Towards a Typology of Disharmony

Paul Kiparsky
Karl Pajusalu

We propose an OT-theoretic typology of vowel harmony systems based on a comparative study of front/back harmony. Harmony processes are governed by a general constraint that imposes feature agreement on neighboring segments. Disharmonic ("neutral") segments arise when this constraint is dominated by markedness constraints and/or by faithfulness constraints that govern segment inventories. These constraint interactions determine whether disharmonic segments are opaque or transparent, and fix the cross-linguistically diverse behavior of the latter. We make crucial use of two modes of local constraint conjunction, which are already implicit in the current theory. Our proposal restricts this theory by eliminating the possibility of freely stipulating the domain of local conjunction.

1 Harmony

1.1 Balto-Finnic vowel harmony

The scope of a harmony process in a language is determined by its phonological inventory in two respects.[1] First, harmony spreads a feature to the fullest extent that the inventory allows: morphological restrictions aside, *all* lexically contrastive vowels participate in vowel harmony unless some constraint on the distribution of the harmonic feature prevents it. Secondly, *only* lexically contrastive vowels participate in vowel harmony, or, to put it another way, lexical harmony is typically *structure-preserving*, in the sense that it introduces no new vowel types.[2]

For example, the fact that *i* and *e* do not become **ɨ* and **õ* (back *i* and back *e*) in back harmony contexts in Finnish is connected with the fact that **ɨ* and **õ* are not phonemic in the language, as we can tell independently from the fact that they do not occur in initial syllables, which display the language's full set of vowel contrasts. Votic and South Estonian, closely related languages which do have *e*∼*õ* harmony, have phonemic /õ/, which is distinctive in initial syllables.

These two generalizations hold for all front/back harmony systems that we know of. All Balto-Finnic languages, at least, obey in principle the same front/back harmony constraint. Their actual harmony patterns vary quite widely, according to how they interact with other constraints. Wiik 1988 documents seven vowel systems in Estonian dialects, and harmony operates to the fullest

[1]This research was supported in part by an NSF Twinning Grant to the authors. Our thanks go to Luc Baronian, Edward Flemming, and Paul Kroeger, for patiently and insightfully discussing this material with us in our Stanford phonology seminar in 2000. We are also indebted to Bert Vaux, and especially to an astute and meticulous anonymous reviewer for raising questions and making suggestions which have helped us improve the final version.

[2]This second generalization has apparent exceptions. Some are clearly due to an overlay of postlexical harmony (Kiparsky 1985) or to local assimilation processes. For example, in Eastern Khanty **ɨ* and **õ* are not phonemic, and do not undergo vowel harmony, but they arise as allophones of /i/ and /e/ by local assimilation in certain back contexts. Whether all apparent exceptions to the generalization can be explained away remains to be seen, of course.

extent in each. All seven of these vowel systems are also instantiated outside of Estonian in other Balto-Finnic languages, and in all of them too harmony operates to the fullest extent. The following table summarizes the data.

(1)

Balto-Finnic	Estonian	Initial syllables	Non-initial syll.	Harmonic alternations
East Votic	N. Seto	*u o a ü ö ä i e õ ɨ*	*u o a ü ö ä i e õ*	*u∼ü, o∼ö, a∼ä, e∼õ*
Votic dial.	S. Seto	*u o a ü ö ä i e õ ɨ*	*u o a ü ä i e õ*	*u∼ü, a∼ä, e∼õ*
Finnish	N.E.	*u o a ü ö ä i e*	*u o a ü ö ä i e*	*u∼ü, o∼ö, a∼ä*
West Votic	N.Tarto	*u o a ü ö ä i e õ ɨ*	*u o a ä i e õ*	*a∼ä, e∼õ*
Enarve Veps	S.W.	*u o a ü ö ä i e õ*	*u a ü ä i e*	*u∼ü, a∼ä*
Veps dial.	Western	*u o a ü ö ä i e õ*	*u a ä i e*	*a∼ä*
Livonian	Northern	*u o a ü ö ä i e õ*	*u a i e*	—

At one extreme, Eastern Votic and the Northern Seto dialect of Estonian have the four harmonic pairs /a∼ä, õ∼e, o∼ö, u∼ü/ plus unpaired /i/ (Kiparsky and Pajusalu MS). At the other extreme are Livonian and Northern Estonian, with their restricted inventory of non-initial vowels, which permits no harmony whatever. Wiik points out for Estonian dialects, and the other Balto-Finnic languages confirm, the following partial hierarchy of intermediate inventories: *ä* ≻ *ü/õ* ≻ *ö*. Any dialect that has vowel harmony at all has at least *a∼ä* harmony; in addition possibly *u∼ü* and/or *e∼õ* harmony; and if one of these, then possibly *o∼ö* harmony. Wiik also observes that these implicational relationships reflect general markedness asymmetries. For example, the generalization that every front/back harmony system has at least *ä:a* harmony reflects the fact that frontness is more compatible with lowness than with rounding, so that *ä* is less marked than *ö, ü*.

Taken together, these two generalizations suggest that a harmony system can be understood as a resolution of the conflicting claims of a very general process which spreads a feature, and specific constraints which neutralize that feature. The vowel inventory, and the extent of vowel harmony, are determined by the interranking of neutralization constraints with antagonistic faithfulness constraints.

1.2 Neutral vowels

By definition, vowels (or more generally, segments) are NEUTRAL if they do not undergo harmony. A vowel fails to undergo harmony when its harmonic counterpart is prohibited, either in the inventory of phonemes (context-free neutralization) or by a distributional restriction (positional neutralization), e.g. the absence of non-initial *ɨ* in Southeastern Estonian.

Although the basic account of disharmony is quite simple, the behavior of neutral vowels shows some interesting complications, and these form the main topic of our investigation. Neutral vowels differ in how they combine with harmonic vowels. The fundamental division among neutral vowels is between OPAQUE vowels and TRANSPARENT vowels. Opaque vowels are defined as those which interrupt harmony and initiate a new harmonic domain, and transparent vowels are those which are "skipped" by harmony.[3] From a theoretical point of view, opaque vowels do not seem very problematic, for two reasons. In the first place, their behavior is quite uniform, and secondly, this

[3]Harmonic transparency and opacity in this sense should be distinguished from derivational transparency and opacity, arising from feeding/bleeding and non-feeding/non-bleeding interactions between constraints, respectively (as well as from other causes). Confusingly, harmonic transparency creates derivational opacity, and harmonic opacity creates derivational transparency, as we shall see directly below.

behavior follows a pattern of minimizing harmony violations which can be readily characterized by almost any OT-based approach.

