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THE "NEUTRAL" VOWELS OF FINNISH: HOW NEUTRAL ARE THEY?*

Finnish is well known for possessing a front-back vowel harmony system, according to which all vowels in native words agree in terms of frontness/backness. Though there are exceptional forms which do not respect vowel harmony, it is a robust and productive aspect of Finnish phonology and morphophonology. Native stems observe vowel harmony and suffixes have two variants, one with a front vowel and one with a back vowel, where the choice of the ending is a function of the frontness/backness of preceding vowels, e.g. *koulu-ssa* 'in the school' vs. *jälje-ssä* 'behind, after'.

It is also well known that there are two vowels, both phonetically front in their articulation, which are neutral for purposes of vowel harmony and can occur with either front or back vowels in a word. These vowels, /i/ and /e/, may be preceded and followed by either front or back vowels (e.g. *selkä* 'back' vs. *velka* 'debt') and do not participate in morphological alternations with back vowels.

1. This study examines the phonetic realization of the neutral vowels. The specific aspect of the neutral vowels under consideration is the extent to which they are truly articulated with the same degree of backness/frontness regardless of the quality of adjacent vowels. The default hypothesis, following traditional descriptions of Finnish, is that the backness/frontness of the neutral vowels does not vary as a function of whether they occur in a front or back vowel environment.

In order to test this hypothesis, a corpus of 32 Finnish words was constructed in which the environment in which each of the neutral vowels occurred was systematically varied. The factors which were manipulated included whether the neutral vowel was in a front or back vowel environment, and whether the neutral vowel was preceded by, followed by, or surrounded by non-neutral vowels in adjacent syllables. The corpus of words examined appears in table 1. One token of each word was read in random order by two native Finnish speakers, one male and one female, both between the ages of 20 and 35, and both from the Helsinki area.

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Table 1

Corpus of words containing neutral vowels

	/i/	/e/
Before front vowel	*ikä* 'age'	*pesä* 'nest'
		hely 'trinket'
Before back vowel	*hiha* 'sleeve'	*pesu* 'wash(ing)'
	iho 'skin'	*teho* 'effect, action'
	tikut 'splinters'	*pensas* 'bush'
After front vowel	*täti* 'aunt'	*säde* 'ray, beam'
	mökit 'cottages'	*ryske* 'crash'
	määkit 'you (sg.) bleat' (dial.)	
After back vowel	*toki* emphatic particle	*ase* 'weapon'
	ukit 'grandfathers'	*todet* 'you find'
	tapit 'plugs'	*puhe* 'speech'
Between front vowels	*tätihän* 'aunt (emphatic)'	*sädehän* 'ray (emphatic)'
	mökithän 'cottages (emphatic)'	*ryskehän* 'crash (emphatic)'
	määkithän 'you (sg.) bleat (emphatic)'	*pyyhehän* 'towel (emphatic)'
Between back vowels	*tokihan* very emphatic	*puhehan* 'speech (emphatic)'
	ukithan 'grandfathers (emphatic)'	*asehan* 'weapon (emphatic)'
	tapithan 'plugs (emphatic)'	*todethan* 'you find (emphatic)'

The data were recorded in an anechoic chamber using a high quality analog cassette recorder. Data were digitized on the Kay CSL at 10 kHz. The first two formants of each of the target neutral vowels were measured using an LPC display in conjunction with an FFT spectrum and waveform. The LPC was calculated over a 30 millisecond window using 14 coefficients and the FFT spectrum was measured over a 25.6 millisecond window. These windows were calculated at the midpoint of the vowel in order to minimize the influence of adjacent consonants. As a further precaution to avoid potentially confounding effects due to adjacent consonants, an attempt was made to position consonants with similar places of articulation around the target vowels.

Of the two formants, the second one is the most relevant for the present study, since it rather closely reflects the degree of backness of the vowel. Although other articulatory settings such as the degree of lip rounding can influence second formant values, in general, the higher the second formant, the fronter the tongue position of the vowel, and conversely, the lower the second formant, the backer the articulation of the vowel. The correlation between second formant values and vowel frontness/backness is evident in any formant plot containing both front and back vowels. Examination of the present data set did not demonstrate any correlation between lip rounding and second formant values. Thus, any meaningful differences in second formant values may be assumed to reflect primarily differences in articulatory frontness/backness and not degree of rounding.

