Seto vowel harmony and the typology of disharmony

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We extend the OT-theoretic typology of vowel harmony proposed in Kiparsky and Pajusalu (200X) to the unusual front/back harmony system of Seto Estonian. Several types of apparent exceptions are explained by the interaction of harmony with other constraints, including those governing syllable structure and stress. We show that our analysis of neutral vowels is superior to those offered by sympathy, turbidity, and targeted constraints.

1 Vowel harmony

1.1 Introduction

The scope of vowel harmony in the Balto-Finnic languages is systematically determined by their vowel systems on the basis of two exceptionless generalizations. The first generalization is that (morphological restrictions aside) all of the languages have front-back vowel harmony to the fullest extent that their vowel system allows. Specifically, all vowels harmonize unless some constraint on the distribution of the harmonic feature prevents it. The second generalization is that only lexically contrastive vowels participate in vowel harmony, or putting it another way, harmony is structure-preserving, in the sense that it introduces no new vowel types. For example, the reason underlying *i* and *e* do not become *1and *¨ in back harmony contexts in Finnish is that *1and *¨ 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). Taken together, these two generalizations mean that a harmony system can be understood as a resolution of the conflicting claims of syntagmatic feature spread paradigmatic feature neutralization.[1]

Within these ironclad limits, the vowel harmony systems of the Balto-Finnic languages vary widely, in consequence of their differing vowel inventories. At one extreme is Northern Estonian, whose restricted inventory of non-initial vowels /i,e,u,a/, allows no harmony whatever. At the other extreme, with three harmonic pairs apiece, are Finnish, with /a∼ä, o∼ö, u∼ü/ plus unpaired /i,e/, and the Southeastern dialects of Estonian, with non-initial /a∼ä, õ∼e, u∼ü/ plus unpaired /i/. The intermediate inventories obey a partial markedness hierarchy *ä* ≻ *ü* ≻ *ö* noticed by Wiik 1988: any dialect that has vowel harmony at all has at least *a:ä*; in addition possibly *u:ü* and/or e ∼õ;

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and if one of these, then possibly *o:ö*.[2] Wiik documents the following vowel systems in Estonian dialects, and harmony operates to the fullest extent possible in each:

[1]	Initial syllables	Non-initial syllables	Harmonic alternations
Northern Seto	*u o a ü ö ä i e õ* 1	*u o a ü ö ä i e õ*	*u*∼*ü*, *o*∼*ö*, *a*∼*ä*, e∼õ
Southern Seto	*u o a ü ö ä i e õ* 1	*u o a ü ä i e õ*	*u*∼*ü*, *a*∼*ä*, e∼õ
Northeastern	*u o a ü ö ä i e*	*u o a ü ö ä i e*	*u*∼*ü*, *o*∼*ö*, *a*∼*ä*
Northern Tarto	*u o a ü ö ä i e õ* 1	*u o a ä i e õ*	*a*∼*ä*, e∼õ
Southwestern	*u o a ü ö ä i e õ*	*u a ü ä i e*	*u*∼*ü*, *a*∼*ä*
Western	*u o a ü ö ä i e õ*	*u a ä i e*	*a*∼*ä*
Northern	*u o a ü ö ä i e õ*	*u a i e*	—

Together, these two generalizations imply that all the Balto-Finnic languages (including as the limiting case even those that have no harmony) obey in principle the same front/back harmony constraint. To characterize the actual harmony pattern of a given language we need only specify what its vowels are, in initial and noninitial syllables. Why this should be so is one of the questions that we wish to address in this paper.

Although the basic picture is quite simple, there are some interesting complications, and these form our second main topic. The complications all have to do with the behavior of the unpaired, or NEUTRAL vowels. By definition, vowels (or more generally, segments) are neutral if they do not undergo harmony, which, to repeat, is always due to a gap in the vowel system, either in the inventory of phonemes (context-free neutralization, e.g. 1in Finnish) or in their distribution (positional neutralization, e.g. non-initial 1in Southeastern Estonian).

However, that is only the beginning of the story. Neutral segments must be further differentiated on the basis of how they combine with harmonic segments. The fundamental division among neutral segments is between OPAQUE segments and TRANSPARENT segments. Opaque segments are defined as those which interrupt harmony and initiate a new harmonic domain, and transparent segments are those which are "skipped" by harmony.[3] From a theoretical point of view, opaque segments do not seem very problematic, for two reasons. In the first place, their behavior is quite uniform, and secondly, this 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 segments, 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 remains so till this day (Bakovic 2000).

Not content with being permeable to harmony, transparent neutral vowels behave in remarkably diverse ways. Some are neutral stem-internally but trigger harmony in morphologically derived

[2]The Tarto dialects of South Estonian have *a:ä*, *e:ö*, but not *u:ü* (Wiik 1988:160).

[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.

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.

Still, all this variation is neither random nor simply a messy matter of "degree of transparency". There are strict generalizations, both absolute and implicational. Here are some examples of such generalizations that we will discuss and try to explain. Universally, neutral vowels show the unmarked value of the harmonic feature for their (paradigmatic and/or syntagmatic) context. In front/back harmony systems, back neutral vowels are always opaque. Front neutral vowels are opaque in some languages and transparent in others, and if there are several such vowels, they are all consistently either opaque or transparent. Our goal is to derive these and other properties of neutral vowels from the interaction of general constraints that can be justified outside of harmony phenomena, in this way contributing to a predictive typology of harmony systems.

As the primary empirical focus of our study we have chosen Southeastern Estonian, which is ideally suited for such explorations because it has the richest vowel system of any Balto-Finnic language, with full front/back vowel harmony and a large number of neutral vowels of both the transparent and the opaque kind, some context-free, others contextually restricted. Of these dialects, we will concentrate specifically on Seto, spoken by approximately 10,000 people in the Southeasternmost corner of Estonia and adjoining parts of Russia, and by a substantial diaspora in Siberia.[4] Virtually the same system is found in the adjoining Võru dialect, particularly in the conservative variety which has been selected as the basis of the new standard Võru literary language (Keem 1997). Other South Estonian dialects, spoken further to the north and west, have a more reduced vowel inventory and accordingly more restricted vowel harmony,[5] and almost all the northern dialects, as well as the standard language, lack harmony entirely.

1.2 The vowel inventory

Seto has a 10-vowel system consisting of five front/back vowel pairs.

[2]

	u	o	a	1	õ	ü	ö	ä	i	e
Back	+	+	+	+	+	−	−	−	−	−
Round	+	+	−	−	−	+	+	−	−	−
High	+	−	−	+	−	+	−	−	+	−
Low	−	−	+	−	−	−	−	+	−	−

Although the system itself is perfectly symmetrical, the distribution of the vowels is skewed in many ways. In fact, almost every vowel has its own personality.

[3] • /i/ is a transparent neutral vowel.

[4]Printed texts in Seto include the collections of narratives in Mägiste 1977 and Hagu 1999, and the Peko epic of Anne Vabarna (Hagu and Suhonen 1995). Pajusalu et al. 2000 give phonetic data on the vowels, and Toomsalu 1995 provides an inventory of verbs and their inflectional patterns. We have drawn on these sources and complemented them with material from three interviews by Paul Hagu with other native speakers of the dialect, which we recorded in three villages of Seto county in July 2000.

[5]In addition, they tend to be more strongly influenced by standard Estonian and consequently show a lot of code-switching and variation.

- /1/ (written *y* in the modern Seto/Võru orthography) is a back harmonic vowel and occurs only in initial syllables.
- /e/ is a neutral vowel in initial syllables, and a front harmonic vowel in non-initial syllables.
- /õ/ is an unrounded back harmonic vowel and occurs in any syllable. In inital, primary stressed syllables it is realized as a full back vowel (*e* in Finno-Ugric transcription, equivalent to IPA [¨]). Elsewhere, it is realized as a retracted, centralized, reduced *e*, or conversely a front schwa (Parve 2000; the customary F.-U. transcription is *e̯*, equivalent to IPA [e], [e], or [@]). The reduced articulation of unstressed /õ/ has consequences, as we shall see.
- /o/ is a back harmonic vowel in initial syllables, and an opaque neutral vowel in non-initial syllables.
- /ö/ is a front harmonic vowel and occurs only in initial syllables.
- /a/, /u/ are back harmonic vowels and occur in any syllable.
- /ä/, /ü/ are front harmonic vowels and occur in any syllable.

Before proceeding we must explain our phonological transcriptions. Forms cited in italics are in standard Seto/Võru orthography, which basically follows the spelling conventions of standard Estonian. However, to minimize confusion we write the high back unrounded vowel as 1(instead of as *y*), and where relevant we mark primary and secondary stress with the usual accents (e.g. *á, à),* morpheme boundaries with hyphens, and extra-long segments with colons (e.g. *t:*). Those same diacritics will be also used when we give underlying and phonetic representations, in slashes and square brackets respectively. The letter *q* represents a glottal stop. Palatalization is marked e.g. as in *t́*. Short ("Q1") consonants, simple geminated ("Q2") consonants, and overlong consonants ("Q3") are marked by *C, C:*, and *CC:*, respectively. However, in line with the orthography, we mark the short ("Q1") lenis stops (which can be voiceless, voiced, or semi-voiced) by *b d g*.

The basic harmony restriction is of course that front and back harmonic vowels do not co-occur. The starred words are not merely nonexistent but impossible in Seto.

[4]	a.	*ruga*	'stack'	*rügä*	'rye'	*(*rugä, *rüga)*
	b.	*s1na*	'word'	*sinä*	'you'	*(*s1nä)*

Harmony induces alternations in inflectional and derivational suffixes, as illustrated in [5].

[5]	a.	*pan-daq*	'to put'	*müü-däq*	'to sell'
	b.	*nõsõ-sõ*	'they rise'	*elä-se*	'they live'
	c.	*opp:a-ji-lõ*	'to teachers'	*rebäs-i-le*	'to foxes'
	d.	*saa:-ma*	'to get'	*jää:-mä*	'to stay'
	e.	*naĺa-tta-nuq*	'joked' (Pp.)	*nälü-ttä-nüq*	'starved' (Pp.)
	f.	*tütt:re-kkene*	'daughter' (dim.)	*maama-kkõnõ*	'mom' (dim.)

Stems containing only transparent neutral vowels (*e* in initial syllables and *i* in any syllable) always take front endings (e.g. *pet-mä* 'to deceive', *ihf́t-mä* 'to poison'). Within a stem, however, these vowels can freely combine with back harmonic vowels.

[6]	a.	*tuli*	‘fire’	*ütsi*	‘alone’
	b.	*kari-sta-ma*	‘to punish’	*käri-stä-mä*	‘to sizzle’
	c.	*kobi-ma*	‘to grope’	*köbi-mä*	‘to grope’
	d.	*klɨbisõ-ma*	‘to rattle’	*libise-mä*	‘to flutter’
	e.	*ilma*	‘without’	*silmä*	‘eye’ (gen.)
	f.	*lippõ*	‘lye’	*nimme*	‘name’ (part.)
	g.	*killõ*	‘shrill’	*kille*	‘flummery’ (part.)
	h.	*teeda*	‘grandpa’	*esä*	‘father’
	i.	*ikkõ-tta-ma*	‘to cause to weep’	*ile-ttä-mä*	‘to shine’
	j.	*vii:ra-ma*	‘to leave a wake’	*hii:lä-mä*	‘to shine’
	k.	*kirsa-hut-ma*	‘to cry out’	*irvä-hüt-mä*	‘to crow’
	l.	*klei:a-ma*	‘to glue’	*lei:nä-mä*	‘to mourn’
	m.	*hibõ-lõ-ma*	‘to fly’ (of flags)	*vide-le-mä*	‘to loaf’

In Western Seto (where our field work was done), the front vowel *ö* is restricted to initial syllables, except for baby talk and certain affective words (e.g. *jäńö* ‘bunny rabbit’, *heŕösk* ‘silly goose’. We treat these as belonging to a separate stratum of the vocabulary and consider that *o* in non-initial syllables is neutral.[6] After such a neutral *o*, back harmony is obligatory:

[7]	a.	*läh:ko-lõ*	‘near’ (allat.)
	b.	*Höödo-kkõnõ*	‘Teddy’ (‘Höödo-diminutive’) (SP 120)

This type of neutral vowel is referred to as OPAQUE, as opposed to I, which is *transparent.*

Certain sound changes turn unstressed /o/ into /u/ and /a/, which are normally harmonic vowels. When /u/ and /a/ are so derived from /o/ they do still not harmonize. In particular, /o/ is variably raised in word-final position, resulting in opaque *u*.

