8-23-2015

The Effects of Turkish Vowel Harmony In Word Recognition

Ece Kilic
DePaul University, ecekilic1@gmail.com

The Effects of Turkish Vowel Harmony

In Word Recognition

A Thesis

Presented in

Partial Fulfillment of the

Requirements for the Degree of

Master of Science

By

Ece Kilic

August, 2015

The Department of Psychology

College of Science and Health

DePaul University

Chicago, Illinois

Thesis Committee

Pablo Gomez, Ph.D.

Kimberly Quinn, Ph.D.

Biography

The author was born in Istanbul, Turkey, July 6, 1989. She graduated from Mott High School in Waterford, Michigan. She received her Bachelor of Arts degree from the University of Michigan- Dearborn in Psychology, with a minor in Women's and Gender Studies.

Table of Contents

List of Figures

List of Tables

Abstract

This thesis examines the effects of Turkish vowel harmony in visual word recognition. Turkish is among a few languages with vowel harmony, which is a process in which words contain vowels only from one specific vowel category. These categories are defined by the vowel's phonological qualities (i.e., similar mouth and lip movement in pronunciation). In Turkish, categories depend on the vowel's roundness/flatness, backness/frontness and whether the vowel's pitch. Vowel harmony occurs naturally in language and is not taught formally. Instead, it is believed to occur due to decreased effort of words with vowel harmony in speech production (Khalilzadeh, 2010). Vowel harmony is very common in Turkish, with over half of all Turkish words (root words and affixes), containing vowel harmony (Güngör, 2003). Turkish is particularly interesting because it contains two types of vowel harmony: primary and secondary vowel harmony. Primary vowel harmony depends on the frontness and backness in vowels and secondary vowel harmony depends on whether a vowel is high or low pitch, in addition to the roundness and flatness. Although vowel harmony is very common, disharmony exists among some native Turkish words, foreign loanwords and compounds. Vowel harmony was explored in this thesis within the context of reading, with a focus on primary vowel harmony. There were two studies, including three experiments. The first study consisted of the development of a database of words in Turkish. The database includes all words from an obtained Turkish lexicon, the number of vowels in each word, the word length, whether the word has primary or secondary vowel harmony, word frequency and the

syllabified version of each word. The second study consisted of three separate lexical decision task experiments, with each having 30 Turkish speaking participants. Experiment 1 consisted of a straight lexical decision task, with a 3 (Target harmony type: front harmony, back harmony, no harmony) x 2 (Target type: word, nonword) design. Experiments 2 and 3 were masked priming studies with word (Experiment 2) and nonword (Experiment 3) primes, in a 3 (Prime harmony type: front harmony, back harmony, no harmony) x 3 (Target harmony type: front harmony, back harmony, no harmony) x 2 (Target type: word, nonword) design. As predicted for Experiment 1, words with vowel harmony had faster and more accurate responses than words without vowel harmony. Nonwords with back vowel harmony had slower and less accurate responses than nonwords without harmony, which was also in line with the prediction. For Experiments 2 and 3, it was predicted that matching harmony types (i.e., front vowel harmony prime - front vowel harmony target) would have faster and more accurate responses. Results of Experiment 2 did not support the prediction in both latency and accuracy. Results of Experiment 3 supported the predicted results in both latency and accuracy. Overall, the results these experiments suggest that primary vowel harmony facilitates word recognition. This is believed to occur due to the usage of phonemic cues in word recognition. Past research has shown that both phonology and orthography is involved in word recognition, especially in languages with shallow orthography such as Turkish (Frost, 1998; Katz & Frost, 1992). In addition, it has been shown that words with harmony are easier to pronounce (Walker, 2005). Word recognition could have been facilitated since vowel harmony is a phonological category of words that are easier to pronounce.

The Effects of Turkish Vowel Harmony in Word Recognition

Introduction

The Turkish language has been of interest to researchers in linguistics, psycholinguistics and other fields. Turkish is a part of the Turkic subgroup of the Altaic language family. There are over 70 million Turkish speakers around the world, making it the most commonly spoken language within the Altaic language family (Lewis, Simmons, & Fennig, 2014). It is the official language in the Republic of Turkey, where it is primarily spoken, and the Republic of Cyprus (Lewis, Simmons, & Fennig, 2014). In addition to Turkish, the Turkic subgroup includes other languages such as Azerbaijani, Uyghur and Turkmen, which have many morphological and phonological commonalities (Boeschoten, 1998).

The most intriguing qualities of Turkish involve the morphology, phonology and the major reforms which occurred within a short period of time. The history of Turkish is very rich, with many changes to both the written script and spoken language. Due to deliberate, and some natural changes, Turkish is now drastically different from what it was in the past. The difference is so widespread that a present day Turkish speaker would not be able to read or understand the majority of old written or spoken Turkish. Because of the major changes, Turkish is separated into three time periods, which consist of Old Ottoman Turkish, Ottoman Turkish and Modern Turkish (Underhill, 1976). Old Ottoman Turkish and Ottoman Turkish refer to the language used under the Ottoman Empire, between the 13th and 19th century. Modern Turkish refers to the language after the Ottoman periods, starting from the 20th century and continues to be used today.

During the Ottoman periods of the language, the written text was in Ottoman script, which was a version of Arabic script with Persian influences (Underhill, 1976). During the 20th century, the Turkish government began changes towards Modern Turkish. The script was reformed to use only Latin characters, which is still used today (Wood, 1929). Currently, the Turkish alphabet contains 29 Latin letters, including 8 vowels (a, e, ı, i, u, ü, o, ö) and 21 consonants (b, c, ç, d, f, g, ğ, h j, k, l, m, n, p, r, s, ş, t, v, y, z).

There are several characteristics to note about this alphabet, which differ from most other Latin alphabets. First is the absence of the letters ‘q’, ‘w’ and ‘x’. Second is the letter ‘ğ’, which has been placed in mostly words with foreign origins, to elongate the vowel that comes before it, making it easier to pronounce in Turkish (Göksel, & Kerslake, 2005). Third, the letter ‘ı’, is a vowel which differs from the letter ‘i’ and has a similar sound to the ‘i’ in the English word ‘cousin’. The letter ‘i’, on the other hand, has a similar sound to the ‘ee’ in the word ‘bee’. Because of this additional letter, the capitalization of ‘i’ differs from the usual, with ‘i’ capitalized as ‘İ’ and ‘ı’ capitalized as ‘I’. Lastly, a relevant facet of the Modern Turkish alphabet is the phonological transparency (i.e., letters have the same exact pronunciation within different words). Due to this grapheme-to-phoneme relationship, Turkish does not contain many consonant clusters, such as the ‘g’ and ‘l’ in the English word ‘glass’, since each letter within a word is pronounced (McLeod, van Doorn, & Reed, 2001).