The very existence of transparent neutral vowels, on the other hand, immediately raises a theoretical puzzle: why should the doubly disharmonic *...a...i...a...* ever be preferable to *...a...i...ä...*, which has just one disharmonic transition? The term "transparent" reflects the powerful intuition, which has guided many an analysis in different ways, that the effect of harmony somehow reaches "across" this kind of neutral vowel. But how can such apparent "action at a distance" be reconciled with the principle of locality on which so many fundamental results in phonology depend? This has been one of the central issues about vowel harmony from the beginning, and has become more urgent still with the advent of OT (Bakovic 2000, Ní Chiosáin and Padgett 2001).

The division of neutral vowels into opaque and transparent vowels, on the basis of whether they trigger harmony or not, only begins to scratch the surface. The harmonic permeability of neutral vowels is manifested in remarkably diverse ways. There are at least as many kinds of neutrality in phonology as there are in international relations. The boundary between them is complex, and various kinds of mixed behavior occur. Some vowels are neutral stem-internally but trigger harmony in morphologically derived environments, others do not. More subtly, some actually *prefer* disharmonic combinations, others prefer harmonic combinations, and which way the preference goes can itself depend on whether the environment is derived or not. Moreover, if there are several transparent vowels, they may diverge in respect to these properties.

All this variation is neither random nor simply a gradient matter of "degree of transparency". We will present evidence for strict generalizations, both absolute and implicational, and propose explanations for them. One of the central results of OT phonology is that many categories previously posited as primitive emerge from the interaction of independently motivated constraints. The best-known example is the foot inventory previously postulated in the theory of stress and prosodic morphology, which has been argued to be derivable from constraints on prosodic form (see Kager 1999, Ch. 4 for a clear exposition). Similarly, we think that the complex patterns of disharmony follow from the same kind of interplay of faithfulness constraints with context-free and context-sensitive markedness constraints that governs harmony itself.

2 Disharmony

2.1 The typology of neutral vowels

Cross-linguistically, so-called transparent vowels may differ with respect to the context in which neutralization occurs. They may be context-freely neutral, or participate in harmony in some contexts while being neutral in others, or finally be idiosyncratically neutral. Contextual neutrality may be determined prosodically (for example, initial/stressed vs. non-initial/unstressed position) or by the harmonic context. For example, in Southern Vepsian (Wiik 1989) and in the South Estonian Mulgi dialect (Tanning 1961:33), *u* is neutral after vowels of unlike height ([...ä...u...] versus *[...ä...ü...]) but harmonic otherwise (*[...u...ü...], *[...ü...u...]), whereas *a* is always harmonic.[4] Because of such contextual neutralization, a vowel may be neutral even if it has a harmonic partner in the language's inventory: the relevant notion of contrast is a *contextual* one.

[4]However, *a* is retained after the neutral vowel *i*, as in *minnas* 'go' (pres.pass.), except in the context of palatalized consonants (e.g. Transl.Pl. *iļļä-ksi* 'quietly'); contrast *jää-nü* 'stayed' *müü-vvä* 'to sell'.

Our study of front/back harmony leads to three typological generalizations.

Unmarkedness. Neutral vowels bear an unmarked value of the harmonizing feature. For example, the unmarked value of backness is [–Back] for unrounded nonlow vowels, and [+Back] for other vowels. For front/back harmony systems, therefore, neutral vowels can be one of *i, e, a, o, u*, but not *ɨ, õ, ä, ö, ü*. In the languages we focus on here, the neutral vowels are *i* and *e*; Seto furnishes an instance of neutral *o*.

Uniformity. All neutral vowels with a given value [αF] of the harmonic feature will be either opaque or transparent. In Seto, for instance, [–Back] neutral vowels are transparent, and [+Back] neutral vowels are opaque.

Asymmetry. Transparent vowels have a predictable feature value; in front/back harmony systems it is [–Back].

In what follows we map out the space of variation and model it by an OT factorial typology, whose leading idea is that the category of "neutral segment" in all its variety arise from the competition between contextual constraints and feature co-occurrence constraints.

2.2 Markedness and faithfulness

The markedness constraints that govern harmony are of two types: *featural markedness constraints*, and context-sensitive *combinatoric* constraints. The ranking of these constraints with respect to faithfulness constraints determines the inventory in a particular position or context.

(2) Featural markedness constraints

a. $\begin{bmatrix}\text{–Lo}\\ \text{–Rd}\end{bmatrix} \Rightarrow$ [–Bk]: If a vowel is nonlow and unrounded, it must be front. This constraint will be mnemonically referred to as **ɨ,*õ*.

b. [–Bk] $\Rightarrow \begin{bmatrix}\text{–Lo}\\ \text{–Rd}\end{bmatrix}$: If a vowel is front, it must be nonlow and unrounded (mnemonically: **ä,*ö,*ü).*

We choose the implicational format in (2) over a co-occurrence format (such as *[–Lo,–Rd,+Bk], *[+Lo,–Bk], *[+Rd,–Bk]) in order to preclude satisfaction of the constraints by vowels that are simply underspecified for one of the features. In order to conform to the implicational constraints (2a,b), vowels must be positively specified for the required feature value. Of course, if other constraints or principles (such as the constraint SPECIFY proposed by Ringen and Heinämäki 1999) rule out underspecified vowels, we may reinstate the simple co-occurrence restrictions. Either way, the important point is that underspecification plays no role in our solution. Every underspecified output candidate succumbs to a more harmonic fully specified candidate, and for every underspecified input, the optimal output candidate is a fully specified well-formed possible word of the language. Let us add that this does not necessarily mean that we consider an underspecification analysis of harmony unfeasible, or undesirable. Our aim is simply to present a coherent account of vowel harmony without using underspecification, not to assess the complex issues raised by the alternative.

The featural markedness constraints in (2) should probably be further decomposed. As mentioned, *ä* is less marked than *ü, ö,* which suggests that in addition to (2b) there is a more specific constraint **ö,*ü*. When the latter is more highly ranked, and other constraints intervene between them, splits such as those noted above for Southern Vepsian and Mulgi result.

The combinatoric markedness constraint that we will assume drives harmony is stated in (3).[5]

(3) Combinatoric markedness constraint
AGR(F): Adjacent segments must have the same value of the feature [F] (Bakovic 2000:4, cf. Krämer 2000).

In the languages studied here, [F] = [Back], but the same constraint holds for any harmonic feature.

