, while Sibe has moved stress to

the initial syllable, probably under the influence of Mandarin Chinese (Zhang 1996:151). Importantly, Sibe has raised what was Manchu /a/ to *i*, and has raised what was Manchu /o/ to /u/. Examples of the correspondences are shown in (78)

(78) Sibe has raised the original Manchu back [-high] vowels to [+high] (Zhang 1996:129):

	Written Manchu	Sibe	gloss
a.	ama	ami	father
b.	ana	ani	push
c.	darama	darim	mosquito
d.	mama	mami	grandmother
e.	tata	tati	draw
f.	talman	talmin	fog
g.	jafa	dzavi	seize
h.	bodo	bodü	think
i.	songgo	soŋu	cry
j.	onggo	oŋu	forget
k.	holto	χoltu	deceive
l.	sokto	soχtu	be drunk

The raising of [-high] vowels under loss of stress can be straightforwardly attributed to the markedness of [-high] in vowels. Stem vowels that were no longer protected by positional prominence lost their marked [-high] feature in Sibe²⁴. This particular featural change must be due to the markedness of [-high], since not every language raises vowels under reduction: Belarussian (Crosswhite 2004) *lowers* the mid vowels when unstressed, as does Makonde (Liphola, 1999). Thus, the diachronic raising of unstressed vowels supports the claim that [-high] is marked in

²⁴The other two [-high] vowels in Sibe, /ε/ and /ö/ did not exist in Manchu, and were created in initial syllables in Sibe by an umlaut process, e.g. WM *omi* → Sibe *ömi* 'to drink' and WM *alin* → Sibe *elin* 'mountain'. Since these low vowels were in the initial, stressed syllable in Sibe, they were not subject to markedness reduction.

Sibe.

Based on the evidence from word-internal cooccurrence restrictions, the distribution of vowels within suffixes, and the quality of epenthetic vowels, the learner may unambiguously conclude that [-high] is the marked value of [high] in Sibe. Once this has been determined, the learner may posit a simple rule governing the alternation of velar and uvular consonants within suffixes:

- (79) Sibe: Copy the closest value of [-high] to the alternating suffixes KI,XI,KINDI.
- a. Marked [high] valuation
Structural Description: $X_{[-high]} \dots C_{target}$
Structural Change: C_{target} becomes [-high]
 - b. Context-free Raising
Structural Description: $X \dots C_{target}$
Structural Change: C_{target} becomes [+high]

This formulation of the locality conditions on Sibe uvularization as in (79) avoids the pitfalls of an underspecification account that were discussed earlier, as all segments are fully specified for [high], and it is simply their *values* that matter for a given process. The visibility of intervening segments in a syntagmatic process such as assimilation is determined by the paradigmatic properties of contrastiveness and markedness.

As Michael Kenstowicz (personal communication, March 2004) points out, if the parametrization of visibility in terms of contrastive vs. marked values is correct, the prediction is that there should be a related language, completely analogous to Sibe, except with access to contrastive specifications of [high] determining the locality conditions of V-C uvularization. In fact, such a language exists, as we see in the next section.

2.4.10. Sanjiazi Manchu: Contrastive Visibility for [high]

As another descendent of Classical Manchu, Sanjiazi Manchu is one of the closest languages to Sibe. The representative of modern Manchu investigated in Li's (1996) book is the dialect spoken in Sanjiazi, near the Nenjiang river in the west part of Heilongjiang province. Sanjiazi Manchu has an identical consonant inventory to Sibe, an almost identical vowel inventory, and also no trace of RTR harmony²⁵. The vowel inventory is in (80).

(80) Sanjiazi Manchu vowel inventory:

	[-back, -rd]	[-back, +rd]	[+back, -rd]	[+back, +rd]
[+high]	i	ü	ɨ	u
[-high]	æ		a	ɔ

The vowels /a/ and /æ/ pattern together in taking the low vowel /a/ in suffixes (as can be seen in the examples below), providing supporting evidence that these two vowels form a natural class in their specification as [-high] (and [-round]).

Like Sibe, Sanjiazi Manchu shows velar/uvular alternations in the Dorsal consonants of the past tense suffix $-\chi a / -x\dot{i} / -xu / -x\dot{o}$, with rounding harmony determining the quality of the suffix vowel. However, unlike Sibe, the visibility of intervening feature values in Sanjiazi Manchu is sensitive to all *contrastive* values for [high].

(81) Sanjiazi Manchu: Copy the closest contrastive value of [high] to the alternating suffixes

a. Contrastive [high] valuation

Structural Description: $X_{\text{contrastive}}: [\alpha_{\text{high}}] \cdots C_{\text{target}}$

Structural Change: C_{target} becomes $[\alpha_{\text{high}}]$

b. Context-free Raising

²⁵For example, stems that took RTR suffixes in Classical Manchu may take suffixes with either u or i in Sanjiazi (Li 1996:157).

Structural Description: $X \dots C_{\text{target}}$

Structural Change: C_{target} becomes [+high]

(The inclusion of (81-b) is for purposes of minimal comparison with Sibe. It may in fact be necessary for alternations after non-contrastive \ddot{u} ; see footnote 26). The results of (81) may be observed in (82).

(82) Sanjiazi Manchu alternations in the past tense (Li 1996:182):

- a. qa-χa to obstruct
- b. mila-χa to roar
- c. ʃudza-χa to rely on
- d. sæ-χa to bite
- e. ɔm-χɔ to drink
- f. davi-xi to stride
- g. ildi-xi to shine
- h. dazi-xi to repair
- i. tæri-xi to plant
- j. sü-xu to mix
- k. dɔndzi-xi to listen
- l. matʃu-xu to grow thinner

As (31a-e) show, when the nearest contrastive specification for [high] to the Dorsal consonant of the suffix is a [-high] vowel, the suffix surfaces with a [-high], uvular [χ], whereas when closest contrastive value is [+high], the suffix surfaces with [+high] velar [x]. Thus, no long-distance copying of [-high] across an intervening [+high] segment can occur in Sanjiazi Manchu, because the intervening values of [+high] are contrastive²⁶. That it is indeed a rule sensitive to contrastive specifi-

²⁶As the Sanjiazi Manchu inventory reveals, the front round high vowel / \ddot{u} / is not contrastive for [high], as it has no [-high] counterpart in the 7-vowel system. However, Li's (1996) book contains no examples of suffix alternations for a word in which / \ddot{u} / follows a [-high] vowel. In addition, Bing Li (personal communication, April 2004) reports that his field notes contains no such verb roots. The prediction here is that / \ddot{u} / should be transparent in such contexts since it is not contrastive for [high], and allow uvularization to pass through it by a preceding [-high] vowel.

cations of [high] can be verified by (31e), in which uvularization occurs across the intervening consonant [m], which is not contrastive for [high].

The distinct parametrization of intervener visibility of Sanjiazi Manchu and Sibe can be seen when comparing Sanjiazi Manchu [dɔndzi-xi], in which contrastive [+high] is visible and yields a velar alternant in the suffix, with near-minimal Sibe [fɔndzi-χi] ('to ask'), in which only marked [-high] is visible, yielding a uvular alternant. Sanjiazi Manchu uvularization is thus formally identical to Sibe, with the difference of the parametric visibility of the specified features resulting in different assimilation behavior.

It is at this point useful to provide a comparison of the analysis offered here, in terms of contrastive and marked values of [high], with a privative analysis. It is indeed imaginable to propose that [high] and [low] are simply different features on different tiers (though certainly not done in practice; see Goldsmith 1987). Their contrastive relation of opposition would be handled by some additional statements of the grammar, but they would formally be defined as two distinct features. With this assumption, one could propose that in Sibe, [low] spreads from low vowels to the Dorsal consonant. In long-distance cases, the spreading of [low] would be across a segment with no specification for [low], only one for [high], which would be on a different tier. Thus, dividing [low] and [high] on separate tiers would allow one to maintain the traditional Line-Crossing approach to locality for Sibe.

Such an analysis, whatever its merits in explaining the transparency of high vowels in Sibe, is to be dispreferred, because such an arrangement cannot be generalized to other for two-height languages. Indeed, having privative [high] and [low] would make the wrong prediction that Sanjiazi Manchu should also have transparent high vowels in uvularization, which we have just seen is false. Once the model allows [low] spreading across any segments not specified on the [low] tier, it becomes difficult, if not impossible, to derive the microparametric difference in locality between Sibe and Sanjiazi Manchu.

2.4.11. Tangential Excursus: Phonetic Evidence for Non-Local [RTR] Copying

It may be proposed that even though [RTR] is not active in Sibe, what is spreading to the Dorsal consonant is actually [RTR] and not [-high] (the proposal would have include that /ö/ was [RTR]). The only reason to invoke such a proposal (as the learner has no evidence that [RTR] is a natural class of vowels in the language, and it is well known that [-high] causes uvularization without [RTR], as shown earlier by Turkana) would be to attempt to maintain that all intervening segments are actually being affected, but that Li somehow missed transcription of the intervening vowels. While I cannot argue against this remote possibility for Sibe, it is known that nonlocal [RTR] spreading is phonologically and phonetically well-attested as well. Consider data from Palestinian Arabic, as reported by Shahin (2002):

(83) Transparency of high vowels to RTR harmony: (Shahin 2002:158):

/ʃubb/	[ʃubb]	*[ʃu ^h bb]	"to pour"
/muh _r -æ:t/	[m _r u.hu.'r-æ:t]	*[m _r u ^h .hu.'r-æ:t]	"fillies"
/b-ʃæti-næ-f/	[b-ʃæ ^h .ti-'næ:-f]	*[b-ʃæ ^h .ti-'næ:-f]	"he doesn't give (something) to us"

Shahin's remarks on the acoustic evidence for non-local harmony (i.e. non-contrastive invisibility of high vowels) are worth repeating here:

"We now consider data on Palestinian non-low vowels in an [RTR] context. We focus on F₂, as the present dataset indicates that F₂ drop is the most salient effect for segments which are presumably produced with uvularization. **Contrasting with the steady lowered F₂ observed for tokens of the low vowel in a uvularization context, no steady lowered F₂ is observed for non-low vowels in that context**" (Shahin 2002: 158)

To conclude this excursus, then, we note that transparency in Palestinian [RTR] harmony shows that the human articulatory system is indeed capable of producing two [RTR] gestures that flank an intervening high vowel and yet, *do not have an*

acoustic effect on that vowel. Thus, an attempt to reanalyze Sibe non-local uvularization as actually local [RTR] harmony is based on nothing more than vain hopes.

2.5. Contrastive [back] harmony in Turkic

I will begin this section by noting that the central role of contrastive values in determining participation harmony bears dramatic consequences in Turkic, where the adoption of (84) (recall also (85)) yields different outcomes depending on the inventory.

- (84) Copy the **closest** contrastive value of [back]
- (85) A segment *S* with specification αF is *contrastive* for *F* if there is another segment *S'* in the inventory that is featurally identical to *S*, except that it is $-\alpha F$

Importantly, the formulation in (84) does not require us to say that “Kyrghyz has vowel harmony”, “Turkish has vowel harmony that is interrupted by some consonants”, and “Karaim has consonant harmony”. All three languages share the single rule in (84). Glides are transparent to [back] harmony throughout Turkic, because they are never contrastive for this feature. Velars and Liquids participate in [back] harmony in Turkish, because they have contrastive counterparts. Finally, all consonants (except glides) participate in [back] harmony in Karaim, because, due to the unusual structure of the inventory, they are contrastive for [back]. We consider each case in turn.

2.5.1. Glides versus Palatalized Consonants in Turkish and Kyrghyz

Glides are transparent to vowel harmony throughout Turkic. In Nevins and Vaux (2004), we examine Kyrghyz as a concrete illustration of this phenomenon, providing phonetic evidence for the transparency of the palatal glide *j* in Kyrghyz [back]

harmony²⁷. We argue that this transparency is due to a contrastive setting of the visibility parameter: importantly, due to the featural representation of glides, they are not contrastive for [back]. We return to the representation of glides after introducing the harmony system of the language. The Kyrgyz vowel inventory is given in (86).

(86)

	[-back, -round]	[-back, +round]	[+back, -round]	[+back, +round]
[+high]	i	ü	ï	u
[-high]	e	ö	a	o

Palatal harmony (copying of [back]) applies to all vowels in suffixes.

(87) LOCATIVE -tA (Wurm, 1949, p.77):

turmuš-ta 'in the life'
 el-de 'in the nation'
 toɣoj-do 'in the forest'
 üj-dö 'in the house'

(88) GENITIVE -dIn (Wurm, 1949, p.77):

iš-tin 'of the work'
 džił-din 'of the year'
 toɣoj-dun 'of the forest'
 üj-dün 'of the house'

(89) ORDINAL -InçI (Poppe, 1963, p.7-8):

beš-inçi 'fifth'
 altï-nçi 'sixth'
 toguz-unçu 'ninth'
 tört-ünçü 'fourth'

(90) DEFINITE PAST -dI (Johnson, 1980, p.90):

²⁷Our research was done in April-May 2004 with Dr. Saltanat Mambaeva, a resident of Bishkek visiting Univ. Wisconsin-Milwaukee.

ber-di 'gave'
al-dī 'took'
tut-tu 'held'
kör-dü 'saw'

Importantly, the palatal glide is transparent to [+back] harmony across it:

- (91) 1SG. POSSESSIVE -Im (SM):
üj-üm 'my house'
oj-um 'my idea'
aj-īm 'my moon'

The glide does not itself undergo harmony (92), nor does it block or initiate harmony across it (93):

- (92) *üüüm, *oūum, *oïim

- (93) *oj-üm, *aj-im

Thus, what is initially surprising about Kyrghyz is that the glide, which is [-back], nonetheless allows as [+back] span across it. Like Kyrghyz, Turkish has a transparent palatal glide²⁸. Recall from Chapter 1, however, that in addition Turkish has three [± back] consonant pairs: k/k', g/g', l/l' (Clements & Sezer 1982, Levi 2004) that are *contrastive* and hence do participate in harmony (94):

²⁸Notably, derivational opacity can be observed in Turkish, where [+back] harmony applies across a [-back] glide, followed by pre-palatal umlaut. Thus, *yap-ma-yaca-m* 'do-neg-future-1sg', shows transparency of the glide to [+back] harmony, followed by the process of pre-palatal umlaut, resulting in surface-disharmonic *yapmiyacam*. I assume a rule-ordering solution to this problem.

- (94)
- | | | |
|---------------------|--------------------------|-----------------------|
| usul ^y | usul ^y -ü | system-acc.sg |
| sual ^y | sual ^y -i | question-acc.sg |
| okul | okul-u | school-acc.sg |
| karakol | karakol-u | police station-acc.sg |
| petrol ^y | petrol ^y -de | petrol-loc.sg |
| mefgul ^y | mefgul ^y -düm | busy-past-1.sg |

The puzzle, therefore, is that [-back] liquids participate in harmony, but the [-back] glide doesn't. The intuition is that there is no [+back] counterpart to the glide. Existing analyses (e.g. Clements & Sezer 1982) of Turkic consonantal participation extrinsically designate *l^j* as an Opaque P-bearing segment and *j* as a transparent, non-P-bearing segment (translated into various vocabularies). Recall, however, that our aim is to *predict* what participates in [back] harmony, simply by inspecting the inventory.

We turn, therefore to the question of the representation of glides, in particular /i/ vs. /j/. We may first briefly review the predominant models in the literature. Many researchers claim that *syllabic position alone* differentiates /i/ and /j/ (Clements and Keyser, 1983; Rosenthal, 1994). An immediate problem arises, however, when *both* can occur in a postnuclear position, yielding minimal pairs:

- (95) Central Alaskan Yupik Eskimo (Woodbury (1987, p.687), Hayes (1989)):
- a. áŋyalíyulúúní boats-excellent-make-3sg.ind.
"He was excellent at making boats"
 - b. áŋyalíyyulúúní boats-EXCELLENT-make-3sg.ind.
"He was excellent-EXPRESSIVE at making boats"

Further Problems for the "/j/ = Non-Nuclear /i/" hypothesis arise when the same surface glide has two distinct underlying sources. One example comes from Karuk (Bright, 1957; Herman, 1994; Levi, 2004), which has two sources for glides, resulting in the (phonologically) minimal pairs θaw_v , 'to knock down acorns' and θaw_c 'to float' (where w_v indicates the glide derived from a vocalic source, and w_c

indicates the glide derived from a consonantal source). This underlying difference arises in the conditioning of phonological rules, as well. For example, Karok has a process of intervocalic deletion of w_v only, so that /ikriw+išrih/ → [ikri:šrih] ‘to sit down’, but the consonantal glide resists this deletion: /ikyiw+išrih/ → [ikyiw+išrih] ‘to fall down’. Turning to a further difference, there is a process of pre-consonantal nasalization, which applies only to the consonantally-derived glide; thus /ʔiw_c+kara/ → [ʔi:mkara]; but /θiw_v+taku/ → [θi:wtaku]. It is thus clear from the Yupik and Karuk data that if there are two distinct underlying sources for surface glides, they cannot be differing only in syllabic position²⁹.

A second class of proposals as to the representational difference between vowels and glides comes from Revised Articulator Theory (Halle, 1995; Halle et al., 2000; Levi, 2004), which proposes that the two differ in their *place* of articulation: /i/ has the [Designated Articulator: Dorsal] and /j/ has the [Designated Articulator: Coronal]. There may be some apparent drawbacks to this approach however; as on it predicts the non-existence of Velar Glides (but cf. Axininca Campa (Black, 1993; Spring, 1993). It also makes it difficult to explain why Semitic roots may contain /j/ (with designated articulator: Coronal) and /k/ (with designated articulator: Dorsal), but do not contain /a/ (which is designated articulator: Dorsal).

There is a solution, however, which we adopt here, that encounters none of the above pitfalls, and also predicts that /j/ and /i/ will differ in their transparency in contrastive-value harmony is to posit that these segments differ in value for the feature [consonantal]. There is suggestive evidence that glides and vowels differ in “consonantality”: (Maddieson and Emmorey, 1985) examined [iji] and [uwu] in Amharic, Yoruba, and Zuni, and found that the glides were produced with (a) a lower F1 than the corresponding vowel, (b) a lower F2 for [w] than for [u], and (c) a higher F3 for [j] than for [i]. A reasonable conclusion is that glides (at least in these languages) are produced with greater *constriction* than vowels. The feature [± consonantal] is a good candidate for representing this constriction

²⁹Further evidence comes from Fula alternations (Paradis, 1992; Halle, 1995): /w_cy_c/ → [b,tʃ], but /w_vy_v/ → [gʒ]

difference. Additional evidence comes from Straka (1964), who found that, when segments were produced under *increased effort*, vowels have *less constriction*, while consonants (and glides) have *greater constriction*. We are led to (96):

- (96) Featural representation of constriction difference between /i/ and /j/: [\pm consonantal] (see especially Hyman (1985))

Before proceeding, however, we must consider phonological evidence that Turkic glides are consonantal in their behavior, external to the facts of harmony. I will review here convincing evidence for Turkish from Levi 2004 (Chap. 4), who shows three sources of evidence. First, there is a general process of CC epenthesis, that applies to glide-consonant sequences *bur.nu~burunlar* ‘nose’, and *boj.nu~bojunlar* ‘neck’³⁰.

In addition, there is evident from a rule of quantity-sensitive stress, found mostly in place names. If the penultimate syllable is heavy, it attracts stress in these words (e.g. *Is.tán.bul*, *Va.šínk.ton*). Importantly, there is penultimate stress in *An.tál.ja*, demonstrating that the glide is a consonantal onset to the final syllable.

A final source of evidence for the consonantal status of glides in Turkish to be considered here is allomorph selection for consonant-final stems. Thus, the genitive affix varies in form for C-final *jlan-i* ‘his pipe’ vs. V-final *boru-su* ‘his snake’. Importantly, it takes the C-final form when the stem ends in a glide, resulting in *saraj-ı* ‘his palace’. We thus propose that the Turkish and Kyrghyz palatal glide is represented as follows:

- (97) Featural composition: [+consonantal, +sonorant, +high, -back, -round]

Recall now our definition for contrastiveness (98), and the rule of [back] harmony for Turkic (99):

- (98) A segment S with specification αF is *contrastive* for F if there is another

³⁰We can tell that this is epenthesis between an underlying cluster created in the plural (and not due to syncope in singular) based on *kojunu~kojunlar* ‘sheep’.

segment F' in the inventory that is featurally identical to S, except that it is $-αF$

(99) Copy the closest contrastive value of [back]

As there is no segment in the Kyrghyz or Turkish inventory that is [+consonantal, +sonorant, +high, -round] and [+back], the palatal glide is correctly predicted to be transparent in harmony. That is, a search for valuation will ignore the non-contrastive glide, but include the contrastive liquids, due to the structure of the inventory. Summarizing briefly, we have noted that, throughout Turkic, segments don't participate in [back] harmony when they are not contrastive for [back]. In Karaim, as we will presently see, all consonants (except glides) do participate in harmony, because they are contrastive for [back], and all non-initial vowels don't participate in Karaim, because they're not contrastive for [back]. This leads to the interesting phenomenon of "consonant harmony", for which we have to add nothing to our original rule in (84).

