Processing of vowel (dis)harmony in Turkish

Ilknur Oded* – William Idsardi* – Ariane Rhone*

Introduction

Turkish vowel harmony is a widely known phenomenon; nevertheless, the studies on Turkish harmony to date have been mostly theoretical (Clements and Sezer 1982, Charette and Göksel 1998 among others). There are a few experimental studies on Turkish such as Zimmer (1969), Yavaş (1980) and Altan (2008) but these studies have not taken into consideration the statistical distribution of vowel pairs in Turkish. However, as Kabak (2007) points out, there are restrictions on the co-occurrence of the vowels from the set of unmarked 5 vowel system [a,e,i,o,u]. As an example, "[i] prefers to precede [a] more than [a] prefers to precede [i]. (31% of all [i]-initial roots are [i-a] vs. 16% of all [a] initial roots are [a-i]). Likewise, [u-a] is far more common than [a-u] among the combination of these two vowels (52% vs. 7% respectively)" (Kabak 2007).

Given this asymmetry in the distribution of vowel pairs, the question is how the frequency and vowel harmony interact, and if frequency can have a stronger influence than vowel harmony. For instance, given [a] in the first vowel position, would Turkish speakers prefer a second vowel as [u] because it agrees with [a] in backness, or would they prefer [i] because it has a higher frequency rate although it violates vowel harmony? How would the speakers of a non-harmonic language like English process the same vowel pairs? (i.e., would frequency be the only criterion in a non-vowel harmonic language?) This study aims to investigate these research questions. The structure of the paper is as follows: In section 1, we will briefly discuss the properties of Turkish vowel harmony. In section 2, we will report the results of two experiments investigating whether the frequency of certain vowel pairs have an effect on processing of vowel harmony. This is followed by a general discussion and summary in section 3.

1. Turkish vowel harmony

Turkish has an eight-vowel system, which consists of all combinations of the distinctive front/back, high/low, and rounded/unrounded features. In native Turkish words with more than one syllable, vowel harmony requires the second vowel to harmonize with the first one. There are two kinds of harmonization processes in Turkish: back-front harmony and rounding harmony (Göksel and Kerslake 2005).

Back-front harmony assimilates a vowel with the vowel in the preceding syllable in terms of backness or frontness. This means that a front vowel can only be followed by a front vowel e.g. *emek* 'effort', *ipek* 'silk', *erik* 'plum', *ekim* 'October'. A back vowel, on the

* University of Maryland.

other hand, can only be followed by a back vowel, e.g. *ara* 'break', *ışık* 'light', *arı* 'bee', *ıslak* 'wet'.

Rounding harmony assimilates a vowel with the vowel in the preceding syllable in terms of roundness. This process affects in particular suffixes, e.g. *gül-dü-nüz* 'you laughed', *don-du-nuz* 'you froze', *böl-üş-tü-nüz* 'you shared'.

2. Testing two hypotheses

The goal of this study is to test two hypotheses. We will refer to the first one as the Vowel-Harmony-based Processing Hypothesis (VHPH) according to which vowel harmony affects how the speakers of a vowel harmonic language process a stream of sounds. Alternatively, the Frequency-based Processing Hypothesis (FPH) would suggest that the speakers of a language process a stream of sounds according to the co-occurrence patterns of vowel pairs.

2.1. Experiment 1

In Experiment 1, we presented native speakers of Turkish with nonsense words that consisted of two vowel harmonic pairs: [a-u] and [u-a] (both back vowels), and two disharmonic vowel-pairs [a-i] and [i-a]. VHPH and FPH make different predictions about how Turkish native speakers process these vowel pairs. According to VHPH, if the speakers of a language have vowel harmony in their native language, they should prefer to process a stream of sounds in a way that the whole word will be harmonic. Therefore, VHPH predicts that upon hearing [a] in the initial position of a word, the native speakers of Turkish should expect to hear a back-vowel, which might lead them to have processing difficulties with [a-i] pairs relative to [a-u] pairs. FPH, on the other hand, predicts that upon hearing [a] in the initial position, the speakers of Turkish should process [i] more quickly and reliably because the [a-i] pair is more common than the [a-u] pair although [a-i] is not vowel harmonic (As we noted earlier, according to Kabak (2007), 16% of all [a] initial roots are [a-i] while the frequency of [a-u] pairs is 7%).

