VOWEL INVENTORIES AND VOWEL PROCESSES WITHIN OPTIMALITY THEORY

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ABSTRACT

Optimality theory allows for a unified analysis of the role of feature combination markedness in both segmental inventories and contextual phonological processes. The data and analyses presented in support of this proposition focus on the distribution of rounded vowels in vowel inventories and on the patterns observed in rounding harmony systems.

INTRODUCTION

The principles which underlie the cross-linguistic patterns observed in the structure of segment inventories play a role in syntagmatic phonological patterns as well. In *The Sound Pattern of English* [1], this relationship was characterized by means of marking conventions characterizing marked and unmarked feature combinations. Marking conventions constituted a theory markedness in segment inventories. Furthermore, given their status as elements of Universal Grammar, any derivation yielding marked feature combinations would necessarily entail language-specific rules, thus adding complexity to the grammar. Under the assumption that simplicity is favored over complexity in grammars, it follows that, all else equal, rules required in order to generate marked feature combinations will be typologically dispreferred.

OPTIMALITY THEORY

In optimality theory [2], [3] the phonological *rule* has no formal status and is instead replaced by constraints on surface representations. While optimality theoretic constraints refer to surface well-formedness, they are not necessarily surface-true. Crucially, constraints may conflict with one another in the sense that a given representation may satisfy one constraint while violating some other constraint.

Such conflicts are resolved by means of a hierarchical constraint ranking. Constraint hierarchies are characterized by what has been termed *lexicographic* ordering: a given constraint overrides all lower-ranked constraints. Thus, a single violation of any given constraint is worse than multiple violations of one or more lower-ranking constraints. The constraints themselves constitute part of Universal Grammar, however their relative ranking is determined on a language-specific basis.

For a given input (or lexical) representation, output (or surface) representations are determined by means of an algorithm which compares an array of candidate output structures and evaluates the extent to which they satisfy the constraint hierarchy. The optimal candidate is that which best satisfies the constraint hierarchy and it is that candidate output structure which surfaces. Clearly, the value of a given output candidate will be determined in part by the degree to which it constitutes a faithful rendition of the input.

The constraints which insure input-output fidelity are referred to as *faithfulness* constraints. Faithfulness constraints require that specifications present in the input remain in the output (PARSE) and that specifications absent in the input are not added to the output (FILL).

SONORITY AND VOICING

Within this model it is thus possible to characterize both surface inventory patterns and contextual phonological patterns. For instance, consider the well-known observation that sonorants are typically voiced. In Maddieson's survey of the segment inventories of 317 languages [4], only 3.4% of nasal consonants, 3.3% of approximant laterals, 2.2% of trills and 1.9% of taps/flaps were voiceless. From this, two conclusions are relevant: (i) voiceless sonorants are rare, and (ii) voiceless sonorants are attested.

Optimality theory is well-suited to account for both of these facts by means of the interaction between constraints on markedness and constraints on faithfulness. Voiceless sonorants will be allowed to surface only if both PARSE$^{[voice]}$ and PARSE$^{[sonorant]}$ outrank the constraint dictating that [-voice] and [+sonorant] are incompatible, which I will label *[-vce, +son]. Of the six logically possible constraint hierarchies in Figure 1, only the first two listed will allow voiceless sonorants to surface:

PARSE$^{[vce]}$ >> PARSE$^{[son]}$ >> *[-vce, +son]
PARSE$^{[son]}$ >> PARSE$^{[vce]}$ >> *[-vce, +son]
PARSE$^{[vce]}$ >> *[-vce, +son] >> PARSE$^{[son]}$
PARSE$^{[son]}$ >> *[-vce, +son] >> PARSE$^{[vce]}$
*[-vce, +son] >> PARSE$^{[vce]}$ >> PARSE$^{[son]}$
*[-vce, +son] >> PARSE$^{[son]}$ >> PARSE$^{[vce]}$

Figure 1. Constraint Hierarchies.

In addition to the rarity of voiceless sonorants in segment inventories, the resistance of sonorants to processes of devoicing can also be attributed to the markedness constraint *[-vce, +son]. In Russian, for instance, the fact that obstruents are targeted by word-final devoicing while sonorants are not can be analyzed as an instance in which *[-vce, +son] outranks the constraint (or set of constraints) which gives rise to final devoicing. In Angas, a Chadic language of Nigeria [5], sonorants are subject to final devoicing. Thus, in this language *[-vce, +son] ranks lower than those constraints which conspire to yield final devoicing.