We also require the faithfulness constraints in (4).[6]

(4) Positional faithfulness constraints:

a. IDENT-σ_1(Back): An [αBack] input segment in an initial syllable must not have a [$-\alpha$Back] output correspondent (Beckman 1998).

b. IDENT-F_1(Back): An [αBack] input segment in an initial foot must not have a [$-\alpha$Back] output correspondent. (The initial foot of a word comprises its first two syllables.)

c. IDENTROOT(Back): An [αBack] input segment in a root must not have a [$-\alpha$Back] output correspondent). (Note that this is an ordinary positional I/O faithfulness constraint à la Beckmann, *not* the Output/Output constraint SA-IDENT(F) proposed by Bakovic 2000:23).

These faithfulness constraints become visible in a language when they dominate markedness constraints such as (3) AGR(Back). They determine the controlling ("triggering") environments in harmony systems. The constraint (4a) IDENT-σ_1(Back) singles out the *first* vowel of the harmonic domain. The privileged status of the word-initial syllable established by IDENT-σ_1(Back) means two things: it is a trigger of harmony, and it is a position of maximal contrast even independently of any harmony. The effects of this constraint are visible in all the languages that we are concerned with. Certain contrasts in the harmonic feature are suppressed in non-initial syllables, regardless of the morphological makeup of the word.

The other privileged environments are the first foot, and the ROOT (the monomorphemic stem). Like IDENT-σ_1(Back), these constraints have two functions. In the resolution of disharmony, they cause the feature value of the first foot and of the root to prevail. And they account for the "derived environment" asymmetries commonly seen in harmony systems. The overarching generalization here is that harmonic constraints may be stricter in derived environments than morpheme-internally, and stricter in non-initial feet.

In Finnish and Vepsian at least, the two relevant faithfulness constraints (4b) IDENT-F_1(Back) and (4c) IDENTROOT(Back) are locally conjoined into a constraint which singles out the *first foot of the root*.

(5) IDENT-F_1(Back) & IDENTROOT(Back): An [αBack] input segment in the first foot of a root must not have a [$-\alpha$Back] output correspondent.

[5]Our reviewer draws our attention to McCarthy's argument (2002:28, fn. 19) that this constraint should be replaced by Padgett's SPREAD constraint: "If any segment is associated with F, then every segment is associated with F". McCarthy points out that a constraint such as AGR(Back) cannot distinguish, for example, between the sequences *a a a ä*, *a a ä ä*, and *a ä ä ä*, because all of them violate it just once. The same is true of symmetric SPREAD(Back). However, a constraint SPREAD(+Back) selects *a a a ä* as the minimal violation, and conversely SPREAD(–Back) selects *a ä ä ä*. In the analysis proposed below, it may be possible to replace the AGR constraints by corresponding SPREAD constraints, with subtle formal and empirical ramifications that remain to be explored.

[6]Faithfulness to lexically stressed syllables (Beckman 1998) also play a role in vowel harmony. Syllables with postlexical rhythmic stress behave just like unstressed syllables, however. On the role of lexical stress in Finnish phonology, including harmony, see Kiparsky 2003.

For example, in Finnish, affixes are fronted after all-neutral stems: *sii-nä* ‘it (essive)’, *viit-tä* ‘five (abessive)’. But within simple disyllabic stems with a neutral vowel in the first syllable, front and back harmonic vowels contrast in the second syllable: *sinä* ‘you’ vs. *kina* ‘squabble’, *riittä-* ‘suffice’ vs. *viitta* ‘cloak’.[7] But this faithfulness effect only extends through the first foot. From the third syllable on, the front/back contrast is neutralized even in roots. After two or more syllables with neutral vowels, only front vowels occur: *kipinä* ‘spark’, *lipeä* ‘lye’ vs. impossible **kipina*, **lipea*.[8]

Local constraint conjunction (Smolensky 1993, Kager 1999:392-400) combines basic constraints into a new constraint which is violated when both its conjuncts are violated. (6) shows how the conjoined constraint (5) works.

(6) Faithfulness in Finnish neutral+back vowel combinations:
   a. ✓*viitta* — *a* is in the first foot of the root (conjoined constraint blocks fronting)
   b. **viit-ta* — *a* is in the first foot but not in the root (conjoined constraint inapplicable)
   c. **kipina* — *a* is in the root but not in the first foot (conjoined constraint inapplicable)

In a suffixing language such as Finnish, the effects of these constraints overlap significantly. The privileged status of the initial syllable determined by IDENT-σ_1(Back) is normally not detectable. Still, it can be seen in loanword adaptation, by a kind of Emergence of the Unmarked. The following instances of loanword adaptation in colloquial/uneducated Finnish show that the first vowel prevails:[9]

(7) a. *Peugeot* → *pösö* (not **poso*)

   b. *olympialaiset* → *olumpialaiset* ‘Olympic games’, *trotyyli* → *rotuli* ‘TNT’, *pulityyri* → *pulituuri* ‘shellac varnish’

2.3 Varieties of neutrality

Before completing the constraints let us review the typological space of neutral vowel behavior descriptively, concentrating first on the purely phonological side. To fix the behavior of an [αF] neutral vowel, we must know three things: whether it transmits [$-\alpha$F] harmony, whether it transmits [αF] harmony, and whether it triggers [αF] harmony on its own. None is entirely predictable from any of the others, but there are many implicational regularities. To schematize the typology for front/back harmony, we symbolize transparent vowels by *i*, back harmonic vowels by *a*, and front harmonic vowels by *ä*, and assume left-to-right harmony in virtue of (4), as in all the languages in our sample.

- *Transparency to back harmony.* Is ...*a*...*i*...*ä*... excluded?

[7]However, vocalic affixes after monosyllabic roots act like stem-internal vowels: *pes-u* ‘washing’, *tiet-o* ‘knowledge’, *el-o* ‘living’. We are not sure what constraint is responsible for this subregularity. Since vocalic suffixes (unlike consonantal ones) induce a root/syllable-boundary mismatch, an *ad hoc* solution would be the conjunction of **ä,*ö,*ü* and the appropriate ALIGN constraint.

[8]Except when a velar precedes, when, on the contrary, the contrast is neutralized in favor of a *back* vowel, e.g. *itikka* ‘mosquito’, *viisikko* ‘group of five’.

[9]When the initial syllable is stressed, as in the languages considered here, the effect of IDENT-σ_1(Back) is indistinguishable from faithfulness to stressed syllables, which raises the question whether the former could be reduced to the latter. But Turkish, in spite of its word-final stress, shows the same special status of initial syllables, an indication that IDENT-σ_1(Back) is not reducible to faithfulness to stressed syllables.

- *Transparency to front harmony.* Is . . . *ä*. . . *i*. . . *a*. . . excluded?

- *Triggering of front harmony.* Is . . . *i*. . . *a*. . . excluded?