The vocabulary of Ottoman Turkish was also reformed, along with the script. The spoken and written language was greatly influenced by Arabic and Persian, including a high number of loanwords and syntactic borrowings such as the word ‘şimal’ (north), which is an Arabic loanword (Lewis, 1999). With the reforms of Modern Turkish, some of these loanwords were replaced with older native words, such as the example of ‘şimal’ (north), which was replaced with a native Turkish word ‘kuzey’ (Khalilzadeh, 2010). Other Arabic and Persian loanwords were replaced with loans from languages, such as French, Greek and Italian (Underhill, 1976). For instance, the Arabic loanword ‘kâtip’ (secretary) was replaced with ‘sekreter’, which is of French origin (Kudret, 1966). Although the language reforms eliminated a great deal of Arabic and Persian loanwords, some still remained (Slobin & Zimmer, 1986). An example is the commonly used suffix ‘-hane’, which comes from the Persian word ‘hane’ (house) and is used to denote a place in a word, as in the word ‘kütüphane’ (library) (Göksel & Kerslake, 2005).

Agglutination

A distinct feature of Turkish is that it is a highly agglutinative language, in which grammatical structures (derivational/inflectional) are added to root words in the form of a suffix (Korkmaz, Kirçiçegi, Akinci, & Atalay, 2003). For example, ‘kedi’ (cat) with the plural suffix of ‘-ler’ becomes ‘kediler’ (cats). Additionally, ‘kediler’ (cats) with the possessive pronoun ‘-im’ is ‘kedilerim’ (my cats). Due to the agglutinative qualities, the Turkish corpus is often double the length of corpuses in other languages (Güngör, 2003).

Vowel Harmony

The focus of this thesis was vowel harmony, which is one of the most distinct and prominent features of Turkish. The phenomenon of vowel harmony can also be found in Finnish, Mongolian and Hungarian. In general terms, vowel harmony is an assimilation process, in which words contain vowels only from one specific vowel category (Clements & Sezer, 1982; Suomi, McQueen, & Cutler, 1997). These vowel categories are defined by the vowel's phonological qualities and categorized according to their similarities. For example, vowels which have a similar mouth and lip movement in pronunciation would be under the same category. In addition to root words, vowel harmony can extend to affixes, which is when harmony is continued in words with the added affixes (Clements, 1976). The languages which have vowel harmony usually differ in their vowel categories, although the overall process is similar.

According the least effort theory, vowel harmony developed in languages to reduce effort in speech (Khalilzadeh, 2010). Since vowel harmony reduces the amount of muscular effort used in the production of words, a word with harmony can be pronounced with less effort than a word without vowel harmony. More specifically, words with vowel harmony can facilitate speech production by having consistent articulatory gestures used in production (Walker, 2005). In other words, it can be easier and less effortful to pronounce a word which has vowel harmony. Although it seems that vowel harmony might be a conscious process, in which a person would have to learn the specifications and categories, it is not the case. The pattern of similar sounds in a vowels category seems to be recognized and applied to words almost naturally.

Turkish Vowel Harmony

The process of vowel harmony in Turkish is similar to other languages with vowel harmony, in which vowels are categorized by their phonological qualities. In Turkish, the vowels within a word "progressively assimilate" to the category of the first vowel (Lewis, 2001; Underhill, 1976). This process is very common, with two different types of harmony; primary vowel harmony and secondary vowel harmony, which have two separate categorization systems (Clements & Sezer, 1982). An analysis of all Turkish words revealed that 58.8% have primary vowel harmony and 72.2% have secondary vowel harmony (Güngör, 2003). Words with vowel harmony include root words and root words with suffixes and grammatical elements added (Durgunoğlu & Güney, 1999).

Primary vowel harmony. Primary vowel harmony, where vowels are classified by the frontness and backness of vowels, is determined by the positioning of the tongue during pronunciation. Front vowels consist of 'e', 'i', 'ö', 'ü' and back vowels consist of 'a', 'ı', 'o', 'u' (See Table 1) (Lewis, 2001). If a word contains only front vowels or only back vowels, it is considered to have primary vowel harmony.

For instance, the Turkish word 'güzel' (beautiful) has primary vowel harmony because it contains vowels that only belong to the front category ('ü' and 'e'). In another example, the word 'çabuk' (quick) also has primary vowel harmony since both of the vowels in this word are back vowels (‘a’, ‘u’) (Dalkılıç & Dalkılıç, 2002).

Secondary vowel harmony. With secondary vowel harmony, the vowels are classified by two different phonological categories; the roundness and flatness of vowels and whether they are low or high pitch. Roundness and flatness is determined by the positioning of the lips during pronunciation. Round vowels consist of ‘o’, ‘ö’, ‘u’, ‘ü’, and flat vowels consist of ‘a’, ‘e’, ‘i’, ‘ı’ (See Table 1) (Lewis, 2001). Low and high categories are determined by the pitch of the vowel. Low vowels consist of ‘a’, ‘e’, ‘o’,‘ö’ and high vowels consist of ‘i’, ‘ı’, ‘u’, ‘ü’.

With second vowel harmony, if the first vowel in a word is flat (‘a’, ‘e’, ‘ı’, ‘i’), the following vowels in a word must also be flat to have harmony. If the first vowel in a word is round (‘o’, ‘ö’, ‘u’, ‘ü’), it has secondary vowel harmony if the rest of the vowels are high and rounded (‘u’, ‘ü’) or low and flat (‘a’, ‘e’). In addition, a word cannot have low and rounded vowels (‘o’, ‘ö’) after the first syllable of a word in order to have secondary vowel harmony (See Table 1) (Dalkılıç & Dalkılıç, 2002).

For instance, in the word “artık” (no longer), the first vowel (‘a’) is flat, and the second vowel (‘ı’) is also flat, which means that the word has secondary vowel harmony. In addition, with the word ‘lütfen’ (please), since the first vowel is round (‘ü’) and the following vowel is low and flat vowel (‘e’), it has secondary vowel harmony.

Turkish Vowels				
	Front		Back	
	Flat	Round	Flat	Round
High	i	ü	ı	u
Low	e	ö	a	o

Table 1. Turkish Vowels. This table demonstrates the classifications of vowels in Turkish.

Suffix harmony. Generally, suffixes in Turkish harmonize with the vowel of the last syllable in the root word, with either front or back vowels. These suffixes generally follow vowel harmony as well (Dalkılıç & Dalkılıç, 2002). Due to this harmony, there are multiple variations of each suffix (Durgunoğlu & Güney, 1999). For example, with the plural suffix, there are two versions which are '-ler' and '-lar'. The suffix '-lar' is used for root words containing a last vowel that is a back vowel ('a', 'ı', 'o', 'u'). The suffix '-ler' is used when the last vowel in the root word is a front vowel ('e', 'i', 'ü', 'ö'). With the example of 'kediler' (cats), the round suffix '-ler' was added, rather than '-lar', since the last vowel in the root word (kedi) is a round vowel ('i'). If the root word is 'araba' (car), the plural would have a back suffix '-lar', making it 'arabalar', since the last vowel of the root word was a back vowel ('a').