VOWEL CONSTRAINTS

A number of very solid generalizations can be made regarding the occurrence of rounded vowels in vowel inventories. With respect to the height dimension, it has long been observed that low vowels are typically unrounded. Of the 523 low vowels recorded in Maddieson's survey, only 37 (or 7%) were rounded. Therefore, it is very clearly safe to say that low rounded vowels are marked. In *The Sound Pattern of English* [1], this correlation is captured in Marking Convention XI, which states that the unmarked value of [±round] is [-round] in the context [__, +low]. In optimality theory, this correlation must be expressed as a constraint on feature incompatibility. I will label the relevant constraint *ROLO. *ROLO dictates that low rounded vowels are dispreferred.

Similarly, front rounded vowels are attested, but typologically dispreferred. Of the 1019 front vowels recorded in Maddieson's survey, only 61 (or 6%) were rounded. This percentage should be compared with the percentage of back vowels in the survey which were rounded. Of the 964 back vowels recorded, 901 (or 93.5%) were rounded. It is therefore reasonable (and not novel) to claim that front rounded vowels are dispreferred. Marking Convention XI in *The Sound Pattern of English* captured the relationship between backness and rounding as well. In optimality theory, we establish a constraint which I will label *FRORO, expressing the dispreference for front rounded vowels. By the same token, back unrounded vowels are clearly in the minority suggesting the need for a third constraint which we may label *BAK-RD.

Now just as the markedness constraint referring to sonority and voicing was shown to play a role both in the shaping of segment inventories and in the typology of final devoicing, the constraints on rounding and the height and backness dimensions can also be shown to participate both in determining the content of vowel inventories and in the typology of vowel harmony.

BACKNESS HARMONY

In the native vocabulary of Hungarian, front and back harmonic vowels do not co-occur within a word [6]. The so-called "neutral" vowels (*i(:)* and *e:*) freely co-occur with vowels of both harmonic classes.

Front	Back	Neutral
y, y:	*u, u:*	*i, i:*
œ, œ:	*o, o:*	*e:*
ɛ	*a, a:*	

Figure 2. Hungarian Harmony Classes.

It is immediately apparent from the harmony classes shown in Figure 2 that the neutral vowels are the front vowels which lack a back counterpart. Thus, the failure of *i(:)* and *e:* to participate in harmonic alternations is apparently linked to the absence of *ɯ(:)* and *ʌ:* in the surface inventory. Those constraints giving rise to backness harmony, discussed in Kaun [7], rank lower than *BAK-RD. And similarly, *BAK-RD outranks the PARSE constraints which would force *ɯ(:)* and *ʌ:* to surface. Stated differently, the grammar places a higher priority on the avoidance of the marked feature combination [-round, +back] than it does on the need to maintain backness harmony throughout the word.

ROUNDING HARMONY

More interesting cases from the perspective of the point I make in this paper are to be found in rounding harmony systems. The interest of these cases lies in the fact that the markedness constraints *ROLO and *FROLO are surface-violated, that is low (or lower mid) rounded vowels and front rounded vowels do occur in the relevant languages. Nonetheless, the effects of these constraints are clearly visible in the observed rounding harmony patterns.

*FROLO

In the Mongolian dialect Shuluun Höh [8], both front and back rounded vowels are present in the surface inventory. Furthermore, both front and back rounded vowels occur as the output of rounding harmony. Rounding harmony is triggered by non-high vowels and targets non-high vowels. Some examples are shown in Figure 3, where the targets of harmony are underlined. In addition to rounding harmony, Shuluun Höh exhibits a system of ATR harmony, described in detail in Svantesson [8]:

joroxøːloxtʃ-	'president'
nɔxœː-	'dog'
doroː-	'stirrup'

Figure 3. Shuluun Höh root harmony, data taken from Svantesson [8].

Front and back vowels do not exhibit entirely parallel distributional patterns, however. While both front and back rounded vowels occur as the output of rounding harmony within roots, only back rounded vowels are found as the output of rounding harmony in suffixes. Examples of suffixal vowels are underlined in Figure 4:

nɔxœː-gɔːr	'dog-instrumental'
doroː-goːr	'stirrup-instrumental'
mœrj-tæː (*mœrj-tœ)	'horse-comitative'
obst-teː (*obst-tøː)	'grass-comitative'

Figure 4. Shuluun Höh suffix harmony, data taken from Svantesson [8].