The table in (8) maps out the different ways in which the Finno-Ugric languages treat these situations. For the time being we focus on morphologically derived environments (where the last vowel is part of a suffix), which show more of the markedness constraints at work: some of the languages impose stricter harmony constraints on them than on root-internal environments because the faithfulness constraint IDENTROOT(Back) introduced in the last subsection blocks the markedness constraints from taking effect. There are eight logically possible combinations, of which the four represented by shaded rows are not instantiated.

(8) The phonological differentiation of neutral vowels in derived environments:

	[[ä] a]	[[a] i]	[[a i] ä]	[[ä i] a]	[[i] a]
a. Finnish	*	✓	*	*	*
b. Uyghur, W Estonian	*	✓	*	*	✓
c. (Unattested)	*	✓	*	✓	*
d. Enarve Vepsian, Mulgi	*	✓	*	✓	✓
e. Khanty, NE Estonian	*	✓	✓	*	*
f. (Unattested)	*	✓	✓	*	✓
g. (Unattested)	*	✓	✓	✓	*
h. (Unattested)	*	✓	✓	✓	✓

The brackets show morphological constituency. Each column in the table represents a type of disharmony.[10] The stars in the first column diagnose harmony itself: if a language does not bar non-neutral disharmonic vowels in adjacent syllables it does not have harmony at all. The check marks in the second column diagnose neutrality: if a language does not allow such sequences of syllables it does not have neutral vowels at all. The last three columns of (8) represent the three critical diagnostics just listed that establish the descriptive typology of neutral vowels.

In all the languages, the vowel *i* is neutral (unpaired); in some also *e* is neutral.[11] But these neutral vowels behave differently, as shown. For example, Uyghur has back vowel endings in both *yol-imiz-Ka* ‘our road-DAT’ and *sinip-ta* ‘class-LOC’ (Vaux 2000), where Finnish treats the corresponding configurations differently, e.g. *sot-i-mis-ta* ‘warring-PART’ versus *sinis-tä* ‘blue-PART’.[12]

We will proceed on the assumption that the four unattested systems in (8) are systematic gaps, for two reasons. First, the attested types are predicted by constraints that are motivated independently of the workings of harmony systems, while the missing types would require additional otherwise unnecessary complications. Secondly, a similar typology seems to holds for ATR harmony. At least three of the four types that we find in back/front harmony occur also in ATR harmony,

[10]The table is based on Wiik 1988, 1989 plus the following: our interpretation of the data in Must 1995 (NE Estonian texts, see esp. p. 22), Juhkam & Sepp 2000 (Western Estonian texts), and Tanning 1961 (texts in the Mulgi dialect of South Estonian), the generative analyses of Uyghur vowel harmony by Lindblad 1990 and Vaux 2000, and the painstaking descriptive study of vowel harmony in Karjalainen’s Eastern Khanty texts by Vértes 1977.

[11]Both languages present interesting complications which we set aside here. As mentioned, in Eastern Khanty, an optional postlexical local assimilation process creates back *ɨ*, *õ*, without interacting with harmony in any way. This is easily dealt with in Stratal OT (Kiparsky 2000, forthcoming) but problematic in parallel OT.

[12]In Uyghur, a closed class of roots exceptionally triggers front harmony: /bir-lAr/ → *birlär* ‘ones’. Also, roots where /i/ is adjacent to /k, g/ regularly induce front harmony (presumably triggered by the palatal consonant): /kigiz+lAr/ → *kigizlär* ‘felt rugs’, /yik-lAr/ → *yiklär* ‘loads’ (Lindblad 1990).

and none of the four types missing in back/front harmony are instantiated in ATR harmony, as far as we know. Wolof (Ka 1994, Archangeli & Pulleyblank 1994) is an analog to Finnish, and Turkana (Noske 1990) and Shilluk (Gilley 1992) are comparable to Uyghur and Eastern Khanty, respectively (in the relevant respects, of course).

The basic phonological typology results from the intersection of two binary properties.

The first binary property distinguishes Finnish and Eastern Khanty from Uyghur and Vepsian. In Finnish and Eastern Khanty, neutral vowels trigger harmony, in Uyghur and Vepsian they do not. This part of the typology is generated by alternative rankings of the two previously introduced constraints (2b) **ä, *ü, *ö* and (3) AGR(Back). Uyghur and Vepsian avoid the marked vowels *ä, ü, ö* at the cost of permitting mildly disharmonic sequences like *i a*. Finnish and Eastern Khanty conversely tolerate these marked vowels in order to eliminate such disharmonic combinations. In terms of constraint ranking:

(9) a. Finnish, Eastern Khanty: AGR(Back) $\gg$ **ä,*ö,*ü*

b. Uyghur and Vepsian: **ä,*ö,*ü* $\gg$ AGR(Back)

(10)

Finnish		. . .	AGR(Back)	**ä,*ö,*ü*	. . .
[i] a	i a		*		
☞	i ä			*	
[i] ä	i a		*		
☞	i ä			*	

(11)

Uyghur		. . .	**ä,*ö,*ü*	AGR(Back)	. . .
[i] a ☞	i a			*	
	i ä		*		
[i] ä ☞	i a			*	
	i ä		*		

This a very simple illustration of how the typology of neutral vowels reflects alternative resolutions of the conflict between syntagmatic constraints (such as AGR(Back)) and paradigmatic constraints (such as **ä,*ö,*ü*).

Of course, this cannot be the whole story: root-internally, Finnish welcomes combinations like *i a* with open arms,[13] whereas it still excludes combinations like *ä a*. This fact tells us that there must be another, more selective constraint which is violated by *ä a* but not by *i a*. This more selective constraint must dominate (5) (since it treats roots and derived environments alike), which as we already know in turn dominates the more general harmony constraint AGR(Back). Suppose this new constraint forbids a harmony violation that involves marked vowels. In other words, disharmony with marked vowels is both worse than disharmony alone, and worse than markedness alone. We need no new primitive constraints to implement this idea. Rather, we again use local constraint conjunction to combine the existing constraints AGR(Back) and **ä, *ö, *ü* into a new constraint MARKED HARMONY (MH):

(12) MARKED HARMONY (MH): (3) AGR(Back) & (2b,c) **ä, *ö, *ü*

[13]In fact, disyllabic roots of the type *i a* are decidedly favored over roots of the type *i ä*, by roughly the same ratio as *a* is favored over ä. Similarly for all other combinations of neutral and harmonic vowels. There are many complications involving both native and foreign vocabulary which we cannot go into here; see Ringen & Heinämäki 1999, Välimaa-Blum 1999, and Kiparsky 2003 for some recent treatments.