2.1.1. Participants

25 native speakers of Turkish took part in the experiment. All participants were undergraduate students at Bogaziçi University, Turkey.[1] The participants took part in the experiment voluntarily and did not receive money compensation or course credit for their participation in the experiment.

1 We would like to thank the Linguistics Department at Bogaziçi University for facilitating the experiment.

2.1.2. Materials

We constructed an artificial nonsense word list by using a CVCVC template. In constructing the artificial words, we used 5 unmarked vowels[2] and 11 consonants (5 labials and 6 coronals), which are listed below:

Vowels: [a e i o u]

Consonants: [p, b, m, f, v, n, t, d, s, z, r] (with some restrictions on C_2 and C_3 positions)

We avoided using CVCV templates with one of the vowels from the set of [i,u,a,e], which are case markers in Turkish in order not to have nonsense words that resemble real words in Turkish.[3] Also note that we avoided using palatal consonants because they are reported to trigger the use of front vowels in Turkish (Kornfilt 1997). Furthermore, we reduced the number of consonants for the second and third consonant positions for the reasons that we will discuss below.

For the second consonant position we excluded the labials [p,b,m,f,v] because according to Lees' (1961) labial attraction rule, intervocalic labial consonants [e.g. *kavun*'melon', *sabun* 'soap', *pamuk* 'cotton', *topuz* 'knob'] influence vowel rounding in the second syllable. There are many exceptions to Lees' labial attraction rule and there are several counter arguments against this rule (Zimmer 1969, Clements & Sezer 1982, Inkelas et al. 2001 among others); however, to eliminate this possible confound, we avoided using labials in the second consonant position and were left with 6 coronals [n, t, d, s, z, r] for this position.

For the third consonant position, we avoided using plosives because according to Kornfilt (1997), "Turkish has a phonological rule that devoices syllable final plosives and affricates. Therefore, no word final plosives or affricates are found in Turkish with very few exceptions" (p. 491). We had no affricates but had 4 plosives [p,b,t,d] and after taking those out, we were left with 7 consonants for the third consonant position: [m, f, v, n, s, z, r]. As one additional constraint on C_3 position, we avoided using [m] and [n] because these two consonants might function as the first person possessive and second person possessive endings in Turkish and we did not want to have nonsense words that might resemble Turkish words. Exclusion of [m] and [n] left us with the following 5 consonants for the final consonant position: [f, v, s, z, r].

To recapitulate, we used 11 consonants for C_1 position, 6 consonants for C_2 position and 5 consonants for C_3 position. This means that there were 330 possible CVCVC templates (11x6x5). Out of these 330 possible templates, we created 84 non-word CVCVC templates.

2 We used 5 unmarked vowels and excluded 3 Turkish vowels that do not exist in English (i.e. vowels I, ü and ö] because we ran the experiment in a non-harmonic language, i.e. English (see Section 2.2.) and wanted to keep the stimuli consistent in both experiments.

3 Note that Altan's (2008) study makes use of CVCV template and some of the non-words that end [i], [u], [a], [e] turn out to be real words. For example, following non-words from Altan (2008) are actual words in Turkish: *tez-i*. Apart from this, Altan's (2008) study consists of some "non-words" which exist in Turkish such as *vize*'visa' and *gezi*'trip'.

In order to ensure that these templates did not give rise to real Turkish words, we tested if each template existed in the Turkish Electronic Living Lexicon (TELL), which is an online database of about 30,000 words.

