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VARIATION IN FINNISH VOWEL HARMONY:
AN OT ACCOUNT*

This paper presents data on vowel harmony with disharmonic roots in Finnish which show that when the last harmonic vowel in a disharmonic root is back, in almost all cases the only possible harmonic suffix vowel is back, but when the last harmonic vowel is front, there is usually variation in suffix vowel choice that seems to be influenced by several factors, including sonority and stress. These data, which cannot easily be accounted for in rule-based theories, can be accounted for in Optimality Theory. A highly ranked alignment constraint accounts for harmony with native roots and loans in which the last harmonic vowel is back. Unranked constraints, which tie suffix vowel choice to stress and sonority, as well as alignment requirements, determine suffix vowel quality for the remainder of forms. Variation is seen to be a function of the relative frequency with which a particular suffix vowel is designated as optimal by the different possible rankings of the unranked constraints.

0. INTRODUCTION

Finnish vowel harmony has received considerable attention in the literature of generative phonology because of its relevance for a variety of issues in phonological theory. Different analyses of Finnish vowel harmony, many of which include discussions of disharmonic roots, are presented in Campbell (1980, 1981), Halle and Vergnaud (1981), Kiparsky (1973, 1981), Goldsmith (1985), Ringen (1988b), Steriade (1987), Valimaa-Blum (1987), and Vago (1988), among others.

This paper reports on the results of our empirical investigation of vowel harmony with Finnish disharmonic roots.[1] Our studies were conducted in

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[1] Practically all disharmonic roots are loanwords, although not all loanwords are disharmonic. The status of these words as loanwords per se is not important. Our claims are about disharmonic roots, regardless of whether or not they are loanwords or whether speakers recognize them as loans.

Helsinki with native speakers of Finnish at the University of Helsinki. We found that vowel harmony with Finnish disharmonic roots has not been accurately portrayed in the literature.[2] Although suffix vowel choice is categorically front or back with some disharmonic forms, there is variation in suffix vowel choice in other cases. In almost all cases when the last harmonic vowel in a disharmonic root is back, the only possible harmonic suffix vowel is back. When the last harmonic root vowel is front, however, most forms exhibit variation that seems to be influenced by the quality of the vowel with primary stress, the quality of the vowel with secondary stress, the quality of the most sonorous vowel, as well as the quality of the last vowel in the root. These data, which cannot easily be accounted for in rule-based theories, can be accounted for in Optimality Theory (McCarthy and Prince 1993a, 1995; Prince and Smolensky 1993) if it is assumed that constraints are partially ranked. A highly ranked constraint requiring that the feature [+back] be aligned with the right edge of the word accounts for harmony with native roots and disharmonic roots in which the last harmonic vowel is back. Unranked constraints which require that suffix vowels agree with the backness of the vowel which is most sonorous, with the vowel with primary stress, with the vowel with secondary stress, and with the last root vowel determine suffix vowel quality for the remainder of forms. For native roots, any ranking of these unranked constraints will give the correct result because all the vowels will be front. For disharmonic roots, however, different results are possible. The variation that occurs is seen to be a function of the relative frequency with which a particular suffix vowel is designated as optimal by the different possible rankings of the unranked constraints.

1. FACTS OF VOWEL HARMONY

The essential characteristics of Finnish vowel harmony are well-known and uncontroversial. There are eight surface vowels which are listed in (1):

(1)   neutral   harmonic
       front   front   back
       i [i]   y [y]   u [u]
       e [e]   ö [ø]   o [o]
                      ä [æ]   a [ɑ]

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[2] See Kontra and Ringen (1986, 1987) and Ringen and Kontra (1989) for discussions of empirical investigations of Hungarian vowel harmony which show that certain widely cited data are, in fact, not accurate.

In native Finnish noncompound words, front and back harmonic vowels
do not co-occur. Neutral or transparent vowels, on the other hand, are
found in words with either front vowels (harmonic or neutral) or with
back vowels. Some examples are given in (2):[3]

(2)   a. pöytä   'table'

        b. póuta   'fine weather'

        c. hämärä   'dusk'

        d. käsi   'hand'

        e. kóti   'home'

        f. késy   'tame'

        g. véli   'brother'

        h. véro   'tax'

        i. tie   'road'

Harmonic suffix vowels usually agree in backness with harmonic root
vowels, as illustrated in (3):

(3)   a. pöytä-nä   'table'   essive

        b. póuta-na   'fine weather'   essive

        c. hämärä-nä   'dusk'   essive

        d. käde-llä   'hand'   adess

        e. kóti-na   'home'   essive

        f. késy-llä   'tame'   adess

        g. véro-lla   'tax'   adess

If all root vowels are neutral, harmonic suffix vowels are (usually) front,
as illustrated by the examples in (4):

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(4)   a. vélje-llä   'brother'   adess.

       b. tié-llä   'road'   adess.

But loanwords often violate harmony restrictions, as illustrated by the disharmonic forms in (5):

(5)   disharmonic loans
       a. vúlgääri   'vulgar'

       b. týranni   'tyrant'

       c. áfääri   'affair'

       d. ánalýysi   'analysis'

It is sometimes claimed that suffix vowels following such disharmonic roots agree with the last harmonic root vowel, e.g., Kiparsky (1973). The situation is not this simple, however. While it is generally agreed that a disharmonic root in which the last harmonic vowel is back requires back harmonic suffix vowels, there is variation with disharmonic roots in which the last harmonic vowel is front. Moreover, what the facts are has not been clear. Different Finnish (normative and descriptive) grammars do not agree with each other or with generative phonologists who have made claims about which suffix vowels occur with such disharmonic roots. The Language Board of the Finnish Literature Society recommended in 1945 (Sadeniemi 1946, pp. 79–80) that in addition to *i* and *e*, *y* should also be treated as neutral in loanwords whereas *ö* and *ä* should always be considered harmonic. Saarimaa's normative grammar (1971, p. 17) presents *y* as basically neutral, while *ö* and *ä* are said to be harmonic, especially when they are long. Penttilä's grammar (1963, p. 17) also considers *y* to be neutral, but *ö* and *ä* are said to be always harmonic. Ikola (1986, pp. 134–135) considers all the front vowels *y*, *ö* and *ä* to be basically harmonic, but states that *y* may also be neutral when unstressed. Campbell (1980, p. 251), on the other hand, claims that in certain disharmonic loanwords both front rounded vowels *y* and *ö* may be treated as neutral, so that both alternates of forms such as those in (6) are possible:

(6)   a. y/ö – neutral   b. y/ö – harmonic
          hiéroglýfi-a   hiéroglýfi-ä   'hieroglyph' part.sg.

          sútenööri-a   sútenööri-ä   'pimp' part. sg.

          ámatööri-a   ámatööri-ä   'amateur' part. sg.

In addition, Campbell, referring to Ikola (1971) and Saarimaa (1971), claims that the forms in (6a), with a back suffix vowel, occur more frequently and are considered to be better, more prestigious, while the forms in (6b), with a front suffix vowel, are more colloquial. However, both Ikola and Saarimaa give normative rules and say nothing about the frequencies of these forms in actual use. Kiparsky, as reported in Steriade (1987), claims that all the front vowels y, $ö$, $ä$ are optionally treated as neutral in disharmonic loanwords. Thus, according to Steriade, Kiparsky claims that both the forms in (7) are possible:

(7)   hýdrosfääri-a   hýdrosfǎǎri-ä 'hydrosphere' part.sg.