[8]	a.	/nüssiko/	*nüssigu*	‘milking pail’ (gen.)
	b.	/lähko/	*läh:ku, läh:ko*	‘near’

Stem-final /-o/ is subject to various contraction processes which result in opaque /-u/ and /-a/ as well. For example, the stem /tütrikko-/ ‘girl’ gives a singular stem /tütrikku-/ by raising, and a plural stem /tütrikka-/ by contraction.

[9]	a.	/tüttrikku-lõ/	‘to the girl’
	b.	/tüttrikka-lõ/	‘to the girls’

The high back unrounded vowel /ɨ/ (usually written *y*, though we will just write ɨ) occurs in initial syllables as an underlying short nucleus, both in native words and as a rendition of Russian /y/ in loans. It is most common before nasals, where *õ* is obligatorily raised to ɨ.

[10]	a.	*sɨs*	‘then’
	b.	*kɨnõlõ-sõq*	‘they talk’
	c.	*nɨna*	‘nose’
	d.	*sɨna*	‘you’

[6] In northern Seto however, *ö* occurs in non-initial syllables because of a sound change which lowered *ü* to ö, e.g. *nännö* ‘seen’, for *nännüq* in the dialect studied here.

The vowel *e* sometimes occurs in back harmonic contects in function words:

[11] a. *laze minnu* ‘let me’
b. *sulle, mulle* ‘me, you’ (allative)
c. *ma ole* ‘I am’ (ST 108)

It also contrasts with *e* when neutral vowels precede within the stem:

[12] a. *ineminõ* ‘human being’
b. *lippõ* ‘lye’

In contexts like /istu-õ/ *ist-õ* ‘sat’, it occurs after a deleted back stem vowel. Otherwise in suffixes, *e* and *õ* alternate very regularly by vowel harmony.

There is also a reduced vowel of rather variable pronunciation which we will write [ɪ], which occurs only as an epenthetic vowel in final C__R clusters, in both front and back words, e.g. /mükr/ [mükır] ‘mole’, /tetr/ [tekır] ‘grouse’, /sõpr/ [sõpır] ‘friend’. In the Seto orthography it is written *y*, but Parve 2000 considers it to be a retracted allophone of the neutral vowel *i*, and indeed its neutral behavior distinguishes it phonologically from the full back vowels /õ/ and /ɤ̃/. This vowel is transparent, as shown by forms like *mükır-ei* (with the harmonizing cliticized negation *-ei*).

2 Harmony and disharmony

2.1 Typology of neutral vowels

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). We think that the complex behavior of “neutral” segments in harmony systems follows from the interplay of faithfulness constraints with context-free and context-sensitive markedness constraints.

Segments which do not undergo harmony are called NEUTRAL. But there are at least as many kinds of neutrality in phonology as there are in international relations. A familiar division of neutral segments is into opaque and transparent segments, on the basis of whether they trigger harmony or not. The boundary between them is complex, however. Various kinds of mixed behavior occur. In [3] we provisionally classified *e* in initial syllables, and *i* in any syllable, as neutral on the grounds that they combine with back and front vowels. But this division is still too crude in several respects. Let us look more closely at the difference between the two neutral vowels *i* and *e*.

When the nucleus of a stem’s first syllable is *i*, the harmonic vowels in the rest of the stem are more often back than front, approximately in the same proportion as back harmonic vowels outnumber front harmonic vowels in the language overall. This, then, is just what we expect if *i* is truly neutral. But when the first syllable has *e*, harmonic vowels in the rest of the stem are predominantly front. Against a very small number of stems with the vowel pattern [. . . *e*. . . *a*. . .] there are many with [. . . *e*. . . *ä*. . .]. In other words, in initial syllables the vowel *e* is actually not

wholly neutral even with respect to stem-internal harmony, but preferentially combines with front harmonic vowels. Thus *e* might be called SEMI-HARMONIC with respect to stem-internal harmony.

As for *i*, while fully neutral in all stem combinations, in derived contexts it too shows its frontness, for stems containing only *i* (or any combination of *i* and *e*) consistently trigger fronting in harmonic suffixes. The three-way distinction between *i, e,* and *ä* in the stem-internal case is schematized in [13], where brackets mark the stem boundaries.

[13] The diversity of disharmonic vowel sequences in Seto

Stem-internal		Stem+ending	
[ä a]	impossible	[ä] a	impossible
[e a]	marked	[e] a	impossible
[i a]	unmarked	[i] a	impossible

This illustrates that the triggering effects of transparent segments may differ in derived and non-derived environments, and that all transparent segments of a language do not necessarily behave the same way.

Cross-linguistically, there is an even more obvious difference among so-called transparent segments: they 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 the 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.[7] Wiik 1988 reports the same system for Southern Vepsian. Because of such contextual neutralization, a segment may be neutral even if it has a harmonic partner in the language's inventory: the relevant notion of contrast is a *contextual* one.

The factorial typology that emerges from the constraints must accommodate such variation. Moreover, there are certain basic typological generalizations that it must explain.

Unmarkedness. Neutral vowels bear an unmarked value of the harmonizing feature, in virtue of suppression of the contrast, either by a context-free feature co-occurrence constraint, or by a prosodically or segmentally defined contextual neutralization. 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, ë, ä, ö, ü*. In Seto, we have already seen that *i, e, o* can be neutral vowels (and even its other two unmarked vowels *a, u* can be neutral in certain cases, as we shall see).

Uniformity. All neutral vowels with a given value [αF] of the harmonic feature will be either opaque or transparent. In Seto, for instance, the [–Back] neutral vowels are all transparent, and the [+Back] neutral vowels are all opaque, a generalization which will be confirmed as examine the whole system and find more instances of each type.

Asymmetry. Going beyond the previous generalization, it seems that transparent vowels have a specific feature value; in the front/back harmony systems we have examined it is always [–Back].

[7] *i...a* is retained, as in *minnas* 'go' (cond.), except in the context of palatalized consonants (e.g. *iļļä-ksi* 'quiet' (Transl.Pl.). *jää-nü* 'stayed' *müü-dä* 'sell'.

In Kiparsky & Pajusalu 200X we document these different kinds of harmonic neutrality and the generalizations about them, and attempt an explication of the space of variation and the limitations on it in terms of a OT factorial typology. Our conclusion is that the category of "neutral segment" comprises a family of disharmonic behaviors reflecting the competition between contextual constraints and feature co-occurrence constraints. In this section we briefly review these findings.

2.2 The constraints

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.

[14] Featural markedness constraints[8]

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 *1*¨.

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)*.

The implicational format in [14] is chosen over the simple 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 [14a,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 Heinämäki and Ringen 2000) 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 either unfeasible or undesirable. It just means that we think it is not necessary, and that we wish to set this complex issue aside for now.

The combinatoric markedness constraint that drives harmony is stated in [15].

[15] Combinatoric markedness constraint

AGR(F): Adjacent segments must have the same value of the feature [F] (in the languages studied here, [F] = [Back]) (Bakovic 2000:4, cf. Krämer 2000).

We also require the two familiar faithfulness constraints in [16].

[16] Faithfulness constraints

[8] Each of these constraints really conflates two constraints, one relating [Back] to [Low], the other relating [Back] to [Round]. Data not treated in the present article show that they are distinct.

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

b. IDENTSTEM(BACK): An [αBack] input segment in a stem must not have a [$-\alpha$Back] output correspondent). (Note that this is an ordinary I/O faithfulness constraint, contrast the Output/Output constraint SA-IDENT(F) proposed by Bakovic 2000:23).

These faithfulness constraints become visible in a language when they dominate some markedness constraint, such as [15] AGR(F). They determine two controlling ("triggering") environments in harmony systems. One is the ***first*** vowel of the harmonic domain, expressed by [16a] IDENT-σ_1(Back). 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. For example, vowel harmony minimally prohibits non-neutral vowels with different values of the harmonic feature in abutting syllables, such as *CäCa* and *CaCä* in front/back harmony systems. In the virtue of constraint interaction, the privileged status of the word-initial syllable established by IDENT-σ_1 (BACK) means two things: it is the position of maximal contrast (even independently of any harmony), and it is a trigger of harmony.

The second controlling environment is the STEM. When stem and affix have distinct harmonic values, the value of the stem prevails. The faithfulness constraint [16a] that ensures this is [16b] IDENTSTEM(Back). IDENTSTEM(Back) has another function as well. It accounts for the "derived environment" asymmetries commonly seen in harmony systems. The overarching generalization here is that harmonic constraints are more severe in derived environments than stem-internally. For example, in Finnish, affixes are fronted after all-neutral stems: *el-el-y* 'living', *tie-tön* 'roadless'. But within simple stems, back and front harmonic vowels contrast after neutral vowels: *hellä* 'tender', *hella* 'stove', *isä* 'father', *kisa* 'game', *kesy* 'tame', *resu* 'rag'.[9]

In a suffixing language such as Finnish, the effects of the two constraints IDENTSTEM(BACK) and IDENT-σ_1(Back) overlap significantly. Still, there there is evidence for both. Although the privileged status of the initial syllable determined by IDENT-σ_1(Back) is normally not detectable, it can be seen in loanword adaptation, by a kind of Emergence of the Unmarked:[10]

[17] a. *Peugeot* → *pösö* (not **poso*)

b. *olympialaiset* → *olumpialaiset, trotyyli* → *rotuli, pulityyri* → *pulituuri*

Before specifying the harmony constraints let us review the typological space of neutral vowel behavior descriptively. 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. To schematize the data 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 [16], as in all the languages in our sample.

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

[9] Vocalic affixes after monosyllabic roots act like stem-internal vowels: *pes-u* 'washing', *tiet-o* 'knowledge', *el-o* 'living'.

[10] 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. 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 [18] maps out the different ways in which languages deal with these situations. Each column represents a type of disharmony. The stars in the first column diagnose harmony itself: if a language does not bar sequences of disharmonic segments 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 [18] represent the three critical diagnostics just listed that establish the descriptive typology of neutral vowels. Since harmony is often suspended inside stems by the faithfulness constraint [16b] — to which we will return in a moment — we consider here the derived environment case (as shown by the brackets), in order to cast our net as wide as possible.[11]

[18] The differentiation of neutral vowels in derived environments:

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

In all four languages, the vowel *i* is neutral (unpaired); in some also *e* is neutral.[12] But these neutral vowel behave differently as shown. For example, Uyghur has *yol-imiz-Ka* 'our road-dat' and *sinip-ta* 'class-loc.' (Vaux 2000), where Finnish has threats the corresponding configurations differently, e.g. *sot-i-mis-ta* 'warring-part', but *sinis-tä* 'blue-part'.

A similar typology could be developed for ATR harmony.