The conjoined constraint is violated when both its conjuncts are violated, as (13) illustrates.

(13) Finnish disharmony within roots:

a. **a ä* — *ä* is both marked and disharmonic (violating the conjoined constraint)
b. ✓*i a* — *a* is disharmonic but unmarked (no violation of the conjoined constraint)
c. ✓*i ä* — *ä* is marked but harmonic (no violation of the conjoined constraint)

It remains for us to account for the fact that "long-distance marked disharmony", exemplified by sequences such as *ä i a* and *a i ä,* is bad in Finnish and Uyghur, and good in the other languages — except of course where excluded by the constraint rankings already established (namely, in Eastern Khanty *ä i a* is rejected in favor of *ä i ä* by (9a), and in Enarve Vepsian *a i ä* is rejected in favor of *a i a* by (9b)). In other words, neutral vowels are *transparent* in Finnish and Uyghur. To account for transparency we need a constraint that somehow forbids disharmony across intervening neutral vowels. When that constraint dominates the stricter local harmony constraint AGR(Back), transparency results.

Again, we need no new primitive constraints to get this result. As formulated in the literature so far (Kager 1999:393), the theory of constraint conjunction requires specification of some domain in which violations of conjoined constraints are assessed, such as a segment, a morpheme, or a word. Instead of embracing this full freedom, let us suppose that there are just two interpretations of conjoined constraints:

(14) a. CONSTRAINT CONJUNCTION (GENERALIZED CASE): A conjoined constraint C_1&C_2 is violated when C_1 and C_2 are violated.

b. CONSTRAINT CONJUNCTION (CORE CASE): A conjoined constraint C_1&C_2 is violated when C_1 and C_2 are violated and the minimal substrings that contain the violations overlap.

By specifying the domain of constraint evaluation in the two alternative ways in (14) we obtain two versions of the conjoined constraint (12) MH that precludes disharmony of marked vowels.

(15) a. GENERALIZED MH: a domain may not contain both a vowel marked for F and a vowel disharmonic for F.

b. CORE MH: a vowel may not be both marked for F and disharmonic for F.

For example, CORE MH is violated by the sequences *a ä* and *ä a*, but not by the sequences *ä i a* or *a i ä*, whereas GENERALIZED MH is violated by all of them. The sequence *ä o ä* has two violations of both constraints (one in the substring *ä o*, the other in the substring *o ä*). The sequence *ä i a i ä* has two violations of GENERALIZED MH (namely *ä i a* and *a i ä*), but no violations of CORE MH.

These constraints complete the desired factorial typology of neutrality. Neutral vowels are transparent if GENERALIZED MH outranks some antagonistic constraint (be it faithfulness or markedness). The precise nature of the transparent behavior follows from the nature of the dominated constraint. In the languages under consideration, it is AGR(Back), which would enforce local harmony, that is, opacity rather than transparency.

(16) a. Transparency (e.g. Finnish): GENERALIZED MH $\gg$ AGR(Back)

b. Opacity (e.g. Eastern Khanty): AGR(Back) $\gg$ GENERALIZED MH

Note that this treatment of transparency requires that a conjoined constraint can be outranked by the conjuncts that compose it (contrary to what is usually assumed, Kager 1999:393).

(17)

Transparent /i/			...	Generalized MH	Agr(Back)	...
[ä i] a		ä i a		*	*	
	☞	ä i ä				
[a i] ä	☞	a i a			**	
		a i ä		*	*	

(18)

Opaque /i/			...	Agr(Back)	Generalized MH	...
[ä i] a		ä i a		*	*	
	☞	ä i ä				
[a i] ä		a i a		**		
	☞	a i ä		*	*	

Combining the three variably ranked constraints discussed so far, we derive the empirically attested four-way typology of (8):

(19) Finnish: Generalized MH ≫ Agr(Back) ≫ *ä,*ö,*ü*

Finnish			Generalized MH	Agr(Back)	*ä,*ö,*ü*
[ä i] a		ä i a	*	*	*
	☞	ä i ä			**
[a i] ä	☞	a i a		**	
		a i ä	*	*	*
[i] a		i a		*	
	☞	i ä			*

(20) Uyghur: Generalized MH ≫ *ä,*ö,*ü* ≫ Agr(Back)

Uyghur			Generalized MH	*ä,*ö,*ü*	Agr(Back)
[ä i] a		ä i a	*	*	*
	☞	ä i ä		**	
[a i] ä	☞	a i a			**
		a i ä	*	*	*
[i] a	☞	i a			*
		i ä		*	

(21) Vepsian: *ä,*ö,*ü* ≫ Generalized MH, Agr(Back)

Vepsian			*ä,*ö,*ü*	Generalized MH	Agr(Back)
[ä i] a	☞	ä i a	*	*	*
		ä i ä	**		
[a i] ä	☞	a i a			**
		a i ä	*	*	*
[i] a	☞	i a			*
		i ä	*		

(22) Khanty: Agr(Back) ≫ Generalized MH, *ä,*ö,*ü*

Khanty		AGR(Back)	GENERALIZED MH	*ä,*ö,*ü
[ä i] a	ä i a	*	*	*
	☞ ä i ä			**
[a i] ä	a i a	**		
	☞ a i ä	*	*	*
[i] a	i a	*		
	☞ i ä			*

Note that there are four rather than six distinct systems. The reason is that, if either the general harmony constraint AGR(Back) or the general anti-harmony markedness constraint *ä,*ö,*ü rank at the top (as in Khanty and Vepsian, respectively) the ranking of other two constraints remains moot.

In all four types of languages, the constraints just discussed are dominated by the three constraints *ɨ,*õ ≫ IDENT-σ_1(Back), CORE MH. That CORE MH is always ranked at least as high as GENERALIZED MH is simply a consequence of the fact that constraints which exclude marked configurations are never outranked by constraints which exclude unmarked configurations (this is really the definition of markedness). Since we are considering only systems with neutral vowels *i e*, the constraint [–Lo,–Rd] ⇒ [–Bk] (*ɨ,*õ) outranks the harmony constraints in all the languages considered here. The lack of nonlow back unrounded vowels imposed by the high ranking of [–Lo,–Rd] ⇒ [–Bk] is typical of front-back harmony systems, and frequent in vowel systems in general, of course. Also common, in languages with and without harmony, is the neutralization of contrasts in non-initial syllables that arises when IDENT-σ_1(Back) outranks markedness constraints which suppress feature contrasts.

In the languages under consideration, then, all candidates with back unrounded vowels are excluded by undominated [–Lo,–Rd] ⇒ [–Bk], and will be omitted in what follows. So /ɨ/ in any input always surfaces as *i*.