2.5.2. Karaim Consonant Harmony: Contrastive Visibility, with Positional Reference

Having demonstrated the role of contrastiveness in limiting the domain of search for valuation rules, we turn to a refinement of the definition of contrastiveness, switching our attention to Karaim, a Turkic language spoken in Lithuania by a diaspora Jewish population. Karaim employs consonant harmony in roots and in affixes, and interestingly, *does so across intervening vowels, without affecting them*. The consonant harmony in Karaim is for the feature [back], which is contrastive for all consonants in the language. Interestingly, the feature [back] is contrastive for vowels as well, but only in initial syllables. Thus, the transparency of vowels to [back] harmony in non-initial syllables may be understood as an instantiation of non-contrastive transparency, but importantly, this transparency must be relativized to positional contrast, since it is not the case that the feature [back] is absolutely non-contrastive in its feature-set on intervening segments, but rather, only non-

contrastive *in that position*. Having briefly motivated its inclusion in this chapter on contrastiveness, we now turn to a more deliberate presentation of the Karaim conditions on harmony, and some background.

2.5.3. Karaim and the Existence of Consonant Harmony

One reason that Karaim is of particular theoretical interest in the present climate of phonological theory is because a growing body of recent work asserts that consonant harmony is either limited to child language or coronal consonants (NiChiosain and Padgett, 2001; Gafos, 1999; Bakovic, 2000; Krämer, 2003). Gafos attributes this restriction on consonant harmony to articulatory contiguity (the units of which are phonetic gestures), whereby “the vowel gestures are contiguous in a VCV sequence but consonant gestures are not contiguous in a CVC sequence” (1999:41). If one assumes that all phonological processes are strictly local, and that the correct notion of locality in phonology is articulatory contiguity, as Gafos suggests, then the logical consequence is that phonological spreading...could not be involved between the two consonants of a CVC configuration...because the vowel interrupts the articulatory contiguity between the two consonants (Gafos 1999:41). This sort of theory, in which assimilation is asserted to be impossible due to phonetic factors, is often referred to as *Strict Locality*, since, by its very nature, it admits no relativized or long-distance assimilation (with the concomitant claim that apparent counterexamples must be morphological, morpholexical, or misanalyzed).

Hansson (2001), on the other hand, documents innumerable cases of consonant harmony. Through the present study of Karaim, we are able to add one more case, of important theoretical interest, to Hansson’s catalogue. The system is one of consonantal harmony involving the feature [back] in the Northwest dialect of the Turkic language Karaim. We demonstrate this system cannot be insightfully accounted for in the surface-phonetics theory espoused by the proponents of *Strict Locality*, nor by the V-Place/C-Place separation theory of Clements and Hume (1995).

Karaim (also sometimes called Karaite) is a member of the Kipchak subgroup

of the Turkic language family (which also includes Kipchak, Karachay, Crimean Tatar, and Kumyk) is spoken by a small Crimean community whose religious beliefs are traced back to a branch of Judaism which, in the 8th century, rejected the Talmud and pursued a doctrine of sola scriptura. Kowalski, a Polish linguist writing in German in 1929, and the foremost secondary source on Karaim, states that “only five [communities] have survived to the present day...in Poniewież (Karaim Ponevež), Troki, Wilno, Łuck, and Halicz. The colony of Poniewież is now in Lithuania; the remaining four are in Poland. The largest and strongest is the colony of Troki (actually Nowe Troki, Karaim Troχ), a small city” (1929:vi).

Regarding the endangered status of Karaim, Csató (1997) observes that “The number of Karaims in Lithuania is about two hundred, but only a fourth of them, mostly members of the eldest generation, still have a communicative competence in the language. In the Ukraine, the number of Karaim speakers is not more than six.” Due to the recent efforts by Eva Csato & Geoffrey Nathan and Yuni Kim & David Mihalyfy to record the current state of this endangered language and document its ethnomusicological traditions, we have the good fortune to have primary audio recordings of several Karaim speakers (see especially Csató and Nathan (2002)) that can be used to verify and build on the detailed grammatical description by Kowalski.

Karaim is traditionally divided into three dialects (Csato 1997). Kowalski 1929 states that only the Northwestern dialect displays the particular form of consonant harmony in which we are interested; this also happens to be the form recorded by Csato/Nathan and Kim/Mihalyfy, and the form on which we focus here.

2.5.4. The Segmental Phonology of Northwest Karaim

Northwest Karaim features the inventory of eight surface vowels in (1):

(100) Karaim Vowel Inventory (Kowalski 1929)

	-back		+back	
	-round	+round	-round	+round
+high	i	(y)	(ɯ)	u
-high	(e)	(ɔ)	ɑ	o

Kowalski notes that the parenthesized vowels in (100) are distributionally restricted.

First, [ɑ] contrasts with [e] only in initial syllables – elsewhere only [ɑ] occurs. The contrast in initial syllables can be seen in t^hav ‘mountain’ vs. el^j ‘hand’, and the neutralization in noninitial syllables can be seen in forms such as Karaim el^j-d^jan^j ‘hand-ABLATIVE’ (cf. Turkish el-den).

Second, the front round vowels {y ɔ} surface only in word-initial position (e.g. ɔz^jan^j ‘river, yv^jr^jat^j ‘study’) – elsewhere only their back counterparts {u o} appear whereas in other Turkic languages we observe {y ɔ} (e.g. Karaim k^hj^un^j ‘day’ vs. Turkish gün).

Finally, underlying (as well as historical) /ɯ/ cannot surface in word-initial position, and merges here with /i/ as [i], regardless of the harmonic polarity of the word in question cf. imurt^hχɑ ‘egg’ (Kowalski 1929:81; expected *umurt^hχɑ) vs. Turkish yumurta. This latter form, as well as forms like ir ‘song’ show that words with “original” (in the underlying representation, or historical) *ɯ show [+back] harmony, not the [-back] value one might expect from the surface featural complement of [i]. This is particularly clear with the plural of ‘song’, which is ir-ɫar, not *ir^jɫar^j.

Thus, the basic generalization concerning Northwest Karaim vowels is that front-back pairs contrast only in initial syllables. The lone exception is the high unrounded pair i ~ ɯ, which as shown in (101) for the genitive /-NIN/ does contrast in non-initial syllables.

(101)	stem	genitive	gloss	
	t ^h av	t ^h av-nɯn	mountain	(cf. Turkish dağ-in)
	el ^j	el ^j -n ^j in ^j	hand	(cf. Turkish el-nin)

Turning to the consonants, most have [+back] and [-back] versions (/t/ and /tʲ/, etc.), as in the ambient languages Russian and Polish. The only exceptions to this generalization are p and r, which according to Kowalski normally have no palatalized version in syllable-final position (cf. k^hʲop^(j) ‘very’). As in many other Turkic languages, including most non-standard dialects of Turkish, the front-back contrast with dorsal stops is reinforced by a contrast in continuancy: as can be seen in (102) (Kowalski 1929:37), [-back] k surfaces as a stop, [k^hʲ], but its [+back] equivalent surfaces as a fricative, [χ]. Illustrative forms follow:

(102)	suffix	root	surface form	gloss
	/-mak/	bar ‘go’	barmaχ	go-INFINITIVE
		k ^h ʲor ^j ‘see’	k ^h ʲor ^j mak ^h ʲ	see-INFINITIVE
	/-kan/	at ‘shoot’	at-χan	shoot-PARTICIPLE
		k ^h ʲe ^h ʲ ‘go’	k ^h ʲe ^h ʲ-k ^h ʲan ^j	go-PARTICIPLE

Thus, Northwest Karaim shares with most other Turkic languages the property of spreading the feature [back] within phonological words, but differs insofar as the harmonic feature generally surfaces on consonants rather than vowels. In Northwest Karaim, root and suffixal consonants agree in backness with the first root consonant that contrasts for backness³¹ regardless of the quality of intervening vowels. Representative alternations for the plural /-LAR-/ and the ablative /-DAN-/ are given in (103) and (104).

- (103) a. k^huŋ-lar-dan servant-PLURAL-ABLATIVE (cf. Tk kul-lar-dan)
 b. k^hʲun^j-lar^j-dʲan^j day-PLURAL-ABLATIVE (cf. Tk gün-ler-den)

³¹The contrast clause is essential here, because /j/, which is not contrastive for [back], does not propagate its [back] specification; cf. *joł* ‘road’ (Kowalski 1929:108). The noncontrastive nature of [back] in glides plays a role in glide transparency throughout Turkic.

(104)	stem	ablative	gloss	
	suv	suv-dan	water	(cf. Tk. su-dan)
	k ^h un ^j	k ^h un ^j -d ^j an ^j	day	(cf. Tk g ^u n-den)
	t ^h ɑf	t ^h ɑf-t ^h an	stone	(cf. Tk. taş-tan)
	m ^j en ^j	m ^j en ^j -d ^j an ^j	I	(cf. Tk ben-den)
	k ^h op ^(j)	k ^h op ^(j) -t ^h an ^j	very	(cf. Tk. çok-dan)

In addition, there are forms that demonstrate multiple propagation of [back], such as that in (105) (Kowalski 1929):

(105) t^hor^jɑ-s^jiz^j-l^jig^j-im^[j]-d^[j]an^j ‘from my injustice’ (Kowalski 1929:69)

Parallel alternations can be seen in the deverbal suffix -v / -v^j / -uv / -uv^j (Kowalski 1929: 33, 108) shown in (106)

(106) k^hiel^j-uv^j ‘arrival’
 atf-uv ‘anger’
 t^jorg^jɑ-v^j ‘belt, sleeve’
 t^huz^ju-v^j-t^ju-d^jan^j ‘from the author’ (create-DEVERB-AGENT-ABL)
 boł-uf-uv-t^ju ‘helper’ (help-VERBAL.SUFFIX-DEVERB-AGENT)

Note that non-initial /a o u/ are transparent to consonant harmony even though they have front counterparts, which, as we have seen, surface in initial syllables. Thus, counter to the predictions of Strict Locality and V-Place theory, Karaim non-initial vowels are transparent in [back] harmony. Supporting evidence for the phonetic transparency of non-initial vowels is provided in Nevins and Vaux (2003), in which spectrographic analysis reveals that the F2 (the primary acoustic correlate of backness) is high for the palatalized consonants and dips low for the intervening back vowels. Although there may be coarticulatory effects that centralize vowels of shorter duration in between palatalized consonants, the phonemic status of the intervening vowels remains intact. We can formulate the rule responsible for the above alternations with the following preliminary statement:

- (107) For \forall segments contrastive for [back], copy the closest leftwards *contrastive* specification for [back] (Preliminary)

There is an important remark to be made about (107). Being contrastive for [back] is not *only* a function of the inventory, it is also a function of the position within a word:

- (108) Positional Contrastiveness: A segment S in position P is **contrastive** for the feature F iff \exists a segment S in the inventory that is featurally identical to S for all values except F , and S' can occur in position P as well.

We turn to a development of (108) in the next section.

2.5.5. Positional Contrastiveness

There are many languages that exhibit restrictions on the distribution of segments or features in non-initial positions. Karaim is thus not unique in this respect; compare for example Bashkir (Pöppe 1964), a language with back and rounding harmony, that systematically bans the high vowels /i ü u/ from non-initial syllables³². However, the Bashkir restriction on high-vowels in non-initial syllables is not particularly interesting from the point of view of harmony in the language: [back] and [round] harmony neither skips nor creates nor is blocked by high vowels in non-initial syllables, because they simply do not exist in those positions. Karaim, on the other hand, exemplifies a distinctly different phenomenon of positional neutralization:

- (109) *Positional Transparency*: When a language bans occurrences of the value αF

³²It may appear surprising, from a cross-linguistic perspective, that a language should exhibit positional “markedness” effects that ban high vowels from weak positions. However, when one takes into account the probable diachronic scenario that led to modern Bashkir, this restriction makes more sense. Specifically, Bashkir exhibits a diachronic exchange rule, whereby all mid vowels became high, and all high vowels became mid (as lexical comparison with any other Turkic language shows; i.e. pan-Turkic *yol* ‘road’ is *yul* in Bashkir, and so forth). It is thus probable that proto-Bashkir exhibited a more familiar restriction on *mid* vowels in non-initial syllables (see Beckman 1997 for an extensive discussion of such a case in the Bantu language Shona), which subsequently underwent the exchange rule.

in non-initial syllables, and F is the harmonic feature in the language, then these positionally noncontrastive values may be *transparent* to valuation.

As noted above, Karaim exhibits the following positional restrictions:

- (110) a. In Karaim, [-back] is banned from cooccurring with [+round] outside of absolute initial position.
- b. [-back] is banned from cooccurring with [-high] outside of initial syllables.
- c. [+back] is banned from cooccurring with [+high,-round] in absolute initial position.

The most relevant cases for positional transparency are (110-a,b). For example, in $k^{hj}or^jmak^{hj}$, the [+back, -high, -round] vowel /a/ is transparent to [-back] harmony, because /a/ is not contrastive for [-back] *in non-initial syllables*. Similarly, in $k^{hj}el^j-uv^j$, the [+back, +round, +high] vowel /u/ is transparent to [-back] harmony, because /u/ is not contrastive for [-back] *in non-initial position* (if preceded by any consonants). Likewise, in the root $k^{hj}op^{(j)}$, the [+back,+round,-high] vowel /o/ is transparent to [-back] harmony, because /o/ is not contrastive for [-back] *in non-initial position*. Finally, in $ir-ɫar$, the vowel /i/ is not visible for [back] harmony (i.e., it does not share its [-back] specification)³³, because only contrastive values of [back] are visible, and [-back,+high,-round] is not contrastive for [back] in absolute initial position.

We may thus assume that harmony is an iterative valuation rule, affecting non-initial consonants and non-initial instances of the [+high, +back] vowel as follows:

- (111) Karaim [back] harmony:

Structural Description: $X_{[\text{positionally contrastive: } \alpha \text{ back}]} \cdots X_{[\text{target}]}$

Structural Change: $X_{[\text{target}]}$ becomes [α back]

³³The assumption is that the lexical form of this root has (noncontrastive) [-back] specified on the initial vowel, and [+back] specified on the following consonant. In left-to-right iterative copying, with visibility only to (positionally) contrastive values, [+back] harmony will arise.

The diachronic scenario that led to Karaim is clear: front/back oppositions on vowels were reinterpreted as part of the surrounding consonants, and consonant harmony obtained. It is interesting to compare this to Maltese which, having lost secondary pharyngealization on consonants, gained [back] and [low] contrasts in its vocalic inventory (R. Hoberman, personal communication July 2004).

Before closing, it is worth considering whether the principle of Visibility to Positional Contrast has applicability elsewhere. We may consider the interesting facts of C'Lela, a Kainji language spoken in Nigeria (Dettweiler, 2000), which has the following vowel inventory:

- (112)
- | | | | |
|------------|---|---|-----|
| +high,-low | i | ɨ | u |
| -high,-low | e | ɛ | ɔ o |
| -high,+low | | a | |

Dettweiler observes that *height harmony* is operative within stems: all stems have either [+high] vowels or [-high] vowels. (He treats ʌ as an excrescent vowel.) Examples of [+high] harmonic stems are in (113), and [-high] harmonic stems are in (114).

- (113)
- | | | |
|----|-----------------------|------------|
| a. | d ^ə tiindi | 'nest' |
| b. | c ^ʌ rini | 'charcoal' |
| c. | irmi | 'man' |
| d. | kumu | 'get' |
| e. | k ^ʌ pɪru | 'flower' |
| f. | dwiri | 'hyena' |
- (114)
- | | | |
|----|-----------------------|------------------|
| a. | kwesa | 'show' |
| b. | ɔ ^ə ddakso | 'palm (of hand)' |
| c. | c ^ə gyɔmbo | 'eyebrows' |
| d. | soma | run |
| e. | dveso | 'broom' |
| f. | s ^ə ?ava | 'tongs' |

Harmonic suffixes include the possessive series: -me/-mi, -vo/-vu, -o/-u, which alternate based on the preceding value of [high]:

- (115) a. i in-mi 'it's my mother'
b. i cet-me 'it's my father'
c. i in-vu 'it's your mother'
d. i cet-vo 'it's your father'
e. i in-u 'it's her mother'
f. i cet-o 'it's her father'
g. i hin-u 'it's his sibling'
h. i waar-o 'it's his child'

Adjectival suffixes and noun class markers also participate in height harmony. According to Dettweiler, the class markers (CM) occur as both prefix and suffix to the adjective, and the adjective marker (ADJM) follows when used attributively.

- (116) i i-rek-e
it's CM-small-CM

- (117) i van i-rek-i-ne
it's knife CM-small-CM-ADJM
'It's a small knife'

Importantly, the class marker undergoes harmony when it follows the non-high vowel in *rek* and is in final position (116), but *does not* undergo harmony when it is non-final, and moreover, is *transparent* to height harmony passing through it to the adjective marker in (117). We can verify that the adjective marker does undergo harmony when we consider the next pair:

- (118) i i-zis-i
it's CM-long-CM

- (119) i van i-zis-i-ni
it's knife CM-long-CM

The simplest analysis, consistent with what has been developed contains the following three ingredients:

- (120) a. The lexical entry for the class marker (for knives) is /i/
 b. [-high,-low] vowels are banned from **medial** syllables in C'Lela
 c. [high] harmony in C'Lela operates Left-to-Right, with visibility to *positionally contrastive* values of [high]

Thus, the class marker, when it is in final position, may undergo height harmony and lower to /e/. However, when it is in medial position, there is no contrastive [high] value for [-low,+high,-back,-round]. Further examples are given below for the class marker /u/, which is used for shoes.

(121) i u-g^hɔz-ɔ
 it's CM-red-CM

(122) i kaat u-g^hɔz-u-ne
 it's shoe CM-red-CM-ADJM

In (122), the class marker is transparent to [+high] harmony, because there is no contrast for [high] in [-low,+round] vowels in medial positions.

What is most striking about the C'Lela data is that *the same suffix* may behave either as an undergoer or as a transparent segment in [high] harmony, depending on its position. An inspection of every form in Dettweiler (2000) thus reveals the following positional licensing statement:

(123) Mid vowels in C'Lela are only admitted in the stem or in final syllables.

That it is word-final, rather than *phrase-final* position that licenses mid vowels can be confirmed by phrases such as i van i-rek-e ig^hɔz-e 'it's a small red knife', in which both class-markers, being word-final, harmonize. The inviolable character of (123), combined with the relativization of [high] locality to positionally contrastive segments, is what enables long-distance height assimilation. Confirmation for the

analysis comes from the perfective suffix *-ine/-ini*, in which the final, but not the penultimate vowel, harmonizes with a [-high] verb stem:

(124) i wen noc hin ep-ine
it's whom man this bite-PERF
'Who did this man bite?'

(125) i wen noc hin sip-ini
it's whom man this grab-PERF
'Who did this man grab?'

(126) a. i wen noc hin bat-ine
'Who did this man release?'

b. i wen noc hin buz-ini
'Who did this man chase?'

c. i wen noc hin fumti-ini
'Who did this man pull?'

In short, positional contrastiveness is a genuine condition in subsegmental locality, and must be, either explicitly or implicitly, encoded in any model of the relationship between the paradigmatic component of vowel systems and how it is accessed by the paradigmatic component of language. For Karaim and C'Lela, this has been done in the most straightforward way imaginable. It may be quite reasonable to suppose that learners of a harmony rule find it most easy to postulate conditions such as (127)

(127) Copy the feature all the way through the harmonic domain, but ignore items in the domain that are not genuinely reflecting harmony, but rather reflecting a fixed and unchangeable fact about which vowels are available.

The translation of a learner's intuitive observation in (127) is directly accomplished in the contrastive valuation format adopted here.

2.6. Conclusions: Non-Contrastive Transparency

We have observed that, in addition to the principle of *closest valuation* developed in Chapter 1, a fundamental determinant of the search domain of harmonic assimilation is whether or not potential sources are contrastive for the harmonic value. Many languages relativize their domain of search to only contrastive values. When a non-contrastive vowel is adjacent to a vowel seeking specification, it is skipped, thus, behaving as a transparent intervener. In the present theory, then, the locality of harmony can largely be predicted based on the structure of the inventory. Full-specification within segments may be maintained, avoiding the pitfalls of underspecification, but indeed, a given harmony policy may simply ignore non-contrastive values, yielding a phenomenological effect of “transparency” or neutrality.

Chapter 3

Sonority-Based Asymmetries

3.1. Introduction

Vowel harmony for a binary feature [\pm F] will yield *pairs* of alternating vowels in harmonic environments. However, due to unbalanced inventories, a *neutral* vowel is one which does not alternate in the harmonic environment. As discussed in Chapter 2, contrastive and asymmetric ('marked') visibility yields transparency effects for interveners; indeed, this is the very essence of the term 'vowel harmony', which, as we have seen in Tangale, and many other languages, ignores all intervening consonants. The fact that vowel harmony should ignore intervening consonants¹ cannot be ascribed to any *sui generis* property of a privileged, non-decomposable phenomenon of harmony itself; although there have been efforts to describe vowel harmony as a nucleus-to-nucleus phenomenon (see van der Hulst and van de Weijer (1995) for a discussion), obtaining at the level of projected prosodic constituents, the fact that contrastive consonants *do* intervene in Turkish ultimately discredits this hypothesis. Thus, the property of *non-contrastive invisibility* developed in Chapters 1 and 2 derives what is arguably the most stunning property of vowel harmony: that consonants do not, for the most part, have any intervention effect at all. Note further that this cannot be ascribed to any privileged structural difference between vowels on the one hand, and consonants, which are

¹Except, of course, in the cases where intervening consonants *are* contrastive for the harmonic feature, as was discussed in Chapter 1 and 2 for Turkic and Barra Gaelic.

inherently transparent to vocalic features on the other (see, e.g., Clements and Hume, 1995), for as we have seen in Chapter 2, in Karaim, it is *vowels* that are transparent to iterative consonant harmony. This effect, of vowel transparency in Karaim, derives from the exact same principle as that of consonant transparency in Tangale: *non-contrastive transparency*.