Of the eight logically possible cases, four are instantiated in [18]. In developing our theoretical typology, we will proceed on the assumption that the other four systems are systematic gaps. Of course that may turn out to be wrong. However, we think it has a good shot at being right, because the attested types are predicted by constraints that we need independently of the workings of harmony systems, and because the missing types would require constraints that not otherwise motivated. We propose that the four actually occurring subtypes of neutral vowels are distinguished from each other, and from the logically possible but unattested ones, by the intersection of two binary properties.

[11] In Seto, for example, front neutral vowels combine with back vowels in stems; the combination is however starred in the last column of the table because suffixal vowels are always fronted after neutral vowels.

[12] The Uyghur system has been treated by Lindblad 1990 and Vaux 2000. For Khanty (Ostyak) we are not aware of any phonological analysis, but the material has been painstakingly analyzed by Vertes 1977, from whom we take our data. Both languages present interesting complications which we set aside here. In Khanty, an optional postlexical local assimilation process creates back 1, ¨, without interacting with harmony in any way (Vertes 1977).

Triggering. The first property distinguishes Finnish and Khanty from Uyghur and Vepsian. In Finnish and Khanty, all-neutral contexts trigger harmony in derived environments, in Uyghur and Vepsian they do not. Alternative rankings of two previously introduced constraints will generate this part of the typology. Uyghur and Vepsian prefer to avoid the marked vowels *ä, ü, ö*. In Finnish and Khanty, avoiding the marked vowels vowels *ä, ü, ö* is less important than eliminating even mildly disharmonic vowel combinations. In terms of constraint ranking:

[19] a. Finnish, Khanty: AGR(BACK) ≫ **ä,*ö,*ü*

b. Uyghur and Vepsian: **ä,*ö,*ü* ≫ AGR(BACK)

[20]

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

[21]

Uyghur	...	**ä,*ö,*ü*	AGR(BK)	...
[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(BK)) and paradigmatic constraints (such as **ä,*ö,*ü*).

Of course, this cannot be the whole story by a long shot: stem-internally, Finnish welcomes combinations like *i a* with open arms, 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*. It also tells us that this more selective constraint dominates IDENT-σ_1(Back) (since it treats stems and derived environments alike), which as we already know in turn dominates the more general harmony constraint AGR(Back). We propose that this new constraint forbids a harmony violation that involves marked vowels. To express the idea that disharmony with marked vowels is both worse than disharmony alone, and worse than markedness alone, we need no new primitive constraints. Rather, we use local constraint conjunction (Smolensky 1993, Kager 1999:392-400) to combine the existing constraints [15] AGR(BK) and [14b,c] **ä, *ö, *ü* into a new constraint MARKED HARMONY (MH):

[22] MARKED HARMONY (MH): AGR(Back) & **ä, *ö, *ü*

A conjoined constraint is violated when both its conjuncts are violated; it universally dominates each conjunct. [23] will help make the general idea clear.

[23] Finnish disharmony:

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)

Transparency. We must still account for the fact that sequences such as *ä i a* and *a i ä* are bad in Finnish and Uyghur, and good in the other languages, except of course where excluded by independent constraints already formulated (namely, in Vepsian *a i ä* is rejected in favor of *a i a* by [19a], and in Khanty *ä i a* is rejected in favor of *ä i ä* by [16b]). This is simply what we normally mean when we say that neutral vowels are *transparent* in Finnish and Uyghur. To account for it we need a constraint that militates against long-distance disharmony. When that constraint dominates the more general harmony constraint AGR(Back), transparency results.

Again, we need no new primitive constraints to get this result. As formulated in the literature so far, the theory of constraint conjunction requires specification of some domain in which violations of the conjoined constraint 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:

[24] a. CONSTRAINT CONJUNCTION (GENERAL 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 [24] we obtain two versions of the conjoined constraint MH that precludes disharmony of marked vowels.

[25] a. GENERAL MH: no domain can contain both a marked vowel and a disharmonic vowel.

b. CORE MH: a marked vowel may not be disharmonic.

This gives us the parametrization of neutrality that we want. 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 GENERAL MH is violated by all of them. *ä o ä* has two violations of both constraints (one in the substring *ä o*, the other in the substring *o ä*). *ä i a i ä* has two violations of GENERAL MH (namely *ä i a* and *a i ä*), but no violations of CORE MH.

Given these constrains, neutral vowels are transparent if GENERAL MH outranks CORE MH, and some anti-harmony constraint (whether faithfulness or markedness) intervenes between them. Otherwise, neutral vowels are opaque. The precise nature of the transparent behavior follows from the nature of the intervening anti-harmony constraint. From the distribution in [13] we know that in the languages under consideration, it is AGR(BACK) that intervenes.

[26] a. Transparency (Finnish and Uyghur): GENERAL MH $\gg$ AGR(BACK)

b. Opacity (Khanty and Vepsian): AGR(BACK) $\gg$ GENERAL MH

[27]

Transparent /i/	...	GENERAL MH	AGR(BK)	...
[ä i] a ä i a		*	*	
☞ ä i ä				
[a i] ä ☞ a i a			**	
a i ä		*	*	

[28]

Transparent /i/	...	AGR(BK)	GENERAL MH	...
[ä i] a ä i a		*	*	
☞ ä i ä				
[a i] ä a i a		**		
☞ a i ä		*	*	

The collated rankings discussed so far are given in [29].

[29] a. **Finnish:** GENERAL MH, IDENTSTEM(BACK) ≫ AGR(Back) ≫ **ä,*ö,*ü* (i.e. [14b] [–Bk] ⇒ [–Lo,–Rd])

b. **Khanty:** CORE MH ≫ IDENTSTEM(BACK) ≫ AGR(Back) ≫ **ä,*ö,*ü*

c. **Uyghur:** GENERAL MH ≫ IDENTSTEM(BACK) ≫ **ä,*ö,*ü* ≫ AGR(Back)

d. **Vepsian:** CORE MH ≫ IDENTSTEM(BACK) ≫ **ä,*ö,*ü* ≫ AGR(Back)

In the conjoined constraints [25], the conjunct that excludes the marked vowels is [14b] *(*ä,*ö,*ü)*. In principle all markedness constraints should conjoin with AGR(Back) both in the core mode and in the general mode.[13] Such conjoined constraints are in fact instantiated. For Turkish, Clements & Sezer 1983 propose the generalization that disharmonic words do not contain the marked vowels *ö, ü,* 1(but only the unmarked vowels *i, e, a, o, u*). This means that [15] also conjoins with [14a] into a constraint AGR(Back) & *1*¨. The constraint ranking for Turkish would be as follows:

[30] **Turkish:** $\left\{\begin{matrix}\text{AGR(Back) \& *1̈}\\ \text{AGR(Back) \&*ä,*ö,*ü}\end{matrix}\right\}$ ≫ IDENTSTEM(BACK) ≫ *1̈, AGR(Back), **ä,*ö,*ü*

Turkish "non-derived environment" disharmony occurs because IDENTSTEM(BACK) intervenes between the conjoined constraint barring marked disharmony and more general markedness constraints including the plain harmony constraint AGR(Back).

[31] Turkish disharmony:

a. **e* 1 — 1is both marked and disharmonic (violating the conjoined constraint)
b. ✓*e u* — *u* is disharmonic but unmarked (no violation of the conjoined constraint)
c. ✓*e ü* — *ü* is marked but harmonic (no violation of the conjoined constraint)

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

Let us see why this is so. The unmarkedness property follows from the leading idea that harmony reflects the interaction of general syntagmatic constraints (in this case AGR(Back)) 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. Therefore neutral vowels are unmarked.

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

The uniformity property is a consequence of the generality of the featural markedness constraints [14]. Note that 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 GENERAL MH (the conjunction of **ä,*ö,*ü* and AGR(Back)) ranks high. In [26] we saw that under the ranking GENERAL MH ≫ AGR(BK), *i* is transparent, and under the ranking AGR(BK) ≫ GENERAL MH, *i* is opaque. But, as the following tableaux show, *ä o a* is better than *ä o ä* under *both* rankings. In fact, *o* comes out opaque with respect to front/back harmony on any ranking of the constraints we have.

[32]

Transparent /i/	...	GENERAL MH	AGR(BK)	...
[ä o] a ☞ ä o a		*	*	
ä o ä		**	**	
[ä o] ä ☞ ä o a		*	*	
ä o ä		**	**	

[33]

Opaque /i/	...	AGR(BK)	GENERAL 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, back neutral vowels are opaque (and not 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.

If this solution is correct, it follows that a conjoined constraint cannot universally outrank the conjuncts that compose it (contrary to what is usually assumed, Kager 1999:393).

2.3 Summary of front-back harmony systems

Input	Khanty	[–Lo,–Rd] ⇒ [–Bk]	IDENT-σ_1(Back)	CORE MH	IDENTSTEM(BACK)	AGR(Back)	[–Bk] ⇒ [–Lo,–Rd]	Vepsian	[–Lo,–Rd] ⇒ [–Bk]	IDENT-σ_1(Back)	CORE MH	[–Bk] ⇒ [–Lo,–Rd]	IDENTSTEM(BACK)	AGR(Back)
[a i]	☞ a i					*		☞ a i						*
	a ɨ	*			*			a ɨ	*				*	
	ä i		*		*		*	ä i		*		*	*	
[a ɨ]	☞ a i				*	*		☞ a i					*	*
	a ɨ	*						a ɨ	*					
	ä i		*		**		*	ä i		*		*	**	
[[a i] a]	a i a					**		☞ a i a						**
	☞ a i ä					*	*	a i ä				*		*
	a ɨ a	*			*			a ɨ a	*				*	
	ä i ä		*		*		**	ä i ä		*		**	*	
[i]	☞ i							☞ i						
	ɨ	*	*		*			ɨ	*	*			*	
[ɨ]	☞ i				*			☞ i					*	
	ɨ	*						ɨ	*					
[[i] a]	i a					*		☞ i a						*
	☞ i ä						*	i ä				*		
	ɨ a	*			*			ɨ a	*				*	
[ä i]	☞ ä i						*	ä i				*		
	ä ɨ	*		*	*	*	*	ä ɨ	*		*	*	*	*
	a i		*		*	*		a i		*			*	*
[ä ɨ]	☞ ä i				*		*	ä i				*	*	
	ä ɨ	*		*		*	*	ä ɨ	*		*		*	*
	a i		*		**	*		a i		*		**		*
[[ä i] a]	ä i a					*	*	☞ ä i a				*		*
	☞ ä i ä						**	ä i ä				**		
	ä ɨ a	*		**	*	*	*	ä ɨ a	*		*	*	*	*
	ä ɨ ä	*		*	*	**	**	ä ɨ 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						*
	ɨ a	*			*			ɨ a	*				*	
	i ä				*		*	i ä				*	*	
[i ä]	i a				*	*		☞ i a					*	*
	☞ i ä						*	i ä				*		
[ä a]	ä a			*		*	*	ä a			*	*		*
	☞ ä ä				*		**	☞ ä ä				**	*	
	a a		*		*			a a		*			*	