2. A series of analyses of variance were calculated with the first and second formant values for the neutral vowels as dependent variables. In the first analysis all tokens were included and three factors were treated as independent variables: vowel (/i/ vs. /e/), speaker (male vs. female) and environment (front vs. back). For both formants, the vowel accounted for the greatest amont of variance ($p < .0001$). Mean first formant and second formant values for /i/ were 383 Hz and 2405 Hz, respectively, compared to 543 Hz and 2130 Hz for /e/ combining both speakers. These significant differences between /i/ and /e/ for

the first two formants are not surprising given the different places of articulation of the two vowels: /i/ is fronter and higher than /e/, corroborating earlier results of K. Wiik (1965).

Only second formant values varied significantly as a function of speaker, with second formant values collapsed over both /i/ and /e/ being much higher for the female speaker than for the male speaker, 2508 Hz vs. 2016 Hz. The difference in second formant values between the male and female speaker is not surprising given the different vocal tract characteristics of females and males. Values for the first formant did not vary significantly as a function of vowel environment (front vowel environment = 454 Hz vs. back vowel environment = 473 Hz), suggesting (not surprisingly) that the backness/frontness of neighboring vowels does not influence vowel height. Nor did values for the second formant differ significantly as a function of whether adjacent vowels were back or front (2284 Hz in back vowel environments vs. 2251 Hz in front vowel environments). This result is compatible with the hypothesis that the frontness/backness of neutral vowels is not influenced by whether they occur in a front or back vowel environment. A slightly larger difference was found for /i/ than for /e/: the second formant for /i/ was 58 Hz higher in a front vowel environment than in a back vowel environment, the second formant for /e/ was 18 Hz higher in a front vowel environment than in a back vowel environment.

A second analysis of variance was performed, this time excluding words in which the neutral vowel preceded and did not follow either a front or back vowel. Thus, disyllabic words in which the first syllable contained a neutral vowel were ignored in this analysis (*hiha, iho, tikut, pesu, teho, pensas*). Excluding these words is justified, since the Finnish vowel harmony system is progressive, in that the choice of vowel backness/frontness is determined by the frontness/backness of the p r e c e d i n g vowel and not the following vowel. Put another way, frontness/backness features spread forward/rightward onto later vowels. Thus, given the nature of the vowel harmony system, we would expect the effect of the vowel following a neutral vowel to be minimal in comparison to the effect potentially exerted by the vowel preceding the neutral vowel.

Results of the second analysis of variance were similar to the first one in many respects. Only values for the second and not the first formant varied significantly ($p < .0001$) as a function of speaker: first formant for male speaker = 476 Hz vs. first formant for female speaker = 450 Hz (both neutral vowels combined), second formant for male speaker = 2037 Hz vs. second formant for female speaker = 2499 Hz. Values for both the first and second formant varied significantly ($p < .0001$) as a function of the vowel: /i/ once again had lower first formant (377 Hz vs. 552 Hz) and higher second formant (2382 Hz vs. 2160 Hz) values than /e/, reflecting the higher and fronter articulation of /i/ relative to /e/. First formant values also did not vary significantly as a function of whether the neutral vowels occurred in back or front vowel environments (first formant in front vowel environment = 448 Hz vs. first formant in back vowel environment = 477 Hz).

More interestingly, unlike in the first analysis, values for the second formant differed significantly ($p < .01$) as a function of the environment in which the neutral vowel occurred. When the neutral vowel followed a front vowel, it had significantly higher second formant values than when following a back vowel (2320 Hz vs. 2228 Hz), suggesting that neutral vowels are in fact fronter when they follow front vowels than when they follow back vowels. Both speakers showed the same trend with a larger difference occurring for the male speaker

than for the female speakers. The second formant was 135 Hz higher in a front vowel than in a back vowel environment for the male speaker; in comparison, the second formant was only 32 Hz higher in a front vowel than in a back vowel environment for the female speaker. The difference as a function of neighboring vowels is almost identical for /i/ and /e/ (88 Hz for /i/ vs. 87 Hz for /e/). The only vowel which did not differ substantially as a function of environment was /e/ for the female speaker (2435 Hz in back vowel environment vs. 2442 Hz in front vowel environment). Other than the lack of difference for /e/ for the female speaker, the pattern is otherwise consistent: second formant values are higher for neutral vowels following front vowels than following back vowels, with the difference being particularly large for the male speaker. Second formant for /i/ for male speaker = 2258 Hz vs. 2152 Hz, second formant for /e/ for male speaker = 1929 Hz vs. 1795 Hz, second formant for /i/ for female speaker = 2594 Hz vs. 2525 Hz.

