Turkish Simulation

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1. Facts

The patterning of vowels in the native words of Turkish is well known. There are eight vowel phonemes, which bifurcate three ways: front/back, high/low, rounded/unrounded:

	front unrounded	front rounded	back unrounded	back rounded
[+high]	i	y	ɨ	u
[-high]	e	ø	a	o

All eight vowels contrast in initial syllables. In non-initial syllables (non-native and other exceptional forms aside), there is just a two-way contrast of high vs. non-high. High vowels harmonize with the vowel of the preceding syllable in both backness and rounding. Non-high vowels in non-initial syllables are unrounded and harmonize with the vowel of the preceding syllable in backness.

These patterns are mostly commonly studied in connection with the phonological alternations in Turkish suffixes. However, they would hold as well (idealizing to some degree) simply as generalizations about Turkish word forms, prior to any sort of morphological analysis. The paper for which this example serves as an illustration models this kind of purely-phonotactic learning.

Thus, construed as a purely-phonotactic problem, the issue is how to single out only 16 of the 64 possible two-vowel sequences as legal (the non-shaded sequences below):

i i	i e	i y	i ø	i ɨ	i a	i o	i u
e i	e e	e y	e ø	e ɨ	e a	e o	e u
y i	y e	y y	y ø	y ɨ	y a	y o	y u
ø i	ø e	ø y	ø ø	ø ɨ	ø a	ø o	ø u
a i	a e	a y	a ø	a ɨ	a a	a o	a u
ɨ i	ɨ e	ɨ y	ɨ ø	ɨ ɨ	ɨ a	ɨ o	ɨ u
o i	o e	o y	o ø	o ɨ	o a	o o	o u
u i	u e	u y	u ø	u ɨ	u a	u o	u u

The problem can be simplified if we factor out the effects of backness harmony, which rules out the upper right and lower left quadrants of the chart. Since backness harmony operates independently of rounding, this is an innocuous simplification; any results we get on the simplified system will carry over to the full system.

To this end, let "i" stand for any high unrounded vowel ([i] or [ɨ]), "a" for any non-high unrounded vowel ([e] or [a]), "u" for any high rounded vowel ([u] or [y]) and "o" for any non-high rounded vowel ([o] or [ø]). We can then represent the crucial pattern as follows:

i i	i a	i u	i o
a i	a a	a u	a o
u i	u a	u u	u o
o i	o a	o u	o o

Here, 8 of 16 logically possible cases are attested. The pattern is that all four of the "archivowels" [i, a, u, o] are legal initially; non-low vowels must be unrounded noninitially, and noninitial high vowels must harmonize in rounding.

2. Constraints

Here are constraints that can be ranked to describe this pattern. They assume that [round] is an autosegmentalized feature that can be linked to multiple vowels, following a research tradition dating from Clements (1976, 1980).

2.1 Markedness

ALIGN(ROUND, RIGHT): Every [round] autosegment must be aligned with (linked to) the final syllable.[1] This constraint favors rounding harmony; it is violated by [u i], [o i], [u a], and [o a].

ALIGN(ROUND, LEFT): Every [round] autosegment must be aligned with (linked to) the initial syllable. This constraint militates against non-initial roundness when it is not supported by harmony; it is violated by the candidates *[i u], *[i o], *[a u], *[a o].

*[+ROUND, -HIGH], abbreviated *O: This constraint is the *ROLO of Kaun (1995; forthcoming). The lower rounded vowels are dispreferred cross-linguistically, probably due to the greater articulatory difficulty of rounding when there is a lower jaw position.

*[ROUND]: This is the general Markedness constraint forbidding rounding.

[1] More precisely, a violation is assessed for every vowel that follows the rightmost vowel to which [round] is linked, which requires harmony to go as far to the right as possible (cf. /u i a i/ → [u u a i], with /a/ blocking harmonic spread).

2.2 Faithfulness

IDENT(ROUND, INITIAL). Violated when the vowel that is in the initial syllable in the surface representation differs from its underlying correspondent in rounding. This is a positional Faithfulness constraint of the type documented by Beckman (1998). This is an expected constraint for a language like Turkish, in which all morphology is suffixing, so that all initial vowels are stem vowels.

IDENT(ROUND). The general Faithfulness constraint for rounding.

IDENT(HIGH). The general Faithfulness constraint for height.

I have experimented with adding IDENT(ROUND, FINAL) to the system as well, under the view that this constraint might be part of the inventory that the child brings to phonological learning. For all algorithms, the ranking came out the same, other than the placement of this constraint at the bottom of the hierarchy. The simulations reported here omit IDENT(ROUND, FINAL).