Input	Finnish	[–Lo,–Rd] ⇒ [–Bk]	IDENT-σ1(Back)	GENERAL MH	IDENTSTEM(BACK)	AGR(Back)	[–Bk] ⇒ [–Lo,–Rd]	Uyghur	[–Lo,–Rd] ⇒ [–Bk]	IDENT-σ1(Back)	GENERAL MH	IDENTSTEM(BACK)	[–Bk] ⇒ [–Lo,–Rd]	AGR(Back)
[a i]	☞ a i					*		☞ a i						*
	a ɨ	*			*			a ɨ	*			*		
	ä i		*		*		*	ä i		*		*	*	
[a ɨ]	☞ a i				*	*		☞ a i				*		*
	a ɨ	*						a ɨ	*					
	ä i		*		**		*	ä i		*		*	*	
[[a i] a]	☞ a i a					**		☞ a i a						**
	a i ä			*		*	*	a i ä			*		*	*
	a ɨ a	*			*			a ɨ a	*			*		
	ä i ä		*		*		**	ä i ä		*		*	**	
[i]	☞ i							☞ i						
	ɨ	*	*		*			ɨ	*	*		*		
[ɨ]	☞ i				*			☞ i				*		
	ɨ	*	*					ɨ	*	*				
[[i] a]	i a					*		☞ i a						*
	☞ i ä						*	i ä					*	
	ɨ a	*	*		*			ɨ a	*	*		*		
[äi]	☞ äi						*	☞ äi					*	
	ä ɨ	*		*	*	*	*	ä ɨ	*		*	*	*	*
	ai		*		*	*		ai		*			*	*
[ä ɨ]	☞ äi				*		*	☞ äi				*	*	
	ä ɨ	*		*		*	*	ä ɨ	*		*		*	*
	ai		*		**	*		ai		*		**		*
[[äi] a]	äi a			*		*	*	äi a			*		*	*
	☞ äi ä						**	☞ äi ä					**	
	ä ɨ a	*		*	*	*	*	ä ɨ a	*		*	*	*	*
	ä ɨ ä	*		**	*	**	**	ä ɨ ä	*		*	*	**	**
	a i a		*		*	**		a i a		*		*		**
[äi a]	äi a			*		*	*	äi a			*		*	*
	☞ äi ä				*		**	☞ äi ä				*	**	
	a i a		*		*	**		a i a		*		*		**
[i a]	☞ i a					*		☞ i a						*
	ɨ a	*	*		*			ɨ a	*		*	*		
	i ä				*		*	i ä				*	*	
[ai]	☞ ai					*		☞ ai						*
	a ɨ	*			*			a ɨ	*		*	*		
	äi		*		*		*	äi		*		*	*	
[i ä]	i a				*	*		i a				*		*
	☞ i ä						*	☞ i ä					*	
[ä a]	ä a			*		*	*	ä a			*		*	*
	☞ ä ä				*		**	☞ ä ä				*	**	
	a a		*		*			a a		*		*		

2.4 Seto

We will say that a feature specification [αF] is MARKED in a given context of a given language if its realization in that context depends on faithfulness constraints, which is to say if it is crucially specified as [αF] in the lexicon. For example, in Finnish the [–Back] specification of /i/ is unmarked in all contexts because the undominated constraint *1ensures that the vowel will be realized as [–Back] in all contexts whether it is specified in the lexicon as [–Back] or not. The [–Back] specification of /ä/ is unmarked in front harmonic contexts because AGR(Back) ensures that it is realized as [–Back] in those contexts whether it is specified in the lexicon as [–Back] or not. But the [–Back] specification of /ä/ in initial syllables is marked, for in that context a back vowel or a vowel unmarked for backness will be realized as *a* by [14c].

[DISCUSSION OF THE DIFFERENCES BETWEEN NEUTRAL /I/ AND SEMI-HARMONIC /E/ COMES HERE.]

[34]	a.	*olle-keltŕi*	'beer-cellar'	(ST 54)
	b.	*paneq*	'put'	(ST 40)

To ensure that *o* in noninitial syllables is neutral, and specifically that it is opaque, the minimal constraint **o* suffices. Ranked below IDENT-σ_1(Back), it neutralizes frontness only in non-initial syllables, and the neutralized vowel is necessarily opaque.

[35] Seto constraint ranking:

IDENT-σ_1(Back) $\gg$ *1$\gg$ **ö* $\gg$ GENERAL MH (no domain can contain both a disharmonic vowel and a marked vowel *ä,ö,ü*) $\gg$ IDENTSTEM(BACK) $\gg$ WEAK*MD (no disharmonic front vowels) $\gg$ *[–Back] (no front vowels)

[36]

Seto		Id-σ1(Bk)	*1	*ö	Str*MD	Reduce	IdSt(Bk)	Wk*MD	Agr(Bk)
	☞ a i õ					**			*
[[a i] e]	a i e					***			*
	a 1õ		*			**	*		
	a 1e		*			***	*		*
	ä i e	*				**	*		
[[ä i] õ]	ä i õ				*	**			*
	☞ ä i e					***			
	ä 1õ		*		*	**	*	*	*
	ä 1e		*			***	*		*
	a 1e	*				**			*
[[ä i] a]	ä i a				*	***			*
	☞ ä i ä					***			
	ä 1a	*	*		*	***	*	*	*
[a i ä]	☞ a i a					***			*
	a i ä				*	***			*
[õ i õ]	☞ õ i õ					**			*
	õ i e					***			*
[e i õ]	☞ e i õ					**			*
	e i e					***	*		
[i a]	☞ i a					**			*
	i ä					**	*		
	1a	*	*			**			
[i] a	i a					**			*
	☞ i ä					**			
	1a	*	*			**	*		
[e a]	☞ e a					**			*
	e ä					**	*		
	õ a	*				**			
[a e]	a e					**			*
	☞ a õ					*	*		
[e] a	e a					**	*		*
	☞ e ä					**			
	õ a	*				**			
[ä a]	ä a				*	**		*	*
	☞ ä ä					**	*		
	a a	*				**			
[a ä]	a ä				*	**		*	*
	☞ a a					**	*		
	ä ä	*				**	*		
[1i]	☞ 1i		*			**			*
	11		**			**	*		
	i i	*				**	*		
[ä o] a	☞ ä o a				*	***		*	*
	ä o ä				*	***		*	**
	ä ö ä			*		***	*		

2.5 Predictions about neutral vowels

In disharmonic loanwords, suffixes harmonize with the last harmonic vowel, e.g. *türanni-a* (back harmony) versus *kupüüri-ldä*. As our analysis predicts, this also holds true for disharmonic *e*, e.g. *Novembri-le*, not **Novembri-lõ*.

[NOTE: should this be *kubüüri-ldä*? or *kuppüüri-ldä*?]

3 Derived transparency and opacity

The harmony process described here has certain prima facie exceptions (Iva 2000). In this section we show that nearly all the systematic exceptions result from other constraints that mask the harmony pattern by introducing neutral vowels into the harmonic domain. These local effects conform to the generalization of section 2 that front neutral vowels will be transparent and back neutral vowels will be opaque.

We first show that palatal and palatalized consonants cause a fronting of the following vowel and that the vowels resulting from this fronting process are transparent. We then briefly discuss the special status of clitics with respect to harmony. Most of this section is devoted to a demonstration that onsetless *õ* is regularly fronted to *e* in the weak syllable of a foot, and that this fronted *e* is also transparent. This fronting process is more complex and its explanation requires a detour through foot structure and syllable structure, which however is of some interest in its own right.

3.1 Palatalization and syllable harmony

In Standard Estonian, distinctive palatalization is restricted to /t́ ś Ĺ ń/ (Hint 1997). South Estonian dialects have more extensive palatalization; in Seto it is in principle distinctive in all consonants, although its functional load is low:

[37]	a.	[(ruu:v́)ma]	‘to lath’ (a roof)
	b.	[(nuu:ḿ)ma]	‘to transform’
	c.	[(nuutsḱ)ma]	‘to blubber’
	d.	[(mää:ŕ)mä]	‘to grease’
	e.	[(halṕ:)ma]	‘to play the fool’
	f.	[(põh́a:)]	‘north’ (gen.)

Before /i/ and the corresponding glide /j/, palatalization is automatic (hence noncontrastive).

[38]	a.	*põrśikkas*	‘piglet’	cf. *põrsas* ‘pig’
	b.	*poiźikkõzõ*	‘little boy’ (gen.)	cf. *pois* ‘boy’ (ST 38)

[NOTE: I changed this from *põrśikas, poiźikõzõ*. Correct?]

Contrastive palatalization arises historically (and perhaps in part synchronically) as a result of deletion of the past tense ending /i/ (see [39a]) and of stem-final /i/ ([39b,c]), and of merger of consonants with /j/ ([39d]).

[39]	a.	*and*	'gives'	*and´* (< **anti*)	'gave' (3.Sg.)
	b.	*lask*	'lets go'	*lasḱ* (< **laski*)	'let go' (3.Sg.Past)
	c.	*kost:ma*	'to answer'	*kosť:ma* (< **kostima*)	'to visit'
	d.	*pusk:ma*	'to butt'	*pusḱ:ma* (< **puskima*)	'to prod'

Before a secondary stress, the deletion is optional, e.g. *keŕikkohe* ∼ *keŕkkohe* 'to church' (ST 190), *poiźikkõzõ* ∼ *poiśkõzõ* (ST 38).

With respect to harmony, palatalized consonants are neutral, like /i/: the rest of the word obeys the normal constraints on vowel sequences, cf. [5a] *oŕõhtõllaq*, [5e] *ḱauma*, [5g] *naĺatanuq*.

Contrastive palatality, and the obligatory redundant palatality triggered by /i/ and /j/, should be distinguished from the gradient allophonic effects of a coarticulatory process which spreads palatality between tautosyllabic vowels and consonants. Consonants are palatalized to varying extent next to all front vowels and palatalized consonants, and in the other direction, distinctively palatalized consonants and the glide /j/ tend to cause some degree of fronting in a tautosyllabic vowel (Hagu 1999:6). We mark such half-fronted vowels with a single dot, e.g. *ťśura* [ťśu̇ra] 'boy'.

This fronting effect too is purely local and does not interact with the harmonic pattern of the rest of the word; regular back harmony always resumes in the next syllable. We assume that fronting is due to a coarticulatory, allophonic process, which we take to be governed by constraints of a separate postlexical module which applies to the output of the lexical phonological constraint system.

The fronting of vowels by palatal consonants is normally partial and does not result in complete merger.[14] However, in the case of /õ/ the fronting seems to be fully neutralizing. In the speech of our consultants, fronted /õ/ is indistinguishable from *e* (to the ear, at least) and it is regularly spelled as *e* in published texts, including those recorded by Mägiste, an excellent phonetician.

[40]	a.	*paĺĺe*	[paĺĺe]	'GLOSS???'	
	b.	*aije-mi*	[ajjemi]	'we drove'	(48)
	c.	*sa-i-je*	[sajje]	'got'	(120, 122)
	d.	*tõ-i-je*	[tojje]	'brought'	(140)
	e.	*raśśeeja-st*	[raśśeejast]	'Russia'(Elat.)	(80)
	f.	*naaśe-lõ*	[naaśelõ]	'woman' (Allat.)	(ST 202)

The fronting of *õ* to *e* after palatals is responsible for a large class of apparent exceptions to *e* ∼ *õ* harmony in the texts. As predicted (section 2), the *e* that results from the fronting is consistently transparent; see [40f].

As stated, the mutual influence of *i,j* and palatalized consonants is consistently neutralizing only in the case of *e*. However, its extent is variable and it may have been more extensive in the past. This can be concluded from the fact that it has led to diachronic reanalyses of the lexical representations of some words, in both directions. Sometimes back vowels subject to coarticulatory fronting by adjacent palatal consonants according to the rules just stated have been reanalyzed as actual phonemic front vowels. In the word */kiŕa/ 'letter' (Part.Sg.), the phonetically fronted /a/

[14]For the fronted allophone of /a/, Mägiste writes [ȧ] either as *a* (fronted [a]), e.g. *naĺas:* 'for fun', or as *ä* (retracted [ä]), e.g. *ajäq* 'drive!' (54), *lakḱä*, *majä* 'house' (118), *sajä* 'wedding' (124), *mõrźä* 'bride' but he never writes it as *ä*. Interestingly, the palatalizing *j* is optionally deleted, creating a surface [Vá]:[Va] contrast, as in *puäq* 'boys' (ST 124) vs. *kua* 'who' (ST 68).

has been reanalyzed as phonemic /ä/. The underlying form is now /kiŕä/, pronounced [kiŕä] with full fronting, and taking front suffixes (e.g. *kirässe* V.-K.L. 90). Of course, the active harmony constraint prevented such reanalysis in words such as /kaŕa/ 'cattle' (gen.), /maŕa/ 'berry' (gen.), and /pṍha/ 'north' (gen.), where the first back vowel unambiguously reveals the backness of the second.