(23)

Input		*ɨ,*õ	IDENT-σ_1(Back)	...
[a i]	☞ a i			
	a ɨ	*		
	ä i		*	
[a ɨ]	☞ a i			
	a ɨ	*		
	ä i		*	
[i]	☞ i			
	ɨ	*	*	
[ɨ]	☞ i			
	ɨ	*		
[ä i]	☞ ä i			
	ä ɨ	*		
	a i		*	
[ä ɨ]	☞ ä i			
	ä ɨ	*		
	a i		*	

The reverse ranking IDENT-σ_1(Back) ≫ **ɨ* is attested in Seto (Southeastern Estonian), where /ɨ/ is a distinctive harmonic back vowel in initial syllables only (Kiparsky and Pajusalu MS).

Finally, the ranking of IDENTROOT(Back) (here conjoined with IDENT-F_1(Back)) with respect to AGR(Back) and **ä,*ö,*ü* is what determines whether otherwise prohibited cases of disharmony involving neutral vowels are tolerated within roots. This seems to be an independent site of cross-linguistic variation which does not interact with the other typological parameters we have considered. The following tableaux show how the root-internal counterparts of the derived cases in (19)-(22) work out in the four types.

In Finnish, IDENTROOT(Back) & IDENT-F_1(Back) and GENERALIZED MH outrank AGR(Back). Consequently sequences of the type *ä i a*, *a i ä*, and *i i a* are precluded across the board, whereas *i a* contrasts with *i ä* root-internally (e.g. *viitta* ‘cloak’ vs. *riittä-* ‘suffice’) but is precluded across a boundary (e.g. *viit-tä* ‘five (partitive)’).

(24) Finnish: GENERALIZED MH, IDENTROOT(Back) & IDENT-F_1(Back) ≫ AGR(Back) ≫ **ä,*ö,*ü*

Finnish			GEN MH	IDRT(Back) & ID-F_1(Back)	AGR(Back)	**ä,*ö,*ü*
ä i a		ä i a	*		*	*
	☞	ä i ä				**
a i ä	☞	a i a			**	
		a i ä	*		*	*
i a	☞	i a			*	
		i ä		*		*
i ä		i a		*	*	
	☞	i ä				*
i i a		i i a			*	
	☞	i i ä				*

For Vepsian, Tunkelo 1946:700 states that *ä* never occurs beyond the second syllable of the word if the preceding syllable has the neutral vowel *i* (cf. Wiik 1989:99). So (at least for low vowels) backness is neutralized after the first foot, but in favor of the back vowel: not only *i i ä* but even *ä i ä* is excluded morpheme-internally. Accordingly, the ranking must be IDENTROOT(Back) & IDENT-F_1(Back) ≫ **ä,*ö,*ü* ≫ GENERALIZED MH, AGR(Back).

(25) Vepsian: IDENTROOT(Back) & IDENT-F_1(Back) ≫ **ä,*ö,*ü* ≫ GENERALIZED MH, AGR(Back)

Vepsian	IdRt(Back) & Id-F_1(Back)	*ä,*ö,*ü	Gen MH	Agr(Back)
ä i a ☞ ä i a		*	*	*
ä i ä		**		
ä i ä ☞ ä i a		*	*	*
ä i ä		**		
a i ä ☞ a i a				**
a i ä		*	*	*
i a ☞ i a				*
i ä	*	*		
i ä i a	*			*
☞ i ä		*		
i i a ☞ i i a				*
i i ä		*		
i i ä ☞ i i a				*
i i ä		*		

In Uyghur, while neutral roots trigger back harmony on suffixes, front and back vowels apparently mix freely with neutral vowels within roots. (At least, we have found no evidence that root length, via Id-F_1(Back), plays a visible role.) In systems of this type, *ä i a* and *a i ä* are permitted if IdentRoot(Back) ≫ Generalized MH, and excluded otherwise (the situation shown in (26)). Demotion of IdentRoot(Back) below **ä,*ö,*ü* moreover neutralizes *i ä* to *i a*.

(26) Uyghur: Generalized MH ≫ IdentRoot(Back) ≫ **ä,*ö,*ü*, Agr(Back)

Uyghur	Gen MH	IdRt(Back)	*ä,*ö,*ü	Agr(Back)
ä i a ä i a	*		*	*
☞ ä i ä		*	**	
a i ä ☞ a i a		*		**
a i ä	*		*	*
i a ☞ i a				*
i ä		*	*	
i ä i a		*		*
☞ i ä			*	
i i a ☞ i i a				*
i i ä		*	*	
i i ä i i a		*		*
☞ i i ä			*	

Eastern Khanty represents the other extreme, where Agr(Back) outranks the other three constraints. The ranking Agr(Back) ≫ IdentRoot(Back) excludes root-internal **i a* (as well as root-internal **ä i a*). In fact, neither the textual data nor the analysis of Vértes 1977 gives any indication of a difference between root-internal and cross-morphemic harmony in this language.

(27) Eastern Khanty: Agr(Back) ≫ IdentRoot(Back), Generalized MH, **ä,*ö,*ü*

Khanty		AGR(Back)	IDRT(Back)	GEN MH	*ä,*ö,*ü*
ä i a	ä i a	*		*	*
	☞ ä i ä		*		**
a i ä	a i a	**	*		
	☞ a i ä	*		*	*
i a	i a	*			
	☞ i ä		*		*
i ä	i a	*	*		
	☞ i ä				*
i i a	i i a	*			
	☞ i i ä		*		*
i i ä	i i a	*	*		
	☞ i i ä				*

In sum, it seems that root faithfulness plays no role either in languages where the harmony constraint AGR(Back) is very strong (such as Khanty), or in languages where the anti-harmonic neutralization constraint **ä,*ö,*ü* is very strong (such as Vepsian). It is in languages where both these constraints are ranked close together (Finnish and Uyghur, in our case) that there is room for morphological and root-faithfulness effects. Here, where the strength of harmony and anti-harmony are more closely matched, faithfulness to the lexical form by IDENTROOT(Back) can tip the balance between their conflicting demands.

Summing up the discussion so far, the collated rankings for the four languages are given in (28).