The fact that second formant values for the neutral vowels differed significantly as a function of neighboring vowel quality in the second analysis but not the first analysis is compatible with the direction of vowel harmony. Vowel harmony at the phonological level in Finnish is progressive rather than regressive. The present study confirms that vowel harmony is progressive rather than regressive even at the phonetic level. It is only when tokens in which the neutral vowel follows a non-neutral vowel are isolated from tokens in which the neutral vowel does not follow a non-neutral vowel that we find a significant effect on the frontness/backness of the neutral vowel. This result indicates that a preceding vowel but not a following vowel exerts an effect on the place of articulation of a neutral vowel. Results of a Fisher's PLSD post-hoc test comparing second formant values for neutral vowels surrounded on both sides by non-neutral vowel (e.g. *tätihän*) with second formant values for neutral vowels o n l y p r e c e d e d by a non-neutral vowel (e.g. *täti*) were non-significant, confirming that coarticulation in Finnish vowels is primarily progressive rather than regressive.

3. Results of the present study suggest that the frontness/backness of neutral vowels is influenced by the frontness/backness of a preceding vowel much like the choice of non-neutral vowel is conditioned by the frontness/backness of a preceding vowel. In the case of the neutral vowels, however, the phonetic difference between the variant occurring after front vowels and the variant occurring after back vowels is much smaller than the more salient differences found in the non-neutral vowels. Vowel harmony for the neutral vowels functions at a low phonetic level, unlike vowel harmony for non-neutral vowels which involves alternations which are represented in the orthography and segments which are distinct phonemes in Finnish. Thus, whereas the two variants of the vowel found in the inessive suffix *-ssa/-ssä* are contrastive in Finnish stems, the two variants of the underlying phoneme /i/, [i] in front vowel environments and the slightly retracted variant [ɨ] in back vowel environments, are nowhere contrastive. The progressive nature of vowel harmony in Finnish was also corroborated by the present study: Second formant values for the neutral vowels are influenced by a preceding rather than by a following vowel.

The present study is not intended to be an exhaustive study of the low level effects of vowel harmony in Finnish. A more extensive corpus examining multiple factors, such as morphological composition, length of words, etc. would be necessary to satisfy this goal. It is hoped, however, that this paper provides some insight into a phenomenon which operates not only at the perceptually salient phonemic level but also on a more subtle phonetic level.

LITERATURE

W i i k, K. 1965, Finnish and English vowels; a comparison with special reference to the learning problems met by native speakers of Finnish learning English, Turku.

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НЕЙТРАЛЬНЫЕ ГЛАСНЫЕ В ФИНСКОМ ЯЗЫКЕ: НАСКОЛЬКО ОНИ НЕЙТРАЛЬНЫ?

Финский язык хорошо известен своей системой гармонии гласных, в соответствии с которой гласные звуки в слове согласуются между собой по нереднерядности / заднерядности. В статье рассматриваются фонетические особенности двух «нейтральных» гласных финского языка, которые не подчиняются закону гармонии гласных. В частности, в статье ставится вопрос: подчиняются ли нейтральные гласные гармонии гласных на фонетическом уровне. Измерения второго форманта нейтральных гласных (основной акустический коррелят заднерядности) показывают, что нейтральные гласные в соседстве с заднерядными гласными произносятся как более задние, чем в соседстве с переднерядными. Это позволяет предположить, что нейтральные гласные тоже испытывают влияние гармонии гласных. Влияние фонетической гармонии изначально носит скорее прогрессивный характер, чем регрессивный, как и в отношении большинства фонологически типичных гласных звуков, подчиняющихся гармонии гласных. Размеры фонетических различий, как и значение контекста, гораздо меньше в случае нейтральных гласных звуков, чем не-нейтральных.