A converse renalysis process has resulted in transfer of fronting from vowels to adjacent consonants. In a switch of the site of distinctive palatality, phonemic front vowels are perceived as fronted back vowels, and the allophonic partial palatalization that they formerly triggered in the the neighboring consonant is phonemicized. This has happened in the word */käü-mä/ 'go', corresponding to Võru *käü-mä* (Toomsalu 1995:13) and to Standard Estonian *käi-ma*, which in Seto has become /ḱau-ma/, pronounced [ḱȧuma]. Similarly perhaps /ńaug-ma/ 'meow' (Standard Estonian *näuguma*).

The schema in [41] summarizes the two reanalysis patterns.

[41] a. */kiŕa/ is reanalyzed as /kiŕä/ (phonetic change: *[kiŕȧ] > [kiŕä])
b. */käu/ is reanalyzed as /ḱau/ (phonetic change: *[ḱäu] > [ḱȧu])

3.2 Opaque clitics

Harmony applies to the phonological word. In the case of the *e* ∼ *õ* alternation, the domain of harmony includes the conjunction *et* 'that' when it cliticizes phonologically to the preceding lexical word (which need not be syntactically related to it).[15]

[42] a. *kõnõli*=*õt*… 'said that'
b. *küll*=*et*… 'surely that' (Mägiste 116)

On the other hand, clitics with other vowels do not harmonize. For example, the conjunctions *a* 'but' and *ja* 'and' are never fronted to **ä*, **jä*.

Another clitic which is subject to harmony is the abessive ending *-lta*, e.g. /töö-ltä/ [tüü:ltä] 'without work' (raising due to Q3).[16] It is a "phrasal affix" which attaches to NPs, as in *tüü: ja leivältä* 'without work and bread', *musta leivältä* 'without black bread'.

However, not all clitics are subject to harmony. The comitative suffix /-ka/, a phrasal affix that syntactically behaves like *-ta*, always has an invariant back vowel (e.g. *tüü:ga* 'with work', *püssüga* 'with a gun' (ST 166)). Historically, the reason why *-ta* and *-na* are harmonic and *-ga* is not harmonic is that *-ta* and *-na* are old clitics, whereas *-ga* only became a clitic rather recently; in the 17th century it still appeared as an independent word *kaas* (< **kansak*) that governs a genitive NP. Synchronically, *-ga* seems to be simply an exception and must be lexically specified as exempt from harmony in some way.

[15] Harmony in clitics is not marked in the standard orthography used for literary texts in Seto and Võru.
[16] See Prince 1980:544 on the Q3-triggering properties of the abessive.

3.3 Vowel sequences and /h/

3.3.1 Another fronting process

Immediately following a back vowel within a foot (see [43]), or separated from it only by a single /h/ ([44]), front *e* shows up regularly instead of expected back *õ*.

[43]	a.	*soe*	'wolf' (Gen.)	(ST 68)
	b.	*kae*	'look'	
	c.	*koes*	'where'	(ST 90)
	d.	*jõe-q*	'rivers'	(ST 48)

[44]	a.	*kohe*	'where' (Illat.)	(ST 28, 52, 68…)
	b.	*ei toheq*	'may not'	(ST 34, 48, 82…)
	c.	*kaugõ-he*	'far' (Illat.)	(ST 50)
	d.	*uibo-he*	'apple tree' (Illat.)	(ST 44)
	e.	*kaĺĺe-he*	'expensively'	(134)
	f.	*taĺĺina-he*	'to Tallinn'	(I3)

In [44e] we have two contextually neutral *e*-vowels in a row, the first by palatal fronting, the second by the process we are now looking at.

Importantly, fronting happens only after a single /h/. After geminate /hh/, the distribution of *õ* and *e* follows the normal rules of harmony.

[45]	a.	*halõhhõhe*	'pitifully'	(202)
	b.	*vaihhõlõ*	'between' (Allat.)	(96)
	c.	*hõbõhhõtsõ*	'silver (adj.)' (Gen.)	(72)

This fronting effect is strictly local, in that harmony resumes in the following syllable.

[46]	b.	*soe-lõ*	'wolf' (Allat.)	(ST 68)
	f.	*sõera-ta-ma*	'to winnow'	(T 27)
	f.	*hahe-tta-ma*	'to dawn'	(T 26) [CHECK GEMINATION]
	e.	*vahet-tõ-t*	'exchanged'	(ST 142)

This confirms once again that front neutral vowels are transparent, rather than opaque.

Two explanations of the *õ*-fronting effect in [43]-[44] may be considered: *dissimilation* and *syllable structure*. The dissimilation account would posit a constraint against sequences of a back vowel followed immediately on the melodic tier by *õ*, — that is, when either no consonant intervenes between the vowels, or only the consonant *h*, which has no (oral) feature content. We reject this idea for two reasons. First, it does not explain why the constraint triggers fronting just of *õ*, and not of the three other back vowels, or why the violations are repaired by fronting the *õ*, and not the preceding back vowel. Also, such backness dissimilation of vowels is typologically unusual. We know of no parallels from other languages; on the contrary, adjacency with possibly

intervening /h/ is the most favored context for backness *assimilation* in closely related dialects and languages.[17] For similar effects in Estonian see Wiik 1988:28 ff.).

Instead, we propose an explanation on the basis of a constraint on well-formed syllables. It depends on an analysis of Seto stress and syllabification, which are close to those of standard Estonian, but show a few telling differences which are relevant to the process we are concerned with. We must therefore look into the metrical structure of the Estonian word. Unavoidably, our path is somewhat circuitous, but the reader may rest assured of a return to vowel harmony.

3.3.2 Feet, syllables, and moras

The core prosodic constraint in Seto, as in Estonian generally, is that words are parsed into disyllabic left-headed feet.

The primary stress of a word usually falls on the initial syllable. The foot that contains that syllable undergoes FOOT-FINAL LENGTHENING.[18] Foot-final lengthening maximizes the duration of the weak branch of a foot, in satisfaction of PEAK-TO-WEIGHT, a constraint of the general STRESS-TO-WEIGHT family (Kager 1999). In disyllabic feet this process lengthens the second, unstressed syllable. In monosyllabic feet, it yields the famous overlong ("Q3") syllables of Estonian. The fundamental insight that monosyllabic feet always have Q3 quantity is due to Prince 1980, and the parallelism between Q3 lengthening in monosyllables and lengthening of the second syllable of disyllabic feet was pointed out by Carlson 1978 for the structurally analogous process of expressive lengthening in Finnish, and for Estonian independently by Wiik 1985. The examples in [47] show simple cases of footing and foot-final lengthening under primary stress. (Here and below, feet are shown by parentheses and foot-final length is marked by a colon.)

[47]	a.	/vana/	[(va.na:)]	'old'
	b.	/kae/	[(ka.e:)]	'look'
	c.	/või/	[(või:)]	'can'
	d.	/maa/	[(maa:)]	'land'
	e.	/tamm/	[(tam:)]	'oak'
	f.	/jumala-ka/	[(júma:)(làka)]	'with God' (ST 34)
	g.	/sulasõ-lõ/	[(súla:)(sõ̀lõ)]	'to the groom' (ST 40)
	h.	/kɨ́nõlõ-sõ/	[(kɨ́nõ:)(lõ̀sõ)]	'they say'

Subject to *CLASH, heavy syllables become feet of their own when there is no next syllable to group them with, as at the end of the word. Since a monosyllabic word constitutes a foot, it necessarily undergoes foot-final lengthening to Q3 (e.g. [47d]).

[48]	a.	/pakohõss/	[(pákoh)(hõ̀ss)]	'escapes'
	b.	/poĺikarp/	[(póĺi:)(kàrp)]	'Polycarp' (personal name)
	c.	/nätäli-t/	[(nätä:)(lìt)]	'week' (part.)
	d.	/maa/	[(máa:)]	'land'

[17] It would be a different matter if the restriction involved just adjacent vowels, but the VhV case cannot be assimilated to any restriction on diphthongs. Wiik 1989:37 points out that some dialects of Vepsian preserve *iCa* sequences (such as *siga* 'pig') except when the intervening consonant is *h*, e.g. *lihä* 'meat'.

[18] Sometimes primary or secondary stress falls on a lexically marked internal syllable. Such syllables are also subject to foot-final lenthening.

Feet which do not bear primary or lexical stress do not lengthen (see the weak feet in [47], and [49a] for an example of a pre-main stress weak foot.[19] Also, feet which are already long do not lengthen further (see [49b,c]).

[49]	a.	/biolóogia	[(bì.o.)(lóo.gi)a]	‘biology’
	b.	/kiŕottettu/	[(kí.ŕot)(tèt.tu)]	‘written’
	c.	/vaparna/	[(vá.par.)na]	‘Vabarna’ (personal name)

A handy diagnostic for the distinction between monosyllabic and disyllabic feet is a process (which Seto shares with other South Estonian dialects) that raises mid vowels in superheavy syllables. In Seto, this raising process also applies to /õõ/, as in [50d,e].

[50]	a.	[(süü:)mä] (cf. Pp. [söönüq)]	‘to eat’	(T 86)
	b.	[(vii:)mä] (cf. Pp. *veenüq*)	‘to bring’	(T 97)
	c.	[(luu)] (cf. Pp. [loonuq])	‘to create’	
	d.	[(m1̈1̈t)ma] (cf. *mõõda*)	‘to measure’	(T 35)
	e.	[(v1̈1̈)ra] (cf. *võõras*)	‘strange’	

There is some question whether this raising process is neutralizing or not. According to Teras 2000, none of the four raised vowels are reliably distinguishable from the underlying high vowels by ear alone, but acoustically they are slightly lower; the distinction between /ii:/ and /ii:/ is particularly clear in his data.[20] The raising is probably a pseudo-neutralization process, like German final devoicing (Port 19XX), or the near-mergers reported by Labov (1994, Ch. 12) for several English dialects).

The negative ending *-i* causes the word stress to shift, but without bleeding foot-final lengthening. For example, in [70b] the first foot retains its final lengthening in spite of ceding the primary word stress to the following *-i*.

[51]	a.	/paratiis/	[(pá.ra:.)(tìis)]	‘paradise’
	b.	/paratiis-ka-i/	[(pà.ra:.)(tìis)(ká.i:)]	‘not even paradise’

We assume that one-mora feet and three-syllable feet are excluded by undominated constraints. Syllables which cannot be accommodated into well-formed feet are stray adjoined at a higher level of structure rather than integrated to form non-canonical (right-headed or ternary) feet. [52a,b] illustrate stray adjunction in word-final and word-initial position.

[52]	a.	*jumala*	[(júma:)la]	‘God’
	b.	*mehe-le*	[(méhe:)le]	‘to the man’ (ST 42)
	c.	*botaanika*	[bot(táani)ka]	‘botany’

That the two-mora lower bound is inviolable is shown by the complete absence of words consisting of just a light syllable (except for function words such as *mi* ‘we’, *a* ‘but’, *no* ‘now, nu!’), and by the obligatory destressing of monomoraic feet, as when the stress-attracting negative *-i* is added to a disyllable.

[19] In metalinguistic discourse, of course, any syllable can be emphasized, and is then subject to lengthening. In commenting on the pronunciation of the word *vaihhõlõ*, one of our consultants twice pronounced it emphatically as [(váih)(hõ̀lõ:)], as if it were a compound.