This chapter explores a principle that trumps non-contrastive invisibility in numerous cases. The discovery of this principle arose through sheer frustration at the fact that, despite the extensive empirical coverage afforded by the principle of non-contrastive invisibility, there remained a handful of cases in which a non-contrastive vowel unexpectedly behaved opaquely. Notably, all of these cases were ones in which there were two (or more) noncontrastive vowels, but one of these behaved opaquely in harmony. For example, Wolof has [ATR]-noncontrastive /i:/, /u:/, and /a:/ among the long vowels, yet only /a:/ behaves opaquely. This fact does not follow from the structure of the inventory.

Researchers working on Wolof alone (or, perhaps more charitably, [ATR] alone) could explain this fact by assuming an asymmetric visibility, of sorts: /a:/ is [-ATR], and the [-ATR] noncontrastive vowels bear the value that is persistently prespecified², hence opaque. But the fact is, the opaque behavior of /a:/ arises in Hungarian as well, which has a [back] harmony system.

Researchers working on Hungarian alone could explain the fact that noncontrastive /a:/ is opaque, but noncontrastive /i:/ is not, by again assuming an asymmetric visibility: /a:/ is [+back], and [+back] is the prespecified value in Hungarian. Thus, researchers could build a somewhat coherent model by assuming that /a:/ is [+back,-ATR], and that, in harmonic languages, both of these features happen to be the prespecified, hence opaque values for harmony. However, there is another set of striking facts that neither non-contrastive invisibility nor asymmetric-prespecification of + or - can handle.

²Prespecified meaning, e.g., in an autosegmental framework, “pre-linked” to a timing slot, preventing its association with floating autosegments, and also blocking any association lines crossing it at any stage of the derivation. We have already discussed numerous problems for this approach; they will arise again in our discussion of Lena Bable below.

In Kalmyk Mongolian (Svantesson, 1985), there is [back] harmony between $u \sim \ddot{u}$, $o \sim \ddot{o}$, $a \sim \text{æ}^3$. The [-back] vowels i, e are both noncontrastive for [back], but only i is neutral. There is no way to appeal to prespecification here: both i and e are [-back] and noncontrastively so, but only the lower one is opaque.

In Written Manchu, both u and e are contrastively [+ATR] (alternating with u and a , respectively). However, as we will see, u occasionally behaves as transparent (*even though it is contrastive*), while e , also a [+ATR] vowel, never does so. Again, a height-based asymmetry arises: the lower of two “system-identical” (i.e. both contrastive or both noncontrastive) vowels is consistently opaque.

The consistent opacity of lower vowels, compared with the relative transparency of higher vowels, then, seeks an explanation in terms of vowel height, which will be understood in this chapter in terms of relative sonority.

The central proposal is that high-sonority vowels remain opaque, and that this principle overrides non-contrastive invisibility. A word of caution is due here about the diction choice “overrides”. This is not to imply a particular implementation at this point. Clearly, in a constraint ranking in which the demand for high-sonority vowels to initiate harmonic domains (via Alignment, Correspondence, etc.) outranks a constraint on extending a contrastive feature to word-bounded complete harmony, it can be said that high-sonority overrides non-contrastiveness. However, this insight can also be captured in a rule system (as will be extensively discussed): a rule of assimilation to the harmonic value of local low vowels will take precedence over rules of unbounded assimilation by the Elsewhere condition. Thus, at this point, the reader is encouraged not to focus too insistently on the particular implementation of sonority-based opacity, and urged to appreciate the overwhelming empirical validity of the generalization first.

It is important to point out immediately that the asymmetry between high-sonority vowels and low-sonority vowels cannot be due to their relative duration. While it is known that high vowels tend to be shorter in duration than lower vowels

³Svantesson reports that Kalmyk indeed has palatal harmony, in contrast to Khalkha Mongolian, which earlier researchers had assumed had palatal harmony, but in fact has [ATR] harmony.

els (House & Fairbanks 1953 Lehiste 1990), there are conceptual, and more serious empirical problems with assuming that duration has anything predictive to say about transparency.

The immediate problem is that Hungarian *long* /i:/ is transparent, while both long and *short* /a/ are opaque. The duration of the Hungarian long vowels as significantly longer has been reported in the acoustic study of Magdics (1969), who recorded two male and three female speakers, each pronouncing 1765 short sentences. Magdic's duration data, reproduced from Table 10 (p.16) of her book, are as follows⁴:

(1)	Vowel	Average Value
	i:	180 ms
	i	102 ms
	e:	190 ms
	ε	117 ms
	a:	231 ms
	a	144 ms
	o	139 ms
	o:	230 ms
	u	132 ms
	u:	220 ms
	ö	117 ms
	ö:	196 ms
	ü	100 ms
	ü:	102 ms

As can be noted, there are at least three comparisons that demonstrate that the sonority effect cannot be replaced by a durational explanation:

(2) Comparisons that discredit a durational approach to transparency:

⁴A scanned version of Magdic's table in the original appears in Appendix Two.

- a. Long *i:* is longer than all short vowels of Hungarian, but it is transparent
- b. Short *a* is opaque, although its average duration is 20% less than that of *i:*
- c. Short *ε* is (often) opaque, while *e:* is transparent, even though the duration of the latter is 38% longer

The intuitive conception that “shorter vowels will be transparent” thus immediately flops in the harmony system of Hungarian. Similar remarks may be made for Finnish (though of a less directly relevant nature, since only the high vowels are noncontrastive), which also has long and short vowels, and in which length plays no role in harmony: /i/, whether long or short, is always transparent, and /a/, whether long or short, is always opaque. Moreover, we know from phonetic studies that there is true articulatory transparency – even for short duration high vowels, in Palestinian Arabic (Shahin 2002).

Theoretically, as well, it is unclear exactly what “short duration enables transparency” means. Is it an articulatory claim: that, if the tongue is initiating a [+back] gesture over two vowels, then, having to initiate a [-back] gesture in between is okay, as long as it’s quick? This seems dubious. Piggott (2004) points out that, in nasal harmony systems, voiceless stops are the segments that are consistently non-participants in nasal harmony, and sometimes, the only segments that are opaque (e.g., in Applecross Gaelic). Nonetheless, voiceless stops are by far the shortest duration segment in the inventory. Short duration, then, affords no reward of transparency in nasal harmony⁵.

Perhaps the conceptual import of “short duration enables transparency” can be understood perceptually, then. This claim has the following logic: very short interveners are less perceptually salient, and hence they can be skipped over in harmony, without inducing a noticeable effect for the listener. That is, the listener who hears a [+back] span across /i/ may not perceive the [-back] gesture of /i/

⁵Rather, what seems to determine opacity in nasal harmony, as we will return to, is relative sonority.

as saliently, so that the perceptual function of harmony (to make [+back] salient throughout the entire domain of the word) is upheld to a reasonable degree. Indeed, we will return to this notion: that the relative perceptibility of an intervener matters. It is important to point out that “perceptibility”, in order to be an experimentally testable concept, translates into performance on tasks of identification, discrimination, and categorization. It is thus incumbent on proponents who insist on phonetically-grounded perceptibility to demonstrate true results on tasks of these sort. Such a task is not incumbent on models that insist on a modular phonology-phonetics divide; the property of relative height/sonority is a grammatical element of the phonological vocabulary, which learners may use in constructing grammars of harmony.

To return to the point at hand, it is sufficient to note here that the height-asymmetry effect discussed thus far has little to do with duration, even on a strongly perceptual account. Increased vowel duration has a huge effect on perceptibility, as shown by Bennett (1968), Ainsworth (1972), and Strange *et. al* 1983). Thus, the transparency of /i:/ in Hungarian cannot be attributed to duration-based perceptual weakness.

The current proposal, then, is that relative sonority determines opacity as follows:

- (3) Implicational Universal: If a neutral vowel of a greater sonority is transparent, then one(s) of lesser sonority will be transparent

Lowness (e.g, [\pm low]) is one of the primary determinants of sonority in vowels. Thus, syllabification of diphthongs in Spanish (Harris 1983) and vowel-sequences in Berber (Dell & Elmedlaoui 1985, Prince & Smolensky 1993) can be determined by sonority, which in turn, is determined by relative vowel height (Jespersen 1904 *et. seq*). Vowel sonority is well-known to enforce prominence-based asymmetries, not only in syllabification and nucleus-choice (Bickmore, 1995), but also in SONORITY-TO-STRESS (Kobon; Kenstowicz (1997) and STRESS-TO-SONORITY (Chamorro; Crosswhite (1998). The role of sonority in determining the transparency vs. opacity of

an unpaired vowel, then, finds explanation within a larger context of syntagmatic interactions determined by vowel height.

Why vowel sonority should matter specifically for vowel harmony can perhaps be understood through a comparison with the role of consonant sonority in nasal harmony. Piggott (2004) suggests that voiceless obstruents never participate in nasal harmony through the constraint MAXSTOPDIST: maximize stop distinctiveness, which is a cross-linguistic *principle* (and not a re-rankable *parameter*) in Piggott's version of OT⁶. The essence of this constraint is twofold: first, it imposes inventory requirements, and is rooted in the fact that every language has stops (Lass 1984, Ladefoged & Maddieson 1996). (The similarity with the fact that every language has a low vowel is irresistible here.) Second, it demands that stops maintain their privileged role of distinctiveness in an inventory, and that they not be altered in any way (nasalization, deletion) to succumb to the whims of nasal harmony. Again, the similarity with the behavior of low vowels is compelling: the intuition (though it may be cashed out in rules) is that the principle of local harmony in the language is coupled with the principle that low vowels remain maximally distinctive, and unaltered (e.g. raised, deleted) for the purposes of harmony.

Piggott's explanation of the resistance of obstruents to harmony is best summarized in the following quote (p.397): "Obstruent stops occupy a privileged position: they...are the best exemplars of the consonant type." Similarly, we might understand low vowels as the best exemplars of the vowel type, as they show a maximal degree of openness in the vocal cavity⁷.

These considerations, however, are of a "why" nature, and are offered here as preliminary, implementation-independent, motivation for why sonority should

⁶Similarly, if one wanted to implement the intuition here within Piggott's framework, MAXLOWDIST would serve the same role.

⁷M. Kenstowicz (personal communication, August 2004) points to an affinity with Jakobson's remarks on the substantive origin of the parental words *mama, papa*: "The compact vowel displays the maximal energy output, while the diffuse consonant with an oral occlusion represents the maximal reduction in the energy output. Thus nursery names for mother and father, like the earliest meaningful units emerging in infant speech, are based on the polarity between the optimal consonant and the optimal vowel." (p.540). And after all, why does the dentist ask you to say "aaah", of all possible phonemes.

matter in harmony. We will return to them at the end of this chapter. First, we turn to a number of cases that exemplify the central empirical claim of this chapter, one that will endure long beyond questions of a teleological nature.

- (4) (Repeated from (3)): If a neutral vowel of a greater sonority is transparent, then one(s) of lesser sonority will be transparent

I will briefly introduce the sonority scale adopted throughout this chapter, which is based on Jespersen (1904); Clements (1990); Parker (2002)⁸:

- (5) Sonority scale for vowels (ascending):

ə Low Sonority ↓
i
u
e, o
ɛ, ɔ
æ, a High Sonority

It is important to point out that although vowel height appears to be the primary determinant of sonority, I will assume that the sonority scale constitutes its own representation, and is not stated in terms of any other features. Sonority constitutes salience: its primary phonetic correlate is loudness, and it functions as an organizing principle in many prominence-based processes in the grammar. A further reason for viewing sonority in this light (i.e. as a purely cognitive representation of prominence along scalar lines) is that it seems to provide the same organizing principle in sign language, where the correlate of sonority is degree of movement

⁸A brief note on (i) is in order concerning the positioning of the high vowels. One reason for assuming that /i/ is of a lower sonority than /u/ comes from differential behavior in diphthongs. One of the purposes of the sonority scale is to allow statements of the Minimal Distance Principle that make predictions about asymmetries in syllabification. Kubozono (2004) presents evidence from English, Romanian, and, in particular Japanese, that support the empirical generalization that /ai/ is preferred over /au/. One of the most straightforward accounts for this asymmetry can be provided in terms of sonority. Thus, asymmetries in the distribution of the two diphthongs /ai/ and /au/, with the former overwhelmingly preferred, may be attributed to the MDP: as the distance between /a/ and /i/, according to the sonority scale in (i), is greater, this diphthong will be preferred over /au/.

(Corina, 1990; Perlmutter, 1992; Brentari, 1993; Sandler, 1993).

3.2. Sonority-Based Asymmetries in Unpaired Vowels

3.2.1. Wolof

The first exemplification of a sonority-based asymmetry in vowel harmony can be drawn from a 7/8-vowel [ATR] system. Wolof is a West Atlantic language spoken in Senegal. Most of the data discussed here is well-described by Ka (1988, 1984), a native speaker linguist; additional data is from Archangeli and Pulleyblank (1994) and my own recordings⁹ with Lamine Toure, a native speaker. Wolof has the long vowel inventory in (6) and the short vowel inventory in (7) (the orthography is shown in parentheses)¹⁰. Notice, importantly, that long /a:/ has no [+ATR] counterpart, and is thus non-contrastive for the feature.

(6)	i: (ii)	u: (uu)	[high, +ATR]
	e: (éé)	o: (óó)	[mid, +ATR]
	ɛ: (ee)	ɔ: (oo)	[mid, -ATR]
	a: (aa)		[low, -ATR]

(7)	i	u	[high,+ATR]
	e (é) ə (ë)	o (ó)	[mid, +ATR]
	ɛ (e)	ɔ (o)	[mid, -ATR]
	a		[low, -ATR]

Wolof has no productive prefixes (Ka 1988: 62). It is thus expected, on the cyclic morphological account developed in Chapter 1, that harmony in Wolof should be exclusively left-to-right, and this is indeed the case. Stem-internal harmony is illustrated in (8). All vowels within a stem are either [+ATR] or [-ATR]; that is,

⁹Many thanks are due to Pranav Anand for assistance in the preparation of these recordings.

¹⁰There is some debate between native speakers over the short vowel [á], which seems to be a version of [a:] before geminates and prenasals that is primarily of orthographic significance.

there are no disharmonic stems in the native vocabulary¹¹. Examples will be given in Wolof orthography.

- (8)
- a. béréb 'place'
 - b. gètèn 'to bother'
 - c. jéégó 'to step'
 - d. gëléém 'camel'
 - e. xóóyël 'to dilute'

 - f. doole 'strength'
 - g. cere 'couscous'
 - h. lempo 'tax'
 - i. xandoor 'to snore'
 - j. nelaw 'to sleep'

Affix alternations are harmonic. The instrumental/locative e/é, participant le/lé, past-tense oon/óón, benefactive ël/al, possessive ëm/am, and comitative ëndóó/andoo are shown (Ka 1994:13-19). The [+ATR] vowels é and ó occur after [+ATR] vowels, and the [-ATR] vowels e and o occur after [-ATR] vowels. All of the stems below are monosyllabic or fully harmonic, and demonstrate that affix alternation can be fully predicted when the preceding vowel is contrastive for [ATR].

- (9) Wolof affixes following *contrastive* sources:

¹¹And I have not discovered any reports about disharmony in loanwords, though, of course like every language with a colonial history and now undergoing "globalization", there are many in Wolof, primarily of French and Arabic origin.

a.	dóór-é	'to hit with'	xool-e	'to look with'
b.	réér-é	'to be lost in'	dem-e	'to go with'
c.	gë-né	'to be better in'	xam-e	'to known in'
d.	dóór-é	'to help hit'	jox-le	'to help give'
e.	réér-lé	'to lose one's property'	dee-le	'to lose a relative'
f.	yëg-lë	'to announce'	takk-le	'to help tie'
g.	réér-óón	'was lost'	reer-oon	'had dinner'
h.	nów-óón	'came'	jox-oon	'gave'
i.	bëgg-óón	'wanted'	takk-oon	'tied'
j.	lééb-ël	'to tell stories for'	bey-al	'to cultivate for'
j.	fóót-ël	'to launder for'	woor-al	'to fast for'
k.	jënd-ël	'to buy for'	wax-al	'to speak for'
l.	sófóór-ëm	'his driver'	nelaw-am	'his sleep'
m.	gënn-ëndóó	'to go out together'	dend-andoo	'to be neighbors'
n.	tóx-ëndóó	'to smoke together'	topp-andoo	'to imitate'
o.	dëkk-ëndóó	'to live together'	wax-andoo	'to say together'

Harmony propagates through a string of agglutinated suffixes. As outlined in Chapter 1, the present model accomplishes this through a cyclic addition of each suffix, followed by an application of the harmony policy.

- (10) a. jubb-ëntéé-ndóó 'to rectify together'
b. mun-ëndéé-ndóó 'to be a little patient together'

The agentive suffix *-kat* fails to alternate (i.e, it has no variant **kët*). On the account developed in Chapter 1, this will reflect a lexical specification for [ATR] in this morpheme. As predicted by the cyclic account, the specification of [-ATR] in the first suffix (the agentive) induces [-ATR] valuation in the following possessive (Ka 1994: 21-22):

- (11) a. tëgg-kat-am 'his drummer'

- b. fóót-kat-am 'his launderer'
- c. ligééy-kat-am 'his worker'
- d. togg-kat-am 'his cook'
- e. jangale-kat-am 'his teacher'

Turning to long vowels, we find evidence for a sonority-effect: long /a:/ is unpaired, but it is not transparent; in the apt words of Kenstowicz (1994), "[aa] finds its confreres only among the [-ATR] set." (354). Stem-internal [-ATR] harmony with long /a:/ is shown:

- (12)
- a. kontaan 'be satisfied'
 - b. perkaal 'percale'
 - c. paase 'to iron'
 - d. jaaro 'ring'
 - e. dóór-aat-e 'to hit usually'
 - f. génn-aale 'to go out'

The vowel /a:/ not only does not undergo harmony, but initiates its own domain. In other words, the long [+low] vowel, even though it is noncontrastive, provides an immediate [ATR] valuation source for the vowels to its right:

- (13)
- a. yóbbu-waale 'to carry away also'
 - b. génn-aale 'to go out with also'
 - c. dóóraate 'to hit usually'
 - d. jéém-ëntu-waal-æeti 'to try also without conviction once more'
 - e. séytaane 'devil' (from Arabic)
 - f. kumaase 'to start' (from French)
 - g. indiw-aale 'to bring in addition'

Importantly, the high vowels are also noncontrastive, as they do not have any [-ATR] counterparts. Nonetheless, unlike /a:/, they are transparent (Ka 1994: 27-30, Archangeli & Pulleyblank 1994: 231), and may co-occur with [\pm ATR]. In addi-

tion, as the high vowels are non-contrastive for [ATR], they allow suffixes to their right to ignore them in the search for contrastive [ATR] valuation, thus behaving transparently.

- (14)
- a. dibéér 'sunday'
 - b. gumbë 'be blind'
 - c. guró 'cola nut'
 - d. guné 'infant'
 - e. tekki-leen 'untie'
 - f. moytu-leen 'avoid'
 - g. watu-leen 'have haircut'
 - h. léttu-léén 'braid hair'
 - i. sóóbu-léén 'plunge'
 - j. gëstu-léén 'research'
 - k. ʔubbi-léén 'open'
 - l. gimmi-léén 'open eyes'
 - m. tóxi-léén 'go and smoke!'
 - n. séénuwóón 'tried to spot'
 - o. y'obbujinë 'he went to bring'

Here are some additional examples of high [+ATR] vowels in medial position, surrounded by [-ATR] vowels (Ka 1994: 30-31, Archangeli & Pulleyblank 1994: 231)

- (15)
- a. barigo 'barrel'
 - b. kamisol 'robe'
 - c. kontine 'to continue'
 - d. korite 'Muslim holiday'
 - e. kelifa 'leader'
 - f. áddina 'word'
 - g. báyyima 'animal'
 - h. taalibe 'student'

- i. kaarite 'butter'
- j. warugar 'obligation'
- k. tɛkkilɛɛn 'untie!'
- l. sɔppiɯulɛɛn 'you have not changed'
- m. tɛɛruwɔɔn 'welcomed'

Notably, when the high vowels are the only vowels in the stem, they take +ATR suffixes (16). This may be accounted for by the rule in (17).

- (16)
- a. tiit-óón 'was afraid'
 - b. gis-léén 'look!'
 - c. njur-éél 'posterity'
 - d. sumb-lé 'help start'
 - e. dugub-ëm 'his millet'
 - f. suul-ël 'bury for'
 - g. ligée 'work for'

- (17) Structural Description: $V \dots V_{\text{target}}$
 Structural Change: V_{target} becomes [+ATR]

What is most interesting, then, about Wolof, is the asymmetry between the high vowels and the low vowels:

- (18) The long vowels /i;u;a:/ are all non-contrastive for [ATR]. Nonetheless, only /a:/ is opaque.

Ka's analysis is that [aa] is lexically linked to [-ATR] before any other rules apply, and that the default rule is to spread [+ATR], and that at a postlexical level, unassociated vowels are linked to the [-ATR] segment. Archangeli & Pulleyblank's analysis makes use of essentially very similar mechanisms. That is, they propose the articulatory-grounded co-occurrence restrictions *[hi,-ATR] and *[lo,+ATR], but have no account for why the former may be flouted, but the latter remains ab-

solute. It is difficult to imagine a principled account for this asymmetry, because the “antagonism” of the gestures should be the same in both directions: if it is difficult to move the tongue body up at the same time as retracting the tongue root, should it be more difficult to move the tongue body down while advancing the tongue root?