Suffix harmony can be seen in other suffixes, such as the containing condition, which uses '-li', '-lı', '-lu', '-lü'. This suffix depends on both the frontness and backness of the vowel, in addition to roundness and flatness. With this suffix, the '-li' is used if the last vowel in a root is a flat and a front vowel ('i', 'e') and '-lı' is used if the vowel is flat and is a back vowel ('ı', 'a'). The suffix ‘-lu’ is used if the last vowel in a root is a round and back vowel (‘u’, ‘o’) and ‘-lü’ is used if the last vowel is a round and front vowel (‘ü’, ‘ö’).

For example, the suffix ‘-li’ would be added to the word ‘şeker’ (sugar), making the word ‘şekerli’ (with sugar), since the last vowel in this word is a flat and front vowel (‘e’). In contrast, the suffix ‘-lı’ would be used with the word ‘anlam’ (meaning), making the word ‘anlamlı’ (meaningful), since the last vowel is a flat and back vowel (‘a’). The suffix ‘-lu’ would be added to the word ‘gurur’ (pride), making the word ‘gururlu’ (prideful), since the last vowel is round and back (‘u’). Lastly, the suffix ‘-lü’ would be used with the word ‘süs’ (decoration), making the word ‘süslü’ (with decoration).

Vowel Disharmony

Although it might seem that the amount of words without vowel harmony is very low, words with disharmony in Turkish do exist. Words without harmony include some native Turkish words but are mainly composed of foreign loanwords, compounds and certain suffixes (Clements & Sezer, 1982; Göksel, 2009). In the example of the native word ‘kardeş’ (sibling), the vowels are back (‘a’) and front (‘e’), which means this word does not have primary vowel harmony, but it does have secondary vowel harmony due the two flat vowels (‘a’, ‘e’). In a loanword example, the word ‘mektup’ (letter), with Arabic origin does not have primary or secondary vowel harmony. It does not have primary vowel harmony since there are front (‘e’) and back (‘u’) vowels within the word, and since the first vowel of this word is flat (‘e’) but the rest of the vowels are round (‘u’), it also doesn’t have secondary vowel harmony. An example of a compound word without vowel harmony is ‘cumartesi’ (Saturday), a compound of ‘cuma' (Friday) and ‘ertesi’ (after). Since the word includes front vowel, a back vowel (‘e’ and ‘u’), it does not have primary vowel harmony. In addition, since the first vowel is round (‘u’), and one of the remaining vowels are flat (‘e’), it also does not have secondary vowel harmony.

Although ‘cumartesi’, along with many compounds do not have vowel harmony, in certain cases the compound words can harmonize. For instance, the compound word ‘yörekent’ (suburb), made up of ‘yöre' (area) and ‘kent’ (city), has primary vowel harmony due to the round vowels (‘ö’, ‘e’, ‘e’). It also has secondary vowel harmony due to the round vowel (‘ö’) in the first syllable, followed by a low and flat (‘e’) vowel.

Suffix disharmony. An example of a suffix which creates disharmony is the word ‘bitiyor’ (stopping), which is ‘bitmek’ (stop), with the present participle suffix ‘-iyor’ (Khalilzadeh, 2010). ‘Bitiyor’ doesn’t have primary vowel harmony due to the flat first vowel (‘i’) with a round (‘o’) vowel. This word also doesn’t have secondary vowel harmony because it contains a round vowel (o) after the first vowel.

Vowel Harmony Research

Multiple studies have been conducted on vowel harmony and auditory word recognition. An experiment examining phonological awareness of Turkish and English children studied the role of vowel harmony (Durgunoğlu & Öney, 1999). The researchers found that Turkish speaking children were able to detect auditory phonemes at an earlier age than English speaking children. They believe that vowel harmony’s characteristics enable Turkish-speaking children to hear separate phonemes quicker, compared to English-speaking children. In a more recent study, authors compared stress and vowel harmony’s effects on speech segmentation in French and Turkish (Kabak, Maniwa, & Kazanina, 2010). Both stress and vowel harmony were examined using an auditory experiment with visual prompts. The experiment items included all nonwords with either harmony matching or harmony mismatching items and stress manipulated to be on either the second or third syllable. They found that stress facilitates word boundary recognition in both Turkish and French. In terms of vowel harmony, they found that word boundary recognition in speech was facilitated only in Turkish. Similar effects have been shown in Finnish vowel harmony. In a study of speech segmentation in Finnish, the authors examined vowel harmony because they believed that vowel harmony might exist to aid in lexical segmentation (Suomi, McQueen, & Cutler, 1997). In these studies, nonword syllables were added to the beginning or end of word items, with matching and non-matching harmony types. Testing reaction time and accuracy in auditory tasks, the authors found that segment detection is facilitated when there is a harmony mismatch. Detection was only facilitated if the nonword was a prefix in the harmony mismatch condition. This suggests that in Finnish auditory word recognition, harmony is used in word beginnings to aid in word boundaries. These studies show that vowel harmony can influence word recognition.

Rationale

Although there have been studies exploring Turkish vowel harmony in auditory word recognition, there were no studies exploring Turkish vowel harmony in visual word recognition experiments. This thesis has explored the effects of vowel harmony in reading in Turkish. More specifically, it has examined whether primary vowel harmony facilitates visual word recognition. Primary vowel harmony will be the focus of this study, since secondary vowel harmony follows a different set of patterns and should be studied separately.

Normally, word recognition in lexical decision tasks indicate how well a word is retrieved from memory (lexical memory). Lexical access in reading is said to involve phonemic codes, in addition to orthographic codes (Frost, 1998; Frost, Katz, & Bentin, 1987). In addition, in languages with shallow orthography, phonemic codes are believed to play a bigger role in the word recognition. According to the orthographic depth hypothesis, when there is a grapheme-to-phoneme correspondence, using phonemic and visual cues together is simpler than using visual cues alone (Katz & Frost, 1992). Since Turkish has shallow orthography, vowel harmony could facilitate word recognition. Facilitation could be due to the phonemic cues of words with vowel harmony.

Statement of Hypotheses

It was hypothesized that primary vowel harmony would facilitate the visual recognition of Turkish words. More specifically, words that contain vowel harmony would be recognized faster and more accurately when compared to words without vowel harmony. It was also expected that matching harmony type of prime and target would facilitate word recognition. More specifically, word and nonword primes with matching harmony to the target words and nonwords (e.g., front harmony prime-front harmony target) were expected to be recognized faster and more accurately, than non-matching prime-target harmony (e.g., front harmony prime-back harmony target).