[20] On the other hand, Toomsalu 1995:35 states that raised 1̈1̈ is identical to basic 11, whereas the other raised Q3 vowels are distinct from the corresponding underlying Q3 high vowels.

[53] a. *ei tohi* [(õi tóhi:)] ‘dare not’ (preposed negation)
b. *tohi-i* [to(híi:)] ‘dare not’ (cliticized negation)

Evidence for the disyllabic upper bound is the fact that foot-final lengthening invariably applies just to the syllable that directly follows the stress. For example, *jumala* ‘God’ (gen.) is pronounced [(júma:)la], not *[(júmala:)], or *[(júmala)], and in *kɨ̀nõ-lõ-misõ* ‘of the speaking’, the second syllable is lengthened even if the secondary stress falls on the fourth syllable, e.g. [(kɨ̀nõ:)-lõ.(mì.sõ)].

Even though three-syllable feet are excluded in Seto, disyllabic intervals between stresses are not infrequent. We think that they are always due to special phonological or morphological factors. For long words, the generalization is that disyllabic endings tend to form feet of their own, while odd-numbered sequences of monosyllabic endings can be grouped in different ways, with preferences governed by morphology. The following data are reported for standard Estonian (Hint 1973:163).

[54] a. *ilu-sa-ma-le* [(ílu:)(sàma)le] ∼ [(í.lu.:)sa.(mà.le)] ‘to the more beautiful’
b. *ilu-duse-le* [(í.lu.:)(tùse.)le] (not *[(í.lu.:)tu.(sè.le)]) ‘to the beautiful person’

Even-numbered sequences of syllables seem to admit variation only by transfer of the prosodic structure of simpler words into more complex words (Hint 1973:165). For example, the pattern in [54] is replicated with addition of the clitic *-ka* in [55].

[55] a. *ilu-sa-ma-le-gi* [(í.lu.:)(sà.ma.)(lè.ki.)] ∼ [(í.lu:).sa.(mà.le).ki] ‘even to the more beautiful’
b. *ilu-duse-le-gi* [(í.lu:.)(tùse.)(le.ki)] (not *[(í.lu:.)tu.(sè.le).ki]) ‘even to the beautiful person’

Alignment constraints, O/O constraints, and cyclic constraint evaluation are the principal alternative approaches to modeling such morphological transfer effects.[21]

The preference for disyllabic endings to coincide with feet can even result in stress clash, causing a compound-like lengthening of monosyllabic stems to Q3:

[56] a. *maalikule* /maa-lìkku-le/ [(máa:)(lìk.ku.le)] ∼ [(máa.lik)(kù.le)] ‘rustic’ (allative)

Perhaps disyllabic suffixes should be regarded as having optional inherent stress. Interestingly, in Seto poetry disyllabic suffixes pattern with second members of compounds in that they can be split off from the rest of the word. Here are examples from the Seto epic.

[57] a. Vaiva- oĺĺ tuu -linõ vaesõ elo
trouble- was that -some orphan’s life
‘that orphan’s life was troublesome’ (l. 6923)

b. ime- õks sa -kene, helläkene
mother ever you -dim., tender-dim.
‘you dear little mother, tender one’ (l. 347)

c. Nägü- õks no -nesse, kuulunõssõ
appear- even now -pot.pres. be heard-pot.pres.
‘it is seen, it is heard’ (l. 4957-8)

[21] See Kiparsky 2000 for arguments in favor of the latter.

The secondary stress of disyllabic endings sometimes leads to them having own front or back harmonic domain.

[58]	a.	*lául-mìne*, gen. *lául-mìse*	'singing'	
	b.	*pűmek-kùlõ*	'till nightfall'	(ST 188)
	c.	*mídä:-gìna*	'anything'	
	d.	*kőllat-sìde*	'yellow' (pl.gen.)	(V-K.L. 9)
	e.	*mät-lìkkanõ*	'turfy'	(V-K.L. 9)

Each member of a compound forms a separate prosodic word. Therefore foot-final lengthening, which applies to the most prominent foot of a word, applies to all members of compounds, not just to the one that bears primary stress. For the same reason, there is no harmony across compound boundaries.

[59]	a.	[vána:-èsä:]	'grandfather'	(ST 54)
	b.	[sä́itse:-sàta:]	'seven hundred'	(ST 50)

Foot structure interacts crucially with syllable weight, of which Estonian distinguishes three degrees: LIGHT, HEAVY, and SUPERHEAVY:

[60] a. A syllable that ends in a short vowel (-V) is light.

b. A syllable that ends in -VC or -VV is heavy.

c. A syllable that ends in -VCC(C) or -VVC(C) is superheavy.

Foot structure and syllable weight influence each other in both directions: footing determines the weight of syllables in the output, but is itself determined by inherent lexical weight.[22]

A light syllable can neither form a foot by itself (by FTMIN), nor be lengthened, so it must be grouped with the next syllable into a foot, or, as a last resort, stray adjoined. If neither is possible, the word is phonologically deviant.

The treatment of heavy and superheavy syllables is in part morphologically determined by the syllable that follows. There are basically three types of endings. Endings of the first type remain stray after a superheavy syllable (such as *laul-*), but are joined with a preceding regular heavy syllable (such as *ḱau-*) into a binary foot. (Note the raising in the superheavy syllable *rüük*).

[61]	a.	*laul-nuq*	[(laul)nuq]	'sung'	*ḱau-nuq*	[(ḱaunuq)]	'gone'
	b.	*röök-väq*	[(rüük)-väq]	'they squall'	*too-vaq*	[(toovaq)]	'they bring'

[22] Wiik 1985 proposes a different analysis which builds foot-final lengthening into the template itself by positing a basic three-mora foot. (More precisely, Wiik posits a "$3\frac{1}{2}$" mora template, in order to approximate the phonetic lengthening data more closely. We should add that Wiik's underlying forms are much more abstract than ours. This is because he was aiming for a practical set of rules for deriving Estonian words from Finnish words.) Although Wiik's analysis is ingenious we prefer the trochaic analysis for several reasons. First, the lengthening can be motivated by other, dominant constraints, as indicated, and bimoraic feet do surface wherever the dominant constraints allow it. For example, feet which do not contain the principal stress do not lengthen. Secondly, the trochaic analysis has the theoretical advantage of using only independently motivated templates/constraints, whereas ternary templates are rarely if at all basic.

We take this to be the optimal metrical parsing, imposed by the phonological constraints if no morphological factors intervene.

The other two types of endings each impose their prosodic selectional requirements on the word. One type, exemplified in [62] by the infinitive *-ma* and by the zero ending of the partitive, must always be directly preceded by a foot. Any preceding heavy syllable becomes superheavy so that it can fulfil that requirement.[23]

[62]	a.	*laul-ma*	[(laul)ma]	'to sing'	*ḱau-ma*	[(ḱau:)-ma]	'to go'
	b.	*Pihkva*	[(pih:k.)va]	'Pskov' (part.)	*kolmõ*	[(kol:)mõ]	'three' (part.)

Estonian (including Seto) has a third type of ending, illustrated in [63] by the genitive. This type can on the contrary never be directly preceded by a foot, but must itself be the weak member of a binary foot. Such endings are the source of the somewhat unusual type of superheavy syllable with Q2.

[63]	a.	*kriipsu*	[(kriipsu)]	'line' (gen.)	*kolmõ*	[(kolmõ)]	'three' (gen.)
	b.	*keel-tte*	[(keeltte)]	'language' (gen.pl.)	*soi-jõ*	[(soijõ)]	'bog' (gen.pl.)

The generalizations stated so far operate as if word-final consonants were not there. In particular, although closed syllables do not undergo final lengthening word-internally, they do undergo final lengthening at the end of a word; contrast [49f,g] with [64].

[64]	a.	/vana-q/	[(va.na:q)]	'old' (Nom.Pl.)
	b.	/tüttär/	[(tüt.tä:r)]	'daughter'
	b.	/kajõ-t/	[(kae:t)]	'I look'
	c.	/või-t/	[(või:t)]	'I can'
	d.	/maa-q/	[(maa:q)]	'lands'
	d.	/külm/	[(kül:m)]	'cold'

Word-final consonants are apparently not weight-bearing; they are *extrametrical* and excluded from the calculus of syllable quantity (Prince 1980:531). We do not discuss here the details of lengthening in syllables that end in two or more consonants, which are quite complex. In general, there is a preference for lengthening voiceless consonants.

We have argued that the constraint that drives lengthening is that feet which constitute prosodic peaks are lengthened to conform to PEAK-TO-WEIGHT. This implies that the lengthening is phonological (rather than simply a matter of phonetic implementation, Prince 1980:514). Therefore, we might expect to find a phonological rationale also for the way the lengthening is realized. For example, why is the *second* syllable of disyllabic feet lengthened, rather than the first, viz. why does (CV.CV) become (CV́.CVV), rather than *(CV́V.CV) or *(CV́C.CV). Why is the lengthening of the second syllable implemented on the vowel, rather than by consonant lengthening (gemination), viz. (CV.CV)CV → (CV́.CV:)CV rather than *(CV́.CVC)CV? And why is lengthening in monosyllabic feet realized on the coda consonant whenever possible, viz. CVC<C> → (CVCC<C>) and CVV<C> → (CVVC<C>)?[24]

[23] If two such endings come together, they must form a foot, e.g. *(vaih:)(hõ-lõ)*.

[24] Remember that final consonants, being extrametrical, are not weight-bearing.

Writing on the similar Finnish expressive lengthening, Carlson 1978 (see Prince 1980:555), proposes that lengthening works so as to minimize loss of distinctive length. We adopt Carlson's functional explanation and model it formally by the constraint PRESERVECONTRAST.[25]

[65] PRESERVECONTRAST: Lexical quantity contrasts must be retained.

From this point of view, the reason why the vowel of the second syllable is lengthened is that vowel length is distinctive in the first syllable, and consonant gemination is distinctive in any syllable. And the reason monosyllables do realize Q3 by consonant gemination is that in precisely that position gemination loses no contrasts.

The functional explanation is supported by an exception to the lengthening pattern which is unique to the Seto dialect: foot-final lengthening can be realized by gemination of /h/ but not by gemination of other consonants. In foot-final position, only geminate /hh/ occurs, in which case the vowel before it remains short:

[66]	a.	/soo-hõ/	[(suuh.)hõ]	'bog' (ill.)
	b.	/laiha/	[(laih)ha]	'lean, emaciated' (Part.)
	c.	/hõpõ-hõtsõ/	[(hõ.põh.)(hõ.tsõ)]	
	d.	/kupõhi-tõ/	[(kúpõh.)(hì.tõ)]	'of the sides' (ST 54)

Interestingly, for some Võru speakers geminated /hh/ triggers consonant gradation in the preceding syllable (Keem 1997:54).

[67]	a.	*magahasõq*	[(má.kah.)(hàs.sõ)]	cf. *(timä) maka*	[(mák.ka)]
	b.	*pagohõss*	[(pá.koh.)(hõ̀ss)]	cf. *pakosõ*	[(pák.ko.)sõ]

This is a telling fact because a closed syllable is the core phonological environment for consonant gradation (even though the process has now become largely morphologized). It shows again that foot-final lengthening is mora addition at the phonological level, rather than simply a matter of phonetic implementation.

The formal constraints that govern Seto foot structure and quantity should capture these basic generalizations: lengthening serves to maximize the weight of peak feet, it adds a mora, and it preserves lexical contrasts. If lengthening is driven by the PEAK-TO-WEIGHT constraint, it must dominate the faithfulness constraints which mandate preservation of contrastive quantity. Moreover, since gemination prevails over vowel lengthening when both are contrast-preserving, the DEP constraint that forbids vowel lengthening must also outranks the DEP constraint that forbids the gemination of consonants. All these constraints are dominated by the constraints requiring that feet contain at least two moras, and at most two syllables.