(28)
a. **Finnish:** **ɨ,*õ* $\gg$ IDENT-σ_1(Back), CORE MH, GENERALIZED MH $\gg$ IDRT(Back) & ID-F_1(Back) $\gg$ AGR(Back) $\gg$ **ä,*ö,*ü*

b. **Vepsian:** **ɨ,*õ* $\gg$ IDENT-σ_1(Bk), CORE MH $\gg$ IDENTROOT(Back) & IDENT-F_1(Back) $\gg$ **ä,*ö,*ü* $\gg$ GENERALIZED MH $\gg$ AGR(Back)

c. **Uyghur:** **ɨ,*õ* $\gg$ IDENT-σ_1(Back), CORE MH, GENERALIZED MH $\gg$ IDENTROOT(Back) $\gg$ **ä,*ö,*ü* $\gg$ AGR(Back)

d. **Eastern Khanty:** **ɨ,*õ* $\gg$ IDENT-σ_1(Bk) $\gg$ CORE MH $\gg$ AGR(Back) $\gg$ IDENT-ROOT(Back) $\gg$ GENERALIZED MH, **ä,*ö,*ü*

Some of the more interesting differences and similarities between the four systems are illustrated in the following tableaux.

	Finnish	*ɨ,*õ	ID-σ$_1$(Bk)	CORE MH	GEN MH	IDRT(Bk)&ID-F$_1$(Bk)	AGR(Bk)	*ä,*ö,*ü	**Vepsian**	*ɨ,*õ	ID-σ$_1$(Bk)	CORE MH	IDRT(Bk)&ID-F$_1$(Bk)	*ä,*ö,*ü	GEN MH	AGR(Bk)
[a i] a	☞ a i a						**		☞ a i a							**
	a i ä				*		*	*	a i ä					*	*	*
	ä i ä		*			*		**	ä i ä		*		*	**		
[ä i] a	ä i a				*		*	*	☞ ä i a					*	*	*
	☞ ä i ä							**	ä i ä					**		
	a i a		*			*	**		a i a		*		*			**
ä i a	ä i a				*		*	*	☞ ä i a					*	*	*
	☞ ä i ä							**	ä i ä					**		
	a i a		*			*	**		a i a		*		*			**
[i] a	i a						*		☞ i a							*
	☞ i ä							*	i ä					*		
i a	☞ i a						*		☞ i a							*
	i ä					*		*	i ä				*	*		
i ä	i a					*	*		i a				*			*
	☞ i ä							*	☞ i ä					*		
i i a	i i a						*		☞ i i a							*
	☞ i i ä							*	i i ä					*		
i i ä	i i a						*		☞ i i a							*
	☞ i i ä							*	i i ä					*		
ä a	ä a			*	*		*	*	ä a			*		*	*	*
	☞ ä ä					*		**	☞ ä ä				*	**		
	a a		*			*			a a		*		*			

Input	Khanty	*ɨ,*õ	ID-σ1(Bk)	CORE MH	AGR(Bk)	IDRT(Bk)	GEN MH	*ä,*ö,*ü	Uyghur	*ɨ,*õ	ID-σ1(Bk)	CORE MH	GEN MH	IDRT(Bk)	*ä,*ö,*ü	AGR(Bk)
[a i] a	a i a				**				☞ a i a							**
	☞ a i ä				*		*	*	a i ä				*		*	*
	ä i ä		*			*		**	ä i ä		*			*	**	
[ä i] a	ä i a				*		*	*	ä i a				*		*	*
	☞ ä i ä							**	☞ ä i ä						**	
	a i a		*		**	*			a i a		*			*		**
ä i a	ä i a				*		*	*	ä i a				*		*	*
	☞ ä i ä					*		**	☞ ä i ä					*	**	
	a i a		*		**	*			a i a		*			*		**
[i] a	i a				*				☞ i a							*
	☞ i ä							*	i ä						*	
[i] ä	i a				*				☞ i a							*
	☞ i ä							*	i ä						*	
i a	i a				*				☞ i a							*
	☞ i ä					*		*	i ä					*	*	
i ä	i a				*	*			i a					*		*
	☞ i ä							*	☞ i ä						*	
i i a	i i a				*				☞ i i a							*
	☞ i i ä					*		*	i i ä					*	*	
i i ä	i i a				*	*			i i a					*		*
	☞ i i ä							*	☞ i i ä						*	
ä a	ä a			*	*		*	*	ä a			*	*		*	*
	☞ ä ä					*		**	☞ ä ä					*	**	
	a a		*			*			a a		*			*		

2.4 Deriving the typological generalizations

If correct, our analysis should derive the remaining true typological generalizations about neutral vowels as well. Above we formulated three empirical generalizations, *unmarkedness*, *asymmetry*, and *uniformity*. These do follow from the factorial typology of the constraint system.

The unmarkedness property follows from the leading idea that harmony reflects the interaction of general syntagmatic constraints (in this case AGR(Back) and its conjoined version) with paradigmatic restrictions on vowel contrasts. There is no "harmony rule", therefore no stipulated contextual restrictions on the harmony process. Rather, neutrality is enforced by markedness constraints. We know that these constraints suppress feature distinctions in favor of the unmarked feature specifications. That is why neutral vowels show the unmarked values of the harmonic feature.

The uniformity property is a consequence of the generality of the featural markedness constraints (2). The prediction here is weaker than in the preceding case, in that it depends on the substance of the actual constraints that we have posited. To the extent that there exist more specific markedness constraints that single out particular neutral vowels, non-uniformity should be possible.

The asymmetry property (in the case at hand, the generalization that back neutral vowels in front/back harmony systems are opaque rather than transparent) follows from the proposed analysis of transparency. Neutral vowels are transparent with respect to backness harmony when GENERALIZED MH (the conjunction of **ä,*ö,*ü* and AGR(Back)) ranks high. In (16) we saw that under the ranking GENERALIZED MH $\gg$ AGR(Back), *i* is transparent, and under the ranking AGR(Back) $\gg$ GENERALIZED MH, *i* is opaque. But, as the following tableaux show, *o* is opaque under *both* these rankings. In fact, the sequence *ä o a* is better than the sequence *ä o ä* with respect to front/back harmony on any ranking of the constraints we have (contrast (30) and (18)).

(29)

Opaque /o/		. . .	GENERALIZED MH	AGR(Back)	. . .
[ä o] a	☞ ä o a		*	*	
	ä o ä		**	**	
[ä o] ä	☞ ä o a		*	*	
	ä o ä		**	**	

(30)

Opaque /o/		. . .	AGR(Back)	GENERALIZED MH	. . .
[ä o] a	☞ ä o a		*	*	
	ä o ä		**	**	
[ä o] ä	☞ ä o a		*	*	
	ä o ä		**	**	

Under every ranking of the proposed constraints, neutral vowels are unmarked with respect to the harmonic feature, back neutral vowels are opaque (rather than transparent), and if even one front neutral vowel is transparent, all of them must be. Moreover, this prediction holds for all types of neutral vowels, whether context-free, contextual, or idiosyncratic.