2. Empirical Investigations

There is very little research on what suffix vowels are found with disharmonic loanwords.[4] In order to find out what kind of variation occurs with disharmonic loanwords such as those in (6) and (7) we administered a series of questionnaires to native speakers of Finnish in Helsinki. In our first test,[5] the subjects were 50 students in four different courses in summer school at the University of Helsinki. The courses were mathematics, statistics, physics, and Swedish for students of math and the natural sciences. Ages ranged from 17 to 49. The subjects were all native speakers of Finnish, and half were male (=25) and half female. Forty of the subjects resided in Helsinki or the surrounding area; the other 10 were from various places in Finland.[6] Subjects were presented with 29 written sentences containing blanks and asked to supply an appropriate form or forms of a word given in its nominative singular. No suffix identical to that appropriate for the test word occurred in the sentence frames since Kontra, Ringen, and Stemberger (1991) found that a preceding identical suffix can influence harmonic suffix vowel choice.[7] Subjects were instructed to

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[4] One study is Levomäki (1972), who tested acceptability of front vs. back vowel suffixes using students in the humanities as subjects. He found a great deal of variation and concluded that, contrary to claims in Finnish grammars, the behavior of y is not the same as the neutral vowels i and e.

[5] A copy of this questionnaire is given in Appendix A.

[6] There was no significant difference between the responses of subjects who were from the Helsinki area and those from other places in Finland.

[7] In a study of Hungarian vowel harmony, Kontra, Ringen, and Stemberger (1991) found that a preceding morphologically identical suffix (within a sentence) influenced speakers' choice of suffix vowel: a preceding (morphologically identical) *front* vowel suffix increased the number of front suffixes that Hungarian speakers used with loanwords, whereas a preceding (morphologically identical) *back* vowel suffix increased the number of back vowel suffixes they used. To check whether there was a similar priming effect in Finnish, we gave another group of 50 students a test where the target words occurred in three environments:

preserve the singulars in their answers and to make decisions only on the basis of what sounded more natural, not what they thought the rules of grammar might say.

All the test words were loanwords, but ten were fillers containing only back vowels. All subjects used back vowel suffixes for all fillers. Some examples are listed in (8):

(8)   All subjects used back suffix vowels for all fillers

    a. tábaskò-a   'Tabasco'   part. sg.

    b. júrtta-a   'yurt'   part. sg.

    c. rótundà-sta   'rotunda'   elat. sg.

    d. sáluunà-sta   'saloon'   elat. sg.

    e. tórnadò-a   'tornado'   part. sg.

There were two types of disharmonic loanwords. In one, the order of vowels was front harmonic vowel then back vowel. The results of this group are given in (9). We see virtually no variation; practically all suffix vowels are back.[8]

(9)

		% Front	% Back	% Both	
	a. sýntaksi	0.0	100.0	0.0	'syntax'
	b. sýmptomi	2.0	96.0	2.0	'symptom'
	c. týranni	0.0	98.0	2.0	'tyrant'
	d. följetòngi	0.0	100.0	0.0	'serial'
	e. kýsta	0.0	100.0	0.0	'cyst'

The other type of loanword had a back vowel followed by a front harmonic vowel. Suffix vowels with these words exhibit variation. There were nine of these words, three for each front vowel height. The results are given in (10)

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in two of them, there was a primer, i.e., a preceding identical suffix with a front vowel or a back vowel. The third environment did not contain any suffix identical to the test word. No priming effect was found. The responses in the three conditions did not differ significantly.

[8] The situation is more complex when a front harmonic vowel is followed by a back harmonic vowel and then more than one neutral vowel as in *dýnamìitti* 'dynamite' where variation is found for some forms. Such examples are discussed below.

(10)	% Front	% Back	% Both	Gloss
a. hiéroglỳfi	80.0	12.0	8.0	'hieroglyph'
ánalỳysi	50.0	36.0	14.0	'analysis'
márttyyri	42.0	42.0	16.0	'martyr'
b. sútenööri	94.0	2.0	4.0	'pimp'
jónglööri	86.0	6.0	8.0	'juggler'
ámatööri	82.0	10.0	8.0	'amateur'
c. míljonääri	100.0	0.0	0.0	'millionaire'
hýdrosfääri	96.0	2.0	2.0	'hydrosphere'
áfääri	80.0	16.0	4.0	'affair'

The numbers indicate the percentages of subjects that responded with a suffix containing a front vowel, a back vowel, or two alternatives, one with a back vowel and one with a front vowel. There is some variation for all but one word, *míljonääri*. However, the majority of subjects responded with a front suffix vowel for all but one of the words, *márttyyri*.[9]

Some have suggested that the variation is related to prestige; one variant has greater prestige than the other. It will be recalled that Campbell suggests that the back suffix vowel "sounds better" and is "more frequent" with these disharmonic roots. However, when asked directly which one sounded better, the majority of our subjects responded with front suffix vowels, not back suffix vowels. Given the formality of the situation, we would not have expected subjects to have used the more colloquial, lower prestige forms.

To see if we could get subjects to respond with more back vowels, we administered another questionnaire to a different group of 30 students at the University of Helsinki, There were 17 females and 13 males, ranging in age from 19 to 39. This questionnaire was identical to the first except that the subjects were asked to use the correct forms, the ones they would use in a formal text. The different directions did not cause subjects to give more back vowel responses. In fact, in six of the nine cases, the percentage

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[9] One reviewer has suggested that we may have found back suffix vowels with these disharmonic roots which end in a front vowel because the filler sentences all had test words with back vowels and therefore there was a priming effect. While we cannot establish that there is no priming effect, we do not think that there was one. First, we checked for priming effects within sentences (see fn. 7) and found none. Second, we find that in some cases all suffix vowels were front (e.g., *míljonääri*) even though the preceding test word had only back vowels (*ánafòra*) and this is one of the last test words on the questionnaire. Third, when we have tested these same words on other questionnaires with no fillers, results are not different.

of front responses was *higher*, not lower than on the first questionnaire. We conclude that although there is clearly variation in suffix vowel choice, our data do not support Campbell's claim that Finnish speakers use back suffixes more frequently than front suffix vowels with loanwords such as in (10) or his claim that the back suffix vowels are viewed as more learned and more prestigious.

Likewise, our results do not support those who suggest that different styles account for the variation. These include Välimaa-Blum (1987), who claims that different rules apply in different styles, Kiparsky (1981) who says that different vowels are opaque in different styles, and Steriade (1987), who says that vowel harmony applies at different points in the derivation in different styles. We found that the same subjects in the same situation on the same day sometimes used back vowel suffixes and sometimes used front vowel suffixes with the forms in (10).[10]

Another explanation for the variation that has been offered in the literature (e.g., by Halle and Vergnaud 1981) is that there are two dialects, one that uses front vowels and another that uses back vowels in suffixes of disharmonic loans. Those who vary in their use of suffix vowel choice are mixing dialects. But this account is not plausible either. First, there is no evidence that we know of, nor that Halle and Vergnaud provide, for the existence of either dialect other than the existence of variation. Second, even if we accept the claim that there are two dialects, the majority of our subjects (68%) on the first test sometimes used back suffix vowels and sometimes used front suffix vowels with disharmonic roots in which the last harmonic vowel is front. These are the subjects who mix dialects according to Halle and Vergnaud. We are still left with the question of why so many more of these subjects use front vowels with some forms (e.g., *hiéroglỳfi*) than with others (e.g., *márttyyri*). If this is simply a matter of dialect mixing, we would expect that *hiéroglỳfi* and *márttyyri* should be equally likely to take back vowel suffixes. Finally, Halle and Vergnaud predict that those who mix dialects will exhibit variation in suffix vowel choice with forms like *miljonääri* and *hỳdrosfääri*, but we find essentially no variation in suffix choice with these forms.