Study 1

Overview of Study 1

Turkish Word Database. A Turkish Lexicon was created for the purpose of creating materials for the experiments conducted in this thesis (Study 2). This file made it possible to control for frequency, word length, presence of vowel harmony and the type of vowel harmony for the word items in the experiments. This lexicon is a useful and collective file, which was essential for this thesis and can be used in future studies and other researchers studying similar topics in Turkish.

Study 1 Method

Materials

Turkish Word Database. The Turkish word database incorporated words from a text corpus (Dave, 2011). This text corpus consists of a compilation of words obtained from publicly available Turkish subtitles (Dave, 2011). More specifically, the corpus is a word list that includes all words observed from Turkish subtitles, along with the frequency of the word's occurrence in the subtitles. Word frequencies from subtitles are often used in psycholinguistic research because they offer several advantages. Firstly, subtitles of films and television series are easily available over the internet (New, Brysbaert, Veronis, &

Pallier, 2007). Secondly, word frequencies from subtitles have been shown to be more representative when compared to previous methods, which were mainly made up of written material such as newspapers, periodicals and books (Brysbaert & New, 2009). In several studies in multiple different languages, subtitle frequencies have been highly correlated with participants' speed of word processing, meaning that the frequencies are more representative of everyday language (Brysbaert & New, 2009; Dimitropoulou, Duñabeitia, Avilés, Corral, & Carreiras, 2009).

Procedure

Turkish Word Database. Since the original text corpus is compiled from subtitles, there were some errors that needed to be fixed. The revisions and deletions were done using the Vi software. The first step in the revisions was to remove characters that appear in this corpus that do not exist in the Turkish language. These characters were a result of errors from the original subtitles. The second step was removing miscellaneous errors, which were not actual Turkish words but were included in the corpus because they appeared in subtitles (e.g., 'aaaaaaaaaaaaaa'). The third step was to change the order of the list in the text corpus. The original text corpus was ordered by frequency, with the highest frequency in the beginning. The edited corpus was transformed to be in alphabetical order to make further corrections.

The fourth step was correcting misspellings due to incorrect usage of Turkish characters. Since some words in Turkish contain letters that do not exist in Standard English keyboards, they are sometimes substituted with similar letters (e.g., ‘u’ instead of ‘ü’). This problem was corrected first by changing the letters into the intended Turkish characters. The incorrect versions of vowels were corrected from ‘i’ to ‘ı’, ‘u’ to ‘ü’, ‘o’ to ‘ö’, ‘c’ to ‘ç’, ‘s’ to ‘ş’ and ‘g to ‘ğ’. This correction resulted in some duplicates due to the corrected items. This problem was fixed by adding the item frequencies and deleting the duplicate. After this process, only one of the two words with the new frequency was used. Some words from the list did not have duplicates and were not removed after correction of their incorrect character.

The fifth step involved correcting identical words, which appear twice on the corpus due to the occasional use of the circumflex (e.g., ‘â’). Circumflex is no longer commonly used in current Turkish text (Can & Patton, 2010). Currently, letters that used to contain the circumflex are simply used without the symbol in the vowel. Words in the text corpus that contained a circumflex were first transformed by changing ‘â’ to ‘a’, ‘î’ to ‘i’ and ‘û’ to ‘ü’. This correction resulted in some duplicates due to the corrected items. This was fixed by adding the item frequencies and deleting the duplicate. After this process, only one of the words with the new frequency was used. Some words from the list did not have duplicates and were not removed after correction of their incorrect characters.

After editing the text corpus, the Turkish word database was created using Python in the Idle software. This database was transformed into a file with seven separate columns. The first column contains the original word from the edited text corpus. The second column consists of syllabified versions of each word from the first column (e.g., ‘an-lat’). Syllabification rules for every word of the text corpus (i.e., suffixes) were created by the researcher. The following rules of syllabification were applied to the text corpus using Idle:

a) If the first letter in a word is a vowel and

i) is followed by one consonant and one vowel (VCV), the first vowel makes up the first syllable and the consonant and second vowel makes up the second syllable (V-CV).

ii) is followed by two consonants and one vowel (VCCV), the first vowel and first consonant makes up the first syllable and the second consonant and second vowel makes up the second syllable (VC-CV).

iii) is followed by three consonants and one vowel (VCCCV), the first vowel makes and the following two consonants make up the first syllable and the third consonant and second vowel makes up the second syllable (VCC-CV).

b) If the first letter in a word in a consonant

i) the consonant is ignored and the same syllabification rules for words that begin in a vowel are applied. For example, CVCCV is treated as VCCV and is syllabified as VC-CV

ii) With a three-letter word which has a consonant-vowel-consonant (CVC) pattern, the entire word will be syllabified as one syllable (CVC).

After the syllabification, the third column was created, which consists of an ordered list of only the vowels of each word. The fourth and fifth columns consist of numbers corresponding to the number of vowels in the word and the word length for the word represented. The sixth column indicates whether or not a word has primary vowel harmony, followed by the seventh column that indicates whether or not a word has secondary vowel harmony. If the word has vowel harmony, it is represented with a “1” and a “0” if it does not have vowel harmony. For these columns, the harmony of each word was identified using the Idle software according to the rules of primary and secondary rules of vowel harmony of Turkish. These rules were adapted to apply to all words on this list and programmed for Idle by the researcher. Lastly, the eighth column in the database includes the frequency of the word from the original text corpus.

Study 2

Overview of Study 2

Study 2 consisted of empirical projects examining the effect of Turkish primary vowel harmony in word recognition. Three separate lexical decision task (LDT) experiments were conducted examining the effect of primary vowel harmony (front and back) using words and nonwords. In Experiment 1, the harmony of words and nonwords were manipulated in a straight LDT. In Experiment 2 and 3, the harmony of word and nonword primes were manipulated in two masked priming LDT experiments. With these experiments, vowel harmony and the influence of phonology were explored. Since both phonemic and orthographic codes are expected to be involved in reading in Turkish, the phonemic cues from vowel harmony were hypothesized to facilitate word recognition. In addition, with masked priming studies, the influence of phonology was studied in a way which is free of conscious influences to the prime target relationship (Forster, 1998).

Study 2 Hypotheses

Experiment 1. Primary vowel harmony was hypothesized to facilitate word recognition, resulting in shorter reaction times and better accuracy for words with vowel harmony (front and back), compared to words with no harmony. In contrast, nonwords with vowel harmony (front and back) were hypothesized to have longer reaction times and lower accuracy compared to nonwords without harmony.