Importantly, no previous authors explain why it is [aa] that is lexically pre-linked to an [ATR] value, as opposed to any other vowel. We can seek a better analysis, with the following ingredients¹²:

- (19)
- a. Affixes seek closest [ATR] valuation leftwards
 - b. Noncontrastive [ATR] vowels are invisible
 - c. The high-sonority [a:] blocks all instances of search
 - d. If no contrastive or high-sonority vowel is found, a context-free rule assigns [+ATR] to the suffixes

The rules to implement this are as follows:

- (20) Harmony Policy for Wolof:

- a. (i) *Rule 1: Contrastive Vowel Harmony (CVH):*
 Structural Description: $V_{[\text{contrastive: } \alpha \text{ ATR}]} \cdots V_{\text{target}}$
 Structural Change: V_{target} becomes $[\alpha \text{ ATR}]$
- (ii) *Rule 2: Low Vowel Harmony (LVH):*
 Structural Description: $V_{[+\text{low}, \alpha \text{ ATR}]} \cdots V_{\text{target}}$
 Structural Change: V_{target} becomes $[\alpha \text{ ATR}]$
- (iii) *Rule 3: Vowel Advancing (VA):*
 Structural Description: $V \dots V_{\text{target}}$
 Structural Change: V_{target} becomes $[+\text{ATR}]$

¹²At this point, it is worth reminding the reader that *valuation* is not a terminological synonym for *spreading*; see Chapter 1 for arguments, based on “non-constituent” copying and bidirectional search.

As we will see, the harmony policy for Hungarian (in one formulation of a grammar that the learner could construct) is completely identical to (20), with [ATR] replaced by [back]. The advantage of the present account, then, is that it relates the behavior of /a:/ in Wolof, an [ATR] system, to the behavior of /a:/ in Hungarian, precisely because of the principle of *high-sonority visibility*.

Wolof thus provides a simple and categorical case in which the asymmetry between low vowels and high vowels with respect to transparency cannot be explained by contrastiveness, and is best explained by sonority, as implemented here by a low-vowel harmony valuation rule.

Before closing, I will highlight the importance of Wolof in discrediting one possible theory of transparency in vowel harmony. It is possible to imagine that a vowel x that has fewer neighbors in the phonetic space will be more likely to be transparent, because x has more acoustic room for variance due to coarticulation. However, /a:/ has few neighbors in the vowel space; indeed, fewer than /i:/ or /u:/, nonetheless, it remains the only opaque vowel in Wolof.

3.2.2. Hungarian

Hungarian vowel harmony exhibits a number of asymmetries that make it difficult to explain in terms of non-contrastive invisibility alone. Like Wolof, it has both long and short vowels, and like Wolof, its long and short vowel inventories are not identical. Examples of words containing each Hungarian vowel are shown in (21), in Hungarian orthography (N.B: orthographic “gy” is IPA d^y).

(21) Examples of all Hungarian vowels:

ɔ	a	agy	brain
a:	á	ágy	bed
ɛ	e	egy	one
e:	é	ért	understand
i	i	irt	eradicate
i:	í	ír	write
o	o	orr	nose
o:	ó	ól	sty
ö	ö	öl	kill
ö:	ő	őr	guard
u	u	ujj	finger
u:	ú	úgy	like that
ü	ü	ügy	affair
ü:	ű	űr	space

Thus, as can be noted, the orthography distinguishes the long and short vowels by an acute accent on the former (this accent has nothing to do with stress); umlauts are turned into two acute accents on the long front rounded vowels. What is important to notice is that, even though this orthographic diacritic makes it look like the long and short versions of each vowel are featurally identical, and differ only in length, this is not the case for the pairs "e/é" and "a/á", as we shall see presently.

(22) Hungarian short vowel inventory

[-back,+round]	[-back,-round]	[+back,+round]	[+back,-round]	
ü	i	u		[+high,-low]
ö		o		[-high,-low]
	ɛ		ɔ	[-high,+low]

(23) Hungarian long vowel inventory

[-back,+round]	[-back,-round]	[+back,+round]	[+back,-round]	
ü:	i:	u:		[+high,-low]
ö:	e:	o:		[-high,-low]
			a:	[-high,+low]

As mentioned, the differences arise in the [-high] vowels. Among them, there is a short ε that is [+low], and a long /e:/, that is [-low]. Both of these vowels are [-back,-round], but they behave quite differently; in particular, the short ε exhibits harmonic behavior, while the long /e:/ is a neutral vowel. The other difference is in the [+back,+low] vowels. The long /a:/ is [-round], while the short ɔ is [+round].

Although the long/short opposition of $\varepsilon \sim \acute{e}$ and $\text{ɔ} \sim \acute{a}$: appears suspect, they do alternate in *shortening stems*. Shortening stems are a class of nouns with the property that when certain affixes (e.g., the plural, and the verbalizing suffix) are attached to them, they shorten the final vowel.

(24) Length alternation in the plural and with the verbalizing suffix (Siptár & Törkenczy 2000:53):

a.	víz	vizek	water (sg./pl)
b.	analízis	analizál	analysis/analyze
c.	tűz	tüzek	fire (sg/pl)
d.	miniatűr	miniatürizál	miniature/miniaturize
e.	út	utak	road (sg/pl)
f.	úr	urizál	gentleman/play the gentleman
g.	tő	tövek	root (sg./pl)
h.	pasztőröz	pasztörizál	pasteurize
i.	ló	lovak	horse (sg.pl)
j.	agónia	agonizál	agony/agonize
k.	kéz	kezek	hand (sg.pl)
l.	prémium	premizál	bonus/ award a bonus
m.	nyár	nyarak	summer (sg./pl)
n.	kanális	kanalizál	canal / canalize

Not only do we find (morphologically-conditioned) shortening, that receives a uniform characterization if long and short vowels are seen as featurally related, but also a morphologically-driven process of vowel *lengthening*, in other environments. Hungarian exhibits a process of low vowel lengthening that affects the last vowel of any morpheme when it precedes a suffix:

(25) Low vowel lengthening (Siptár & Törkenczy 2000:170):

- | | | | | |
|----|--------|----------|---------|--------------------------------------|
| a. | alma | almát | | apple/ apple-acc. |
| b. | tartja | tartják | | he holds it / they hold it |
| c. | kutya | kutyyául | | dog / like a dog |
| d. | óra | órája | óráját | watch / his watch / his watch (acc.) |
| e. | epe | epés | | bile / bilious |
| f. | vitte | vitték | | he carried it / they carried it |
| g. | este | estére | | evening / by evening |
| h. | mese | meséje | meséjét | tale /his tale / his tale (acc.) |

Thus, the phonological process in shortening stems and in low vowel lengthening may be uniformly characterized if we indeed understand them as only involving manipulations of vowel length¹³. The following “redundancy” rules must be present for application after lengthening/shortening¹⁴:

¹³There are three implementations: addition/deletion of a timing slot, addition/deletion of a mora, and polar reversal of a [length] feature. Though researchers have many reasons for favoring one over the other (in particular, I find the postulation of [length] as a feature potentially attractive for the statement of length dissimilation rules, such as quantitative complementarity in Ponapean, and the *Lex Mamilla* rule of Latin), there is no Hungarian-internal evidence that favors one over the other, and indeed, the statement of readjustment rules (such as rounding of *ɔ*) are more compactly stated in terms of [-long] rather than “when associated with only one timing slot”. Further evidence that length may be a feature can be considered in Leggbo; Hyman and Udoh (2002) discuss a process of “length harmony” by which root vowels are lengthened before long-vowelled suffixes. Hyman & Udoh show that the phenomenon does not receive a principled account in metrical terms, and conclude that the process is indeed one of manipulating the length of a segment depending on the length of another; importantly, moreover, this assimilation can be long-vowel-induced-by-long-vowel, and, in some cases, long-consonant-induced-by-long-consonant. Hyman & Udoh do not spell out a complete analysis, but one possibility that appears to have merit is that there is a feature [long], and it is what is undergoing long-distance assimilation.

¹⁴These do not represent any innovation on my part; see Ringen (1975); Reiss (2003a) for similar formulations of redundancy rules.

- (26) a. [+long,+back,+low] → [-round]
 b. [-long,+back,-low] → [+round]
 c. [+long,-back,-high,-round] → [-low]
 d. [-long,-back,-high,-round] → [+low]

The importance of the redundancy rules in (26) is that they are necessary for the adjustment of suffixal alternations as the result of [back] harmony. For example, suffixes such as inessive *-ban/-ben* surface as *-ban* after back vowels and *-ben* after front vowels: *dob-ban* in a drum, *szem-ben* 'in an eye. On the account developed here, the inessive and dative affixes are lexically stored with [-long,-high,+low, -round] vowels: *-bAn,-nAk*. When valued [+back] through harmony, the adjustment rule (26)[b] applies, yielding ɔ . When it is valued [-back] through harmony, the result is ɛ .

There are also alternations involving the long versions of a/e, as in the translative suffix *-vá/-vé* (the *v* assimilates to a preceding consonant): *dob-bá* '(turn) into a drum, *szem-mé* '(turn) into an eye, *tök-ké* '(turn) into a pumpkin. The translative suffix is thus stored *-vA:*, with a [+long, -high,-round,+low] vowel. When valued [-back] through harmony, the adjustment rule (26)[c] applies, yielding /e:/. When valued [+back] through harmony, the result is /a:/.

Other suffixal [back] alternations have round vowels. Some are specified [-long,+high,+round]: *angol-ul* 'in English, *török-ül* 'in Turkish, *lengyel-ül* 'in Polish. Others are specified [+long,+high,+round]: *láb-ú* -legged, *fej-ű* '-headed. Another set is [+long,-high,-low,+round]: *dob-tól* 'from a drum, *szem-től* 'from an eye, *tök-től* 'from a pumpkin. Finally, there is a set specified [-long, -high, -low, +round], and these actually alternate with an unround vowel, as seen in the superessive suffix *-en/-ön/-on*: *szem-en* 'on an eye, *tök-ön* 'on a pumpkin, *dob-on* 'on a drum. The unrounding occurs when the preceding vowel is [-round], and is thus a case of derounding, as proposed in Ringen and Vago (1998) and Polgárdi and Rebrus (1998). This derounding due to failure of licensing does not reflect anything terribly deep about the Hungarian vowel system: the Szeged dialect, for example, does

not show it, and has only the round variants of this affix (Ringen and Szentgyörgi, 1999), thus *szem-ön* is attested in Szeged.

Having described the range of alternating suffixes that receive valuation for [back], which are straightforwardly understood, with the addition of the adjustment rules, we may turn to what are the more compelling properties of Hungarian vowel harmony: the transparency and harmonicity of valuation sources.

Given the definition of contrastiveness from chapters 1 and 2 (27), it is clear that only the [-low, +round] vowels are contrastive for [back] in Hungarian.

- (27) A segment *S* with specification αF is *contrastive* for *F* if there is another segment *S'* in the inventory that is featurally identical to *S* (and with the same length / moraic licensing requirements), except that it is $-\alpha F$

However, of the remaining vowels (i,i:,e:,e:,a:,o), the first three are transparent, while the latter three are not:

- (28) a. kavics-nak 'pebble'
b. radír-nak 'eraser'
c. tányér-nak 'artist'
d. Jozsef-nek 'Joseph'
e. nőnysz-nak 'nuance'
f. biká-nak 'bull'

This fact cannot be attributed to any version of non-contrastive transparency developed in this dissertation¹⁵. In fact, all previous accounts of Hungarian vowel harmony have essentially stipulated the fact that /a:/ is opaque, with no attempt to derive this from anything more universal.

¹⁵It is worth noting that Calabrese (2003) attempts to account for Hungarian vowel harmony by assuming that the opaque vowels are contrastive for the feature [back], but that there is an accidental gap, and its contrastive counterpart is missing. That is, if there were a long version of *e*, then /a:/ would be contrastive for [back]; similarly, the logic may be extended to Wolof: if there were a long version of *ɛ*, then /a:/ would be contrastive for [back]. However, we will not pursue this logic further, as it does not account for the opacity of /a/ as opposed to the transparency of /i,e/ in Ife Yoruba, a system identical to Wolof, except lacking a [+ATR] counterpart to /a/ entirely.

However, the sonority-based account can provide a straightforward explanation: the [+low] vowels are harmonic, irrespective of their contrastiveness, because of their high sonority.

A thorough discussion of Hungarian will follow in the next chapter, to account for variable behavior in ϵ . We may advance our initial understanding by assuming that ϵ is, in many cases, a harmonic vowel (while $i, i:, e:$ never are). Ringen (1975) presents very good arguments that ϵ is harmonic. First of all, of the fifty or so monosyllabic stems of the *hid-nak* type, which have [-back,-round] vowels in the stem, but irregularly take [+back] suffixes, there are none that have e as the stem vowel. This can be clearly understood if we assume that stems of the type *hid* are associated with a [+back] diacritic¹⁶, and that contrastive [-back] stems can never be associated with such a diacritic. Second of all, while there are invariable [-back] suffixes with $i, e:$ (e.g. *-ig, -ik, -ke:nt, -e:rt*), there are none with ϵ : these always alternate (Ringen 1975:109).

We may characterize an implementation of *sonority-based harmony* as follows:

(29) Sonority-Based Policy for Hungarian [back] harmony

a. Rule 1: Contrastive Vowel Harmony (CVH):

Structural Description: $V_{[\text{contrastive: } \alpha \text{ back}]} \cdots V_{\text{target}}$

Structural Change: V_{target} becomes [α back]

b. Rule 2: Low Vowel Harmony (LVH):

Structural Description: $V_{[+\text{low}, \alpha \text{back}]} \cdots V_{\text{target}}$

Structural Change: V_{target} becomes [α back]

c. Rule 3: Vowel Fronting (VF):

Structural Description: $V \cdots V_{\text{target}}$

Structural Change: V_{target} becomes [-back]

¹⁶I assume this diacritic is a *copy-value* that may be added to non-contrastive stems. Its function is to provide a value if a search is initiated, but the presence of this copy-value will not affect its host.

The effects of sonority on determining vowel harmony are clear: the rule of Low Vowel Harmony is a direct reflection. In fact, the importance of sonority in Hungarian transparency has further effects. Hayes (2004), in a quantitative study of suffix choice for *-nAk* conducted on the internet browser Google, has found that /e:/ is less transparent than /i/. Hayes's study allows us to compare different approaches to the following two questions:

- (30) **Central Puzzles for Hungarian [back] harmony:**
- a. Why is /e:/ transparent, but ϵ opaque?
 - b. Why is /e:/ less transparent than /i/

It should be clear that, given the transparency scale: $i > e: > \epsilon$, duration is not a viable explanation for relative transparency. Nor is "perceptibility", if duration is to play a role in how perceivable a vowel is. Hayes' explanation for the "height effect" is that, the lower a vowel is, the less robust its F2 is, hence, the lower a front vowel is, the more it "needs help" for recovery of its [-back] feature, and thus will tend to spread it to the following vowel. Hayes' explanation suffers from certain problems. First of all, as we have mentioned in the beginning of this chapter, the long vowels of Hungarian are indeed quite long, and thus there is not a perceptual basis for saying that /e:/ is more likely to be mis-perceived than short /i/; as observed in ??, the average duration of long /e:/ is 90% greater than that of short /i/. Secondly, an accurate discussion of perceptual recovery should be stated in terms of F2-prime (F2'), the weighted average of F2 and F3; as Fant (1973) has shown, F2' is a measure that achieves the closest correspondence between acoustic data and perception of vowel quality. Finally, Hayes' "need more help" metaphor comes from a particular reading of Kaun (1995), which in turn, depends on a particular reading of Suomi (1983) that turns out to be quite different from the original.

Suomi's insight was indeed that the backness of non-initial vowels may be difficult for listeners to accurately perceive, and thus, that vowel harmony was a perceptually-motivated phenomenon. However, Suomi's actual idea was that

vowel harmony is a co-occurrence principle to enhance predictability in a language with many vowels at the same height. By structuring well-formed words such that, after the initial or second vowel, the [back] value of all following vowels will be completely predictable, perceptibility of [back] becomes much simpler, as it can be done with much less accuracy of detection needed (if any at all). Notice that Suomi's principle, as stated, could thus lead to a vowel *disharmony* rule: such a rule would, just like a harmony rule, enforce complete predictability for the [back] value of a non-initial vowel.

Suomi's idea, therefore, was far from one in which spreading occurs from Vowel n to Vowel $n+1$ because vowel n "needs help" in recovery of its [back] feature. His idea was rather that *Vowel $n+1$ is the one that needs help*, and that this help may be furnished by making the value of [back] on Vowel $n+1$ completely predictable on the basis of the value of [back] on Vowel n .

Before concluding, it is worthy of mention that all of these vowel-perceptibility explanations do not go very far when it comes to *height* harmony (of for example, the type found throughout Bantu, in which high suffix vowels lower to mid, or the type found in Woleaian/Basque, in which low /a/ raises). Hayes/Kaun's theory is entirely predicated on the finding that F2 is perceptually unstable in comparison to F1. Why, then, should height harmony, a manipulation of F1, exist at all? F1, being perceptually robust, and in particular, present within a stem, should need no help at all.

Returning to the relative transparency facts in Hungarian, we note that sonority, on the other hand, yields a perfect explanation: decreasing transparency follows directly from increasing sonority, an observation made for gradient patterns of this sort by L. Anderson (1980). Unlike the claim of perceptual weakness of F2 in long vowels, sonority is a well-understood property of phonology, with effects in syllabification, diphthongization, stress assignment, and hiatus resolution.

A brief remark is in order here about the phonetic correlates of sonority. Selkirk 1984 and others have commented that sonority probably translates most straightforwardly into intensity, the amount of spectral energy in a segment, which has

a perceptual correlate with loudness. Parker (1999) conducted a series of experiments to investigate the phonetic correlates of sonority in vowels and consonants, and found that, in a factor-analysis, intensity (as measured in decibels) was indeed the best predictor of correlation with the Jespersen sonority scale. Interestingly, Parker also found that *duration* had the *worst* goodness-of-fit as a predictor of sonority in consonants, and had little predictive power in vowels as well.

However, Parker found very weak (and in some cases, opposite) results for intensity/sonority correlations in *vowels*. Parker's explanation for this contradictory finding was that the vowels also differed in F0, with vowels of increasing height having higher F0 than lower ones. Since higher F0 increases intensity, this has the effect of shadowing the decreased intensity due to lower sonority.

Parker's view is thus that sonority is a single phonological property with a multiple of phonetic correlates. The fact that there is no one single phonetic correlate is not considered problematic for him, and we should take his remarks seriously:

"..there is a presupposition in this claim that I do not find convincing, namely, that if we cannot find a single physical correlate for sonority, then sonority must not exist. If this were true, we would also have to deny the existence of stress, tenseness, and many other distinctive features."

At present, it seems premature to offer a phonetic explanation for why sonority should determine opacity in vowel harmony, just as it seems unlikely that we will find a phonetically-grounded explanation for why sonority should matter for hiatus resolution or stress-assignment. Intuitively, the principle makes sense: higher sonority means "greater prominence", and greater prominence affords vowels the opportunity to preferentially be retained in a hiatus situation, to preferentially be assigned metrical stress, and to preferentially provide valuation in a harmonic system. This "greater prominence" however, is probably a concept whose most reliable correlate ultimately resides in the mind of the language user.

This is an apt occasion to conclude this section with a recap. We examined Wolof [ATR] harmony and Hungarian [back] harmony, two cases in which *non-contrastive invisibility* proved insufficient in explaining a particular asymmetry: both languages had more than one non-contrastive vowel, but in each language, the low vowels behaved as opaque, while the higher vowels behaved transparently. In the next section, we will turn to another, rather different instantiation of the principle of *sonority-based harmonicity*.

3.3. Sonority-Based Asymmetries in Harmonic Vowels

In this section we consider the behavior of Finnish, a [back] harmony system, and Manchu, an [ATR] harmony system. Both of these languages share the interesting property that certain *contrastive* vowels occasionally behave as transparent. Importantly, however, not all contrastive vowels are transparent in these languages, only those of low-sonority. Thus, while the preceding section illustrated cases of *non-contrastive, high-sonority* vowels behaving as opaque, this section illustrates cases of *contrastive, low-sonority* vowels behaving as transparent.

3.3.1. Finnish

Finnish has the following vowel inventory for both long and short vowels.

- (31) i ü u
 e ö o
 ä a

Thus, the vowels *i, e* are non-contrastive for [back], and, predictably, behave as transparent in [back] harmony. The following set of examples illustrate the basic operation of harmony in Finnish native vocabulary. (Note that *y* in Finnish orthography corresponds to *ü*.)

- (32) Finnish root-internal vowel harmony: neutral vowels behave as ‘front’
 (Ringen & Heinamaki 1999:305):

- a. pöytä-nä table-essive
- b. pouta-na ‘fine weather-essive’
- c. hämärä-nä ‘dusk-essive’
- d. käsi-llä ‘hand-adess’
- e. koti-na ‘home-essive’
- f. kesy-llä ‘tame’
- g. vero-lla ‘tax-adess’

The grammar to capture these suffixal alternations is straightforward, given the valuation mechanisms developed thus far.

(33) Finnish Harmonic Policy

- a. *Rule 1: Back Vowel Harmony (BVH):*
 Structural Description: $V_{[+back]} \dots V_{target}$
 Structural Change: V_{target} becomes [+back]
- b. *Rule 2: Vowel Fronting (VF):*
 Structural Description: $V \dots V_{target}$
 Structural Change: V_{target} becomes [-back]

There is occasional transparency for front vowels, but never for back vowels. Thus, Campbell (1980:250) remarks “In specialized loans *y* is considered a neutral vowel” and cites the following examples:

- (34) Finnish loanwords with neutral *y*: brodyyri, daktyyli, katalyytti, klorofylli, miniatyyri, manikyyri, molekyyli, parfyymi, polyypi, pseudonyymi, satyyri, overtyyri, vampyri, volyyymi

The most interesting asymmetry is between the low and non-low [-back] vowels. Campbell (1980:251) reports that *ä* never allows [+back] suffixes, while *ü* and *ö* often do: “Thus, *sutenööri* and *amatööri* are both prestigious sounding, though *sutenööriä* and *amatööriä* are perfectly acceptable. However, **hydrosfääriä*,

**följetongiä*, and the like are impossible.” In Chapter 4, we will revisit the issue of variation, and what properties of Finnish lead to it, but at present, we will note the existence of this height-based asymmetry.