Yet another explanation that has been offered in the literature for the suffix vowel variation in loanwords is that some of the words are analyzed by speakers as compounds. With compounds, suffix vowel quality is determined by the harmonic quality of the vowels in the last member of

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[10] We have not, of course, shown that there are no differences in usage in different styles, but we have shown that there is substantial variation that does not seem to be a function of style.

the compound. For example, Välimaa-Blum (1987) cites Sadeniemi (1949), who suggests that subjects analyze loanwords such as those in (11) as compounds because their stress patterns are like those of compounds, which have secondary stress on the first syllable of the second element in the compound (e.g., kírja#kàuppa 'bookstore').

(11)   áppelsìini   'orange'

         káramèlli   'candy'

         dýnamìitti   'dynamite'

The results with some of the disharmonic loanwords in (10) might be explained as cases that speakers analyze as compounds. This is illustrated in (12).

(12)   % Front
         hiéro#glỳfi   80%

         ána#lỳỳsi   50%

         súte#nööri   94%

         áma#tööri   82%

         míljo#nääri   100%

         hýdros#fääri(or hýdro#sfääri)   96%

The suggestion is that speakers who use front vowels are analyzing, for example, ánalyỳsi as a compound, ána#lyỳsi. Since the second member of the 'compound' contains only front vowels, the suffix vowels are front. In contrast, those speakers who use back suffix vowels are using a prescriptive rule which treats *all front vowels as neutral in disharmonic loanwords*. Hence, for these speakers a disharmonic loanword such as ánalyỳsi will require back suffix vowels because there is a back vowel in the word.[11]

   There are two problems with this account. First, we still cannot explain the difference between the forms. Why, for example, do we have 100% front suffix vowels with míljonääri but 50% front suffix vowels with ánalyỳsi? Second, three of the words we tested are not plausible compounds and hence are incorrectly predicted to allow only back suffix vowels. These are given in (13a) below. Thus, even if we accept the claim that the back suffixes for *some* of the disharmonic loans can be explained by assuming that some speakers treat all front vowels in disharmonic loanwords as

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[11] This position is similar, but not identical to that of Välimaa-Blum (1987).

neutral and others analyze the same words as compounds, there are other disharmonic loans that cannot be so explained. In addition to the three listed in (13a), we tested other words that cannot be analyzed as compounds on a second questionnaire. The results for these words are given in (13b):

(13)			% Front	% Back	% Both
	a.	áfääri	80.0	16.0	4.0
		jónglööri	86.0	6.0	8.0
		márttyyri	42.0	42.0	16.0
	b.	kásööri	64.0	32.0	4.0
		vúlgääri	58.3	29.2	12.5

Finnish (non-derived) nouns usually consist of two syllables. If three syllable words such as *márttyyri* are analyzed as compounds, then one of their component words must be monosyllabic. Although Finnish does have some monosyllabic nouns, these contain long vowels or diphthongs, e.g., *maa* 'earth', *yö* 'right'.[12] Neither the first nor the last syllable of the three syllable words in (13) fit this pattern. Finnish also has restrictions on word-final consonants: no word-final consonant clusters are permitted, and only dentals, i.e., t, s, n, r, and l, are permitted word-finally – and even these are relatively rare in the nominative singular form. Hence, four-syllable words where the second syllable ends in a vowel are the best candidates for a compound analysis. For example, there is no way to analyze *jónglööri* as a compound. While *lööri* is a possible Finnish noun, *jong* is not. Nor is there any other way to divide this word into two possible Finnish nouns. In short, the 'compound' analysis hypothesis might account for some of the variation, but it cannot account for all of it.

We did, however, find some evidence in support of the idea that speakers do sometimes treat disharmonic loanwords as compounds. Neutral vowels are not supposed to have any effect on the suffix vowel choice. Yet it has been reported (e.g., by Campbell 1980; Levomäki 1972; Sadeniemi 1946) that there are loanwords with back vowels followed by several neutral vowels with which people tend to use front harmonic suffix vowels. We included words with back vowels followed by several neutral vowels on questionnaires 1 and 2 in order to see if this is true. These are given in (14). As can be seen, not all of these forms show any significant number of front suffix vowels. Indeed, the only forms for which many subjects

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[12] *yö* is a diphthong.

used *front* suffix vowels are the first four, those that are most plausibly analyzed as compounds.

(14)	% Front	% Back	% Both	Gloss
árkkitèhti	48.0	34.0	18.0	'architect'
bólshevìkki	26.0	70.0	4.0	'Bolshevik'
káramèlli	16.0	78.0	6.0	'candy'
dýnamìtti	8.0	70.8	20.8	'dynamite'
kátrilli	6.0	94.0	0.0	'quadrille'
fákultèetti	4.8	95.2	0.0	'faculty'
ádjektìvi	4.0	92.0	4.0	'adjective'
ártikkèli	4.0	96.0	0.0	'article'
fákiiri	0.0	100.0	0.0	'fakir'
mátrikkèli	0.0	96.0	4.0	'register'
pártikkèli	0.0	96.0	4.0	'particle'
áteisti[13]	0.0	96.0	4.0	'atheist'

It seems to us that these results do not support the claim that roots ending with more than one neutral vowel tend to have more front suffix vowels than otherwise would be predicted by the regular operation of harmony.[14] Rather, these data seem to support the claim that the suffix variation that is found is due to (some) speakers' analysis of certain forms as compounds. That is, the reason that some speakers use front suffix vowels with the first four forms is that they are treating these words as if they were compounds. If this is correct, then when a compound analysis is plausible, variation can be expected in words with a back vowel followed by several neutral vowels. Specifically, if subjects were treating all the forms in (14) as noncompound forms, we would expect only back suffix vowels, essentially as we see in the last eight forms. If, however, some of the subjects treat some of the forms as compounds, we would expect to see front suffix vowels, as we do in the first four forms. For example, if *árkkitèhti* is analyzed as *árkki#tèhti*, then by the regular rules of harmony, we would expect front suffix vowels. If all speakers analyze this form as a compound, we would expect only front suffix vowels, which is not what we find. It appears that, on average, about 25% of the subjects treated those forms for which a compound analysis is plausible as compounds.

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[13] Valimää-Blum (1987) mentions *áteisti* as a form which could be analyzed as a compound, but few of our subjects seem to have treated it this way.

[14] Neutral vowels do affect suffix harmony in Hungarian. Subjects use almost exclusively front harmonic suffix vowels in words with back vowel(s) followed by more than one neutral vowel (*bronchitisz* 'bronchitis' *bronchitisznek*) (Ringen 1988a; Kontra and Ringen 1986, 1987).

Summarizing at this point, we find that in disharmonic loanwords there is no variation in suffix vowel choice when a front harmonic vowel is followed by a back vowel, but there is variation when a back vowel is followed by a front harmonic vowel. Contrary to what Campbell (1980) has claimed, however, with disharmonic roots in which the last harmonic vowel is front, front harmonic suffix vowels – and not back vowels – are more frequent, sound more natural, and are thought to be correct by the majority of our subjects. Our results suggest that the variation of the suffix vowels cannot be accounted for by saying that there are two dialects and that individual variation results from dialect mixing (as Halle and Vergnaud 1981 have claimed). Likewise, our results do not support those who suggest that different styles account for the variation. Finally, our results show that the 'compound analysis hypothesis' cannot alone account for all of the data although they do seem to support the claim that some loanwords are analyzed as compounds.