After creating 84 CVCVC templates, we constructed two different sets of test items by using these templates. In one set we plugged in [a] as the initial vowel, and then [i] or [u] in the second vowel position, which gave us a total of 168 items. In the second set, we created another set of test items by inserting in the CVCVC templates [i] or [a] in V_1 position, and [a] in V_2 position, which gave us 168 items. Hence, altogether we had 336 test items of [a-i], [a-u], [i-a] and [u-a] pairs.

Note that the experiment included an equal number of harmonic and disharmonic nonsense words to make sure that the participants would not be able to form a vowel-harmonic or vowel-disharmonic bias within the experiment.

2.1.3. Procedure

All experimental stimuli were presented using an HP computer via Presentation stimulus presentation software (Neurobehavioral Systems, Inc., Albany, CA). Participants heard all the stimuli over head-phones and all stimuli were presented in the background of wide-band noise which was mixed at runtime.

Experiment 1 consisted of two conditions: vowel-final and vowel-initial. Each part of the experiment was preceded with a training phase to familiarize the participants with the task. The training items consisted of 8 non-words (4 harmonic and 4 disharmonic items) which were different from the test items.

In the vowel-final condition, the participants were instructed to listen to the second vowel sound, and were presented with non-words from the lists that contained [a-i] and [a-u] pairs. In the vowel-initial condition, the participants were instructed to listen to the first vowel sound and they heard CVCVC pairs from the non-word list (i.e. from [i-a] and [u-a] pairs). For each word they listened to, the participants were instructed to press "F" on the keyboard if the vowel in the critical position was [i], and "J" if the vowel in the critical position was [u]. Presentation of test items was randomized with a different order for each participant.

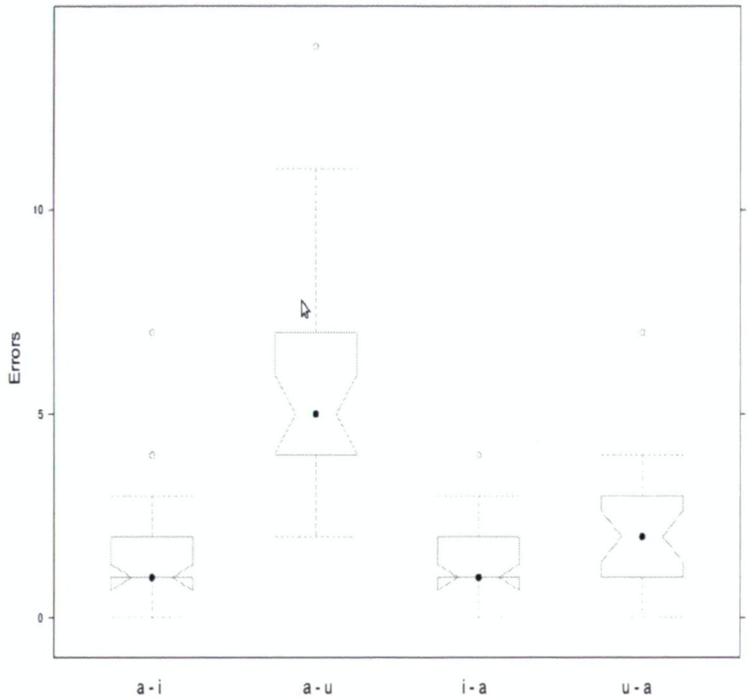
Note that half of the participants were first presented with vowel-initial items and then with vowel-final items while the other half was presented with items in the reverse order to ensure that the order in which the items were presented would not be a confounding factor.

2.1.4. Results

Participants' errors were recorded for both harmonic and disharmonic non-words. We ran a Generalized Linear Mixed Model analysis in R (2.9) modeling the errors with Poisson distribution, with subject as a random effect and condition as the fixed effect. Figure 1 illustrates the errors that Turkish native speakers made.

Errors for Turkish speakers

Figure 1. Boxplots showing error data from all Turkish speakers (R 2.9; see Crawley 2005).