There is nothing in the inventory contrasts of Finnish that would predict this, but of course, the sonority-based account can, by the addition of the following rule:

- (35) *Low Vowel Harmony (LVH):*
 Structural Description: $V_{[+low, \alpha back]} \cdots V_{target}$
 Structural Change: V_{target} becomes $[\alpha back]$

The addition of (35) will account for the dialects reported by Campbell, in which all front vowels except /ä/ are transparent.

3.3.2. Manchu

Written Manchu has an [ATR] harmony system. Ard (1984) does a very good job of showing the flaws in the scholarship of earlier treatments by Vago and Odden who assumed that Manchu harmony was palatal, mainly based on the interpretation of the [-ATR,+back] vowel *u* as the [-back] vowel *ü*¹⁷. He builds a case that the harmony is based on height. Zhang, however, further critiques Ard, and develops an account of the harmony as [ATR]. Basically, height harmony cannot characterize the alternations as a unitary process, since *u*/*ü* are both [+high], while *e*,*a* are both [-high]. The inventory is as follows:

- (36)
- | | | |
|---|---|---------------|
| i | u | [+high,+ATR] |
| | ü | [+high, -ATR] |
| e | | [-high, +ATR] |
| a | ǝ | [-high, -ATR] |

¹⁷The same mistake has plagued many analyses of Khalkha Mongolian, which also has the [-ATR,+back] vowel *u*, but which was analyzed as the [-back] vowel *ü*; detailed arguments that the vowel in question is [-ATR,+back] can be found in Svantesson (1985); Djamouri and Rialland (1984). Ard is probably correct in assessing these errors of *u-as-ü* interpretation as reflecting an analytic bias based on the fact that both Manchu and Mongolian are in the Altaic family.

The [ATR] contrasts are thus between $u \sim \upsilon$ and $e \sim a$. The reader may be tempted to view these as height-based alternations. However, external facts discredit this hypothesis, as there is a velar/uvular alternation based on following [ATR] values¹⁸¹⁹. The velars /k,g,h/ occur before [+ATR] /i,e,u/ (Zhang 1996:41).

- (37)
- a. etu-ku 'clothing'
 - b. here-ku 'ladle'
 - c. kimu-ngge 'harbouring enmity'
 - d. urgu-ngge 'joyous'
 - e. dergi-ken 'somewhat on top'

The uvulars, on the other hand, (denoted by capital letters in Zhang's transcription: K,G,H) occur before /a,ɔ,ʊ/

- (38)
- a. taci-Kʊ 'school'
 - b. Gɔsin 'pity'
 - c. ilHa 'flower'
 - d. nuHa-Kan 'somewhat easy'
 - e. Gunin 'thought'
 - f. fɔHɔɔ-Kan 'somewhat short'

There is thus independent evidence that Manchu maintains an active [ATR] contrast within the inventory. A height-based explanation cannot account for the velar/uvular alternations: /e/, a non-high vowel, takes the velar alternant, while /ʊ/, a high vowel, takes the uvular alternant.

Finally, to establish that the [ATR] contrast in [+back,+round] vowels is indeed phonemic (and not, say, conditioned *by* the dorsals), it can be shown that there are minimal pairs of /u/ and /ʊ/ after non-Dorsal consonants (Zhang 1996:43):

¹⁸This fact was also noted in Bert Vaux's (1993) LSA presentation, subsequently elaborated in Vaux (1999).

¹⁹The reader will notice that these velar/uvular alternations are very different from those in Sibe, which are based on the feature [high]. In Sibe, unlike Manchu, ϵ conditions the uvular alternant.

- (39)
- | | | | | |
|----|--------|--------------------|--------|--------------------|
| a. | butun | 'hibernation' | butun | 'crock, large jar' |
| b. | mungku | 'a frozen fish' | munggu | 'bird's nest' |
| c. | tuku | 'the outside' | tuku | 'wooden mallet' |
| d. | ulen | 'irrigation ditch' | ulen | 'house' |

The stem co-occurrence restrictions in Manchu (Ard 1984:60. Zhang 1996:44) are:

- (40) *a-e, *u-e, *ɔ-e, *e-a, *e-u

Thus, the noncontrastive /i/ can co-occur with any vowels. Contrastive [+ATR] /e/ cannot occur with the [-ATR] vowels. Contrastive [-ATR] /a/ and /u/ can co-occur with the [-ATR] vowels and the high vowels. Additionally, non-initial ɔ must be licensed by an ɔ in the preceding syllable²⁰. Finally, and most surprisingly, /u/ can occur with any vowels, even though it is contrastive for [ATR]. These conclusions are summarized as:

- (41)
- There is [ATR] harmony in Written Manchu stems
 - The lowest-sonority (i.e. high, +ATR) vowels are transparent for [ATR] harmony in stems
 - The low round vowel ɔ must be licensed

What is of greatest theoretical interest is (41-b). Before continuing, however, let us take note of vowel alternations in suffixes, to see what is paired for alternating [ATR] (and round) harmony. The [-high] suffix will be *e* if the preceding vowel is [+ATR], *a* if the preceding vowel is [-ATR], and ɔ if the preceding vowel is ɔ.

- (42) Alternating suffixes (Zhang 1996: 46):
- de/da/dɔ (verb suffix)
 - he/ha/hɔ (verb suffix)

²⁰We find similar licensing requirements on mid round vowels (/o/) in Hungarian, Lowland Murut (Steriade, 1988), Ineseño Chumash, and perhaps elsewhere

- c. le/la/lə (verbalizing suffix)
- d. ne/na/nə (verbalizing suffix)
- e. huri/huri (adjective suffix)
- f. shun/shun (adjectivalizing suffix)
- g. ku/kʊ (noun suffix)
- h. ngge/ngga/nggə (adjectivalizing suffix)
- i. cuke/cuka (adjectivalizing suffix)

The [ATR] alternations are thus {e/a} and {u/ʊ}, with ə-harmony in addition applying to the [-high] vowels. It becomes clear, then, that within the 6-vowel system of Written Manchu, there are five alternating vowels, with /i/ remaining unpaired. The transparency of /i/ is thus quite expected on account of it being non-contrastive for [ATR]. However, the occasional transparency of /u/ (evidenced even in the suffix (42-h), which can be either *cuke* or *cuka*, with the final vowel determined by the [ATR] value preceding /u/) does not follow from any principles of contrastiveness²¹. The sonority-based explanation, however, offers an insight to the following puzzle:

- (43) In Written Manchu, /e/ and /u/ are both [+ATR]. /u/ is occasionally transparent to [ATR] harmony, but /e/ never is.

We return to this issue; let us first examine the conditioning of the above suffixal alternations in (43), with actual examples based on the stem.

- (44) [+ATR] suffixal variants (Zhang 1996:48):

²¹Ard (1984) in fact classifies /u/ as a neutral vowel, but its vacillation in suffixes suggests this is not the right way to think about it.

- a. dergi-ken 'somewhat on top'
- b. eri-he 'swept'
- c. ebiše-ne 'go to bathe'
- d. ice-le 'make new'
- e. ceku-de 'swing in a swing'
- f. eru-le 'torture'
- g. hure-ne 'arch'
- h. juwe-le 'lean to two sides'

(45) [-ATR] suffixal variants (Zhang 1996:49):

- a. algin-ngga 'famous'
- b. ilha-na 'bloom'
- c. nika-ra 'speak Chinese'
- d. dulba-da 'act carelessly'
- e. farhu-kan 'somewhat dark'
- f. malhu-ngga 'frugal'
- g. Hula-na 'go to read'
- h. asha-na 'develop wings'
- i. ilhu-ngga 'lying straight'
- j. gurgi-la 'to flame'
- k. muku-ha 'held a liquid in the mouth'

The transparent behavior of [+ATR] /u/ is exemplified by the following cases.

(46) Transparent /u/: (Zhang 1996:49)

- a. dacu-kan 'somewhat sharp'
- b. agu-sa or agu-se 'sirs'
- c. nakcu-ta or nakcu-te 'mother's brothers'
- d. gusu-la 'tie up with thick rope'
- e. hudu-ngga 'speedy'

Importantly, while the [+high, +ATR] vowel /u/ shows occasional transparency and/or vacillation, allowing [-ATR] valuation to propagate across it, the [-high, +ATR] vowel /e/ never displays this transparency or vacillation. We may understand this in the following terms:

- (47) **Given two harmonic or two noncontrastive vowels ϕ and ψ , where ϕ is of a higher sonority (i.e. lower height) than ψ , it will never be the case that ϕ is transparent while ψ is not.**

In fact, if the stem only contains instances of /u/, the {e/a} alternation in suffixes is unpredictable (Zhang 1996:52):

- (48)
- | | | |
|----|-----------|--------------------|
| a. | uru-sa | 'daughters-in-law' |
| b. | kumu-ngge | 'noisy' |
| c. | usu-kan | 'fussy' |
| d. | juru-ken | 'paired' |

These seem to be quite similar to what we see in Hungarian, in which alternating ϵ takes vacillating endings (e.g. *agnes-nak/nek*). However, when the stem only contains /i/, the suffixal vowel is [-ATR] (49). This is attributed to a rule that inserts [-ATR] by default, a context-free valuation (50).

- (49) Suffixes are [-ATR] on all-/i/ stems (Zhang 1996:56):

- | | | |
|----|----------|--------------------|
| a. | fili-kan | 'somewhat solid' |
| b. | ici-ngga | 'having direction' |
| c. | jili-da | 'get angry' |
| d. | isi-ha | 'pulled up grass' |
| e. | iji-shun | 'obedient' |
| f. | sifi-ku | 'hairpin' |

- (50) *Rule: Vowel Retraction (VR):*

Structural Description: $V \dots V_{\text{target}}$

Structural Change: V_{target} becomes [-ATR]

The importance of (50) for the general theory of harmony developed here is that it demonstrates that *transparent/neutral vowels do not participate in harmony, as interveners, or as sources of valuation*. While in Finnish, in which the transparent [-back] vowels, in isolation, took [-back] suffixes, it was possible to hypothesize that they were conditioning harmony, such a model is not possible for Written Manchu, in which suffixes that are affixed to transparent vowels take the opposite harmonic value.

Thus far, we have looked at {e/a} alternations in suffixes. Let us consider {u/u} alternations.

(51) [+ATR] suffixal variants (Zhang 1996:50):

- a. sidere-shun 'hobbled,lame'
- b. site-ku 'a bed-wetter'
- c. etu-ku 'clothing'
- d. here-ku 'ladle'
- e. sehe-huri 'towering high'

(52) [-ATR] suffixal variants (Zhang 1996:50):

- a. banji-shun 'having money'
- b. saci-ku 'hoe'
- c. fula-huri 'fire-red'
- d. suja-ku 'supporting stick'
- e. bakta-ku 'internal organs'
- f. Gakda-huri 'skinny man'

The Analysis

- (53) a. Suffixes seek specification from the closest contrastive [+ATR] value, yielding the {a,e} or {u,u} alternation.
- b. The [high, +ATR] vowel /u/, being of low-sonority, is the only contrastive [ATR] segment that occasionally behaves as transparent.

Now, a brief comparison with Zhang's analysis. He assumes an abstract *u* in all cases where /u/ is behaving transparently, which is later neutralized. The problem with this analysis is it leaves unexplained why only /u/ has a non-surface-later-neutralized twin. Why couldn't /e/ or /a/ also have one²²? The sonority-based explanation avoids the postulation of abstract, neutralized vowels, and connects the occasionally transparent behavior or harmonic /u/ with its [+high] status, providing an understanding *why* /u/ behaves occasionally transparently. The mechanism for *how* this variation results will be deferred until Chapter 4, where an analysis in terms of multiple grammatical policies will be offered. At present, the two policies will be shown: (54) accounts for the state of affairs in which /u/ determines [+ATR] harmony, and (56) for the state of affairs in which /u/ is transparent and provides no source of [ATR] valuation.

(54) **Manchu Grammar M1: /u/-valuation:**

- a. *Rule 1: Contrastive Vowel Harmony (CVH):*

Structural Description: $V_{[\text{contrastive: } \alpha \text{ ATR}]} \cdots V_{\text{target}}$

Structural Change: V_{target} becomes $[\alpha \text{ ATR}]$

- b. *Rule 2: ɔ-Harmony (OH):*

²²In addition, Zhang assumes the contrastive hierarchy approach of the Toronto school (e.g. Dresher (2003) *et. preq*). He thus assumes that among the high vowels, /i/ vs /u,u/ are only distinguished by coronality, whereas among the low vowels, /e,a/ vs. ɔ are distinguished by labiality. The reason is that only ɔ induces rounding harmony with the low vowels. But this is not an argument that u,u are not specified for labiality. Manchu, like many Tungusic languages, has labial attraction only among the low vowels. That is, only [-high] vowels are subject to an α round assimilation. There is no need to assume underspecification here. Moreover, there is a diachronic development that supports the fact that high round vowels are indeed specified for [round]. Modern Spoken Manchu has the vowel *ü*, which results historically from sequences of /i/ followed by /u/ in Written Manchu:

- (i) The development of /*ü*/ in Modern Spoken Manchu (Zhang 1996: 111)

WM	MSM	
ninggun	nüᅅᅅun	six
tugi	tüu	cloud
tuweri	tüli	winter

The creation of /*ü*/ in Modern Spoken Manchu makes sense in terms of the transfer of [+round] to the initial syllable (which incidentally, becomes stressed in MSM, though WM had final stress). Zhang, on the other hand, has to assume the language underwent an intermediate stage during which /u/ suddenly became specified for [+round].

Structural Description: $V_{[+round,-high]}$ σ -precedes $V_{[-high]}_{target}$

Structural Change: V_{target} becomes [+round]

c. *Rule 3: Vowel Retraction (VR):*

Structural Description: $V \dots V_{target}$

Structural Change: V_{target} becomes [-ATR]

The reader is reminded that σ -precedes is an explicit formulation of the one-syllable adjacency requirement on σ -harmony. Where not indicated (in fact, where indicated by ...), the structural description will be met in a search for the *closest* determinant, but this search is unbounded by explicit adjacency restrictions. Representative example inputs, and the rule that applies, are as follows:

- (55) /fili-kAn/: VR applies, yielding [fili-kan]
/iji-kU/: VR applies, yielding [iji-ku]
/agu-sA/: CVH applies, yielding [agu-se]
/eri-hA/: CVH applies, yielding [eri-he]
/hure-nA/: CVH applies, yielding [hure-ne]
/ilhu-nggA/: CVH applies, yielding [ilhu-ngga]
/saci-kU/: CVH applies, yielding [saci-ku]

We turn to the harmony policy in which /u/ is transparent, which in fact, only requires the sonority-based valuation rule, and a context-free retraction rule²³.

(56) **Manchu Grammar M2: /u/-transparency:**

²³Some learners may construct their sequence so as to add the following rule:

- (i) *Rule 3: Retracted Vowel Harmony (RVH):*
Structural Description: $V_{[-ATR]} \dots V_{target}$
Structural Change: V_{target} becomes [-ATR]

Given the fact that the context-free retraction rule will value a suffix as [-ATR] if there are no high vowels in the stem, and given that *u* can only occur with high vowels and [-ATR] vowels (the only vowel it cannot occur with is *e*), Rule 3 will have no effect in M2, always being taken care of by context-free retraction. However, since an imaginable variant of the grammar might not have Rule 1 or Rule 2, it is included here. Readers interested in the most minimal analysis of Manchu are free to omit it, with no loss of empirical coverage.

- a. *Rule 1: Low Vowel Harmony (LVH):*
 Structural Description: $V_{[-\text{high}, \alpha\text{ATR}]} \dots V_{\text{target}}$
 Structural Change: V_{target} becomes $[\alpha\text{ATR}]$
- b. *Rule 2: Vowel Retraction (VR):*
 Structural Description: $V \dots V_{\text{target}}$
 Structural Change: V_{target} becomes $[-\text{ATR}]$

Representative example inputs, and the rule that applies, are as follows:

- (57) /fili-kAn/: VR applies, yielding [fili-kan]
 /iji-kU/: VR applies, yielding [iji-ku]
 /agu-sA/: LVH applies, yielding [agu-sa]
 /eri-hA/: LVH applies, yielding [eri-he]
 /hure-nA/: LVH applies, yielding [hure-ne]
 /ilh υ -nggA/: VR applies, yielding [ilh υ -ngga]
 /saci-kU/: LVH applies, yielding [saci-ku]

The acquisition sequence leading to the choice of M1, M2, or both, will be discussed in Chapter 4. What is crucial to the current discussion, however, is the fact that a complete analysis for /u/-transparency relies on a privileged valuation status for the low vowels.

To conclude this subsection, we have examined the harmonic behavior of Finnish and Manchu, in which, occasionally, *contrastive* vowels behave as transparent.

3.4. Low Transparent Vowels Imply High Transparent Vowels

The previous discussion has examined cases in which the principle of *non-contrastive invisibility* has been shown to be insufficient, and its shortcomings can be entirely explained by the substantive factor of sonority. In the first set of cases, we examined languages with more than one non-contrastive vowel, in which one of these was *not* invisible, precisely because of high-sonority. In the second set of cases, we examined languages with more than one contrastive vowel, in which one of these

was invisible, precisely because of low-sonority.

All of these cases, however, showed opaque/harmonic behavior for the low vowels. In this section, we will examine low vowels that behave transparently. These are, in fact, the only cases of transparent /a(:)/ that seem to exist in the entire harmony literature. Importantly, none of them contradict the generalization here. A language that would do so would have the following properties:

(58) *An Example that would Falsify the Sonority-Harmony Generalization:*

- a. The language would have an unpaired /a/ which is transparent
- b. The language would have a higher vowel (i.e. one of lower sonority) that was opaque

The three cases of transparent /a/ we examine here do not display effects of clause (58-b). We will consider each in turn.

3.4.1. Lena Bable

Lena Bable is an Asturian dialect of Spanish, with metaphony: a final high vowel causes the stressed vowel to raise. (We will return to the metrical characterization of this process momentarily.) This can be observed in masculine singular nouns ending in the theme vowel *-u*, as compared with the feminine singular *-a*, or the masculine plural *-os* (Hualde, 1989, 775). In all of the following examples, stress is on the penultimate syllable, and the stressed syllable undergoes raising in the masculine singular²⁴:

²⁴Inanimates that show gender alternations do so with a corresponding change in diminution: the masculine *benténu* indicates a smaller window than a *bentána*.

- (59)
- | | | | | |
|----|---------|----------|---------|--------------|
| a. | gétu | gátos | gáta | 'cat' |
| | séntu | sántos | sánta | 'saint' |
| | benténu | bentános | bentána | 'window' |
| b. | nínu | nénos | néna | 'child' |
| | kordíru | kordéros | kordéra | 'lamb' |
| | tsúbu | tsóbos | tsóbas | 'wolf' |
| c. | kabrítu | kabrítos | kabríta | 'young goat' |

As can be observed in (59-a), an underlying /a/ raises to [e] under metaphony²⁵, while in (59-b), mid vowels raise to high. Thus, the feature [+high] is transferred from the final vowel to the stressed vowel, with an implementation as follows:

- (60) **Lena Metaphony: Structural Description:** $\acute{V}_{\text{target}} \dots V_{\text{[+high]}\#}$
Structural Change: V_{target} becomes [+high]

A brief remark is in order about the use of \acute{V} and $V\#$ in the above structural descriptions. As described in Chapter 1, there are only three positional landmarks that may be referred to in the structural description of vowel harmony rules: initial, final, and stressed. The learner will not posit any rules that refer to structural landmarks other than these²⁶.

As in all Asturian and Cantabrian dialects, in Lena, stress may also fall on antepenultimate syllables. Importantly, any vowels that intervene between the final

²⁵The implementation of this process will not be discussed here. One possibility is a particle-phonology based representation, which allows a uniform characterization of one-step raising (Hayes, 1990); another is a repair rule (Calabrese, 1988) that adjusts the addition of [+high] to the [+low] vowel /a/, yielding a mid-vowel. See Goad (1993) and Zetterstrand (1998) for some discussion of these issues. While the repair-rule approach seems cumbersome, the advantages of employing binary features (first, in order to express natural classes between high and mid, or between mid and low, and second, to enable expression of height-based exchange rules in English, Flemish, and Zok, as discussed in Chapter 1) far outweigh this technicality, in my opinion. Indeed, the rarity of /a/-raising to /e/ (it does not occur in Tudanca Montañes (Hualde 1989), or even in Asturian dialects related to Lena) is perhaps evidence that the repair-rule needed in /a/-to/e/ raising is of a formally marked character. However, this remark should not be taken too strongly, as /a/-to-/e/ raising, due to a preceding [+high] vowel, is instantiated throughout dialects of Basque (Hualde, 1988).