The measure of the variation in suffix vowel choice that we used for an individual is the percentage of subjects who responded with two alternatives, one with a back suffix vowel and another with a front suffix vowel. Subjects were not asked whether both forms would be appropriate. We thought that actual individual variation might be greater than our tests suggested. As can be seen in (10), the percentage of people who gave more than one form of the test words is very small: it was under 10% for all but two disharmonic words, *anályỳsi* with 14% and *márttyyri* with 16% both responses. In order to see whether individuals' variation is greater than our tests suggested, the same questionnaire was given to a group of students twice, with an interval of one month between tests. The group consisted of 50 students of foreign languages, 38 female and 12 male. The ages ranged from 18 to 34. Thirty of the students resided in the Helsinki area, while the other 20 were from various places in Finland. The results are given in (15). % Stable Front and % Stable Back show the percentage of subjects who were *consistent* in their choice of front or back suffix vowels on *both* tests. % Variation shows the percentage of subjects who either gave both alternatives on one or both of the tests, or who gave different responses on the two tests, e.g., a front suffix vowel on one and a back suffix vowel on the other test.

(15)   Results of Tests 3 & 4

		% Stable		% Variation
		Front	Back	
a.	hiéroglỳfi	68.0	6.0	26.0
	ánalyỳsi	40.0	12.0	48.0
	márttyyri	24.0	44.0	32.0
b.	sútenööri	90.0	0.0	10.0
	ámatÖÖri	80.0	2.0	18.0
	jónglÖÖri	72.0	2.0	26.0
c.	hýdrosfääri	96.0	0.0	4.0
	míljonääri	92.0	0.0	8.0
	áfääri	68.7	6.3	25.0

When we compare the figures in (15) to those in (10), we see that the variation on an individual level is clearly greater than suggested by the percentage of subjects who supplied two forms. The greater variation in (15) is not due to differences between the groups themselves. The reader is referred to Appendix B to see that the subjects' both responses are very similar to those of the group whose results were given in (10).

In (15a), where a back vowel is followed by *y*, roughly one fourth to one half of the subjects showed variation in their suffix vowel choice. In (15b), where a back vowel is followed by *ö*, the variation ranges between 10% and 26%. Least variation was found in (15c), where a back vowel is followed by *ä*: even though *áfääri* shows 25% of variation in suffix vowel choice, *hýdrosfääri* and *míljonääri* remain under 10% in variation. Taken together, the variation in suffix vowel choice is greatest in words where the front harmonic vowel *y* follows a back vowel.

3. AN OT ACCOUNT

We have seen that earlier attempts to explain variation are unsatisfactory. Moreover, it is not clear that any rule-based account within any framework can account for the variation we found. The challenge these data present, when considered in the context of native roots, is that suffix vowel choice for native roots shows no variation – it is categorical: whether front vowel suffixes or back vowel suffixes occur is a function of the quality of vowels in the root. Similarly, when the last harmonic vowel in a disharmonic loanword is back, the suffix vowels are categorically back. But there is significant variation when the final harmonic vowel is front in a disharmonic loanword. We suggest that Optimality Theory (OT) provides a way

not only to account for the this kind of asymmetry – there is variation with disharmonic roots in which the final root vowel is front but not when the final root vowel is back or with harmonic roots – but also to predict how much variation occurs. It is not clear how any rule-based account could do the former. It *is* clear that no rule-based account has ever been proposed that is capable of doing the latter.

We will argue that the choice of suffix vowel is influenced by stress and openness of root vowels. Initial vowels are stressed in Finnish with secondary stress on subsequent odd vowels except that vowels in final syllables are not stressed. Stress seems to play some role in suffix vowel choice as claimed by Anderson (1980), among others, who suggests that the harmonic strength of vowels is weaker when they are unstressed. For example, subjects report more back suffix vowels with *análỳsi* where the vowel with primary stress (the first vowel) is back than with *hiéroglỳfi* where the vowel with primary stress is neutral. And they report more back suffix vowels with *márttyyri* than *hiéroglỳfi*, both of which have *y* preceded by a back vowel, but the former has a *stressed* back vowel and an *unstressed* front harmonic vowel whereas the latter has an *unstressed* back harmonic vowel and a front harmonic vowel with (secondary) *stress*. Similarly, subjects report substantially more front suffix vowels with *hýdrosfääri* than with *áfääri*, even though both end with a back vowel followed by (long) *ä* and then *i*. Here the back vowel is unstressed and the front harmonic vowel is stressed in the former, but the back vowel is stressed and the front harmonic vowel is unstressed in the latter. In addition, the data in (10) and (15) support the suggestion that in disharmonic loans harmonic strength of front vowels correlates with openness: *ä* is most strongly front harmonic and *y* is weakest.

Many recent analyses of vowel harmony in the framework of OT have assumed that harmony results from alignment constraints (McCarthy and Prince 1993b) which require that two linguistic constituents be aligned at some edge as suggested by Kirchner (1993).[15] Zoll (1996), however, points out that alignment constraints do not, as commonly assumed, differentiate between constituents that miss alignment at some edge by one segment or by two or several segments. Either the constituents are aligned or they are not; more misalignment does not result in multiple violations. Following Zoll (1996), we adopt the formulation of alignment suggested in Ellison (1995), NO-INTERVENING, for which there is a straightforward way to compute multiple violations:

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[15] This analysis will work equally well if we assume a constraint MULTIPLE LINK [+back] which requires that the feature [+back] be multiply linked.

(16)   No INTERVENING[+back]
        No vowel intervenes between [+back] and the right edge of
        the word.

One violation is assessed for each vowel that intervenes between the
feature [+back] and the right edge of the word.

In Finnish, root vowels determine suffix vowel quality, never the re-
verse. We assume a positional faithfulness constraint that mandates faith-
fulness to input specification for backness in *harmonic root vowels*. Seg-
ments in prominent positions such as roots, stressed syllables and initial
syllables are often subject to more stringent faithfulness constraints than
are other segments, as has recently been well documented (Beckman 1997,
1998; McCarthy and Prince 1995).[16]

(17)   IDENT-IO$_{HARM/ROOT}$
        Correspondent harmonic root vowels have identical specifi-
        cations for backness in the input and output (where harmonic
        vowels are vowels that are either low or round).

This means that an input harmonic root vowel must have the same specifi-
cation for backness as does its correspondent vowel in the output and an
output harmonic root vowel must have the same backness specification as
does its correspondent input vowel.

In addition, we assume an inventory constraint which disallows non-low
back unrounded vowels, which do not occur in Finnish (Kiparsky 1981,
Ringen and Vago 1995, 1998; Smolensky 1993):

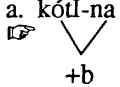(18)   *ɨʌ If a vowel is non-low and unrounded, it must be front.

These constraints will give us the desired results for native roots with back
vowels and for disharmonic loanwords in which the final harmonic vowel
is back. In particular, the prediction is that these forms will always require
back suffix vowels.

In the case of a native back harmonic root *kóti*, these constraints will
correctly choose an output candidate with a back suffix vowel over one
with a front vowel (3d), as illustrated in (19). Vowels unspecified for
backness are indicated by capital letters. Note that the optimal output has
a vowel unspecified for backness. Unrounded non-low vowels unspecified
for backness must be interpreted as front.

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[16] Beckman (1998) attributes the original idea to Selkirk (1994) who uses positional PARSE(F)
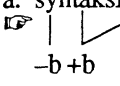constraints.

(19)   input: koti + nä[17]
                 | | |
                +b–b –b
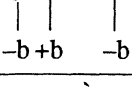
Candidates	*ᵢ∧	ID-IO$_{HARM/ROOT}$	NO-INT + B
a. kótI-na ☞ \/ +b			
b. kóti-na \/ +b	*!		
c. kóti-nä |/ +b–b			*!*
d. kÓtI-na / +b		*!	