Experiment 2 & 3. For Experiment 2 and 3, it was hypothesized that the prime will facilitate word recognition when the harmony type of the prime is the same as the harmony type of the target. This was expected to result in targets with front vowel harmony having shorter reaction times and better accuracy when primed with front vowel harmony items, compared to back vowel harmony and no harmony primes. For targets with back vowel harmony, it was expected that there would be shorter reaction times and better accuracy when primed with back vowel harmony, compared to primes with front harmony and no harmony. For targets with no vowel harmony, it was expected that there would be shorter reaction times and better accuracy when primed with no vowel harmony, compared to primes with front harmony and back harmony.

Study 2 Method

Research Participants

The participants in this study included individuals who were native and fluent speakers of the Turkish language. Each experiment included 30 participants, with a total of 90 participants. The participants were within the age range of 18 and 64 and were recruited by the researcher using a verbal script in Yeditepe University, Istanbul, Turkey.

Materials

The Turkish word items used in each experiment were obtained from the Turkish word database, created by the researcher (Study 1). Since Turkish words can have both primary and secondary vowel harmony, the harmony and no harmony word items did not include words with secondary vowel harmony. The length of the words used in this experiment was controlled. Since the average word length for the most frequent words in the Turkish language is 5 letters and the overall average length of a word is 6.1 letters, the experiments included words that are 4 to 7 letters (Carki, Geutner, & Schultz, 2000; Güngör, 2003). Word items were also controlled for frequency using the Turkish word database. The orthographic neighborhood size was also controlled for the word items, using the Wuggy program (Keuleers & Brysbaert, 2010). The neighborhood of a word consists of the words that exist if one letter was changed in the original word (e.g., 'cut' with neighbors 'put', 'cup', 'cat', etc.). The neighborhood size of a word is the amount of real words that are orthographic neighbors (Yates, 2011).

The Turkish nonword items used in this experiment were also created by inputting the word items from the Turkish word database (Study 1) into the Wuggy program (Keuleers & Brysbaert, 2010). With Wuggy, the item length was controlled, while creating the nonwords items, which were also between 4 to 7 letters. Since Wuggy does not include the harmony type of words, multiple nonwords had to be created for each word and the correct harmony type had to be selected. The orthographic neighborhood size was also controlled for the nonword items.

The prime items used in Experiments 2 and 3 had both the word length and vowel controlled according to the accompanying target. Within each prime-target combination, the primes had the same word length as the target. In addition, to avoid priming effects, the prime targets combinations were created containing different vowels and were not semantically related to each other.

All three experiments were conducted using DMDX Display Software on a laptop computer for all participants. DMDX is an experiment software for stimulus presentation that has millisecond precision for response times of visual stimuli (Forster & Forster, 2003). This software records the participants’ response times and accuracies for their word/nonword responses.

Design

For each experiment, an experimental research design, using a series of lexical decision tasks (LDT) was used. The trials were randomized for each participant for all of the experiments. The frontness and backness of vowels were controlled for, since the type of harmony depends on these qualities.

Experiment 1. This experiment was a straight lexical decision task, with a 3 (Target harmony type: front harmony, back harmony, no harmony) x 2 (Target type: word, nonword) design. There were six different types of items, consisting of three types of words and three types of nonwords. The word items consisted of words with front vowel harmony, words with back vowel harmony and words without vowel harmony. The nonword items consisted of nonwords with front vowel harmony, nonwords with back vowel harmony and nonwords without vowel harmony. There were 90 items for each type of word, with a total of 270 words. There were also 90 items for each type of nonword, with a total of 270 nonwords. This resulted in 540 total items presented individually with a total of 540 randomized trials.

Experiment 2. This experiment was a masked priming LDT, using words as primes. A 3 (Prime harmony type: front harmony, back harmony, no harmony) x 3 (Target harmony type: front harmony, back harmony, no harmony) x 2 (Target type: word, nonword) design was used. A mask was presented (e.g., "######"), which was followed by the word prime item and the target item. There were six different targets items, consisting of three types of word items and three types of nonword items. The three types of word targets were words with front vowel harmony, words with back vowel harmony and words without vowel harmony. The three types of nonword targets were nonwords with front vowel harmony, nonwords with back vowel harmony and nonwords without vowel harmony. There were three different types of primes. The primes consisted of words with front vowel harmony, words with back vowel harmony and words without vowel harmony.

Each type of the three types of primes was presented with each of the six types of target items (e.g., Prime: word with front vowel harmony/target: word without vowel harmony). This resulted in a total of 18 different prime-target combinations. Each prime-target combination included 30 trials with different prime-target items, resulting in a total of 540 masked priming trials.

Experiment 3. This experiment was a masked priming LDT, using nonwords as primes. A 3 (Prime harmony type: front harmony, back harmony, no harmony) x 3 (Target harmony type: front harmony, back harmony, no harmony) x 2 (Target type: word, nonword) design was used. A mask was presented, which was followed by the nonword prime item and the target item. There were six different targets items, consisting of three types of word items and three types of nonword items. The three types of word targets were words with front vowel harmony, words with back vowel harmony and words without vowel harmony. The three types of nonword targets were nonwords with front vowel harmony, nonwords with back vowel harmony and nonwords without vowel harmony. There were three different types of primes. The primes consisted of nonwords with front vowel harmony, nonwords with back vowel harmony and nonwords without vowel harmony.

Each type of the three types of primes was presented with each of the six types of target items (e.g., prime: nonword with front vowel harmony/target: word without vowel harmony). This resulted in a total of 18 different prime-target combinations. Each prime-target combination included 30 trials with different prime-target items, resulting in a total of 540 masked priming trials.

Procedure

The principal investigator conducted the study for each participant in this study. The location of the experiment was a classroom of Yeditepe University. Upon arriving to the classroom, the participants first received the information sheet. The information sheet included basic information about the study's aims. After obtaining consent, the participants were instructed by the researcher about the LDT. The researcher informed the participant that they will be visually presented with items on the screen, with one item presented at one time. They were told that they will have to make judgments on whether or not the items on the screen are words or not words. To respond to the items, they were instructed to press the "M" key on the keyboard if the item is a word and the "Z" key if the item is not a word. They were asked to respond only to items that are written in capital letters (i.e., DALGA) and to respond to these items as quickly and accurately as possible. After the directions, the researcher asked if there are any questions and the participant was prompted on the screen to press any key to begin the experiment when they are ready to begin.

In Experiment 1, each trial included a fixation point (i.e., '####') presented in the center of the screen for 500 milliseconds (msec). The fixation point was followed by one item presented in the center using Courier font type, size 26 with uppercase letters. The item remained on the screen until the participant pressed one of two keys indicating whether the item presented on the screen was a word or a nonword. The inter-trial interval was approximately under one-second (60 ticks in DMDX). There were breaks every 50 trials, which ended only when the participant pressed the space bar. During this time, the screen displayed a message indicating that the break had begun and that the experiment would continue when they were ready and press the space key (See Figure 1).