²⁶Importantly, these are the same landmarks that characterize all and only the endpoints of precedence-adding relations in reduplication (Iba & Nevins 2004).

syllable and the stressed syllable will not be raised, and will not intervene with metaphony at all. (This differs from other Asturian dialects, in which intervening vowels are raised):

- | | | | | | |
|------|----|------------|-------------|------------|----------------------------|
| (61) | a. | burwíbanu | burwébanos | | 'wild strawberry' |
| | b. | péšaru | pášaros | pášara | 'bird' |
| | c. | kékabu | kákabos | | 'wreck' |
| | d. | kéndanu | kándanos | | 'dry branch' |
| | e. | sébanu | sábanos | sábana | 'sheet' |
| | f. | silikútiku | silikótikos | silikótika | 'suffering from silicosis' |
| | g. | trwíbanu | trwébanos | | 'beehive' |

What is interesting about these examples is that the intervening vowels are not raised, even though these are vowels that may raise when they are in stressed position. The Lena case demonstrates a significant challenge to the association-line approach to the locality of spreading, since there is no way to render invisible the height features of the intervening vowels. Jose Hualde (personal communication, July 2004) confirms that the intervening vowels are not reduced to schwa, and notes that his sources are very explicit in their description of the intervening vowels as unaffected by the [high] copying.

In addition, in a later article, Hualde (1998) notes that these proparoxytones show transparent /a/ in other dialects, where the effects of metaphony on /a/ may differ: in Alto Aller, it is raised to ϵ , whereas in Bimenes, it is raised to ɔ :

- (62) Asturian metaphony (Hualde 1998:104):

Lena (Neira 1955)

- | | | |
|----|-------------------------|--------------------------------|
| a. | péšaru, pašarín, pášara | bird, little bird, female bird |
| b. | pémpanu, pámpanos | old person masc.sg/ masc.pl |
| c. | kéndanu, kándanos | dry branch (sg.pl) |

Alto Aller (Rodríguez-Castellanos 1952)

- | | | |
|----|-------------------|-------------------|
| d. | péšaru, pašarín | bird, little bird |
| e. | téladru, táladros | drill (sg./pl) |
| f. | ébanu, ábanos | snow embankment |

Bimenes, Nalón Valley (García Alvarez 1960)

- | | | |
|----|----------------------|----------------------|
| g. | póšaru, pášaros | bird (sg/pl) |
| h. | mótolu, mátola, máto | I kill him/her/∅ |
| i. | mótalú, mátala, máta | S/he kills him/her/∅ |

The explanation of what is going on in these Asturian dialects is straightforwardly accounted for by the rule in (60). Quite likely, the learning scenario that leads to the transparency of the intervening vowels is that the rule in (60) is posited on the basis of paroxytones, and when proparoxytones are encountered, the rule is retained.

What is most crucial to the current discussion is that the intervening /a/ is transparent in Lena [high] copying. Importantly, however, all intervening vowels in this position are transparent, so Lena does not constitute a counterexample to the implicational sonority generalization.

3.4.2. Londongese

Although many 5-vowel Bantu languages have [high] harmony among the high and mid vowels, /a/ remains opaque, even though it is noncontrastive for the feature [high], given the definition for contrastiveness employed throughout this dissertation. This may be exemplified by the following data from Shona (Beckman,

1998):

- (63) Shona [-high] harmony: Applicative and Causative copy [high] from preceding [-low] source
- a. ip-ira 'be evil for'
 - b. son-era 'sew for'
 - c. bvum-isa 'make agree'
 - d. per-era 'end in'
- (64) Shona [-high] harmony blocked by intervening [+low] /a/:
- a. pofomasz-ira 'blind for'
 - b. cheyam-isa 'make be twisted'

The blocking of [high] harmony by intervening /a/ constitutes a case of *defective intervention*, as characterized in Chapter 1: even though a feature that is copied, [-high], exists on the intervening /a/, there is a requirement that the source for copying is [-low], and /a/ does not satisfy this condition. Regardless of this particular implementation, however, the point remains that /a/ behaves opaquely in height harmony throughout 5-vowel systems in Bantu height harmony. In the scores reviewed by Hyman (1999), there is no Bantu language in which /a/ is transparent to this process. Additionally, Larry Hyman (personal communication, July 2004) and David Odden (personal communication, July 2004) confirm that they have never found a Bantu language in which /a/ is transparent to mid-vowel harmony.

It is interesting, however, to consider the behavior of /a/ in 7-vowel Bantu languages, in particular, those which exhibit [ATR] harmony. There is exactly one case that has been found in which /a/ is transparent. Leitch (1996) provides a study of Londengese (C-80: Goemaere 1981, Hulstaert & Goemaere 1984), a language spoken in the Congo, that has transparent [a], allowing the final vowel to undergo [+ATR] harmony:

(65) Londengese [a] transparent to FV harmony (Leitch 1996:138):

- a. t-ok-ak-e 'n'écoute pas'
- b. t-o-ya-k-e 'ne viens pas'
- c. t-enj-ak-ε 'ne tire pas'
- d. t-ɔngw-ak-ε 'ne vole pas'
- e. t-ɛ-k-ε 'ne mange pas'
- f. a-yo-tepy-ak-e 'qu'il aille parler continuellement'
- g. a-y-ɔs-ak-ε' qu'il aille prendre continuellement'
- h. n-kend-ak-ε 'dois-je partir'
- i. b-ɔs-ak-ε 'ils doivent prendre'

The existence of transparent /a/ is not only evidenced in pre-final vowel position; there is supporting evidence for /a/-transparency from CV reduplication. The diminutive plural prefix is *to-*, and undergoes regressive [-ATR] harmony. When the stem is monosyllabic, the consonant is copied, and a default /a/ is inserted in the reduplicant. Importantly, [-ATR] harmony to the prefix can occur across this fixed-segment:

(66) Londengese reduplicant [a] transparent to diminutive prefix harmony (Leitch 1996:139):

- a. to-fu-fumbe 'esclave'
- b. tɔ-lɔ-lɔi 'goutte'
- c. to-ta-taa 'chèvre'

- d. to-ta-ta 'arc'
- e. to-ba-bo 'amende'
- f. tɔ-wa-wɔ 'bras'
- g. tɔ-ya-yɛ 'feu'
- h. tɔ-sa-se 'querelle'
- i. tɔ-ta-twɔ 'prix'

Perhaps the most fitting example to drive the point home is the transparent prefix *ya-*, which means, believe it or not, "action at a distance" (Leitch 1996:140).

(67) ε -sɔmba ε -ya-nde njale 'le bateau remonte la rivière là-bas'

Of course, for the generalization in (68) to be upheld, it must be the case that high vowels are transparent in Londengese, too.

(68) Given two harmonic or two noncontrastive vowels ϕ and ψ , where ϕ is of a higher sonority (i.e. lower height) than ψ , it will never be the case that ϕ is transparent while ψ is not.

There are not many high-vowelled affixes in Zone C, and as Leitch reports, "There is not a single example of a form with an overt intervening high vowel and retraction in *Hulstaert et Goemaere 1984*." (1996:141). There is some indirect evidence, however, that supports the conclusion that high vowels may turn out to be transparent in Londengese. The causative morpheme (historically *-is-*) is expressed as palatalization of the root-final consonant. In Babole, and other "well-behaved" Zone C languages, the palatalized consonant induced by the causative blocks [-ATR] harmony across it to the following suffix. However, in Londengese, these consonants are transparent, as can be seen by the FV alternation:

- (69) Londengese palatalized consonants (the reflex of high vowels) transparent to [-ATR] harmony (Leitch 1996:141):
- | | | |
|----|-----------------------------------|-------------------|
| a. | -sin-y-e | 'faire écrire' |
| b. | -somb-y-e | 'faire acheter' |
| c. | -amb-y-e | 'faire raconter' |
| d. | -sɔk-y- ε | 'fatiguer' |
| e. | -bots-e (root: -bot-) | 'faire engendrer' |
| f. | -pits-e (root: -pit-) | 'faire abimer' |
| g. | -kɛnj- ε (root: kɛnd) | 'faire aller' |

If this suggestive evidence is correct (and it is all that is presently available), then Londengese also constitutes a case in which /a/ is transparent, but so are the other higher, non-contrastive vowels.

Lena Bable and Londengese thus together constitute two out of the three the only cases I have found in the literature in which /a/ is transparent to vowel harmony. Importantly, neither case is one in which other lower-sonority non-contrastive vowel in the inventory, in contrast to /a/, are opaque.

3.4.3. Menominee

Menominee vowel harmony, as described by Bloomfield (1962) and Milligan (2000), constitutes a case in which /a/ is transparent to harmony, and another vowel in the inventory is opaque. However, before we proceed to discuss the details of the harmony process and the intervention configurations, it is important to clarify an oft-misunderstood point about the Menominee vowel inventory.

As Goddard (1987) discusses in great detail, the publication of *The Menomini Language* represents quite an intrigue in the historiography of linguistics. What is important for our purposes is Goddard's mention of the extremely normative character of Bloomfield's approach to Menominee in particular, and his mention of the extreme inconsistency in the transcription of the low front vowel that Bloomfield originally wrote *ä*, but later, for reasons of typographical preference²⁷, changed to "ε". This vowel is, by all accounts (Bloomfield, 1962; Miner, 1979; Hockett, 1981; Milligan, 2000), a low vowel; however, its transcription with epsilon has led some scholars to interpret this vowel as the mid [-ATR] vowel ε, with unfortunate consequences for subsequent understanding of the process.

The short vowels, particular when front or low vowels show great variability in their surface pronunciation in Menominee²⁸; as Bloomfield (1962) remarks, "the determination of short vowels in normal form is the greatest difficulty of Meno-

²⁷In a 1920 letter to Michelson, Bloomfield wrote "I like to use ε for ä, whether long or short" (Goddard 1987: 208).

²⁸And in the Eastern Algonquian language Penobscot as well (Conor Quinn, personal communication, August 2004).

mini phonemics" (p.6). However, I will follow Milligan (2000), who, based on recordings and formant analysis, has posited the following underlying inventory for Menominee (See also Appendix C for a reproduction of the formant frequencies in Milligan (2001), which clearly demonstrate an F1 of the same value for /æ:/ and /a:/.):

(70) Short vowels:

/i/ [i],[ɪ] /u/ [u]
 /e/, [ɪ] /o/ [o],[ʊ]
 /æ/, [æ],[ɛ],[ɪ] /a/ [a],[ʌ]

(71) Long vowels:

/i:/ [i:],[ɪ] /u:/ [u:]
 /e:/, [e:] /o/ [o:]
 /æ:/, [æ:] /a:/ [a:],[ɔ:]

We wonder if the long and short variants are really the same vowels. Archangeli & Pulleyblank (1994: 381) point to length alternations that make it look so. I employ their transcription:

- (72)
- | | | |
|----|---------------|--------------------------------------|
| a. | ɑ:hkuhnəʔ | as far as he walked |
| | ahku:hnəw | he walks so far |
| | ahku:pi:kat | the water extends so far |
| b. | nikʊt | one |
| | niku:tə:yaw | one affair |
| | niku:tikaʔaw | one-legged being |
| c. | ʊkima:s | man's name: 'Little Chief' |
| | ʊk::ma:hkatam | he is chief over it |
| | ʊki:mu:hkiw | chieftaness |
| d. | ʊmə:kiciw | he has scars/scabs on his belly/body |
| | ʊmə:kɪ:w | he has a scab or a scar |
| | wə:miki:qkit | 'he has a scarred or scabby face' |

The facts of harmony are as follows: [e:] and [o:] are raised to [i:] and [u:], respectively, when a high vowel follows in the word. There are a number of puzzling properties of this harmony. The first concerns the length restriction. It seems that this is not a true restriction on the formal characterization of the process, but rather, an indeterminate fact: “it is impossible to hear if vowel harmony affects short vowels, since there is no phonetic difference between an /e/ and an /i/.” (Milligan 200:251). We will thus follow Milligan, and assume that the length restriction is not part of the statement of harmony.

The next issue is, what is the feature that is being copied in Menominee harmony? Hockett’s (1981) analysis of the Menominee vowel system is as follows:

(73) u i
 o æ e a

An inspection of the F1 of the long vowels of Milligan (2001) shows that /i:/ differs from /e:/ by 100 Hz: the former has an average around 425 Hz, while the latter have an average around 525 Hz. Interestingly, the F1 of /u:/ is significantly higher than that of /i:/, at around 510Hz. At the same time, the F1 of /o:/ is around 610 Hz. Thus, based on the formant values alone, it looks as though even though the “mid vowels” have radically different values, they share the fact that their opposition to the high vowels may be similarly characterized: the *u:~o:* distinction and the *i:~e:* distinction are both 100 Hz differences.

I will thus follow Archangeli and Pulleyblank (1994) and Milligan (2000) in hypothesizing that the vowel harmony process in Menominee is a [+ATR] harmony, and not a height harmony. This assumption allows for a straightforward characterization for why /a/ is transparent to harmony, while /æ/ is not. No explanation is available (though this is merely a *poverty-of-the-imagination* argument) if the harmony is analyzed as height harmony.

It is important to realize, however, that whatever the ultimate characterization of Menominee vowel harmony is, the fact that /æ/ is opaque to harmony, while /a/ is transparent, does not constitute a counterexample to the central generaliza-

tion of this chapter, because *both of these vowels are the same height*.

In proceeding with an [ATR] analysis of Menominee, we may postulate the following specifications:

- (74)
- a. /i/: [-low, +ATR, -back, -round]
 - b. /e/: [-low, -ATR, -back, -round]
 - c. /u/: [-low, +ATR, -back, +round]
 - d. /o/: [-low, -ATR, -back, +round]
 - e. /a/: [+low, -ATR, +back, -round]
 - f. /æ/: [+low, +ATR, -back, -round]

In this regard, it is important to note that Nez Perce vowel harmony, which also opposes *u* and *o*, is argued to be [ATR]-based by Hall and Hall (1980).

The Menominee harmony rule is one of asymmetric feature copying: only [+ATR] is copied. Importantly, however, it is a parasitic harmony²⁹, with the requirement that the source be [-low]. Intervening /æ/ thus constitutes a defective intervener, of the same formal status as that of labial consonants in Nawuri rounding harmony (Casali, 1995), discussed in Chapter 1, where the requirement that the closest valuation source be [-consonantal] causes failure of copying.

(75) Menominee Advancement Vowel Harmony:

Structural Description: $V_{[-low]_{target}} \cdots ![-low] V_{[+ATR]}$

Structural Change: V_{target} becomes [+ATR]

The reader will recall from Chapter 1 that the notation $\cdots ![-low]$ indicates that, if any potential determinant is encountered (in this case, a [+ATR] vowel), and that determinant **does not** meet the requirement [-low], then the search for a valuation source is terminated.

The insight of the analysis is similar in spirit to that of Archangeli and Pulleyblank (1994); Milligan (2000), who analyze /æ/ as [+ATR], and hence opaque to

²⁹Though clearly not of the type envisioned by Cole and Trigo (1988), who analyzed æ as a mid, -ATR vowel.

[+ATR] harmony among the [-low] vowels. In fact, by positing that /æ/ is [+ATR], we may gain insight into its wide range of surface variability. As Doug Pulleyblank suggests (personal communication, July 2004), there is more variability in the realization of vowels that have specifications that are, to some extent, articulatory antagonistic. The fact, then, that /æ/ is both [+low] and [+ATR] may lead to its surface variability and frequent raising.

Before concluding, however, I wish to emphasize that the Menominee data is that which I feel the least confident in among all of the data in this chapter, for, it is one of the only languages that has not been described by a native speaker. Moreover, in an oft-uncited passage of *The Menomini Language*, Bloomfield notes that there are a number of exceptions to /æ/-opacity:

“Quite often this raising is carried out when the causing sound is in a following compound member, or in a following word in a close-knit phrase, even with intervening ϵ , [ɛ]: *ki:s-pi:w* beside *ke:s-pi:w* ‘he has come’; *pepu:n* ϵ :*hkwah* beside *pepo:n* *ehkwah* ‘all winter long’; *ni:pen* ϵ :*hkwah* beside *ne:pen* ϵ :*hkwah* ‘all summer long’” (p.97)

In the absence of detailed further investigation of the systematicity of these exceptions, we may nonetheless note that the interesting behavior of Menominee /æ/ provides a further exemplar of a low vowel whose opacity does not follow from principles of contrastiveness, but can rather be understood in terms of its height specification yielding a defective intervention.

3.5. Closing Considerations: Height as a “Primary Feature”

Many of the rules developed in this chapter relating to sonority have a substantive basis. There is nothing inherent in the constraint-based formalism that makes it more appropriate for describing phonetically-grounded processes. An OT constraint is still a formally defined function that takes a representation as input and yields an integer as an output. The motivation for this formally-defined object may lie in articulatory dynamics, but the constraint itself does not refer to articulatory

dynamics. The same is true of rules, they may be (and in fact almost always have been) *grounded* in interface conditions as well.

Before closing this chapter, it is worth discussing further the role that vowel height seems to play in the syntagmatic and paradigmatic organization of vowel systems. I will suggest the following:

(76) A vowel receives at least one specification for height before anything else

That is to say, the lexical representation of a vowel must include a value of {+,-} for either {high,low} before any other feature values are to be specified, either through harmony or through contrastive divisions of the vowel space³⁰. In this way, [low] becomes similar to what Stevens and Keyser have called a *primary feature*.

Stevens and Keyser (1989), working within consonantal contrasts, propose that segmental systems are arranged with *primary features*, which are "perceptually the most salient". It is well-known that F1 is the most salient formant: Harms (1987)

"The burden of phonological distinctiveness is greater over those harmonics with the greatest energy...in other words, if God had wanted man to make greater use of higher frequencies, he would have (a) put more energy there or (b) made our basilar membrane significantly more sensitive to those frequencies" (Harms 1987:389)

Stevens & Keyser suggest that the (consonantal, in their case) segments that are most prevalent in language are those that are distinguished from one another by the most salient features, i.e. the primary features (p.389). It seems quite natural, based on these considerations, to propose that height is a primary feature for vowels.

There is both a perceptual and articulatory basis for height as a primary feature.

In a sense, it functions as a *stricture* feature among the vowels. Steriade (1987), in a discussion of predicting redundant features, notes that triangular three vowel systems are not well-characterized by statements like [+round] → [+high], since, in

³⁰In fact, the first marking convention in SPE Chapter 9 is [± low].

Nyangumata and other three-vowel systems, /i/ and /u/ behave as [high] vowels together throughout the phonology.

In articulatory terms, height also seems to be “primary’ in vowels: Harshman, Ladefoged, and Goldstein (1977) applied the PARAFAC model of statistical factor analysis to x-ray data on ten vowels produced by five speakers of American English. Two parameters accounted for over 96% of the variance: a **front-raising** gesture and a **back-raising** gesture.

We may note that all 2-vowel systems (e.g. Kabardian: Colarusso and Marshallese (Bender; Choi)) are vertically arranged, establishing that [\pm high] is one of the primary contrasts that a language establishes when opposing vowels

Moreover, as described in Chapter 1, “non-constituent” copying in Turkish and Dagaare leads to change the question from “what spreads together” to “what is the typology of underspecified vowels that need valuation for more than one feature?”. Consider the categorizations of the following systems:

- (77) •Turkic suffixes: Copy everything but [+high]
- Dagaare: Copy everything but [-high]

In a sense, the archiphonemic intuition of /I, A/ is correct: affixes seem to be specified *only* for height in systems with palatal, labial, and/or tongue-root harmony. Height-harmony is much rarer, and even then, already involves a specification for height:

- (78) Shona affixes: already specified for [-low]

One way of understanding all of this is as follows:

- (79) Affixes in harmonic languages have incomplete lexical representations. However, before anything else, they are specified for height.

These closing considerations can be thus understood as follows: we have seen throughout this chapter that sonority (which in the case of vowels, is determined

by height) is one of the primary determinants in participation in harmony. Once we began to ask the question of why height should matter so much among vowels, we may return to a question that was raised in Chapter 1. Recall that trigger-centric theories of harmony characterize multiple-feature harmony in terms of “what spreads together”, but that in the case of non-constituent copying, the answer is perhaps better framed as “what is the only feature a vowel *doesn't* need”. Recall that Dagaare is a 9-vowel system, with [ATR] contrasts among the [-low] vowels, as shown in the inventory:

(80) Dagaare Vowel inventory

-back,-round		+back,+round	
i,ɪ		u,ʊ	[+high,-low]
e,ɛ		o,ɔ	[-high,-low]
	a		[-high,+low]
	+back,-round		

In Dagaare, we find [round] and [ATR] being copied together. These do not form a constituent in any feature-geometric models (i.e. Sagey 1986, Odden 1991). The imperfective suffix in Dagaare copies the features [ATR] and [round] from a preceding source:

(81) Imperfective suffix always [-high]: Bodomo 1997:25)

Verb	Impf	Gloss
do	duo-ro	climbing
tu	tuu-ro	digging
bɔ	bʊɔ-ro	looking for
mɔ	mʊɔ-ro	wrestling
bʊ	bʊʊ-ro	discussing
mi	mii-re	raining
piiri	pii-re	discovering
siri	sii-re	touching
ɲɛ	ɲɛ-re	beating
kpe	kpe-re	entering
ɣpe	ɣpie-re	grinding roughly
kpa	kpa-ra	boiling
la	laa-ra	laughing

We may formalize the representation of the Dagaare imperfective suffix as follows. The affix is lexically stored with *only* a height specification: [-high]. Immediately upon phonological spell-out, the affix seeks values for the features [ATR] and [round]. What is most interesting here is that the suffix already bears a specification for height. Rather than asking the question “why are [back] harmony, [ATR] harmony, and [round] harmony so much more common than height harmony”, we might instead, in current terms, ask why underspecified affixes tend to bear a height feature before any others. If the articulatory and perceptual motivations explored in this subsection are on the right track, and the dimension of height is more salient and constitutes a “primary feature” (in Stevens & Keyser’s sense), we can begin to explore an answer.