2.3 Hand Ranking

We cover first the rankings responsible for the vowel inventory of initial syllables. IDENT(ROUND, INITIAL) must dominate *ROUND to permit any initial-syllable rounded vowels to surface as rounded, and it must dominate *[+ROUND, -HIGH] to permit [o] to survive in initial syllables.

/u e/	ID(RD)/INIT	*O	*ROUND
☞ [u e]			*
*[i e]	*!		

/o e/	ID(RD)/INIT	*O	*ROUND
☞ [o e]		*	*
*[i e]	*!		

IDENT(HIGH) must also dominate *[+ROUND, -HIGH], else we could have no non-high rounded vowels at all:

/o/	ID(HI)	*O
☞ [o]		*
*[u]	*!	

Next, we can consider the rankings that determine when second vowels are required to agree with initial vowels in rounding. In particular, ALIGN(ROUND, RIGHT) must dominate IDENT(ROUND) and *ROUND:

/o i/	ALIGNR	*ROUND	ID(RD)
☞ [o u]		**	*

*[o i]	*!	*	

However, the harmony principle is overridden by the requirement not to create non-high rounded vowels; hence *[+ROUND, -HIGH] must dominate ALIGN(ROUND, RIGHT):

/o o/	*O	ALIGNR	ID(RD)
☞ [o e]	*	*	*
*[o o]	**!		

The same tableau tells us that IDENT (ROUND) must also be dominated by *[+ROUND, -HIGH]: a non-initial non-high rounded vowel cannot survive on grounds of Faithfulness, any more than it can on grounds of obeying harmony.

We must consider in addition why high rounded vowels don't survive in non-initial syllables unless supported by harmony. It turns out that there are two possible rankings that could guarantee this, either ALIGN(ROUND, LEFT) >> *IDENT(ROUND) or *ROUND > *IDENT(ROUND):

/i u/	ALIGNL	*ROUND	ID(RD)
☞ [i i]			*
*[i u]	*!	*	

Since there is no evidence that ALIGN(ROUND, LEFT) is ever violated in a winner, it seems simplest to suppose that it is the constraint responsible. But there would be no harm, either, in adding the ranking *ROUND > *IDENT(ROUND) (this is in fact exactly what pure phonotactic learning algorithms do).

Three more subtle ranking arguments are possible:

1) One might imagine the forms that "want" to harmonize, but can't due to *[+ROUND, –HIGH], might solve the problem by sacrificing the rounding of the initial syllable. They don't, because IDENT(ROUND, INITIAL) dominates ALIGN(ROUND, RIGHT).[2]

/u e/	ID(RD)/INIT	ALIGNR
☞ [u e]		*
*[i e]	*!	

2) The inability of forms with non-high non-initial vowels to undergo harmony is not repaired by raising the non-initial vowel. Hence IDENT(HIGH) dominates ALIGN(ROUND, RIGHT):

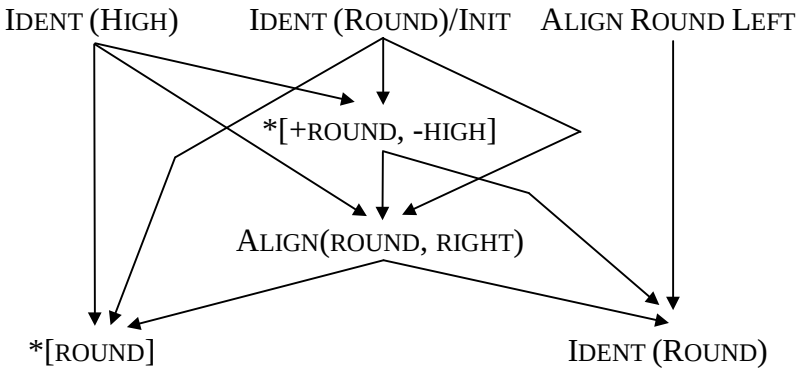
[2] To be honest I find this a worrisome consequence of the constraint set, which detracts from its realism. I know of no harmony languages in which rounding is allowed on an initial vowel of a polysyllable in general, but not if a harmony-opaque vowel like /e/ follows. But this is what is predicted if we switch the ranking shown; i.e. ALIGN(ROUND, RIGHT) >> *[+ROUND, -HIGH] >> IDENT(ROUND, INITIAL).

/o e/	ID(HI)	ALIGNR
☞ [o e]		*
*[o u]	*!	