These constraints also give the correct results for the disharmonic loans such as those in (9), that is, loanwords in which the final harmonic vowel is back. The tableau in (20) shows this for *sýntaksi* (19a):

(20)   input: syntaksi- nä
                 | | | |
                –b +b –b –b

Candidates	*ᵢ∧	ID-IO$_{HARM/ROOT}$	NO-INT + B
a. sýntaksÌ-na ☞ | / –b +b			
b. sýntaksì-na | / –b +b	*!		
c. ‚ṣýntaksÌ-nä | | | –b +b –b			*!*
d. súntaksÌ-na \/ +b		*!	

---

[17] We assume, arbitrarily, that the input suffix vowel is specified as [−back]. Regardless of whether this suffix vowel is specified as [+back], [−back], or is unspecified for backness, the same output candidate will be optimal.

The unsuffixed form of *syntaksi* in (21) shows that *$*_{iʌ}$ must be ranked higher than No-Intervening [+back].

(21)   input: syntaksi
                  | | |
                 –b +b –b

Candidates	*$_{iʌ}$	ID-IO$_{HARM/ROOT}$	No-Int + B
a. sýntaksi ☞ | | | –b +b –b			*

b. sýntaksɪ
    | \/
   –b +b
	*!		

*$_{iʌ}$ » No-Int + B

These contraints do not predict the correct form for suffix vowels following native roots with only front vowels or for disharmonic roots in which the final harmonic vowel is front. In (22) the native root *hämärä* (2c, 3c) is shown. Since the alignment constraint refers only to [+back], it will not align a [−back] feature.

(22)   input: hämärä + nä
                   \/ |
                  –b   –b

Candidates	*$_{iʌ}$	ID-IO$_{HARM/ROOT}$	No-Int + B

a. hámärà-nä ☞
   \\/\/
    –b			

b. hámärà-nA ☞
    \/
    –b			

c. hámärà-na ☞
   \/ |
   –b +b			

Notice that for a native root with only front vowels such as *hämärä* 'dusk' several constraints would work. A constraint requiring that no vowel intervene between the feature [−back] and the right edge of the word would give the correct output, as would a constraint requiring that all vowels have the same specification for backness as does the vowel with

primary stress (or the root-initial vowel), the vowel with secondary stress, or a constraint requiring that all vowels have the same specification as does the most sonorous root vowel. That any of these constraints will give the same and the correct output for front harmonic roots is the key to explaining the distribution of suffix vowels with disharmonic loans in which the last harmonic vowel is front. Suppose we assume that there are several constraints, all of which would give the same result for native front harmonic roots, and that they are unranked below the three constraints assumed so far: *ɨA, IDENT-IO$_{HARM/ROOT}$, and NO-INTERVENING[+BACK]. Since they all make the same prediction, this lack of ranking makes no difference in the case of native roots. Whichever ranking is utilized will have the same result.[18] But in the case of disharmonic loanwords in which the last harmonic vowel is front, these constraints are capable of predicting different outcomes, depending on the other vowels in the word. Here we follow Kiparsky (1993) and Anttila (1997) who have used such unranked constraints to account for variation. Given that such constraints all make the same predictions for the vast majority of Finnish words, it is not unreasonable to assume that they are not ranked because there is no evidence in Finnish as to an appropriate ranking.

We suggest that there are two constraints that are concerned with stress, one right alignment constraint, and one that designates the most sonorous vowel as the trigger of harmony:

(23)   NO-INTERVENING[−BACK]
        No vowel intervenes between a [−back] feature and the right edge of the word.

(24)   PRIMARY STRESS
        All vowels have the same specification for [±back] as does the vowel with primary stress.

(25)   SECONDARY STRESS
        All vowels have the same specification for [±back] as does the vowel with secondary stress.

(26)   SONORITY
        All vowels have the same specification for [±back] as does the most sonorous vowel of the root.

---

[18] Note that when a native root such as *pöytä* is combined with a suffix such as *-lla/llä*, there will be no secondary stress and the decision will be passed to the next constraint in the ranking.

According to the sonority hierarchy, Finnish vowels would be ranked as in (27):

    (27)   Sonority Scale[19]
               ä, a ≫ ö, o, e ≫ i, y, u (low vowels are more sonorous than mid vowels, mid vowels are more sonorous than high vowels).

Because Finnish has both long and short vowels, we need to know how length figures into this scale. Assuming that length enhances sonority, we suggest that all long vowels are more sonorous than their short counterparts. This will give the following rankings:

    (28)   Sonority Scale   ää, aa≫ä, a,≫i, y, u
                                     ee, oo, öö ≫ ö, o, e ≫ i, y, u
                                       ii, yy, uu ≫ i, y, u

Let us suppose that all long vowels EXCEPT *yy* and *ii* are more sonorous than any short vowel. *yy* and *ii* are then only more sonorous than *y*, *i* and *u*.

    The resulting scale, in terms of sonority and length, will be as in (29):[20]

    (29)   Sonority Scale   ää, aa ≫ öö, oo, ee ≫ uu ≫ ä, a ≫ ö, o,
                                       e ≫ ii, yy ≫ i, y, u

There are 24 different possible rankings (4!) of the four constraints in (23)–(26). In six of these rankings, PRIMARY STRESS will be highest ranked and hence will determine the optimal output. If we take the predicted variation to be a function of the number of times a particular candidate is designated as optimal in the 24 rankings, then it is possible to predict different percentages of back suffix vowels for different disharmonic loan-words. On this view, the grammar consists of some ranked constraints and 4 which are not ranked. To obtain an output, however, it is necessary to have some arbitrary ranking of these unranked constraints. There are 24 such possible rankings and the grammar will then yield different outputs with different rankings. With a native root like *hámärä*, with front harmonic vowels, all rankings will produce the same optimal output – one with a front harmonic suffix vowel. But for disharmonic roots, different results are possible. This is illustrated for *hiéroglỳfi* (6a, 10a) which can take either a back vowel or a front vowel suffix.

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[19] Anttila (1997) suggest that sonority plays a role in the selection of variants of the GEN-PL in Finnish.

[20] The data we have are consistent with other scales. For example, Harms' (1982) tonality scale for front vowels or Bladon and Lindblom's (1981) perceptual scale will also work.

(30) input: hiéroglỳfi-a   **6 rankings yield ä**
       \| \| $\mathcal{V}$ \|
    –b+b–b +b

Candidates	*iʌ	ID-IO_{HARM/ROOT}	NO-INT + B	PRIM	SEC	SON	NO-INT – B
a. hiéroglỳfi-ä ☞ $\mathcal{V}$ | $\mathcal{V}$ –b +b –b				***	*	*	*****	****
b. hiéroglỳfi-a $\mathcal{V}$ | $\mathcal{V}$ | –b +b –b +b				***	**!	**	****	*****
c. hiéroglùfl-a $\mathcal{V}$ $\mathcal{V}$ –b +b			*!		****	***	***	****

ID-IO_{HARM/ROOT} » NO-INT + B

If PRIMARY is ranked immediately below NO-INTERVENING[+ BACK], then the candidate with the front suffix vowel will be optimal. There are 6 rankings in which PRIMARY STRESS is ranked over SECONDARY STRESS, SONORITY, and NO-INTERVENING[– BACK] (because there are 3! rankings of the other constraints) and hence in 6 out of the 24 rankings the optimal output will have a front harmonic suffix vowel. These 6 rankings are illustrated in (31):

(31) PRIMARY SECONDARY SONORITY NO-INT[– BACK]
    PRIMARY SECONDARY NO-INT[– BACK] SONORITY
    PRIMARY SONORITY SECONDARY NO-INT[– BACK]
    PRIMARY SONORITY NO-INT[– BACK] SECONDARY
    PRIMARY NO-INT[– BACK] SONORITY SECONDARY
    PRIMARY NO-INT[– BACK] SECONDARY SONORITY

Since the top-ranked constraints will never be the deciding constraints when a front harmonic vowel is final in a disharmonic root, these constraints are not included in tableaux which follow.