Chapter 4

Underdetermined Learner Analysis and Variation in Harmony

“The assumptions on which this model are based are (1) that innovation in the phonological structure of a language can only be explained on the basis of ambiguities in the corpus of utterances from which the new grammar is inferred.” (H. Andersen 1973: 774)

“Between [the formation of explanatory hypotheses in science and the nature of the perceptual judgement] lies what is the most important abductive activity in the life of the individual, the acquisition of a cultural pattern – including, in particular, the formation of a grammar – based on the observed behavior of other members of the community in which he is brought up. In acquiring his language, a learner observes the verbal activity of elders, construes it as a ‘result’, – as the output of a grammar – and guesses at what that grammar might be. ” (Andersen, 1973, 776)

In this theory of conditions on harmony, or any other such theory, there will be more than one parametric setting that may accurately describe every input-output theory that a learner may have encountered. A linguistic researcher may think that he or she has the entire potentially occurring corpus, or at least the assumption that the data encountered are exhaustive. The knowledge state S_j of a learner after the presentation of the j^{th} data point, however, may represent an alto-

gether different object than the neat single rule that the linguist may have deemed best, for the standard reasons having to do with how science is conducted (and indeed, advances). However, considering a model of the *incremental* theory of a learner, exposed to successive tokens of (dis)harmony in the ambient language, and attempting to generalize at each step, has its merits, even beyond the obvious consideration of ultimately striving for a psychologically realistic theory of the “growth” of a phonological component. The languages whose variation will be presently examined are two extremely well-studied ones: Finnish and Hungarian. However, it is quite likely that such variation is present in every language with a harmony system¹.

What is under scrutiny, then, is the results of incremental exposure to data of an underdetermined nature, that dictate *more than one hypothesis* for the most compact and organic grammar of co-occurrence principles on well-formed words. It is a completely theory-independent observation that if the learning-rate plateaus, and there are multiple compatible “grammars” (i.e. rule-sets, parametric settings of rule-variables, or constraint-rankings), then the state S_n of the learner will, when presented with an input for which the remaining grammars are not identical in their computed output, produce *variable outputs*.

An idealized scenario will help. Suppose that there are two grammars, G_1 and G_2 , both of which, when presented with the input I_j (e.g., /viz-nAk/), each yield the same output, O_j [viz-nek]. As outside observers, we only have access to the input that this function receives, and the output it produces, but no definitive knowledge of the “black box” that resides in between. One point of view, which is predominant in the current field, is that the representation of the speaker is one in which *either* G_1 or G_2 is the function in the box, but not both.

Consider, however, an alternate possibility: *both* G_1 and G_2 are in the box. Whenever an input comes, it is handed off to one of G_1 or G_2 , for the duration of that single computation. Thus, for input I_j , though we *cannot tell* as outside

¹This statement might be more effectively understood by restricting the domain of quantification to those consisting of more than two alternating vowel-pairs and some non-empty set of transparent vowels.

observers which of G_1 or G_2 is being employed to compute the output, the fact remains that only one of them does. Let us call this grammar G_* . It takes an input I , and consists of a selection function that will determine which grammar to send I as its input.

The result of such a scenario is that, when a certain input, I_m is passed to G_* , the output of G_* may appear, in fact, to be *variable*: that is, not unique and/or consistent, or, more properly, not bijective. It is important to realize that the appearance of *variable* output does not say anything in particular about the *input* from which it was derived, i.e. that it is in some way “special”. The state of affairs described with G_* above is one in which the output of G_* is *always* variable: that is, it could be the result of *either* of G_1 or G_2 . Since for input I_j considered above, the *outputs* of G_1 and G_2 happen to be identical, it *looks* as if G_* is behaving in a deterministic fashion, in yielding a fully bijective input-output pairing. However, this is only because the outputs of G_1 and G_2 are identical for I_j . In reality, the situation we are entertaining is one in which the non-deterministic nature of G_* can only be observed by looking at multiple instances of application of G_* to an input I , and seeing that they do not always yield the same output.

Variation, on this model, is not the result of a “variable rule”. There is no sense in which a particular rule of the grammar is marked [+optional]. Rather, there are two grammars, which may differ in the presence of this rule, and what is optional is which of these grammars is chosen.

The parametrized system of vowel harmony rules developed in Chapters 3 and 4 will be repeated here. Suppose that learners have five binary parameters that circumscribe the search space for harmony policies. Each is independent of the other:

- (1) a. All Value Harmony: (\forall VH): The value of F for the suffixal vowel will be determined by the closest source of F. *Values*: ON or OFF
- b. Contrastive Value Harmony (CVH): The value of F for the suffixal vowel will be determined by the closest contrastive source of F. *Values*: ON or

OFF

- c. Asymmetric Value Harmony (AVH; name usually provided by the value in consideration, e.g. BVH for [+back]): The value of F for the suffixal vowel will be determined by the closest source of the {+,-} value F (with the corollary (but independent) hypothesis that this value will always be the *marked* value for F). *Values:* +, -, or OFF
- d. Sonority-Based Vowel Harmony (SVH; name usually provided by the cutoff value in consideration, e.g. LVH for [+low]): The value of F for the suffixal vowel will be determined by the closest source of the value F that is above the vowel sonority threshold in that language. *Values:* +LOW, -HIGH, or OFF.
- e. Context-Free Value Change (CFVC; name usually provided by the change in consideration, e.g. VF for context free [-back]): The value of F for the suffixal vowel will be assigned to a designated value. *Values:* +, - or OFF (Note: CFVC can only be definitively OFF in a system without neutral vowels, e.g. Turkish [back] harmony).

There are, in fact, $2*2*3*3*3= 108$ policies/grammars to consider. This is an easily tractable number, and the search space can be rapidly pruned within a handful of forms. This has been demonstrated by Nevins and Iba (2004) for parametric grammars of reduplication. A computational simulation for the vowel harmony parameters proposed here is currently underway. An example representation of the policies for some of the languages considered thus far is:

- (2) a. AllVH: 01
CVH: 0 1
AVH: 0 - +
SVH: 0 L M
CFVC: 0 - +
- b. Turkish (back): 10000

Tangale (ATR): 10000

Wolof (ATR): 010L+

Uyghur (back): 0100+

Finnish1: 0100-

Of course, the presence of each parameterized rule is not all that there is to the policies; the principles of evaluation and application play a critical role, as will be demonstrated in turn.

4.1. Finnish Transparent Front-Vowel Variation

It's time for a concrete example. In Finnish loanwords in which a back vowel precedes a front, contrastive vowel, speakers exhibit variation when choosing the form of the suffix vowel. There is thus vacillation for the choice of affix, which "probably depends on, still poorly understood, factors such as speech rate, rhythm, information structure, style, etc. In other words, the observed free variation in the suffixes is indeed free in the sense of not depending on contextual segmental information." (Välismaa-Blum 1999:263):

(3) marttyyri-ko, marttyyri-kö

Suffixation in native words does not exhibit this sort of variation, because native words do not contain vowels from *both* the back set {u,o,a} and from the front set {ü,ö,ä}. (The neutral vowels {i,e} can of course occur with both sets in native words and in loanwords).

(4) pouta-na 'fine weather', pöytä-nä 'table', velje-llä 'brother', koti-na 'home',
kesto-a 'of duration'

The present assumption is that affixes are stored without specification for [back]. Discussion of this assumption was provided in Chapter 1. Briefly, such an assump-

tion is framed in terms of a commitment to a model of the lexicon, and does not directly bear on the nature of phonological computation. To briefly recap, the motivation for this assumption is that, in completely agglutinative languages such as Finnish, there is no reason to store an underlying value of [back] for alternating suffixes, as it is entirely predictable based on harmony, and these affixes never surface ‘on their own’ (i.e., freestanding), so any underlying value will be changed by the rules given here. Certain researchers, motivated by the hypothesis that there are no feature-changing rules, only feature-filling rules, assume a stored lexical value for alternating affixes. However, since Chumash sibilant harmony (Chapter 2) demonstrates incontrovertible evidence for feature-changing rules, this hypothesis cannot be maintained. Moreover, since the best-understood ‘function’ of vowel harmony is to facilitate word-segmentation (Suomi et al., 1997; Vroomen et al., 1998), then on this understanding, there is no reason to store a lexical value for [back]. Finally, we may note in passing that models in which *both* alternants of the affixes are lexically stored, and harmony is seen as allomorph-selection (Hayes, 2004; Albright, 2004) are possible as well, although by viewing harmony as selection between two atomically-stored affixes, there is no *explicit* connection between the structural determinant of harmony (a [back] value) and the structural change (choosing an allomorph with a certain [back] value).

However, on the basis of the the preceding native words, Finnish learners can construct many possible compatible grammars.

(5) **Grammar F1**

a. *Rule 1: Back Vowel Harmony (BVH):*

Structural Description: $V_{[+back]} \dots V_{target}$

Structural Change: V_{target} becomes [+back]

b. *Rule 2: Vowel Fronting (VF):*

Structural Description: $V \dots V_{target}$

Structural Change: V_{target} becomes [-back]

In Grammar F1, Rule 1 takes precedence over Rule 2 through disjunctive ordering as dictated by the Elsewhere condition, since the structural description of Rule 2 is a proper subset of the structural description of Rule 1.

(6) Results of Grammar F1:

- a. /pouta-nA/: BVH applies, yielding [pouta-na]
- b. /pöytä-nA/: VF applies, yielding [pöytä-nä]
- c. /velje-llA/: VF applies, yielding [velje-llä]
- d. /koti-nA/: BVH applies, yielding [koti-na]
- e. /kesto-A/: BVH applies, yielding [kesto-a]

Thus, Grammar F1 is compatible with the input-output pairings observed in Finnish native words.

However, on the basis of these same native words, Finnish learners can construct another possible grammar.

(7) Grammar F2

- a. *Rule 1: Contrastive Vowel Harmony (CVH):*
Structural Description: $V_{[\text{contrastive: } \alpha \text{ back}]} \dots V_{\text{target}}$
Structural Change: V_{target} becomes [α back]
- b. *Rule 2: Vowel Fronting (VF):*
Structural Description: $V \dots V_{\text{target}}$
Structural Change: V_{target} becomes [-back]

In Grammar F2, Rule 1 takes precedence over Rule 2 through disjunctive ordering as dictated by the Elsewhere condition, since the structural description of Rule 2 is a proper subset of the structural description of Rule 1.

(8) Results of Grammar F2:

- a. /pouta-nA/: CVH applies, yielding [pouta-na]
- b. /pöytä-nA/: CVH applies, yielding [pöytä-nä]

- c. /velje-llA/: VF applies, yielding [velje-llä]
- d. /koti-nA/: CVH applies, yielding [koti-na]
- e. /kesto-A/: CVH applies, yielding [kesto-a]

Thus, both Grammar F1 and Grammar F2 are each completely successful generalizations to build over these four input-output pairs. We may consider other grammars that would not do as well.

(9) **Grammar F3**

- a. *Rule 1: Front Vowel Harmony (FVH):*
 Structural Description: $V_{[-back]} \cdots V_{target}$
 Structural Change: V_{target} becomes [-back]
- b. *Rule 2: Vowel Backing (VB):*
 Structural Description: $V \cdots V_{target}$
 Structural Change: V_{target} becomes [+back]

Grammar F3 would fail for words with back vowels together with neutral vowels. As will be discussed below, counterexamples to a grammar/policy result in discarding that grammar forever².

(10) Results of Grammar F3:

- a. /pouta-nA/: VB applies, yielding [pouta-na]
- b. /pöytä-nA/: FVH applies, yielding [pöytä-nä]
- c. /velje-llA/: FVH applies, yielding [velje-llä]
- d. /koti-nA/: FVH applies, yielding [*koti-nä]
- e. /kesto-A/: FVH applies, yielding [kesto-ä]

Thus, a learner will discard Grammar F3 very quickly in the observation sequence, as words like *koti* are quite common. There are other grammars that may be also

²This may represent an idealization; it could be that a certain threshold number of distinct tokens of a counterexample of a given form result in decreasing the preference-weight of a grammar/policy by a highly significant quantity. Filling in the model with numbers of this sort will not make any substantially different predictions from the idealized account presented here.

briefly considered by the learner, but that will be quickly discarded. Any variants of Grammars F_{1-3} that do not have a vowel fronting rule will fail for words with all neutral vowels. Similarly, a grammar with *only* a vowel fronting rule will fail for words like *koti*, which take back suffixes.

There is at least one more grammar that the learner may consider.

(11) **Grammar F4**

- a. *Rule 1: Front Vowel Harmony (FVH):*
 Structural Description: $V_{[-back]} \cdots V_{\text{target}}$
 Structural Change: V_{target} becomes [-back]
- b. *Rule 2: Back Vowel Harmony (BVH):*
 Structural Description: $V_{[+back]} \cdots V_{\text{target}}$
 Structural Change: V_{target} becomes [+back]

These rules cannot be disjunctively ordered by the Elsewhere condition, as there is no subset relation between their structural descriptions. Thus the rules are scanned for matching structural descriptions from right to left, and as soon as either is met, the other is disjunctively blocked.

(12) **Results of Grammar F4:**

- a. /pouta-nA/: BVH applies, yielding [pouta-na]
- b. /pöytä-nA/: FVH applies, yielding [pöytä-nä]
- c. /velje-llA/: FVH applies, yielding [velje-llaä]
- d. /koti-nA/: FVH applies, yielding [*koti-nä]
- e. /kesto-A/: BVH applies, yielding [kesto-a]

There are four grammars that the learner may seriously consider. Only two of them turn out to be compatible with the five input-output pairings observed here. The simplest architecture for “finding” the correct grammar is one as follows:

(13) For G_* which contains grammars $G_{1...n}$,

- a. For each input-output pairing, see whether each G_j is compatible with that pairing.
- b. If G_j is not compatible with an input-output pairing, remove it from G_* .

Given this procedure, and the five input-output pairs considered above, only Grammars F1 and F2 remain for Finnish. Now suppose that after a certain number of exposures, the grammar-discarding process in (13) ends, and everything that remains in G_* is kept; we may refer to this state as S_n , one of plateauing the discarding process³. The production component of the speaker proceeds as described earlier: G_* selects any one of its constituent grammars by some nondeterministic process, and a given input will result in an output computed *by any one of these* constituent grammars. Consider how this proceeds for the five inputs above. Each of them could be passed to either F1 or F2, and an outside observer would have no way of knowing which was selected at any step, because the outputs are identical. Now consider the input *martyyri-kO*⁴:

- (14) F1 selected: /martyyri-kO/ undergoes BVH, yielding [martyyri-ko]
 F2 selected: /martyyri-kO/ undergoes CVH, yielding [martyyri-kö]

This is exactly the observed variation reported by Campbell (1980), Kiparsky (1981), and subsequent authors: loanwords of the type *back + contrastive-front* yield variable outputs in suffixation. However, not all mixed loanwords exhibit variation. More precisely, consider the input *tyranni-kO*, which only has a back-vowel suffix, and no variation.

- (15) G1 selected: /tyranni-kO/ undergoes BVH, yielding [tyranni-ko]
 G2 selected: /tyranni-kO/ undergoes CVH, yielding [tyranni-ko]

³In reality, the learning rate probably does not completely cease, but approaches an extremely low value, in which only repeated divergences in the constituent grammars may lead to discarding one. The reader is referred to various discussions in the literature of the "absoluteness" of the critical period.

⁴According to Skousen (1973, 118), "These words are cultural loans and infrequently used."

It is important to take a step back and consider what property of Finnish it is that is structurally ambiguous. Here is what it is: by virtue of having neutral vowels that are [-back] and, themselves, take [-back] suffixes. the learner must posit a context-free vowel fronting rule (VF). However, once this rule is present in a particular grammar/policy, it will do a lot of the work that having contrastive vowel harmony will do, since all of the contrastive [-back] vowels (e.g. {ü,ö,ä}) will induce valuation under the conditions of VF as well. The structural ambiguity of *pöüt-ä-nä* is thus whether it is due to CVH, or due to the effects of VF in a grammar without CVH. It is precisely because the neutral vowels are [-back] that Finnish has this ambiguity. Thus, *tyranni* could never result, because there are no neutral [+back] vowels in Finnish. However, if there were a language, Finnish-Prime, in which there was no /i,e/, but there were the transparent back vowels /i,Λ/, it *would*, under the system of parameters here, have variation in *tyranni-kO*, and none in *martyri-kO*.

4.2. Hungarian Doublets

The next example to be considered comes from the behavior of the low vowel ϵ in Hungarian, when it is preceded by a back vowel. This results in so-called “vacillating” “doublets” (Esztergar 1971), which we will exemplify with:

(16) a:gnes-nak, a:gnes-nek

Recall that ϵ is a low vowel, and that only $u \sim \ddot{u}$ and $o \sim \ddot{o}$ are contrastive for [back], given the inventory (17) and the definition of contrastiveness adopted throughout this dissertation (18):

(17) $\ddot{u}(:)$ $i(:)$ $u(:)$
 $\ddot{o}(:)$ $e:$ $o(:)$
 ϵ ɔ $a:$

(18) A segment S with specification αF is *contrastive* for F if there is another segment S' in the inventory that is featurally identical to S (and with the

same length / moraic licensing requirements), except that it is $-\alpha F$

Clearly, /i(:),e:/ are not contrastive for [back], since there is no [+back] counterpart with the same values for [round] and height. Similarly, /ε/ is not contrastive, since there is no [+back] counterpart with the same values for [round] and [low], and /ɔ,a:/ are not contrastive, since there is no [-back] counterpart with the same values for [round] and [low].

Contrastiveness thus plays an important role in the theory of harmony developed here. Autosegmental analyses, such as that of Clements (1976), must posit that the autosegments associated with the neutral vowels are deleted by rule before harmony applies. This is the problem with assuming a non-relativized theory of locality. Clements' association-line view forces an analysis in which one must delete an autosegment from a lexical representation, to allow a clean statement of the spreading rule, then do mitosis on the shared autosegment, then put [-back] *back* on the intervening neutral vowel. Learners on the current model have to posit one single rule, of contrastive visibility, instead of this Duke-of-York sequence of three ordered operations.

There are two grammars that the learner will retain in consideration after presentation of the following inputs⁵:

(19) radir-nak, kostúm-nek, bíro-nak, fűszer-nek, fille:r-nek

(20) **Grammar H1:**

a. *Rule 1: Contrastive Vowel Harmony (CVH):*

Structural Description: $V_{[\text{contrastive: } \alpha \text{ back}]} \cdots V_{\text{target}}$

Structural Change: V_{target} becomes $[\alpha \text{ back}]$

⁵In addition, the ε/ɔ suffixal alternation in question is governed by a final pair of adjustment rules (Vago, 1975; Ringen, 1975), since orthographic short "a" is phonetically [ɔ]:

(i) For [-high, +low] vowels linked to one moraic unit, [+back] implies [+round]

Thus, the [+back] alternant of the [-high,-round] suffix is [ɔ] (orthogr. "a"), while the [-back] alternant is [ε] (orthogr. "e"). The inclusion of this rule has no bearing on the variation between constituent grammars discussed in the text.

- b. *Rule 2: Back Vowel Harmony (CVH):*
 Structural Description: $V_{[+back]} \dots V_{target}$
 Structural Change: V_{target} becomes [+back]
- c. *Rule 3: Vowel Fronting (VF):*
 Structural Description: $V \dots V_{target}$
 Structural Change: V_{target} becomes [-back]

Rules 1 and 2 would be evaluated in parallel at each potential locus of the structural description, in a manner rather similar to the mechanism outlined by Howard (1972), and evaluated and exemplified in Chapter 1:

- (21) After identifying the *focus* of the valuation rule, advance the pointer leftwards.
 - a. At each potential context required by the structural description(s), evaluate whether the structural descriptions all relevant rules are completely satisfied.
 - b. If so, apply the associated structural change(s), and terminate the procedure.

(There are, of course, potential loci in which both Rules 1 and 2 are satisfied by the same structural context. We may suppose that the learner has no ordering among the application of these structural changes.)

- (22) Results of Grammar H1 (determining structural context indicated in **bold-face**):
 - a. /radir-nAk/: BVH applies, yielding [radir-nak]
 - b. /kostúm-nAk/: CVH applies, yielding [kostúm-nek]
 - c. /biro-nAk/: BVH/CVH applies, yielding [biro-nak]
 - d. /fűszer-nAk/: CVH applies, yielding [fűszɛr-nek]
 - e. /me:rnök-nAk/: CVH applies, yielding [me:rnök-nek]
 - f. /fille:r-nAk/: VF applies, yielding [fille:r-nek]

The advantage of the context-free rule of vowel fronting (as opposed to associating all *back+neutral/ neutral+back* stems with a single [+back] autosegment) is that it accounts for hypocoristic formation in Hungarian; as Vago (1974) observes, names like *Tibor* take the [+back] *-nak* suffix, but, when nicknamed to *Tib*, they take the [-back] *-nek* suffix.

The other grammar that is compatible with all six data points is Grammar H2. Grammar H2 differs in that it contains a rule of low-vowel [back] valuation, which values the suffixal vowel with the back value of a preceding low vowel⁶.