For Experiment 2 and 3, a mask of hash signs (#'s) were presented for 500 msec in the center of the screen. This mask was followed by the prime items in lowercase letters and was presented for 50 msec in the center. Primes were presented around 50-60 msec in masked priming paradigms, which helps avoid effects of participant awareness of the prime (Forster, 1998). The hash sign length matched the prime character length (e.g., #### - kedi). After each prime item, the target item was presented immediately in uppercase letters in the center until the participant responded. The participant responded only to the target item in both Experiment 2 and Experiment 3. The inter-trial interval was approximately under one-second (60 ticks in DMDX). All items were presented in Courier font type and size 26 (See Figure 1).

Similar to Experiment 1, Experiments 2 and 3 had breaks every 50 trials, which ended only when the participant presses the space bar. During this time, the screen displayed a message indicating that the break had begun and that the experiment would continue when they are ready and press the space key.

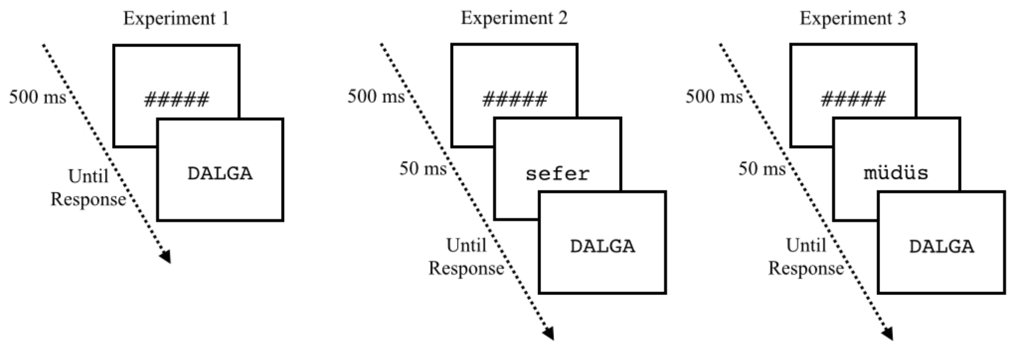

Figure 1. Example of trial displays for Experiments 1, 2 and 3.

When the participant finished the LDT, the researcher thanked the participant and handed out a debriefing form, describing the study in greater detail. The entire study, including the LDT, was approximately 30 minutes for Experiment 1. Experiments 2 and 3 were approximately 35 minutes.

Study 2 Results

Experiment 1

Response latency and accuracy were analyzed for all items. The response latencies did not include response errors in the analysis. Two separate one way Analysis of Variance (ANOVA) were conducted on the latencies of word and nonword items (front vowel harmony vs. back vowel harmony vs. no vowel harmony), with a repeated measures design.

For word items, the results of the ANOVA showed that there was an overall main effect of vowel harmony, $F(2, 56) = 4.76$, $p = .012$. Words that contain back vowel harmony had shorter response times ($M = 678$, $SE = 23$), when compared to words with front vowel harmony ($M = 685$, $SE = 24$) and words without vowel harmony ($M = 704$, $SE = 22$). Paired samples t-test comparisons revealed that words without vowel harmony were significantly different from both words with front vowel harmony ($p = .045$) and words with back vowel harmony ($p = .006$). Words with front vowel harmony were not significantly different from words with back vowel harmony ($p = .498$). The prediction that front and back vowel harmony words would have shorter response times than words without harmony was supported by these results.

For nonword items, the results showed that there was an overall main effect of vowel harmony, $F(2, 56) = 5.68$, $p = .006$. Nonwords without vowel harmony had shorter response times ($M = 824$, $SE = 33$), than nonwords with front vowel harmony ($M = 841$, $SE = 31$) and nonwords with back vowel harmony ($M =860$, $SE = 35$). Paired samples t-test comparisons revealed that nonwords without vowel harmony were significantly different from nonwords with back vowel harmony ($p = .018$). However, nonwords with front vowel harmony were not significantly different from both nonwords without vowel harmony ($p = .131$) and nonwords with back harmony ($p = .131$). These results supported the prediction that front and back vowel harmony nonwords would have longer response times, than nonwords without harmony.

Additionally, an ANOVA was conducted on the mean accuracy of word and nonword items (front vowel harmony vs. back vowel harmony vs. no vowel harmony), with a repeated measures design. The results of word items showed that there was a main effect of vowel harmony in accuracy of responses, $F(2, 56) = 13.28$, $p < .001$. Words with back vowel harmony had a higher percentage of accuracy (95%), when compared to words with front vowel harmony (94%) and words without vowel harmony (92%). A paired samples t-test revealed that the accuracy of words with front vowel harmony is significantly different from both words with back vowel harmony ($p = .032$) and words without vowel harmony ($p = .032$). In addition, accuracy of words without vowel harmony was significantly different from words with back vowel harmony ($p < .001$). These results supported the prediction that words with front and back vowel harmony would have higher accuracy levels than words without harmony.

The results of nonword items showed that there was a main effect of vowel harmony in accuracy of responses, $F(2, 56) = 4.16$, $p = .021$. Nonwords without vowel harmony had a higher percentage of accuracy (93%), when compared to nonwords with front vowel harmony (91%) and nonwords with back vowel harmony (91%). A paired samples t-test revealed that the accuracy of nonwords without vowel harmony is significantly different from nonwords with front vowel harmony (*p* = .041). In addition, accuracy of nonwords with back vowel harmony was not significantly different from nonwords without vowel harmony (*p* = .076) and nonwords with front vowel harmony (*p* = .937). These results somewhat supported the prediction that words with front and back vowel harmony would have lower accuracy levels than words without harmony.

