Perception of centralized vowels in a language with vowel harmony

Subphonemic variation that had been previously treated as irrelevant for language has become more important in theoretical frameworks that do not explain universal features in languages with an innate Language Faculty. Diachronic approaches like Blevins (2004) and functional approaches using exemplar-based models like Bybee (2001) rely on strict phonetic forms that are stored in the lexicon and categories evolve or emerge based on these forms.

Vowel centralization is a subphonemic process in Hungarian. Perceptional studies of this process have been very scarce, with Gósy (1997) claiming that 49.3% of all vowels in a pre-recorded speech had been perceived as [ə]. Acoustic studies have shown that unstressed vowels do undergo reduction, but not in a uniform centralizational manner: while back vowels do centralize towards the target of [ə], front vowels do not lower their F2 formant, rather merging near the quality of [ɪ] (Szeredi 2008).

The aim of the experiment presented here was to see if the F2-based dichotomy seen above is found in perception as well, because if it is, it might also prove that subphonemic processes might work on phonological categories, be influenced by the phonological system of a language and therefore be able to possibly influence the phonology of the language as predicted by the above mentioned functional approaches.

The pilot study presented here was conducted with 3 native speakers of Colloquial Standard Hungarian, who had the task to assign an acceptance score in the range of 1 to 7 to 180 test sentences. Test sentences were built on the same syntactic construction. The verbs in the sentences took the PAST.3SG.DEF suffix /tɒ/∼/tɛ/. The verbal prefix [ki] always followed the main verb, therefore all tested vowels were in the environment of [t_k]. Every verb stem was monosyllabic and all distinct vowel qualities in Hungarian were used as stem vowel of a verb in a sentence (quantity distinction was not taken into account). The neutral /i/ vowel was tested as the stem vowel for two verbs: one taking front suffixes and one taking back ones to test the effect of different kind of lexical storage for the two classes argued for by Benus and Gafos (2007). The hypotheses of the experiment described below were that centralized vowels would be accepted as vowel reduction is present in Hungarian and that [ə] would be more accepted in the place of a back vowel than in the place of a front one ([ɒ] and [ɛ] in the experiment respectively).

The test sentences were synthesized using the MBROLA text-to-speech system (Dutoit et al., 1996), thereafter the tested vowel of the suffix was altered using Praat (Boersma and Weenink, 2008) to six affix vowel variables: [ɒ], [ɐ], [ə], [ɜ], [ɛ] and [ɪ], with [ɐ] placed halfway between [ɒ] and [ə], [ɜ] placed halfway between [ɛ] and [ə] and the F1 of [ɪ] halfway between [ɛ] and [eː] and $F2_{[I]} = \frac{2*F2_{[E]}+F2_{[e:]}}{3}$.

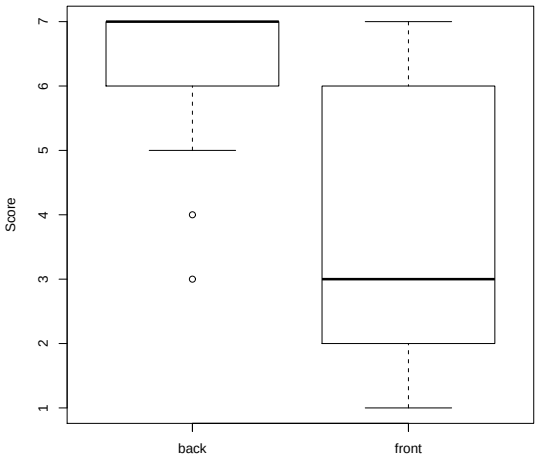
The results of the pilot experiment can be summarized statistically in the following table ($N = 45$ for front, $N = 36$ for back vowels in all columns as stems with [i] and back affixes were excluded; t-test was used for significance analysis):

affix vowel	[ɒ]	[ɐ]	[ə]	[ɜ]	[ɛ]	[ɪ]
mean score for front stem vowels	1.89	2.38	2.73	4.88	6.24	5.98
mean score for back stem vowels	6.53	6.64	6.42	5.03	2.39	2.17
p value	<0.001	<0.001	<0.001	0.3881	<0.001	<0.001
significance	***	***	***	none	***	***

The most striking observations that can be made from the study are:

- scores for [ə] were significantly worse for front stems than for back stems: t test shows t=12.14 with d.f.=71.52 meaning highly significant difference of means. The boxplot for this difference is shown on the figure below.
- there is no significant difference of scores at the quality of [ɜ], which is quite on the front half of the vowel chart (F2=1637).
- scores for [ɛ] were non-significantly different from scores for [ɪ] for front stem vowels (t=1.135 with d.f.=82.335 meaning $p = 0.2596$).
- scores for [ɒ], [ɐ] and [ə] were non-significantly different for back stem vowels ($p = 0.55$ for [ɒ]∼[ɐ], $p = 0.27$ for [ɐ]∼[ə] and $p = 0.61$ for [ɒ]∼[ə]).
- stems taking back suffixes with [i] as stem vowel show significantly better scores than other back stems for an [ɪ] affix vowel ($p \approx 0.01$) and significantly worse for an [ɒ] affix vowel($p \approx 0.02$), thus tolerating fronter affixes better.
- stems with front round vowels [y] and [ø] showed a significantly better score for centralized affix vowels than front non-round stems: $p \approx 0.04$ for [ə] and $p \approx 0.01$ for [ɐ].

The conclusion of the results above confirms the findings of the acoustic study and further underlines the need of a theoretical framework able to account for the pattern seen above. The framework of Dispersion-Focalization Theory (DFT, Schwartz et al. 1997) claims that the peripheral vowels [a], [i], [u] (and possibly [y], cf. Schwartz et al. 2005) are perceptionally the best fit for the listener, and are used as a reference for categorization for other vowels. Harris (2005) uses a representational framework based on DFT to explain phonemic vowel reduction in several languages.



Boxplot for the scores if the affix vowel is [ə] for back and front stem vowels

This framework provides the most simple explanation for the dichotomical behavior of Hungarian vowels in reduction (cf. Szeredi 2008): the focalized qualities of [a] and [u] are lost, but the one of [i] is not, probably showing the effect of vowel harmony, which works on this [i] 'element' in Hungarian. Pearce (2009) has indeed shown that vowel harmony languages generally preserve the feature the harmony works on, i.e. frontness in Hungarian. This study supports these findings showing significant difference between the behavior of front and back vowels. The continuation of this study and further research on this topic might give more details about the behavior of subphonemic vowel centralization in Hungarian and therefore on the patterns that could possibly emerge from vowel reduction in a vowel harmony language.

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