[68] a. PEAK-TO-WEIGHT
b. PRESERVECONTRAST
c. DEP-μ_V
d. DEP-μ_C

[25] See Flemming 1997 for arguments that preservation of contrast governs in phonological processes via constraints that can be ranked among other constraints.

[69]

Seto	PK-TO-WT	PRESCONTR	DEP-μ_V	DEP-μ_C	...
Input: /jumala-ka/ 'with God'					
1a. ☞ (júma:)(làka)			*		
1b. (júma)(làka)	*				
1c. (júma:)(làka:)			**		
1d. (jú:ma)(làka)		*	*		
1e. (júmma)(làka)		*		*	
1f. (júmal)(làka)		*		*	
1h. (jú:mal)(làka)		**	*	*	
Input: /hõpõhõt/					
2a. (hṍpõ:)(hõ̀t)			*		
2b. (hṍ:põ)(hõ̀t)		*	*		
2c. (hṍppõ)(hõ̀t)		*		*	
2d. ☞ (hṍpõh)(hõ̀t)				*	

3.3.3 The status of quasi-diphthongs

In addition to indubitable diphthongs such as *ai, au,* Estonian has a series of vowel sequences, such as *ae, oa,* which are usually also considered as diphthongs. We think that they are actually phonologically disyllabic sequences. For purposes of this discussion, let us refer to them as quasi-diphthongs, without any intent to prejudge the issue. Historically, and in part synchronically too, quasi-diphthongs arise from the loss of intervening consonants by consonant gradation and by other weakening processes. Hint 1973:189-191 reports that they are normally pronounced as monosyllabic but can count as disyllabic in poetry and then be pronounced accordingly. This is not enough to determine their phonological status, but there are other things to look at.

Evidence for the disyllabic status of quasi-diphthongs comes from morphophonemic patterning. Consider the following verb paradigms, paying particular attention to the distribution of Q3, again marked by the colon.

[70]

		Infinitive	Past Participle	Imperative	
a.	/saa/	*saa:ma*	*saanuq*	*saa:*	'get'
	/jää/	*jää:mä*	*jäänüq*	*jää:*	'stay'
	/võ/	*võ:ma*	*võinuq*	*võ:*	'be able'
	/ḱau/	*ḱau:ma*	*ḱaunuq*	*ḱau:*	'go'
	/müü/	*mü̈ü̈:mä*	*möönüq*	*mü̈ü̈:*	'sell'
b.	/joo/	*juu:ma*	*joonuq*	*juu:*	'drink'
	/löö/	*lü̈ü̈:mä*	*löönüq*	*lü̈ü̈:*	'hit'
	/vee/	*vii:mä*	*veenüq*	*vii:*	'take away'
c.	/vala/	*vala:ma*	*vala:nuq*	*vala:*	'pour'
	/jürä/	*jürä:mä*	*jürä:nüq*	*jürä:*	'gnash'
	/kosi/	*kosi:ma*	*kosi:nuq*	*kosi:*	'propose (marriage)'
d.	/vao/	*vao:ma*	*vao:nuq*	*vao:*	'sink'
	/kae/	*kae:ma*	*kae:nuq*	*kae:*	'look'
	/häö/	*häö:mä*	*häö:nüq*	*häö:*	'perish'

In [70a,b] we see that monosyllabic verb stems (which are always heavy) become overlong before the infinitive *-ma* but retains regular (Q2) length before *-(d)aq*. As /joo/ 'drink' in [70b] shows, mid

vowels are regularly raised in Q3 in accord with the process described in [50]. CVCV stems like [70c], on the other hand, lengthen the vowel of their second syllable before both types of syllabic endings. The reason is that (as noted above) ternary feet are not allowed in Estonian, so that the second syllable must terminate the foot, and hence undergoes foot-final lengthening regardless of the morphological type of the ending.

Now let us use the contrast between [70a,b] and [70c] as a test for the syllable structure of quasi-diphthongal stems. We find that they also undergo foot-final lengthening before both types of syllabic endings (see [70d]), thus patterning with the disyllabic stems. For example, the quasi-diphthong in [71c] patterns with the disyllabic [71b].

[71] a. /saa-nuq/ [(saa.nuq)]
b. /vala-nuq/ [(va.la:)nuq]
c. /va.o-nuq/ [(va.o:)nuq]

Another class of arguments for the disyllabic status of "contracted diphthongs" comes from stress. For standard Estonian, Hint (1973) shows that quasi-diphthongs ("late diphthongs") are associated with a different secondary stress than long vowels and diphthongs. He documents an intricate pattern of variation and preferences which do not easily yield to any simple formula.[26] However, a first-order generalization which covers much of his stress data is that feet with "contracted diphthongs" normally behave like disyllabic feet, and only optionally and in limited circumstances like monosyllabic feet.

Consider words of the form F$\sigma\sigma$, where F is a monosyllabic or disyllabic foot. If the final $\sigma\sigma$ sequence consists of two light syllables, it may form the second foot:

[72] a. Monosyllabic: [(vánk.)(krì.le)]
b. Disyllabic: [(nóo.rik.)(kù.le)]
c. Quasi-dipthong: [(vé.ok.)(kì.le)]

But when the word ends in a light-heavy sequence, the place of secondary stress does depend on the shape of F (Hint 1973:158-9). If F is monosyllabic, the footing is either (F)(LH) or (FL)(H). If F is disyllabic, or has a contracted diphthong, the penult is normally stressed:[27]

[73] a. Monosyllabic: [(káu:.)(kù.ses)] $\sim$ [(káu.ku).(sès)]
b. Disyllabic: [(í.lu:.)(tù.sest)]
c. Quasi-diphthong: [(té.os.)(tù.sel)]

Again, we see that quasi-diphthongs pattern with disyllables, not with monosyllables. Presumably the option in [73a] reflects the effect of constraint *CLASH, which prohibits stress on adjacent syllables. But in order to explain why high-ranking *CLASH does not similarly push the stress to the last syllable in [73c], we must assume that *té.os-* counts as two syllables.

[REPLACE THESE STANDARD ESTONIAN EXAMPLES WITH SETO EXAMPLES.]

[26] See Kager 199X...

[27] Final stress is possible in poetry, however.

Similar constraint competition occurs in longer words, but with more variability. Consider now cases where F is followed by *three* syllables (Hint 1973:162-3). If F is monosyllabic, CLASH normally drives the secondary stress to the third syllable, as in [74a]. If F is disyllabic, as in [74b], there is no question of violating CLASH and the alternating secondary stress pattern is obligatory. Again quasi-diphthongs preferentially behave like disyllabic sequences, see [74c].

[74] a. Monosyllabic: (rarely [(áu.)(sàt.te.)le], usually [(áu.sat.)(tè.le)]
b. Disyllabic: [(válu.)(sàt.te.)le]) (not *[(válu.sat.)(tè.le)])
c. Quasi-dipthong: [(vé.ok.)(kìt.te.)(lè.ki)], or marginally [(vé.ok.)kit.(tè.le.)ki)]

The same pattern is repeated in longer words:

[75] a. Monosyllabic: rarely [(kínt.)(lùs.te.)(lè.ki)], usually [(kínt.)lus.(tè.le.)ki]
b. Disyllabic: [(ők.pet.)(tùs.te.)(lè.ki)] (not *[(ők.pet.)tus.(tè.le.)ki)]
c. Quasi-dipthong: [(vé.ok.)(kìt.te.)(lè.ki)], or marginally [(vé.ok.)kit.(tè.le.)ki)])

Quasi-diphthongs usually pattern with function as disyllables, but in longer words there is a less frequent option which seems to reflect an alternative monosyllabic syllabification. It is possible that it is a matter of a disyllabic lexical syllabification and a monosyllabic postlexical syllabification.

[GET CORRESPONDING STRESS DATA FOR THE SETO DIALECTS.]

3.3.4 The analysis of *õ*-fronting

We are finally ready to formulate the constraint that drives the *õ*-fronting process discussed here. Final lengthening and *h*-gemination (section 3.3.2) tells us that the *e* is always unstressed in [V.he] sequences, and the analysis of quasi-diphthongs (section 3.3.3) tells us that adjacent [Ve] sequences such as that in [ka.e] are disyllabic. Therefore, the *õ*-vowels subject to fronting are *unstressed nuclei*.

That leads to the the generalization that *õ*-fronting applies just to unstressed onsetless *-õ* and to *-hõ*. Stated this way, the process acquires a rationale. As we stressed above, unstressed *õ* is phonetically a reduced vowel similar to @ and cross-linguistically, such reduced vowels on their own make poor syllables. Specifically, the typological observation is that onsetless syllables with a reduced nucleus are excluded in some languages. For example, word-initial @ is not possible in French or German. Moreover, the onset requirement cannot be satisfied by a placeless consonant such as *h* or *ʔ*. Let us refer to this constraint as σ-WF.

This interpretation, then, posits the motivation of the fronting process seen in [43] and [44] as that of avoiding syllables with reduced nuclei and no onset, or an onset with no oral articulation. Given the prosodic structure we have assumed, σ-WF explains everything about the fronting. First, it explains why the fronting only applies to *õ*, not to any other back vowel, and then only if it immediately follows a vowel or is separated from it by a single *h*. For it is only then that the prohibited type of weak syllable arises. The otherwise puzzling fact that there is no fronting after geminate /hh/ is also explained, on the basis of the foot structure that we motivated.

By tying the fronting to the reduced character of the back unrounded vowel in non-initial syllables, we predict that a dialect that has a full back vowel *õ* in this position. We know of no such Seto

dialects, but Votic, which otherwise has a very similar harmony system, including *õ* ∼ *e* harmony, seems to be a case in point. Its *õ* seems to be a full back vowel in all positions, transcribed as *e* (=IPA [¨]), and this vowel is indeed not subject to postvocalic fronting.[28]

4 Constraint interaction

4.1 Sympathy

The local effects discussed in the preceding section mask the effects of vowel harmony in two ways: by creating islands of frontness in back harmonic domains (transparent vowels), and by introducing new back domains (opaque vowels). The theoretical interest of this interaction between harmony and local fronting is that it shows the need for a theory of constraint masking ("opaque constraint interaction"), and eliminates some candidates for such theories from contention, including in particular Sympathy.

A Sympathy solution of the type advocated by McCarthy posits that harmony is outranked by a constraint which requires a vowel to have the same backness as a Sympathy candidate that does not undergo umlaut. The Sympathy candidate (the "☸-candidate") must be the optimal candidate that satisfies some Faithfulness constraint (with the understanding that all sympathy constraints are excluded from the selection process). In the derivation of a case such as *vahettõt*, the back vowel of the final syllable must harmonize with the preceding back vowel in **vahõttõt*. This is the Sympathy candidate. The Faithfulness constraint that selects it must then be IDENT-I/O(BACK).

McCarthy's most recent formulation of Sympathy theory (McCarthy 2000) posits two constraints, ☸CUMUL and ☸DIFF, universally ranked in that order. ☸CUMUL winnows out all candidates which are not CUMULATIVE, meaning that they do not have a superset of the ☸-Candidate's faithfulness violations. Such "incommensurable" candidates can never be optimal. The sympathetic candidate itself, therefore, does not violate ☸CUMUL, but, in the cases where sympathy does any work, it is rejected by some higher-ranking constraint. The function of ☸DIFF is to choose between remaining candidates, possibly in conjunction with other constraints of the system. ☸DIFF assigns one violation mark to every candidate for each unfaithful mapping that it does not share with the ☸-Candidate. Thus, it chooses the candidate that is most similar to the Sympathy candidate.

McCarthy's formulation of the constraints ☸CUMUL and ☸DIFF is reproduced in [76].