If SECONDARY STRESS is highest ranked, as in (32), there are six rankings which will also yield a front harmonic suffix vowel.[21]

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[21] It might appear that SECONDARY would not have an effect with three-syllable roots like *áfääri* because there is no secondary stress on the final root vowel since no stress falls on word-final syllables. But when a suffix is added, e.g., *áfääri-ssä*, there will be stress on the third vowel because it is no longer in the final syllable.

(32)   input: hieroglyfi-a   **6 rankings yield ä**

Candidates	SEC	SON	NO-INT – B	PRIM
☞ a. hiéroglyfi-ä –b +b –b	*	*****	****	*
b. hiéroglyfi-a –b +b –b +b	**!	****	*****	**

In contrast, if SONORITY is ranked highest, then the back vowel alternant will be optimal as illustrated in (33):

(33)   input: hieroglyfi-a   **6 rankings yield a**

Candidates	SON[22]	NO-INT – B	PRIM	SEC
a. hiéroglyfi-ä –b +b –b	*****!	****	*	*
☞ b. hiéroglyfi-a –b +b –b +b	****	*****	**	**

Finally, in six of the rankings NO-INTERVENING[−BACK] will be ranked highest and the optimal candidate will have a front harmonic suffix vowel. This is illustrated in (34):

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[22] We assume that *o* is more sonorous than the diphthong *ie*.

(34)   input: hieroglyfi-a   **6 rankings yield ä**
        |/ | |/ |
        –b +b –b +b

Candidates	No-Int – b	Prim	Sec	Son
a. hiéroglỳfi-ä ☞ |/	|/ –b +b –b	****	*	*	*****
b. hiéroglỳfi-a |/	|/	–b +b –b +b	*****!	**	**	****

Thus, 18 of the 24 possible rankings of these constraints (that is, 75% of the possible rankings) will choose the front vowel suffix as optimal. However, as noted above, evidence suggests that those forms that can be analyzed as compounds such as *hiéroglỳfi* are indeed so analyzed approximately 25% of the time. If we assume that 25% of Finnish speakers analyze *hiéroglỳfi* as a compound, then the harmony constraints we have assumed will require that suffix vowels be front, no matter which ranking is used, because in *glỳfi* there are only front vowels. As we have just seen, for the 75% of the speakers for whom *hiéroglỳfi* is not treated as a compound, the likelihood of a ranking that yields a front suffix vowel is 75%. Overall the grammar predicts front suffix vowels in 81.3% of all cases ($0.75 \times 0.75 + 0.25 \times 1.00 = 81.3\%$).

Our tests did not involve a forced choice and hence we do not know what percentage of our subjects would have reported front suffix vowels with *hiéroglỳfi* if they had been forced to give only one response. We do know that 40 subjects responded with a front suffix vowel and 6 with a back suffix vowel, while 4 gave two forms, one with a front vowel and one with a back vowel. In computing the observed frequencies for comparison with the predictions of our grammar, we have eliminated those subjects who gave both responses. This means that 40 of 46, or 87%, of the subjects responded with a form with a front suffix vowel for *hiéroglỳfi*.

Assuming that plausible compounds are assumed to be compounds 25% of the time, the predicted vs. observed frequencies of front suffix vowels are given below. Since *márttyyri*, *kásööri*, *jónglööri*, *áfääri*, and *vúlgääri* are not plausible compounds, we assume these forms should never receive the compound analysis and, hence, the predicted frequencies for these forms are those predicted by the twenty-four different rankings of the constraints. Where we tested two different words for which the constraints make identical predictions, we have combined responses.

(35)   % FRONT SUFFIXES OBSERVED COMPARED WITH
        PREDICTED VALUES

test word	observed %	predicted %
hiéroglỳfi	87.0	81.3
ánalyÿsi	58.0	62.5
márttyyri	50.0	50.0
sútenööri	98.0	81.3
jónglööri/kásööri	84.0	75.0
ámatööri	89.0	81.3
hýdrosfääri	100.0	100.0
míljonääri	98.0	100.0
áfääri/vúlgääri	78.0	75.0
tábasko/júrtta/rótunda/tórnado	00.0	00.0
sýntaksi/sýmptomi/týranni	00.5	00.0
fóljetòngi	00.0	00.0

The correlation r (Pearson product moment correlation coefficient), be-
tween the predicted and observed results is +0.9903 indicating a very
strong linear relationship[23] between the predicted and observed results.

4. CONCLUSION

We have shown how Optimality Theory can account for both the categori-
cal suffix vowel choice which occurs with most roots and the variation that
occurs with other roots – not only where the variation will occur, but also
how much variation will occur. Our analysis shows that variation data can
be modeled by a grammar with partially ranked constraints.

There are several questions raised by our discussion that deserve some
comment. The first has to do with underspecification. It is assumed that
there are no constraints on *inputs* in OT, which means that the crucial
use of *input* underspecification, as has been common in rule-based analyses
of transparent vowels, is inconsistent with the basic tenets of OT. The

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[23] In fact there is evidence that the relationship between the predicted and obtained results
is the *identity* relationship; the predictions directly account for 97.97% of the variance in the
data.

analysis we have assumed does not make crucial use of *input* underspecification, but some *outputs* are underspecified. The status of *output* underspecification in OT is less clear. On the one hand, the analysis of Ito, Mester, and Padgett (1995) works whether or not inputs are fully specified, but some of their outputs do involve underspecified forms. On the other hand, Kirchner (1997; pp. 97–89) claims that Smolensky (1993) has shown that "phonological inactivity of predictable features may be attributed to rankings of a particular class of constraints, rather than to the absence of such features from the representation at some stage of a derivation". The example he uses is that of Finnish. While it is beyond the scope of this paper to consider the entire question of output underspecification here, Kirchner's argument does not show underspecification is unnecessary in an account of Finnish vowel harmony because the analysis he proposes is problematic.[24]

Kirchner's account involves the constraints ALIGN(+bk-R), which requires that a [+backj specification be linked to a segment at the right edge of the word,[25] *EMBED, which prohibits embedding of a [−back] domain inside a [+back] domain, *[-low, -round, +bk] (which is the same as our *ɨʌ constraint), PARSE(bk), which is a faithfulness constraint requiring that input and output be minimally different with respect to specific features, and *[-low, +rd, -bk], which prohibits *ü* and *ö*. Kirchner gives three hypothetical forms and concludes that there is no need for feature underspecification at underlying or intermediate stages of the derivation.

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[24] Unlike Kirchner, Smolensky (1993) assumes that *all suffix vowels are unspecified for backness in the input.* If we make this assumption, it may be possible to account for Finnish vowel harmony without underspecification of *transparent vowels* as Smolensky suggests, but, of course, such an analysis *does* involve input underspecification and hence cannot be used to argue that no input underspecification is necessary.

[25] Kirchner's constraint is violated only if there is no [+back] feature aligned with the right edge of the word (if there is a [+back] feature somewhere in the word), whereas our alignment constraint is violated for every [+back] feature that is not aligned with the right edge of the word.