3) High vowels in non-initial syllables cannot escape their duty to harmonize by becoming non-high; hence IDENT(HIGH) >> *ROUND:

/o u/	ID(HI)	*ROUND
☞ [o u]		**
*[o e]	*!	*

Putting the rankings all together, we obtain the following Hass diagram:



The goal of a successful learning simulation is to learn at least these rankings, and no rankings that contradict them; additional, superfluous pairwise rankings are harmless. This holds true of the rankings obtain by Low Faithfulness Constraint Demotion and Biased Constraint Demotion as amplified with the provision ***Favor Specificity*** (see text of paper). They obtain identical constraint strata:

Stratum	**Constraint Name**	**Abbr.**
Stratum #1	ALIGN ROUND LEFT	ALIGNL
Stratum #2	IDENT (ROUND)/INIT	ID(RD)/INIT
	IDENT (HIGH)	ID(HI)
Stratum #3	*+LOW/+ROUND	*O
Stratum #4	ALIGN ROUND RIGHT	ALIGNR
Stratum #5	*+ROUND	*ROUND
Stratum #6	IDENT (ROUND)	ID(RD)

However, the original version of Biased Constraint Demotion promotes IDENT (ROUND) too high:

Stratum	**Constraint Name**	**Abbr.**
Stratum #1	ALIGN ROUND LEFT	ALIGNL
Stratum #2	IDENT (ROUND)	ID(RD)
Stratum #3	ALIGN ROUND RIGHT	ALIGNR
	*+ROUND	*ROUND
Stratum #4	IDENT (HIGH)	ID(HI)
Stratum #5	*+LOW/+ROUND	*O
Stratum #6	IDENT (ROUND)/INIT	ID(RD)/INIT

This overgenerates, in essence abolishing vowel harmony (non-initial vowels may assert their own rounding value). Thus, for instance, it allows *[u i] as a legal form.

/u i/	ALIGNL	ID(RD)	*ROUND	ALIGNR	ID(HI)	*O	ID(RD)/INIT
☞*[u i]			*	*			
*[u e]			*	*	*!		
(*)[u u]		*!	**				
*[u o]		*!	**		*!	*	
*[o u]		*!	**		*!	*	
*[o o]		*!	**		*!*	**	
*[o i]		*!	*	*	*	*	
*[o e]		*!	*	*	**	*	
*[i i]		*!					*
*[e i]		*!			*		*
*[i e]		*!			*		*
*[e e]		*!			**		*
*[i u]	*!	**	*				*
*[e u]	*!	**	*		*		*
*[i o]	*!	**	*		*	*	*
*[e o]	*!	**	*		**	*	*

It also allows non-high rounded vowels in non-initial syllables:

/o o/	ALIGNL	ID(RD)/INIT	ID(HI)	*O	ALIGNR	*ROUND	ID(RD)
☞* [o o]				**!		**	*
*[o e]				*	*	*	
*[u e]			*!		*	*	
*[o u]			*!	*		**	*
*[u o]			*!	*		**	*
*[o i]			*!	*	*	*	
*[u u]			*!*			**	*
*[u i]			*!*		*	*	
*[e e]		*!					*
*[i e]		*!	*				*

*[e i]		*!	*				*
*[i i]		*!	**				*
*[e o]	*!	*		*		*	**
*[e u]	*!	*	*			*	**
*[i o]	*!	*	*	*		*	**
*[i u]	*!	*	**			*	**

See simulation details, from the main Web site (http://www.linguistics.ucla.edu/people/hayes/acquisition/). for how these rankings are obtained.

References

Beckman, Jill (1998) *Positional Faithfulness*, Ph.D. dissertation, Department of Linguistics, University of Massachusetts, Amherst. [Rutgers Optimality Archive 234, http://ruccs.rutgers.edu/ROA/search.html]

Clements, George N. (1980) *Vowel Harmony in Nonlinear Generative Phonology: an Autosegmental Model*, Indiana University Linguistics Club, Bloomington, Indiana, 1980

Clements, George N. (1976) "The Autosegmental Treatment of Vowel Harmony," in Wolfgang U. Dressler and Oskar E. Pfeiffer, eds., *Phonologica 1976* (Innsbrucker Beiträge zur Sprachwissenschaft, vol. 19), Innsbruck, 111-119.

Kaun, Abigail (1995) The Typology of Rounding Harmony: An Optimality Theoretic Approach, Doctoral dissertation, UCLA. [Rutgers Optimality Archive 234, http://ruccs.rutgers.edu/ROA/search.html.]

Kaun, Abigail (forthcoming) "The Typology of Rounding Harmony," to appear in Bruce Hayes, Robert Kirchner, and Donca Steriade, eds., *Phonetically Based Phonology*, Cambridge, Cambridge University Press.