[76] Given a sympathetic candidate ☸-Cand, to evaluate a candidate E-Cand:

a. ☸CUMUL: E-Cand is cumulative with respect to ☸-Cand. That is, $U_{☸\text{-Cand}} \subseteq U_{\text{E-Cand}}$ (where U is the set of a candidate's faithfulness violations).

b. ☸DIFF: Every unfaithful mapping incurred by E-Cand is also incurred by ☸-Cand. That is, assign one violation mark for every member of the set $U_{\text{E-Cand}}$ which is not in $U_{☸\text{-Cand}}$.

c. ☸CUMUL ≫ ☸DIFF (universally).

[28] See however Lauerma 1993:258.

To make it clear how this idea works, we show the derivation in two stages. The first stage is represented in [77] and shows how ✯IDENT(Back) selects the sympathy candidate. For clarity, I omit ❁CUMUL and ❁DIFF from this tableau because the theory stipulates that they must be disregarded for this purpose. Assume first that the underlying form is /vahõt-tõt/.

[77]

Seto	…	…	…	✯IDENT(Back)	…	…
Input: /vahõt-tõt/ ‘exchanged’						
a. ❁ vahõt-tõt				✓		
b. vahet-tõt				*		
c. vahet-tet				**		
d. vahõt-tet				*		

The most harmonic candidate that conforms to the selector constraint ✯IDENT(Back) is ❁*vahõt-tõt*. The next tableau [78] shows how the actual output candidate is chosen by sympathy to ❁*vahõt-tõt*, by σ-WF and ❁DIFF. Here we let AGR(Back) stand for whatever constraint or constraints drive vowel harmony.

[78]

Seto	σ-WF	❁CUMUL	❁DIFF	AGR(Back)	✯IDENT(Back)	…
Input: /vahõt-tõt/ ‘exchanged’						
a. ❁ vahõt-tõt	*					
b. ☞ vahet-tõt			*	**	*	
c. vahet-tet			**	*	**	
d. vahõt-tet	*		*	*	*	

Since the Sympathy candidate (a) ❁*vahõt-tõt* has no faithfulness violations relative to underlying /vahõt-tõt/, all candidates have a superset of its faithfulness violations. The Sympathy candidate (a) *vahõt-tõt* and candidate (d) are thrown out because they violate σ-WF (which has to dominate the Sympathy constraints ❁CUMUL and ❁DIFF if these are to have any effect). Of the remaining two candidates, (b) *vahet-tõt*, being closer to ❁*vahõt-tõt*, better satisfies ❁DIFF. In this way Sympathy defeats AGR(Back), as desired.

Let us record that this is in effect a Duke of York derivation. Although sympathy theory is designed to exclude Duke of York derivations, certain subtypes of them including the one seen above are readily tractable within sympathy theory.

The problem for the sympathy account is that, by Richness of the Base and Freedom of Analysis, we must allow any combination of /e/ and /õ/ in inputs, and, moreover, since frontness beyond the initial syllable is nondistinctive, the choice of /e/ or /õ/ in those positions must converge on the same output. Suppose, then, we choose the input /vahet-tet/. ✯IDENT(Back) will now choose this input as the Sympathy candidate.

[79]

Seto	…	…	…	✯IDENT(Back)	…	…
Input: /vahet-tet/ ‘exchanged’						
a. vahõt-tõt				**		
b. vahet-tõt				*		
c. ❁ vahet-tet				✓		
d. vahõt-tet				*		

Again all the candidates are commensurable with the Sympathy candidate (c) ❁*vahet-tet*, because each has a superset of the latter's faithfulness violation relative to underlying /vahet-tet/. Of the two candidates that survive σ-WF, it is the Sympathy candidate itself, identical to the underlying form, that best satisfies ❁DIFF.

[80]

Seto	σ-WF	❁CUMUL	❁DIFF	AGR(Back)	✯IDENT(Back)	...
Input: /vahet-tet/ 'exchanged'						
a. ☞ vahõt-tõt	*		**			
b. vahet-tõt			*	**	*	
c. ☞❁ vahet-tet				*	*	
d. vahõt-tet	*		*	*	*	

Therefore, under this choice of input form, Sympathy again fails to select the desired output.

4.2 Extended Sympathy

The argument so far has respected McCarthy's stricture that sympathy candidates must be selected by Faithfulness constraints. It should not be given up in a casual way, because it is conceptually an essential part of the theory and has important empirical consequences. But problems like the one we have sketched out have nevertheless led several authors to propose that markedness constraints can also function as selector constraints (Itô and Mester 1997, Merchant 1997, De Lacy 1998, Walker 1999). The version of Sympathy Theory in which this is allowed is called EXTENDED SYMPATHY. Walker specifically argues that harmony is transmitted across intervening neutral vowels in local fashion via a Sympathy candidate in which neutral vowels participate in the harmonic process.

But Extended Sympathy fares no better than original Sympathy in this case. True, we can now force the Sympathy candidate *vahõt-tõt* by using harmony as the selector. But using harmony as the selector has the unfortunate effect of making opaque vowels transparent. In Seto, for example, we would get **lähko-le* instead of *lähko-lõ*, on the basis of sympathy to the fully harmonic Sympathy candidate **lähkö-le*. [81] shows the selection of the ❁-candidate under Extended Sympathy.

[81]

Seto	...	...	...	✯AGR(Back)	...	...
Input: /lähko-le/ (or /lähkö-le/, /lähko-lõ/, etc.)						
a. ❁ lähkö-le				✓		
b. lähko-lõ				*		
c. lähko-le				**		
d. lähkö-lõ				*		

The most harmonic candidate that conforms to the selector constraint is ❁*lähkö-le*. [82] shows how the incorrect output candidate **lähko-le* is chosen by sympathy to ❁*lähkö-le* on the assumption that the underlying form is /lähkö-le/.

[82]

Seto	*ö	❁CUMUL	❁DIFF	AGR(Back)	★IDENT(Back)	...
Input: /lähkö-le/						
a. ❁ lähkö-le	*					
b. lähko-lõ			**	*	**	
c. ☞ lähko-le			*	**	*	
d. lähkö-lõ	*		*	*	*	

Candidates (a) and (d) are thrown out because they violate **ö* (which, as before, has to dominate the Sympathy constraints in order for the whole machinery to have any effect at all). ❁DIFF then decides against the desired (b) *lähko-lõ* in favor of the unwanted (c) **lähko-le*. We conclude that even the Extended Sympathy approach to opacity is inconsistent with OT's fundamental principles of Richness of the Base and Freedom of Analysis.

4.3 Turbidity

Goldrick (2000) attacks the problem of non-patent constraint interaction by introducing two types of input/output relations, an abstract, structural relation of PROJECTION, and an audible, surface relation of PRONUNCIATION. Normally the two relations coincide — what is projected is pronounced and vice versa. But because the two relations are subject to separate MAX and DEP constraints they can diverge under the pressure of structural markedness constraints.

Turbidity theory offers another way to achieve partial output visibility of neutralized underlying information. Any such solution runs into the problem discussed in connection with sympathy in the preceding section, namely that the required underlying representations cannot be guaranteed were they are noncontrastive, as in the case at hand.

4.4 Targeted constraints

Bakovic (2000) develops yet another approach to neutral segments based on the notion of TARGETED CONSTRAINTS, which he credits to Colin Wilson. As Bakovic explains, the appealing intuition behind it is that "transparent-vowel candidates have more in common with the ideal, fully-harmonic candidate than opaque-vowel candidates do" (p. 272). Let us agree that *kopima* sounds more like **kop1ma* than *kopimä* does.

In our analysis of neutral vowels this could be understood as a consequence of the fact that transparency leads to maximization of unmarked vowels (in this case *i*), and that unmarked vowels such as *i* are by their very nature less salient than the marked vowels such as *ä* which would result from opacity.

Now let us see how targeted constraints cash in this intuition. They do so by carrying out *pairwise* (rather than global) constraint evaluations of candidates. Constraint evaluation proceeds by a series of pairwise comparisons between candidates, and the outcomes are accumulated until the optimal candidate is found.

The targeted version of the constraint that rules out **1* in Seto (a direct translation of a similar constraint of Bakovic's) would be:

[83] $\odot$[–Back,–Round,+High]

Let *x* be any candidate and ζ be any [–Back,–Round,+High] vowel in *x*. If candidate *y* is exactly like *x* except that ζ is not [–Back,–Round,+High], then *y* is better than *x*.

Much depends on the right sequence of pairwise comparisons, for which Bakovic adopts the following principles formulated by Wilson:

[84]
a. *Ordering.* Starting with the highest-ranked constraint in the hierarchy, if the current constraint asserts the ordering $x \succ y$, then add $x \succ y$ to the cumulative ordering *O*, except when the opposite ordering (i.e. $y \succ x$) is in *O*. Repeat for the next highest-ranked constraint in the hierarchy. [To which Bakovic adds: The order in which the relative orderings among candidates that a given constraint asserts are added to *O* is given by the absolute ranking which that constraint establishes among the candidates.]

b. *Transitive closure.* For any candidates *x*, *y*, and *z*, if both $x \succ y$ and $y \succ z$ are in the cumulative ordering *O*, then $x \succ z$ is also in *O* (i.e. $x \succ y$ & $y \succ z \Rightarrow x \succ z$).

c. *Optimality.* A candidate is **optimal** if and only if it is not worse than any other candidate in the first cumulative ordering (i.e. when the loop in (a) ends).

Still following Bakovic's exposition, we consider the derivation of *kopima* from /kopi-ma/ 'to grope'. This time we need not worry about the backness of the non-initial input vowels, for targeted constraints, to their credit, do not rely on faithfulness to underlying representations. Narrowing down the field to the four most interesting candidates, we obtain the tableau in [86].

[85]

Candidates	$\odot$[+Back,–Round,+High]	AGR(Back)
Input: /kopi-ma/		
a. kop1ma	$d \succ a$!	
b. kopimä		$a \succ b$!
c. kop1mä	$b \succ c$!	
d. ☞ kopima		$a, b, c \succ d$
Cum. ordering:	$d \succ a, b \succ c$	$d \succ a \succ b \succ c$

Crucially, both [+Back,–Round,+High] and AGR(Back) must be targeted constraints, evaluated in the pairwise fashion stipulated in [84].

Now consider the vowel *o*. Recall that we got the desired opaque behavior simply by ranking the corresponding constraint **ö* with **1* after IDENT-σ_1(Back). Under targeted constraints this is no longer the case. There is no reason why *o* would not be transparent like *i*. The tableau is exactly the same.

[86]

Candidates	$\odot$[–Back,+Round,–High]	AGR(Back)
Input: /lähko-le/		
a. ☞ lähko-lõ	$d \succ a$!	
b. lähko-le		$a \succ b$!
c. lähkö-lõ	$b \succ c$!	
d. lähkö-le		$a, b, c \succ d$
Cum. ordering:	$d \succ a, b \succ c$	$d \succ a \succ b \succ c$

In fact, it is not clear how to formulate a targeted constraint that accounts for opaque behavior. Suppose however that there is such a targeted constraint, or that we find a way of orchestrating a mix of targeted and ordinary constraints within one constraint system. Then we still lose the prediction that back neutral vowels are opaque and front neutral vowels are transparent.

5 Conclusions

We have presented an analysis of the vowel harmony system of Seto Estonian, with its abundant disharmony phenomena which involve both transparent and opaque vowels. Drawing on a preliminary typology of disharmony developed in another study of ours, we showed that the Seto system reveals the interaction of markedness constraints that govern segment inventories with faithfulness constraints and a feature agreement constraint. The constraints themselves are all uncontroversial; the only theoretical novelty was to make use of two modes of constraint conjunction which emerge naturally when the procedure for evaluating conjoined constraints is spelled out.

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