Experiment 2 & 3

Response latencies of Experiment 2 and 3 were each analyzed with a 3 (prime harmony type: front harmony vs. back harmony vs. no harmony) x 3 (target harmony type: front harmony vs. back harmony vs. no harmony) ANOVA, with a repeated measures design. The latencies did not include response errors in the analyses. For Experiment 2, the results of the ANOVA showed that there was a prime harmony x target harmony interaction in words, $F(4, 112) = 3.11$, $p = .018$. Paired samples t-tests were conducted to compare reaction times of matching and nonmatching prime harmony types on each target type. Targets with front harmony did not have significantly different response times with front harmony word primes ($M = 716$, $SE = 22$), compared to back harmony word primes ($M = 708$, $SE = 18$); $t(28) = 0.71$, $p = .48$. Front harmony word primes ($M = 716$, $SE = 22$) were not significantly different from no harmony word primes ($M = 729$, $SE = 20$); $t(28) = -.91$, $p = .37$. Targets with back harmony had significantly shorter response times with no harmony word primes ($M = 691$, $SE = 18$), compared to back harmony primes ($M = 729$, $SE = 21$); $t(28) = 3.18$, $p = .004$. Front harmony word primes had significantly shorter response times than back harmony word primes (*M* = 729, *SE* = 21); *t*(28) = 2.63, *p* = .01. Lastly, targets with no harmony did not have significantly different response times with no harmony word primes (*M* = 725, *SE* = 20), compared to front harmony primes (*M* = 746, *SE* = 27); *t*(28) = -1.45, *p* = .16. No harmony word primes were also not significantly different than back harmony word primes (*M* = 751, *SE* = 22); *t*(28) = -1.77, *p* = .08. These results did not support the prediction that matching harmony types would have shorter response times than non-matching harmony types (See Figure 2).

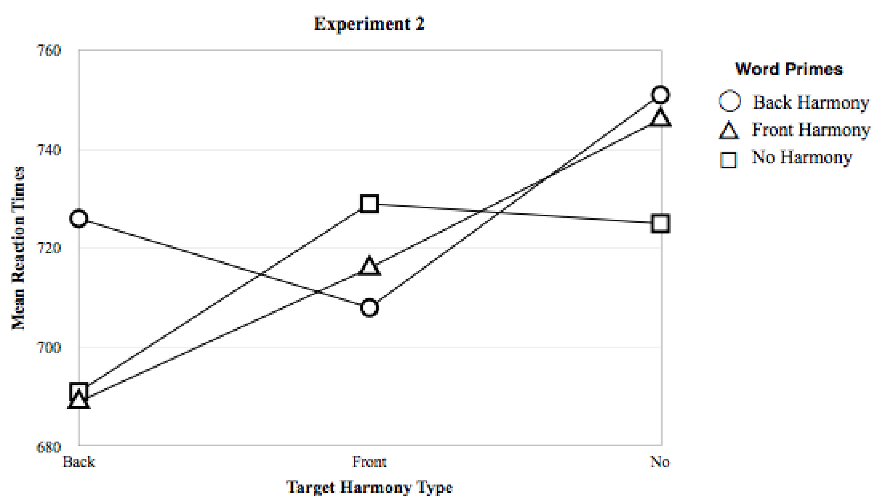

Figure 2. Experiment 2. Plotted mean reaction times for Experiment 2.

For Experiment 3, the results of the ANOVA showed that there a prime harmony x target harmony interaction in words, *F*(4, 112) = 5.09, *p* < .001. Paired samples t-tests were conducted to compare reaction times of matching and nonmatching prime harmony types on each target type. Targets with front harmony had significantly shorter response times with front harmony nonword primes (*M* = 654, *SE* = 17), compared to no harmony nonword primes (*M* = 701, *SE* = 26); *t*(28) = -2.30, *p* = .03. Front harmony nonword primes (*M* = 654, *SE* =

17) were not significantly different from back harmony primes (*M* = 671, *SE* = 19); *t*(28) = -1.97, *p* = .06. Targets with back harmony had significantly shorter response times with back harmony nonword primes (*M* = 655, *SE* = 17), when compared to front harmony primes (M = 690, SE = 24); *t*(28) = -2.94, *p* = .01. Back harmony primes did not have significantly shorter response times than no harmony primes (M = 678, SE = 20); *t*(28) = -1.75, *p* = .09. Lastly, targets with no harmony did not have significantly different response times with no harmony nonword primes (*M* = 679, *SE* = 17), when compared to back harmony primes (*M* = 713, *SE* = 23); *t(*28) = -1.68, *p* = .10. No harmony nonword primes also did not significantly differ from front harmony nonword primes (*M* = 733, *SE* = 36); *t*(28) = -1.92, *p* = .06. These results supported the prediction that matching harmony types would have shorter response times than harmony types that did not match (See Figure 3).

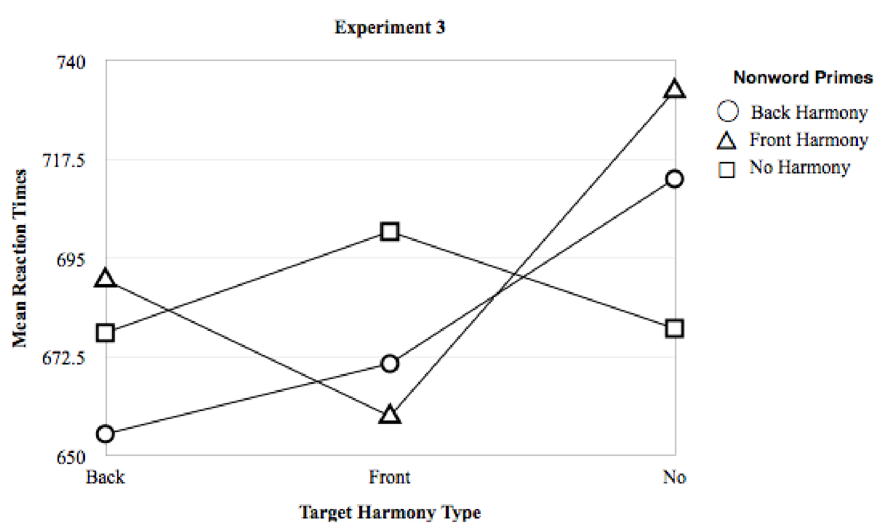

Figure 3. Experiment 3. Plotted mean reaction times for Experiment 3.

Additionally, response accuracies of Experiment 2 and 3 were analyzed separately with 3 (prime harmony type: front harmony vs. back harmony vs. no harmony) x 3 (target harmony type: front harmony vs. back harmony vs. no harmony) ANOVAs, with a repeated measures design. For Experiment 2, the ANOVA showed that there was a prime harmony x target harmony interaction in accuracy, $F(4, 116) = 12.18$, $p < .001$. Paired samples t-tests were conducted to compare accuracy of matching and nonmatching prime harmony types on each target type. With back vowel harmony word targets, no harmony word primes (95.5%), had significantly higher accuracy, when compared to back harmony primes (93.5%); $t(28) = -2.39$, $p = .02$. Front harmony primes (95.4%) had significantly higher accuracy when compared to back harmony primes (93.5%) ; $t(28) = -2.09$, $p = .05$. With front vowel harmony word targets, no harmony word primes (94.6%) had significantly higher accuracy when compared to front harmony primes (92.3%); t(28) = -2.12, $p = .04$. Back harmony primes (94.5%) was not significantly different from front harmony primes (92.3%); $t(28) = -1.94$, $p = .06$. With no vowel harmony word targets, front harmony word primes (92.6%), were not significantly higher in accuracy levels, when compared to no harmony primes (92.0%); $t(28) = -.58$, $p = .57$. No harmony word primes (92.0%) were also not significantly different from back harmony primes (90.9%); $t(28) = .67$, $p = .51$. The results of Experiment 2 did not support the prediction that matching harmony type would have higher accuracy than non-matching harmony types in word recognition.