(36)

	*[–low, –rd, +bk]	ALIGN(+bk, –R)	PARSE(bk)	*[–low, +rd, –bk]	*EMBED
a. /u-I-U/					
☞ u-i-u					*
u-i-u	*!				
u-i-ü		*!		*	
u-i-ü	*!	*		*	
ü-i-ü			*!	**	
b. /u-i-u/					
☞ u-i-u					*
u-i-u	*!		*		
u-i-ü		*!	*	*	
u-i-ü	*!	*	**	*	
ü-i-ü			*!*	**	
c. /u-i-u/					
☞ u-i-u			**		*
u-i-u	*!		*		
u-i-ü		*!	*	*	
u-i-ü	*!	*		*	
ü-i-ü			**	*!*	

Although this set of constraints seems to handle neutral vowel tranparency without underspecification, this constraint set does not work with the rest of the language. To take just one simple case, consider a root which requires front harmonic suffix vowels such as *pöytä: pöytä-nä*. If this root is followed by a suffix with an underlying back vowel, the wrong output would result:

(37)

	*[–low, –rd, +bk]	ALIGN(+bk, –R)	PARSE(bk)	*[–low, +rd, –bk]	*EMBED
a. /ö-ä-a/					
☺ ö-ä+a				*	
o-a+a			*!		
ö-ä+ä			*!	*	

The correct surface form would be one with a front harmonic vowel (*pöyta-na*), yet this constraint system chooses one with a back harmonic vowel (**pöyta-na*). Nor is it clear how this constraint set could be modified

to handle the forms in (36) as well as front vowel roots. Adding a constraint, Align(-b-R) does not help, as illustrated in (38):

(38)

	*[–low, –rd, +bk]	ALIGN(+bk, –R)	ALIGN(–bk, –R)	PARSE(bk)	*[–low, +rd, –bk]	*EMBED
a. /ö–ä–a/						
☺ ö–ä+a			*!		*	
o–a+a				*		
ö–ä+ä				*	*!	

We conclude that it has not been demonstrated that it is possible to provide an analysis of a significant body of data in a vowel harmony language such as Finnish without some type of underspecification, *output* underspecification as assumed here, or *input* underspecification as assumed in Smolensky (1993).[26]

Our aim in this paper is not to argue that output underspecification is or is not necessary to account for transparent vowels in Finnish. Indeed, the issue we want to address, namely how to account for the variation, is independent of the issue of underspecification in the sense that our account of variation does not crucially depend on assuming that output forms are underspecified. That is, when the final harmonic root vowel is *back*, there is no variation. Some high-ranking constraint or constraints must account for this. We have adopted an account that involves output underspecification. It is possible, however, that there is an interesting account of the forms with no variation (that is those in which the final harmonic root vowel is back) which does not involve output underspecification. Our account of the variation that occurs when the last harmonic vowel is *front* would not, in principle, be incompatible with such a (fully-specified-output) account of forms in which the last harmonic vowel is *back*.

Second, it might seem that we are not justified in assuming that the variation in suffix vowel choice is a result of grammars with unranked constraints because it is conceivable that the variation could be accounted for by different grammars with different fixed rankings. This is a version of the 'different dialect' hypothesis. Such an alternative is not supported by our data. For example, two of the subjects whose responses are reported in (10) reported back suffix vowels with *ámatööri*, *ánalyỳsi*, and *márttyyri*,

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[26] The facts of Hungarian vowel harmony are also incompatible with an analysis along the lines that Kirchner suggests, as well as with that of Smolensky (1993), because suffix vowels in Hungarian cannot all be unspecified for backness. See Ringen and Vago (1998) for discussion.

and front suffix vowels for the other seven words in (10). There is no fixed ranking of the four constraints PRIMARY, SECONDARY, SONORITY, and NO-INT [−BACK] that will predict this distribution. A ranking of PRIMARY highest will choose an output with a back suffix vowel as optimal for *ámatöö̀ri*, *ánalyỳsi*, and *márttyyri* (if we assume that *ámatöö̀ri* and *ánalyỳsi* are not analyzed as compounds), but this ranking will also incorrectly choose as optimal a candidate with a back suffix vowel for *sútenöö̀ri*, *jónglööri*, and *áfääri*, which is not consistent with these subjects' responses. Even if we assume that these subjects analyze *sútenöö̀ri* as a compound, thereby explaining their choice of front suffix vowels for this form, we are still left with the wrong predictions for *jónglööri* and *áfääri*, which cannot be analyzed as compounds, as we have seen above. Similarly, two other subjects reported back suffix vowels for *áfääri*, *ánalyỳsi*, *márttyyri*, and *hiéroglỳfi* and front suffix vowels for the other five words in (10). There is no fixed ranking of the four constraints PRIMARY, SECONDARY, SONORITY, and NO-INT[−back] that will predict this distribution of responses. The responses of subjects who gave front responses for all forms in (10) can be accounted for by assuming a fixed ranking of NO-INT[−back] highest. But aside from these, the reports of the rest of the subjects are not consistent with any fixed ranking of these constraints. This, of course, does not show that there is no set of constraints for which different fixed rankings can account for the variation data in (10). But the burden of proof is on those who would suggest that variation in suffix vowel choice can be accounted for by assuming different fixed rankings of a set of constraints to propose a set of constraints that can account for variation in suffix vowel choice for (some) disharmonic forms. We have shown that these data can be accounted for if we assume one grammar in which some constraints are unranked and may occur in different rankings for one speaker in different productions of a given form.

Aside from the fact that there is no apparent way to account for the variation data with a fixed ranking, there is another reason to believe that the account with unranked constraints is correct. This analysis, but not the fixed rankings alternative (the 'different dialect' account) predicts that there is intrasubject variation. Our tests with these same words with another group of subjects on two separate occasions show that there is considerable intrasubject variation (see (15) above). These results are not consistent with the idea that the variation in (10) can be accounted for if we assume that there are different grammars of Finnish with different fixed rankings of the same constraint set.

Third, we may well wonder about the status of the constraints we have proposed in accounting for the variation we find with Finnish disharmonic

loanwords. The constraints No-INTERVENING[−BACK] and No-INTERVEN-ING[+BACK] are not particularly controversial and have been employed in accounts of other vowel harmony systems (Kirchner 1993, Ringen and Vago 1995, Smolensky 1993). However, the other constraints (PRIMARY, SECONDARY, and SONORITY) do not have this status. There is some evidence that stress does play some role in vowel harmony in other languages. For example, Ultan (1973) notes that unstressed vowels are more likely to harmonize than are stressed vowels and that stressed vowels often determine the quality of unstressed vowels, and Beckman (1998) discusses cases where the stressed vowel is the trigger for assimilation. But if these constraints are indeed universal, we make certain unsupported cross-linguistic predictions. For example, it is difficult to imagine that a language exists in which root faithfulness is ranked above PRIMARY STRESS, which in turn is ranked above No-INTERVENING[+BACK] and No-INTERVENING [−BACK], resulting in non-adjacent assimilation of all suffix vowels to the backness of vowels with primary stress. Hence, it may be that certain rankings of these constraints are universally prohibited or, as one reviewer has suggested, it may be that some of these constraints represent available strategies for dealing with loanwords. There is some evidence that this may be the case. As Holden (1972) notes, when Kazakh (a language with front-back harmony) borrows from Russian, it is the quality of the *stressed* Russian vowel that determines the harmonic quality of all the vowels in the word in Kazakh.

Fourth, it may be important to clarify what is being claimed here with respect to language production. When a linguist elicits data from a single consultant, we take the consultant to be providing data about the language that, in turn, must be accounted for by a grammar of that language. If the consultant reports that there are acceptable alternative pronunciations or alternative ways of expressing some idea, we expect an analysis (grammar) to provide an account of this. We take the results of elicitation to be data about the language that our grammars should model.