(23) **Grammar H2:**

a. *Rule 1: Contrastive Vowel Harmony (CVH):*

Structural Description: $V_{[\text{contrastive: } \alpha \text{ back}]} \dots V_{\text{target}}$

Structural Change: V_{target} becomes $[\alpha \text{ back}]$

b. *Rule 2: Low Vowel Harmony (LVH):*

Structural Description: $V_{[+\text{low}, \alpha \text{ back}]} \dots V_{\text{target}}$

Structural Change: V_{target} becomes $[\alpha \text{ back}]$

c. *Rule 3: Vowel Fronting (VF):*

Structural Description: $V \dots V_{\text{target}}$

Structural Change: V_{target} becomes [-back]

(24) **Results of Grammar H2 (determining structural context indicated in bold-face):**

a. /radir-nAk/: LVH applies, yielding [radir-nak]

b. /kostűm-nAk/: CVH applies, yielding [kostűm-nek]

c. /biro-nAk/: CVH applies, yielding [biro-nak]

d. /fűszer-nAk/: LVH applies, yielding [fűszer-nek]

e. /me:rnök-nAk/: CVH applies, yielding [me:rnök-nek]

f. /fille:r-nAk/: VF applies, yielding [fille:r-nek]

⁶That low vowels should be the only height to categorically provide specification for the harmonic feature is derived from substantive properties of sonority, discussed in the previous chapter. That is to say, there could not be a Hungarian grammar with only a rule of High vowel harmony. This imposes an a priori limitation on the hypothesis space of harmony rules.

By inspection, then, we may note that a learner that has both H1 and H2 in G_* will produce identical outputs for the six inputs chosen above.

There are other grammars to consider. One has only contrastive vowel harmony and vowel fronting.

(25) **Grammar H3:**

- a. *Rule 1: Contrastive Vowel Harmony (CVH):*
 Structural Description: $V_{[\text{contrastive: } \alpha \text{ back}]} \dots V_{\text{target}}$
 Structural Change: V_{target} becomes $[\alpha \text{ back}]$
- b. *Rule 2: Vowel Fronting (VF):*
 Structural Description: $V \dots V_{\text{target}}$
 Structural Change: V_{target} becomes $[-\text{back}]$

This grammar will be discarded, however:

(26) **Results of Grammar H3 (determining structural context indicated in bold-face):**

- a. /radir-nAk/: VF applies, yielding [*radir-nek]
- b. /kostúm-nAk/: CVH applies, yielding [kostúm-nek]
- c. /biro-nAk/: CVH applies, yielding [biro-nak]
- d. /f
 Huszer-nAk/: CVH applies, yielding [fúszér-nek]
- e. /me:rnök-nAk/: CVH applies, yielding [me:rnök-nek]
- f. /file:r-nAk/: VF applies, yielding [file:r-nek]

Thus, a Hungarian grammar without a rule that initiates harmony by the non-contrastive back vowels $[a:,ɔ]$ will fail on forms such as *radir*. The learner, however, has two rule-variables within the repertory of compatible grammars that may capture the generalization that these $[+\text{low}, +\text{back}]$ vowels are a source of suffixal $[\text{back}]$ valuation: one is to use $[\text{+back}]$, as in Grammar 1, and the other is to use $[\text{+low}]$ as in Grammar 2.

Finally, we may consider the feasibility of a postulated grammar without vowel-fronting. It will fail on inputs such as *fille:r*, as the suffixes to these words will simply never receive a [back] valuation⁷.

While identical for their predictions on the six representative stimuli we have considered, these grammars *diverge* when it comes to a certain form of words. Suppose that G_* has plateaued with only Grammars H1 and H2 remaining. Inputs such as /a:gnes, dzsungel/ will demonstrate “vacillation” in the output of G_* , because G_* will sometimes be passing this input to Grammar H1 and sometimes to Grammar H2.

- (27) H1 selected: /a:gnes-nAk,dzungel-nAk/ undergoes BVH, yielding [a:gnes-nak,dzungel-nak]
H2 selected: /a:gnes-nek/ undergoes LVH, yielding [a:gnes-nek, dzsungel-nek]

Thus, the multiple-grammars scenario, in which H_1 and H_2 cohabit G_* provides a model of variation on the low, front vowel, that is based on underdetermination in the input. It is important to realize that the variation in *a:gnes* is intimately dependent on the behavior of /ɔ,a:/ elsewhere in Hungarian. Since these vowels are harmonic, and *both* low and back, they provide a source of structural ambiguity: either [+low] is categorically harmonic, or [+back] is categorically harmonic, and the learner will have to add one of these statements to his/her policy in order to account for the most basic facts of Hungarian. The ambiguity in the assignment of a policy for the low, back vowels, however, leads to emergent variation with the low front vowels. If lowness is chosen as the determining factor for /ɔ,a:/, then ε will behave as harmonic. If backness is chosen, then ε will behave as transparent. Thus, it is not an accident that *a:gnes* shows variation, and it is not something to

⁷While it is well-known that Hungarian has around fifty stems such as *hid*, which exceptionally take [+back] stems, these may in fact be accommodated by whatever mechanism in the learning algorithm handles exceptions. We return to discussion of this issue in Section 4. At that point, an implementation in terms of generalizing over exception classes, that has been verified for incremental learning of exceptions in Lakhota reduplication, will be presented to accommodate non-catastrophic incremental learning of forms such as *hid*.

be handled simply by a [+optional] rule for /ε/. Rather, a set of different but consistent generalizations made based on the core vocabulary of Hungarian leads to divergent predictions when words of the form *a:gnɛs* are introduced as inputs.

4.3. The One-vs.-Many Neutral Vowel Effect in Hungarian

Farkas and Beddor (1987) and Ringen and Kontra (1989) discovered that when there are more than one neutral vowel in a row, speakers exhibit variation. Thus, while *papi:r* takes a [+back] suffix, *aszpirin* shows variation between *-nek* and *-nak*.

It is not clear how any of the rule-based analyses of Hungarian vowel harmony can account for this variation. Ringen & Vago (1998) do not provide an account, and neither do Siptár & Törkenczy (2000)⁸. One could imagine certain possibilities; there could be a “[+optional]” rule of vowel fronting after [-round,-low] vowels, but of course, this would essentially just restate the issue.

The intuition, however, shared by all, seems to be that even though neutral vowels are “neutral”, when the distance between the suffixal vowel and a back vowel is increased, the ability of long-distance [+back] valuation is diminished. In what follows, a formal account for this intuition will be provided. In essence, it is an implicit component of all compatible harmony grammars in G_* that neutral vowels in isolation provide the context for the rule of vowel fronting. However, the application of this rule is blocked in many cases by the Elsewhere principle. What the formal account cashes in on is that in certain cases, two instances of satisfying the structural description of the context-free vowel fronting rule are enough to suspend Elsewhere disjunctivity. This will be expressed and exemplified in detail below, but first, it is worth briefly considering an alternative.

Benus et al. (2003) maintain the intuition that distance between the source of valuation and the suffixal vowel is what underlies the variation, but they provide an explanation in completely articulatory terms, without any relativization of “distance” to potential contexts for vowel fronting. Their account is as follows: “The

⁸Van der Hulst (1984) states a rule that obligatorily associates the [-back] autosegment to neutral vowels when there are two of them and the second one is ε. Again, there is no explanation of why only ε should undergo this rule.

crucial idea is that the degree of retraction on TVs [transparent vowels] should diminish with the distance between the initial back vowel of the stem and the TV [transparent vowel]. The farther the TV from the initial back vowel triggering harmony, the less retracted it will be" (Section 4, paragraph 10)⁹. But this proposal, which describes the behavior of two neutral vowels in terms of articulatory distance, makes a prediction that has not been verified, and never been observed by any scholar working on Hungarian: that in words with large consonant clusters, harmony should be somehow decreased, and that suffixation of *-nAk* will potentially result in less coarticulation of the retraction gesture.

(28) Triconsonantal clusters in Hungarian (Siptár & Törkenczy 2000:116)

- a. mumpsz 'mumps'
- b. szkunksz 'skunk'
- c. vurst 'sausage'
- d. kunszt 'trick'
- e. lejszt 'hard work'

It is especially unclear what this proposal predicts for the following words, in which a back vowel is separated by a consonant cluster from the following front vowel. These should show an overwhelming bias towards taking [-back] suffixes, which is a tendency that has never been reported.

(29) burleszk, groteszk, pittoreszk, konsern, bakfis 'young girl', apszis 'apse'

Moreover, as Bessell (1998) has instrumentally demonstrated for Interior Salish, sequences of intervening consonants seem to pose no barrier for the transmission of harmony: in Cour D'Alene, up to six consonants may intervene in VC faucal harmony. It is thus unlikely that Benus *et.al*'s explanation for the "more-than-one effect" of neutral vowels can literally be cashed out in terms of articulatory distance.

⁹This proposal is never spelled out in terms of Optimality-Theoretic constraints in Benus *et. al*'s paper (which does, however, provide OT analyses for other phenomena, e.g., disharmonic roots).

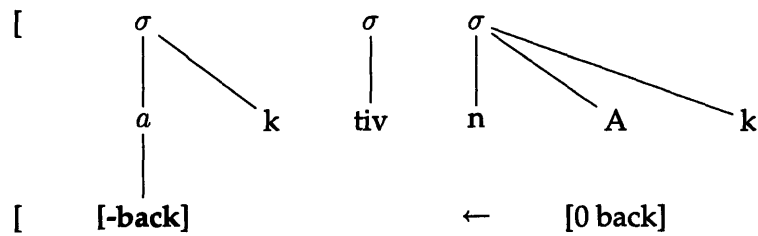
The current proposal, however, can accommodate variation in words with back-neutral-neutral sequences of vowels, without making potentially erroneous predictions for words with intervening consonant clusters. The adjacency parameter approach developed in Chapter 1, following Odden (1994); Suzuki (1998) is such that there is ambiguity in the interpretation of BVH. In forms such as *aktiv-nak*, the size of the intervener can be set to either one-syllable or unbounded.

Let us consider possible representations of harmony policies that contain an adjacency parameter. If speakers consider all possible parametric-settings for adjacency when constructing the rule, then there is ambiguity in the interpretation of Hungarian [back] harmony. Upon observation of forms such as *aktiv-nak*, the speaker could either posit an *unbounded* search domain, or a search domain that contains all [-back] values, but is limited to only a two-syllable window. This latter domain-restriction amounts to *intervening-syllable-adjacency*: as, at most one transparent syllable may intervene between source and target. The four settings that I propose for the parameter are in (30); a formal description of search-delimitation is in (31).

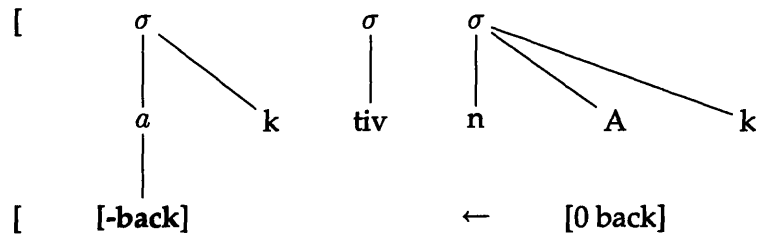
- (30) Adjacency Parameter (adj):
- a. Unbounded
 - b. Immediate-Adjacency
 - c. Syllable-Adjacency
 - d. Intervening Syllable Adjacency

As stated above, observation of *aktiv-nak* is thus compatible with the single-syllable or the unbounded parameter. If each of these is maintained in a separate policy, then when a *longer* distance between focus and potential source is encountered, variant suffixes will result, depending on whether the policy in terms of intervening syllable adjacency is chosen, or the one in terms of unbounded intervener size is chosen.

- (31) Unbounded ADJ:

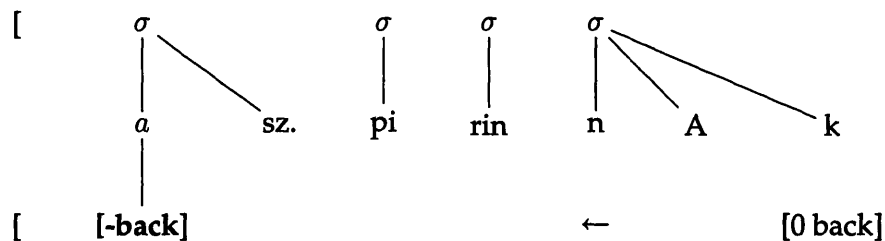


(32) Intervening-syllable ADJ:

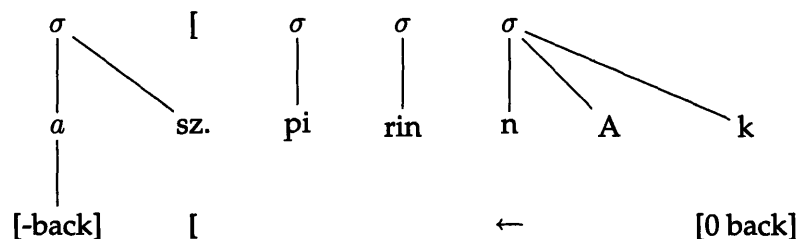


Let us now consider what happens for the input *aszpirin*. According to Ringen and Kontra, it takes 58% [-back] suffixes, and for many speakers, both *aszpirin-nak* and *aszpirin-nek* are possible. On the model developed here, it is because the intervening-syllable-adjacency policy leads to a search that terminates in failure:

(33) Unbounded ADJ:



(34) Intervening-syllable ADJ:



Thus, on the unbounded setting of the parameter, search successfully finds [-back] in the initial syllable, and it is copied, yielding *aszpirin-nak*. However, on the

intervening-syllable-adjacency setting, no [-back] value is found within the domain, and search terminates in failure. The context-free [-] insertion rule in the policy may now apply, yielding *aszprin-nek*.

Observation of *aktiv-nak* is thus compatible with the single-syllable or the unbounded parameter. If each of these is maintained in a separate policy, then when *aszpirin/alibi* is encountered, the variant suffixes will result, depending on whether the policy in terms of maximum- 1σ intervener is chosen, or the one in terms of unbounded intervener size is chosen.

The structural property of Hungarian that leads to variation in *back+neutral+neutral* (BNN) words, then, is due to the fact that BN words are *ambiguous* between different parametric settings of locality restrictions. This size-based ambiguity is a rampant fact about any parametrized theory of phonological rules. For example, as Nevins and Iba (2004) have discussed, a monosyllabic reduplicant such as Chinese *tian-tian* is ambiguous between first-syllable reduplication, last-syllable reduplication, total reduplication, and iterative reduplication, all of which are independently attested reduplication policies. Total reduplication and iterative reduplication are, in a sense, *trivially* satisfied by monosyllabic reduplication. A similar scenario arises with respect to BN+*nak* words in Hungarian. Since the distance between the affix and the valuation source is one syllable, the locality condition is, in this case, ambiguous between single syllable adjacency, and unbounded adjacency, with the latter being trivially satisfied in this example. It is only on longer forms that these parametric options make different predictions, and that is precisely where we see variation emerge: on BNN words, *not* on BN words. We turn to a further case of distance-based ambiguity, in dissimilative voicing.

4.4. Variation in the Dissimilative Voicing of Embu Prefixes

Further support for an underdetermined setting of the intervener-size parameter comes from variation in the application of Dahl's Law, a rule in which *k*-initial prefixes become voiced before voiceless consonants. Davy and Nurse (1982) provide a study of the variation in different languages. One of the most interesting ones

for our current discussion is Embu¹⁰. Combinations of three consecutive *k*-initial prefixes in Embu are possible. Dissimilation occurs before the voiceless segments *s, t, k*:

- (35) a. *yo-siara* 'GERUND-giving birth'
 b. *yo-teya* 'GERUND-trapping'
 c. *yo-kama* 'GERUND-milking'

When there is one prefix, the structural analysis is ambiguous. The intervener-limit could be either a syllable, an intervening-syllable, or unbounded (Davy & Nurse 1982: 165):

- (36) /*ko-ikia*/ 'to throw' → [*ywii.kia*]
- a. The focus and determinant are in adjacent syllables: SATISFIED by [*ywii.kia*]
 b. There is no more than a single syllable between the focus and determinant: SATISFIED by [*ywii.kia*]
 c. The focus and determinant are unbounded: SATISFIED by [*ywii.kia*]

Consider now two instances of *k*-initial prefixes:

- (37) /*a-kaa-ke-ikia*/ 'he(1)-will-it(7)-throw' → [*a.yaa.yii.kia*] or [*a.kaa.yii.kia*]
 (but importantly, not *[*a.yaa.kii.kia*])
- a. The focus and determinant are in adjacent syllables: NOT SATISFIED by [*a.yaa.yii.kia*], SATISFIED by [*a.kaa.yii.kia*]
 b. There is no more than a single syllable between the focus and determinant: NOT SATISFIED by [*a.yaa.yii.kia*], SATISFIED by [*a.kaa.yii.kia*]
 c. The focus and determinant are unbounded: SATISFIED by [*a.yaa.yii.kia*],

¹⁰Davy & Nurse also discuss S. Gikuyu, which allows no variation in Dahl's Law, and Kuria, in which all applications of Dahl's Law are optional and rate-of-speech dependent even in cases of single application. While interesting from a cross-language perspective, these languages do not offer the within-language variation of the right grain size to provide an illuminating discussion here.

NOT SATISFIED by [a.kaa.yii.kia]

Thus, all three policies are maintained. Importantly, the variability of Dissimilative Voicing is not “random” or [+optional]. Only 2 of 4 logical outcomes arise when two *k*-initial prefixes are stacked. When three such prefixes are stacked, Embu speakers only allow 3 of the 8 logical possibilities.

(38) /ka-kaa-ke-ikia/ ‘he(12)-will-it(7)-throw’ → [ya.ɣaa.yii.kia] or [ka.ɣaa.yii.kia]
or [ya.kaa.yii.kia]

- a. The focus and determinant are in adjacent syllables: SATISFIED [ya.kaa.yii.kia], NOT SATISFIED by [ya.ɣaa.yii.kia], [ka.ɣaa.yii.kia]
- b. There is no more than a single syllable between the focus and determinant: SATISFIED by [ka.ɣaa.yii.kia] , NOT SATISFIED by [ya.kaa.yii.kia], NOT SATISFIED by [ya.ɣaa.yii.kia].
- c. The focus and determinant are unbounded: SATISFIED by [ya.ɣaa.yii.kia], NOT SATISFIED by [ka.ɣaa.yii.kia], [ya.kaa.yii.kia]

Importantly, the three policies that were compatible with single *k*-initial prefixes turn out to yield three different variants in Embu when there are three prefixes. This variability can be clearly formulated in terms of the same parameters on intervener-size that were appealed to in the analysis of Hungarian BNN words. The approach of Benus et al. (2003), in terms of variable articulatory distance, makes no predictions for Embu Dissimilative Voicing.

4.5. A Closing Discussion of Approaches to Variation

Now that the modes of evaluation are clear, let us turn to a model of what is happening. I assume that in small parametric spaces, learners consider all possible compatible hypotheses until one is proven wrong early on. We may suppose that speakers maintain both, and choose between them probabilistically; I thus adopt a learning that follows the lines of Yang (2003), who develops the “competing grammars” model in further detail, with predictions for development and language

change. However, as for predicting exact ratios in production, I will remain agnostic here. It is true that certain sociolinguistic registers, and so on may “weight” one of these grammars more than others on a given input. But do we have any model of what percentage of the time a given speaker is within a certain register? At present we seem to lack a model of how these weights may a) change over time b) be predicted in any given instance. The model developed here is not tailored to predicting exact percentages in the cases of variation; what I find ultimately interesting is which items variation is *possible* for and which it is not.

Boersma & Hayes (2002) model variation within stochastic OT, where there is no separation between principles and parameters. An problem with their account, therefore, is that principles that are completely invariant in a parameter-based model (such as the Closest-variation principle of Chapter 1, and the Elsewhere condition) are predicted to show statistical fluctuation as well. As for Boersma/Hayes’s idea that variation just reflects ambient variation in the ambient language – where does the ambient variation come from?

The real problem with the ambient variation account is that it makes no predictions about the kinds of variation that will and won’t actually exist in an ambient language. For instance, *tyranniko* is never variant in Finnish. There is a systematic reason for this in the account developed here: variation would require one policy in which there is only FVH (so that /a/ would not induce harmony) and another policy in which /a/ induced harmony (e.g. the presence of any of CVH, BVH, LVH). However, a policy with only FVH would never survive the native lexicon, due to words like *koti*, which take [+back] suffixes. Thus, the fact that mixed-harmonic words like *front+back tyranniko* never alternate can be connected to the behavior of *back+neutral* words elsewhere in the language. However, in a theory of surface analogy alone, it is an accident that *koti* should influence the behavior of *tyranni*.

A decidedly positive aspect of Boersma & Hayes’ model is that it has been implemented on a computer. This is extremely important when considering the learning scenario, especially if it is modeled as *incremental* and *error-driven* (as theirs,

and my own are). There is simply no way to compute by hand the exact outcomes of grammatical generalization for the range for possible input-presentation orderings. Boersma & Hayes' learning algorithm allows for inspection of the state of the grammar after any given point¹¹.

In closing this chapter, I will state the obvious: I have only scratched the surface here, in demonstrating some of the most well-known cases of variation in harmony, and I have chosen examples largely on the basis of their illustration of the parameter space, as in the exposition of Dahl's Law in Embu. Continued typological and theoretical research will refine the values of these parameters. And my hope is that revealing insights will come from a computational implementation of the selectionist learner that I have proposed here, similar to the one computational exploration of the parametric space for reduplication that was conducted and reported in Nevins and Iba (2004). The theory of universal grammar can benefit greatly from opportunities to explore whether the learner would accurately converge on the correct forms for any learning sequence, and can verify that the parametric space under scrutiny generates variation in exactly the restricted range of forms resulting from ambiguity in earlier inputs encountered in the learning sequence.

¹¹To be precise, Boersma & Hayes present each input token thousands of times, so the exact inspection after any given input presentation will not look exactly like the scenarios I have sketched here, in which incompatible policies are immediately demoted.

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