In the instantiations of the conjoined constraint schema (15) considered so far, the conjunct that excludes the marked vowels is (2b) *(*ä,*ö,*ü)*. In principle all markedness constraints should conjoin with AGR(Back) both in the core mode and in the general mode.[14] Such conjoined constraints are in fact instantiated. For Turkish, Clements & Sezer 1983 propose the generalization that stable exceptions to front/back harmony do not contain the marked vowels *ö, ü, ı* (but only the unmarked vowels *i, e, a, o, u*). This means that (3) also conjoins with (2a) into a constraint AGR(Back) & **ı,*õ*. The constraint ranking for Turkish would be as follows:

(31) **Turkish:** $\left\{\begin{array}{l}\text{AGR(Back) \& *ı,õ} \\ \text{AGR(Back) \& *ä,*ö,*ü}\end{array}\right\} \gg$ IDENTROOT(Back) $\gg$ **ı,õ*, AGR(Back), **ä,*ö,*ü*

Turkish root-internal ("non-derived environment") disharmony as discussed by Clements and Sezer occurs because IDENTROOT(Back) intervenes between the conjoined constraint barring marked disharmony and more general markedness constraints including the plain harmony constraint AGR(Back).

(32) Turkish root disharmony:
  a. **o ü* — *ü* is both marked and disharmonic (violating the conjoined constraint)
  b. ✓*o e* — *e* is disharmonic but unmarked (no violation of the conjoined constraint)
  c. ✓*ö ü* — *ü* is marked but harmonic (no violation of the conjoined constraint)

[14] However, as Itô and Mester have noted, conjoined constraints should be mutually relevant, in some sense which remains to be precisely explicated.

Clements & Sezer report a similar situation with respect to rounding harmony, which can be accounted for in a parallel fashion.

3 Conclusions

We have presented a tentative typology of front/back vowel harmony systems, concentrating on disharmony phenomena. Disharmonic vowels are either opaque or transparent, and the latter show cross-linguistically very diverse behavior. The leading idea of our analysis is that disharmony arises when a general harmony constraint that imposes feature agreement on neighboring vowels is dominated by faithfulness constraints and by markedness constraints that govern vowel inventories. We showed that the empirically attested typology of disharmony is derivable from these assumptions on the basis of uncontroversial constraints. The only novelty was to make use of two modes of local constraint conjunction, which however are already implicit in the theory. Far from being a weakening of the theory, our proposal is in this respect more restrictive than the heretofore countenanced alternative of allowing the domain of local conjunction to be freely stipulated.

Bibliography

ARCHANGELI, DIANA AND & DOUGLAS PULLEYBLANK. 1994. Grounded phonology. Cambridge, Mass.: MIT Press.

BAKOVIC, ERIC. 2000. Harmony, dominance, and control. Rutgers University dissertation.

BECKMAN, JILL. 1998. Positional Faithfulness. U.Mass. Dissertation.

CLEMENTS, G.N. AND ENGIN SEZER. 1983. Vowel and consonant disharmony in Turkish. In H. van der Hulst and Norval Smith (eds.) The structure of phonological representations, II. Dordrecht: Foris.

GILLEY, LEOMA G. 1992. An autosegmental approach to Shilluk phonology. Dallas, TX: Summer Institute of Linguistics.

JUHKAM, EVI AND ALDI SEPP. 2000. Läänemurde tekstid. Eesti murded VIII. Tallinn: Eesti Keele Instituut.

KA, OMAR. 1994. Wolof phonology and morphology. Lanham, Md.: University Press of America.

KAGER, RENE. 1999. Optimality theory. Cambridge: Cambridge University Press.

KIPARSKY, PAUL. 1985. Some consequences of Lexical Phonology. Phonology Yearbook 2:85-138.

KIPARSKY, PAUL. 2000. Opacity and cyclicity. The Linguistic Review 17:351-366.

KIPARSKY, PAUL. 2003. Finnish Noun Inflection. In Diane Nelson and Satu Manninen (eds.) Generative Approaches to Finnic Linguistics.

KIPARSKY, PAUL, AND KARL PAJUSALU. 2001. Seto vowel harmony and prosody. MS.

KRÄMER, MARTIN. 2000. A correspondence approach to vowel harmony and disharmony. MS, Heinrich-Heine-Universität Düsseldorf.

LINDBLAD, VERN. 1990. Neutralization in Uyghur. MA Thesis, University of Washington.

MCCARTHY, JOHN. 2002. Against Gradience. ROA 510. `http://roa.rutgers.edu/view.php3?roa=510`.

MUST, MARI. 1995. Kirderannikumurde tekstid. Eesti murded V. Tallinn: Eesti Keele Instituut.

NÍ CHIOSÁIN, MÁIRE, AND JAYE PADGETT. 2001. Markedness, segment realization, and locality in spreading. MS.

NOSKE, MANUELA . 1990. Vowel harmony in Turkana. Studies in the Linguistic Sciences 20:123-34.

RINGEN, CATHERINE, AND ROBERT M. VAGO. 1998. Hungarian vowel harmony in Optimality Theory. Phonology 15:393-416.

RINGEN, CATHERINE, AND ORVOKKI HEINÄMÄKI. 1999. Variation in Finnish vowel harmony: an OT account. NLLT 17:303-337.

PRINCE, ALAN, AND PAUL SMOLENSKY. 1993. Optimality theory: constraint interaction in generative grammar. MS.

SMOLENSKY, PAUL. 1993. Harmony, markedness, and phonological activity. ROA-87, `http://roa.rutgers.edu/view.php3?roa=87`.

TANNING, SALME. 1961. Mulgi murdetekstid. Eesti murded I. Tallinn: Eesti Riiklik Kirjastus.

TUNKELO, E.A. 1946. Vepsän kielen äännehistoria. Suomalaisen Kirjallisuuden Seuran Toimituksia 228. Helsinki.

VAUX, BERT. 2000. Disharmony and derived transparency in Uyghur vowel harmony. NELS 30.

VÉRTES, EDITH. 1977. Morphonematische Untersuchung der ostjakischen Vokalharmonie. Budapest: Akadémiai Kiadó.

VÄLIMAA-BLUM, RIITTA. 1999. A feature geometric description of Finnish vowel harmony covering both loans and native words. Lingua 108.247-268.

WIIK, KALEVI. 1988. Viron vokaalisointu. Helsinki: Suomalaisen Kirjallisuuden Seura.

WIIK, KALEVI. 1989. Vepsän vokaalisointu. Helsinki: Suomalaisen Kirjallisuuden Seura.