As can be seen in Figure 1, [a-u] vowel pair had significantly more errors than the other conditions ($p<0.0001$, post-hoc Tukey HSD), and there was no other significant difference. These results do not support a vowel-harmony based hypothesis, according to which we would expect to see more errors with non-harmonic vowel pair [a-i]. However, they do lend some support for the frequency-based hypothesis because, as noted earlier, the frequency of [a-i] pair in Turkish is higher than the frequency of [a-u] pair, and hence it is not surprising that given [a] in the first position, Turkish speakers responded with [i] leading them to make more errors with [a-u] pair.

The number of errors for [i-a] and [u-a] pairs is not predicted either by VHPH or by FPH because VHPH predicts that the number of errors should be higher with [i-a] pair since it is disharmonic. FPH also predicts that the number of errors would be higher with [i-a] pair because as reported by Kabak (2007), [i-a] pair is less common than [u-a] pair (31% frequency rate for [i-a] pair vs. 51% frequency rate for [u-a] pair). However, as can be seen in Figure 1, the number of errors is fairly close to each other. This unexpected result is probably due to the fact in [i-a] and [u-a] pairs, the vowel sound being tested was in the initial position, and therefore the participants could not make use of the information about co-occurrence patterns or vowel harmony both of which require identification of the first vowel sound.

2.2. Experiment 2

In this experiment, we used the same stimuli as Experiment 1 but this time we presented the items to native speakers of English. Since English does not have a phonological process like the vowel harmony rule in Turkish, the VHPH predicts that vowel harmony will not have an effect on the way native speakers of English process the vowel pairs, and hence they are likely to have fairly close number of errors both for harmonic and disharmonic pairs. The FPH, on the other hand, predicts that the frequency of the vowel pairs in the test items will affect the way English speakers process these pairs. In Gage Dictionary (a database of 27,310 English words), the [a-i] vowel pair is more common than the [a-u] vowel pair (1.79% vs. 0.20%) while the frequency of [i-a] and [i-u] pairs are fairly close to each other (0.2 % for [i-a] vs. 0.1% for [u-a] pair).[4] Therefore, the FPH predicts that English native speakers are more likely to have [a-u] errors, and the number of errors for [i-a] and [i-u] pairs should be close to each other as their frequency rate is fairly similar. In other words, the FPH predicts that the native speakers of English process the test items like Turkish native speakers.

2.2.1. Participants

30 native speakers of English took part in the experiment for course credit. All participants were undergraduate students from the University of Maryland who had no previous knowledge of a vowel harmonic language.

2.2.2. Materials

Materials used in Experiment 2 were identical to the ones used in Experiment 1.

2.2.3. Procedure

The procedure was identical to that of Experiment 1.

4 The frequencies of vowel pairs for English were calculated by conducting a search for the number of lexical items that have [a-i], [a-u], [i-a] and [u-a] vowel pairs in Gage dictionary, and then type counts were converted into percentages. We would like to thank Brian Dillon for his help in calculating the relative frequencies of vowel pairs in English.