In optimality theory this asymmetry is elegantly captured by means of constraint ranking. Specifically, the constraint which gives rise to rounding harmony within roots, which I will label EXTEND^{R,Root} outranks *FROLO (see Kaun [7] for a full analysis). The analogous constraint which operates at the level of the word, EXTEND^{R,Word}, is ranked below *FROLO. Stated in prose, it is more important to extend the domain of rounding throughout the root than it is to avoid generating the typologically marked front rounded vowels. The avoidance of such vowels in Shuluun Höh takes precedence over the importance of extending the domain of rounding throughout the entire word. The relevant partial constraint hierarchy is therefore:

EXT^{R,Root} >> *FROLO >> EXT^{R,Word}

Shuluun Höh thus constitutes a case in which a constraint on feature combination markedness plays an active role in the phonology while not imposing a limitation on the surface segment inventory. The constraint *ROLO can be shown to play a role in some rounding harmony languages which feature low (or lower mid) rounded vowels in the surface inventory.

*ROLO

In Turkish, rounding harmony is triggered by high and non-high rounded vowels, but targets only high vowels. Thus, a high vowel suffix such as /-Im/ 'first person singular possessive' surfaces with a rounded vowel whenever the preceding vowel is rounded. Vowels in Turkish are subject to backness harmony as well, as indicated: *buz-um* 'my ice', *kɔl-um* 'my arm', *gül-üm* 'my rose', *gœz-üm* 'my eye'. A non-high suffix vowel surfaces as unrounded regardless of the quality of the preceding vowel: *buz-da* 'on the ice', *kɔl-da* 'on the arm', *gül-dε* 'on the rose', *gœz-dε* 'on (in) the eye'.

The failure of non-high vowels to undergo rounding harmony is attributable to the constraint *ROLO . In Turkish, the relevant PARSE constraint must rank above *ROLO, giving rise to non-high rounded vowels on the surface. Non-high rounded vowels are not found as the output of harmony however, and this distributional fact can be accounted for if we assume that *ROLO ranks above the relevant EXTEND constraints. The distribution of the marked vowels ɔ, œ in Turkish is therefore quite restricted. These vowels occur where required to satisfy PARSE, i.e. in positions lexically specified as [+round, -high]. They fail to occur in positions where EXTEND would dictate in their favor due to the influence of the higher ranking constraint *ROLO. We thus have the partial constraint hierarchy shown here for Turkish:

PARSE^R >> *ROLO >> EXTEND^R

In Kachin Khakass, a Turkic language documented in Korn [9], high and non-high rounded vowels are found in the surface inventory. Rounding harmony applies only between a high trigger and a high target, however:

kuʃ-tuŋ	'of the bird'
kɔzuk-ta (*kɔzuk-tɔ)	'in the nut'
ɔk-tuŋ (*ɔk-tuŋ)	'of the arrow'
pɔl-za (*pɔl-zɔ)	'if he is'

Figure 4. Rounding Harmony in Kachin Khakass, data from Korn [8].

An additional constraint is relevant to the Kachin Khakass pattern which, in Kaun [7], is labeled UNIFORM^R. This constraint is operative in a variety of other rounding harmony languages including the Mongolian and Tungusic languages, and dictates that a single [+round] autosegment in the phonology should correspond to a uniform articulatory setting in the phonetics. UNIFORM^R rules out harmony when the trigger and target are of distinct heights, since the lip activity involved in the articulation of non-high rounded vowels is distinct from that involved in the articulation of high rounded vowels [10].

The constraint hierarchy for Kachin Khakass is therefore the following:

PARSE^R >> UNIFORM^R , *ROLO >> EXT^R

This hierarchy gives rise to a decidedly limited range of harmony configurations in the language. EXTEND^R may prevail only when its satisfaction entails violations of neither UNIFORM^R nor *ROLO .

CONCLUSION

I have shown that optimality theory provides a unified means of characterizing the role of markedness constraints on feature co-occurrence in both inventory structure and in contextual phonological phenomena. In this model constraints are universal, but also violable. We therefore expect to find cases in which a given markedness constraint is ranked quite high, imposing limitations on both the segmental inventory and syntagmatic phenomena (e.g. Hungarian). In addition, we expect to find cases in which the markedness constraints rank somewhat lower, and fail to impose restrictions on the shape of the surface segmental inventory. In such cases, the markedness constraints may still be expected to play a role in certain contextual phonological manifestations. It is this situation which is encountered in Shuluun Höh, Turkish, and Kachin Khakass.

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