In this study we have consulted a large number of consultants and recorded their judgments about the appropriate forms to determine where and how much variation occurs. We have demonstrated that an OT grammar with some unranked constraints can model the variation, if we take the variation predicted by the grammar to be a function of the number of times a particular candidate is designated as optimal by the 24 possible rankings of the unranked constraints in the grammar. The grammar we constructed has unranked constraints, but to relate any given input to a single output, we must impose some arbitrary ranking on the unranked constraints. By computing the frequency with which a particular input

results in various outputs, when all possible permutations of the unranked constraints are considered, it is possible to derive statements like "this grammar predicts that both *áfäärìllä* and *áfäärìlla* are possible in Finnish, but *áfäärìllä* is three times more likely than *áfäärìlla*".

Such an account is consistent with the traditional view that grammars are about linguistic competence, rather than production. But it is legitimate to ask why our consultants exhibited the pattern of responses that they did. Our account would appear to be consistent with different conceptions of the role of grammar in production. That is, our account is consistent with the view that speakers actually consult the constraints when they produce a form so that the actual form that is produced on a given occasion is determined by the particular ranking of the unranked constraints that they 'happen to use' on a given occasion. This account is undoubtedly consistent with connectionist models where the (unranked) constraints might be viewed as equally weighted units in an interactive activation model. Thus, the activation of any particular constraint might reduce the probability of activation of the others. Full discussion of this important issue is beyond the scope of this paper.

Finally, we have tested a relatively small number of forms. Clearly, more data need to be gathered to see if similar results are found when more forms are tested. However, our preliminary results are promising, suggesting that the variation in suffix vowel quality found with Finnish loanwords can be accounted for with the same constraint set that accounts for the categorical suffix harmony of native roots, if we adopt the proposal of Kiparsky (1993) and Anttila (1997) that some constraints are not ranked in the grammar. Not only are we able to predict where variation will occur, but such a theory is capable of modeling frequency of various alternants with considerable accuracy.

APPENDIX A: TEST 1

Ikä: _____ vuotta
age   years

Merkitse rastilla oikea vaihtoehto: nainen _____; mies _____
mark the correct alternative with an X: female   male

Kotipaikka: Helsinki _____; muu (mikä?) _____
home town   other (where?)

Äidinkieli: suomi _____; muu mikä? _____
mother tongue: Finnish   other (which?)

 1. Haluaisin maistaa _____ (tabasko)
 2. En ole kiinnostunut _____ (afääri)
 3. En ole koskaan rakentanut _____ (jurtta)
 4. Pyysimme piirustukset _____ (arkkitehti)
 5. En ole vielä nähnyt _____ (fakiiri)
 6. Oireet johtuvat _____ (kysta)
 7. Tämä piirre esiintyy _____ (katakana)
 8. Nyt keskustellaan _____ (analyysi)
 9. Poliisi etsii _____ (sutenööri)
10. Sheriffi tuli ulos _____ (saluuna)
11. Haluaisin opiskella _____ (syntaksi)
12. Opas kertoi meille _____ (marttyyri)
13. Meidän ei tarvitse pelätä _____ (trakooma)
14. Lääkäri kiinnostui _____ (symptomi)
15. Koko illan he tanssivat _____ (katrilli)
16. Liisa otti kuvan _____ (hieroglyfi)
17. Haluaisitko soittaa _____ (kontrabasso)
18. Hän kuulostaa melkein _____ (tyranni)
19. Minä katselin _____ (jonglööri)
20. Kaikki lapset pitävät _____ (karamelli)
21. Näyttely siirrettiin pois _____ (rotunda)
22. Tuo mies näyttää ihan _____ (amatööri)
23. Monet pelkäävät _____ (tornado)
24. Muutos on jo havaittu _____ (hydrosfääri)
25. En halua lukea _____ (följetongi)
26. Liisa piti esitelmän _____ (anafora)
27. Sain rahat _____ (miljonääri)
28. Hän vaikuttaa ihan _____ (bolshevikki)
29. Kaikki olivat mukana _____ (karonkka)

DIRECTIONS: The following directions (in Finnish) were given to the subjects in writing and also read to the subjects before they began the task.

On the following page there are 29 sentences. Each of them has an empty space marked with a line. Your task is to fill in the space by writing an appropriate form of the word that is given in parentheses after the sentence.
Example:

1. Tämän neuvon sain _____ (juristi)
   This piece of advice I received _____ (lawyer)

   The appropriate form would be juristilta, so that your answer is as follows:

2. Tämän neuvon sain _____ juristilta _____ (juristi)
   This piece of advice I received ____ from a lawyer ____ (lawyer)

   If in your opinion more than one form is possible, write them on the line (one on top of the other or one after the other) and mark them with a number in the order of their naturalness; the most natural alternative is 1. Example:

3. Taiteilija työskenteli _____ (ateljee)
   (The artist worked _____ (workshop)

   If you think that the most appropriate form would be ateljeessa, but you think the form ateljeessä is also possible, answer as follows:

                                         1 ateljeessa
4. Taiteilija työskenteli _____ 2 ateljeessä _____ (ateljee)
   (The artist worked _____ in the workshop _____ (workshop)

   If on the other hand you think that the different forms are equally natural, write them on the line and put braces around the words. Example:

5. Taiteilija viimeisteli _____ {krusifiksiä krusifiksia} _____ (krusifiksi)
   (The sculptor was finishing ___ {the crucifix the crucifix} ___ (crucifix)

   Make your choice of forms only on the basis of what you feel is more natural. Do not try to remember any rules!
   All the words given in parentheses are in the singular. Keep the singular in your answers. Try to make your handwriting as clear and legible as possible!

Appendix B: Stability of vs. Variation in Suffix Vowel Choice

test word		suffix vowel		
		% Front	% Back	% Both
hieroglyfi	Test 3[27]	76.0	8.0	16.0
	Test 4	78.0	14.0	8.0
	Stable	68.0	6.0	
	Varying			26.0
analyysi	Test 3	52.0	22.0	26.0
	Test 4	54.0	28.0	18.0
	Stable	40.0	12.0	
	Varying			48.0
marttyyri	Test 3	30.0	58.0	12.0
	Test 4	36.0	56.0	8.0
	Stable	24.0	44.0	
	Varying			32.0
sutenööri	Test 3	96.0	0.0	4.0
	Test 4	94.0	2.0	4.0
	Stable	90.0	0.0	
	Varying			10.0
amatööri	Test 3	88.0	4.0	8.0
	Test 4	90.0	8.0	2.0
	Stable	80.0	2.0	
	Varying			18.0
jonglööri	Test 3	84.0	2.0	14.0
	Test 4	80.0	14.0	6.0
	Stable	72.0	2.0	
	Varying			21.0
hydrosfääri	Test 3	98.0	0.0	2.0
	Test 4	96.0	2.0	2.0
	Stable	96.0	0.0	
	Varying			4.0
miljonääri	Test 3	100.0	0.0	0.0
	Test 4	92.0	4.0	4.0
	Stable	92.0	0.0	
	Varying			8.0
afääri	Test 3	77.6	8.2	14.2
	Test 4	79.2	16.6	4.2

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[27] Tests 3 and 4 were identical to Test 1 given in Appendix A.

Stable	68.7	6.3	
Varying			25.0

Test 3:   Results of the group when tested the first time.

Test 4:   Results when the same group was tested the second time, one month later.

Stable: The percentage of subjects who chose a front suffix vowel or a back suffix vowel on both tests.

Varying: The percentage of subjects who chose both suffix alternatives on at least one of the tests, or who chose a front suffix in one and a back vowel suffix on the other.

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