2.2.4. Results

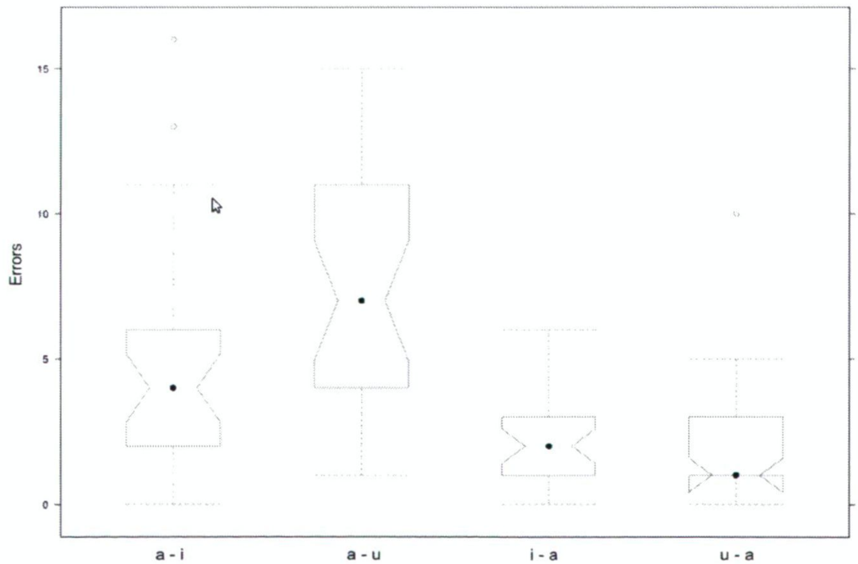
Similar to Experiment 1, we ran a Generalized Linear Mixed Model analysis in R modeling the errors with Poisson distribution, with subject as a random effect and condition as the fixed effect. Figure 2 illustrates the errors that English native speakers made. As can be seen in Figure 2, [a-u] pair had significantly more errors ($p<0.0001$, post-hoc Tukey HSD) followed by [a-i], [u-a] and [i-a] pairs. There was no significant difference between [i-a] and [u-a] vowel pairs.

Hence, predictions of the VHPH were not borne out in Experiment 2 either. As can be seen in Figure 2 below, the highest number of errors for English native speakers was with [a-u] vowel pair. As indicated earlier, a vowel harmony based account predicts that English native speakers would make fairly close number of errors for both harmonic and disharmonic pairs.

However, predictions of the FPH were borne out because [a-u] vowel pair is less frequent than [a-i] pair, and the highest number of errors for English speakers was with [a-u] pair. This indicates that given the vowel sound [a] in the first position, English native speakers perceived the second vowel sound as [i] even when they heard [u] because [i] is more likely to follow [a] than [u]. Note that since the frequency of [i-a] and [i-u] pairs is close to each other, it is not surprising that the number of errors for those two pairs is fairly close.

Errors for English speakers

Figure 2. Boxplots showing error data from all English speakers (R 2.9; see Crawley 2005).



3. General Discussion

In this study, we investigated the processing of four vowel pairs by native Turkish speakers and English native speakers. A table summarizing the frequency of the vowel pairs used in this study is given below in Table 1:

Frequency of the vowel pairs

Vowel Pair	Frequency Turkish	English
[a-u]	7%	0.20 %
[a-i]	16%	1.79%
[u-a]	52%	0.175 %
[i-a]	31%	0.22%

Table 1. Frequency of [a-u], [a-i], [u-a] and [i-a] vowel pairs[5]

What was crucial for this study was the fact that in Turkish, disharmonic [a-i] pair is more common than harmonic [a-u] pair. Turkish speakers are more than twice as likely to hear [i] as compared to [u] (16% to 7%). If they hear [u], then they are very likely to hear [a] next (52%) but less so if they hear [i] first (31%). Also note that interestingly both in Turkish and English disharmonic vowel pair [a-i] is more common than harmonic [a-u] pair. Taking this as a starting point, we conducted two experiments to test a vowel harmony based account (referred to in this study as the VHPH) and a frequency based account (referred to here as the FPH).

Experiment 1 was conducted on Turkish native speakers. According to the VHPH, if we expect Turkish speakers to comply with vowel harmony in processing a stream of sounds, then given [a] in the first syllable, we would expect them to anticipate [u] in the second syllable, and hence more readily perceive the second sound as [u].

On the other hand, the FPH predicts that since [a-i] is more common than [a-u], the Turkish speakers will anticipate [i] in the second vowel position. The results of Experiment 1 showed that the predictions of the FPH were borne out because Turkish speakers favor the co-occurrence patterns of vowel pairs over vowel harmony making fewer errors with [a-i]. In other words, Turkish speakers made more errors with [a-u] pairs indicating that given [a] in the first vowel sound position, they perceived the second vowel sound as [i] which does not comply with vowel harmony.

As for the second part of the study, in Experiment 2, we tested the VHPH and the FPH on native speakers of English in order to investigate the processing of vowel harmonic and disharmonic vowel pairs from Experiment 1 in a language that does not have vowel harmony.

5 As noted earlier, the frequency of Turkish vowel pairs are based on the figures from Kabak (2007), and frequency of vowel pairs in English was calculated by using Gage dictionary.

The VHPH predicts that since English does not have vowel harmony, vowel harmony should not have an effect, and therefore upon hearing [a] in the first vowel position, native speakers of English might either anticipate [i] or [u] in the second position. The FPH, on the other hand, predicts that given [a] in the first vowel position, English speakers would anticipate hearing [i] in the second vowel position as [a-i] pair is more common in English. This would translate into more errors with [a-u] pairs for English speakers. As we noted earlier in the discussion of Experiment 2, English speakers made more errors with [a-u] pairs showing that the predictions of the FPH are borne out.

We noted that the number of errors made by both Turkish and English speakers were fairly close to each other for [i-a] and [u-a] pairs. This was unexpected under the FPH at least for Turkish because in Turkish, the frequency of [u-a] is higher than that of [i-a]. We accounted for this result by pointing out that with these two vowel pairs, the vowel sound that was being tested was in the initial position, and therefore the participants could not make use of the frequency information. In other words, for the speakers to be able to make use of the frequency of vowel sequences, first they need to be able to identify the first vowel in the word.

To sum up, the results of this study show that since both in English and Turkish [a-i] is more common than [a-u], both languages pattern the same way although English is a vowel disharmonic language, and Turkish is a vowel harmonic language. What this means is that the relative frequencies of vowel sequences in a language affect the way how the speakers of a language process a stream of sounds regardless of whether the language has vowel harmony or not.

References

Altan, A. 2008. *The Influence of Vowel Harmony on Turkish Native Speakers Learning an Artificial Language System.* Unpublished PhD Thesis, Hacettepe University: Ankara.

Charette, M. & Göksel, A. 1998. Licensing constraints and vowel harmony in Turkic languages. In: *Structure and interpretation: Studies in phonology.* Cyran, E. (ed.) Lublin: Folium. 65–88.

Clements, G. N. & Sezer, E. 1982. Vowel and consonant disharmony in Turkish. In: Van der Hulst, H. & Smith, N (eds.) *The Structure of Phonological Presentations* (Part II). Dordrecht: Foris. 213–255.

Crawley, M. 2005. *Statistics: An Introduction using R.* Chichester: John Wiley & Sons.

Göksel, A. & Kerslake, C. 2005. *Turkish: A comprehensive grammar.* London, New York: Routledge.

Inkelas, S. & Hansson, G. O.& Küntay, A. & Orgun, C. O. 2001. Labial attraction in Turkish: an empirical perspective, *Turkic Languages* 5, 169–197.

Kabak, B. & Kasselkus, E. & Maniwa, K. & Weber, S. 2008. Vowel Harmony has direction and context: a corpus study. *16th Manchester Phonology Meeting. 22–24 May 2008.*

Kabak, B. 2007. Co-occurrence patterns in Turkish vowel harmony. Paper presented at *Old World Conference in Phonology* 4, 18–21 January 2007, University of Aegean, Mytilene, Greece.

Kornfilt, J. 1997. *Turkish Grammar.* London, New York: Routledge.

Lees, R. B. 1961. *The Phonology of Modern Standard Turkish.* Bloomington: Indiana University.

R Development Core Team. 2008. *R: A language and environment for statistical computing* (R Foundation for Statistical Computing, Vienna).

Underhill, R. 1986. Turkish. In: Slobin, D. I. & Karl Zimmer, K. (eds.) *Studies in Turkish Linguistics.* Amsterdam: Benjamins. 7–22.

Yavaş, M. 1980. Some pilot experiments on Turkish vowel harmony. *Papers in Linguistics: International Journal of Human Communication* 13: 3, 543–562.

Zimmer, K. 1969. Psychological correlates of some Turkish morpheme structure conditions. *Language* 45, 309–321.