For Experiment 3, the results showed that there was a prime harmony x target harmony interaction in the accuracy of responses, $F(4, 116) = 12.18$, $p < .001$. Paired samples t-tests were conducted to compare accuracy of matching and nonmatching prime harmony types on each target type. With back vowel harmony word targets, back harmony nonword primes (93.3%), had significantly higher accuracy, when compared to front harmony primes (88.1%); $t(28) = 5.51$, $p < .001$. Back harmony nonword primes also had significantly higher accuracy when compared to no harmony primes (90.0%); $t(28) = 2.6$, $p = .01$. With front vowel harmony word targets, front harmony nonword primes (91.7%), had significantly higher accuracy, when compared to back harmony primes (85.9%); $t(28) = 6.26$, $p < .001$. Front harmony nonword primes also had significantly higher accuracy when compared to no harmony primes (88.3%); $t(28) = 3.54$, $p = .001$. With no vowel harmony word targets, no harmony nonword primes (88.4%), did not have significantly different accuracy, when compared to back harmony primes (88.0%); $t(28) = .38$, $p = .71$. No harmony nonword primes also did not have significantly different accuracy when compared to front harmony primes (88.4%); $t(28) = 1.37$, $p = .18$. These results support the prediction that matching harmony types will have higher accuracy levels in recognition.

General Discussion

This thesis explored the effects of Turkish primary vowel harmony in visual word recognition. The experiments demonstrate that, in general, the presence of harmony affects latency and accuracy in reading. Turkish words with primary vowel harmony were recognized both faster and more accurately than words without harmony (Experiment 1). With nonwords, primary vowel harmony had inhibitory effects in certain cases (i.e., latency of back vowel harmony nonwords and accuracy of front vowel harmony nonwords). In line with the hypothesis, harmony seems to aid in the visual recognition of words and can sometimes inhibit visual recognition.

The experiments also show that, when primed with nonwords, matching harmony types play a significant role in word recognition (Experiment 3). Words were recognized faster and with higher accuracy with a matching nonword prime. In line with the hypothesis, matching harmony had facilitative effects on the speed and accuracy of recognition.

In addition, the experiments show that matching harmony types with word primes did not facilitate speed and accuracy (Experiment 2). These results differ from both the predicted effects of matching harmony and the facilitative effects shown with nonword primes. With masked priming studies, it is common for word primes to inhibit targets (Rastle, 2007). Davis and Lupker (2006) have shown that lexical inhibition occurs when targets are primed with words. They have shown that orthographically related word primes inhibit word targets, while nonword primes facilitate. In addition, they have shown that word primes with high frequency inhibit targets with low frequency. It is believed that when primed with words, compared to nonwords, lexical representations become activated and compete with the target, resulting in inhibition

(Davis, 2004). In this thesis, although the targets were identical, word primes and nonword primes had a different effect. Word primes could have competed with activations of the target words, especially in the cases with matching harmony, which would have inhibited target recognition.

Overall, these results show evidence for Turkish primary vowel harmony facilitation of word recognition. This suggests that phonemic cues are involved in visual word recognition of Turkish words. Vowel harmony is a phonological occurrence, with harmony types categorized by certain qualities that vowels possess during speech (i.e., mouth movement) (Clements, 1976). Because of the similar movements in pronunciation, words with harmony are easier to pronounce (Khalilzadeh, 2010; Walker, 2005). The facilitation of word recognition vowel harmony points to phonemic cues being used. This is similar to research in multiple languages, which show that phonemic and orthographic codes are used in visual word recognition (Carreiras, Ferrand, Grainger, & Perea, 2005; Frost 1998; Frost, Katz, & Bentin, 1987). Additionally, the facilitation of vowel harmony could be stronger in Turkish because of its shallow orthography. Katz and Frost (1992) have shown that languages with shallow orthography use more phonemic cues than languages with deeper orthography. In addition, they have found that the amount of phonemic cues vary depending on the specific orthographic depth of the language. Because of the very consistent grapheme-to-phoneme correspondence of Turkish, phonemic codes seem to aid reading. Future studies should be conducted on the effect of secondary vowel harmony in visual word recognition. In addition, similar vowel harmony experiments could be conducted on early readers of Turkish to examine the possible development of visual-orthographic codes.

References

Boeschoten, H. (1998). The speakers of Turkish languages. In L. Johanson, L., & É. Á Csató (Eds.), *The Turkic languages* (pp. 1-15). New York, NY: Routledge.

Brysbaert M., New B. (2009). Moving beyond Kucčera and Francis: a critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavioral Research Methods, 41*, 977–990.

Can, F., & Patton, J. M. (2010). Change of word characteristics in 20th-Century Turkish literature: A statistical analysis. *Journal of quantitative linguistics*, *17*(3), 167-190.

Carki, K., Geutner, P., & Schultz, T. (2000). Turkish LVCSR: Towards better speech recognition for agglutinative languages. *Acoustics, Speech, and Signal Processing. ICASSPProceedings. 3*, 563-1566.

Carreiras, M., Ferrand, L., Grainger, J., & Perea, M. (2005). Sequential effects of phonological priming in visual word recognition. *Psychological Science*, *16*(8), 585-589.

Clements, G. N. (1976). Vowel harmony in nonlinear generative phonology: An autosegmental model. *Bloomington: Indiana University Linguistics Club*.

Clements, G. N., & Sezer, E. (1982). Vowel and consonant disharmony in Turkish. *The Structure of Phonological Representations*, *2*, 213-255.

Dalkılıç, M. E., & Dalkılıç, G. (2002). On the cryptographic patterns and frequencies in Turkish language. *Advances in Information Systems, 2457*, 144-153.

Dave, H. (2011). Turkish Frequency Word List. Retrieved from http://invokeit.wordpress.com/frequency-word-lists/.

Davis, C. J. (2004). Factors underlying masked priming effects in competitive network models of visual word recognition. In S. Kinoshita & S. J. Lupker (Eds.) *Masked Priming: The State of the Art* (pp. 107-170). New York: Psychology Press.

Davis, C. J., & Lupker, S. J. (2006). Masked inhibitory priming in English: Evidence for lexical inhibition. Journal of Experimental Psychology: Human Perception and Performance, 32(3), 668.

Dimitropoulou, M., Duñabeitia, J. A., Avilés, A., Corral, J., & Carreiras, M. (2009). Subtitle-based word frequencies as the best estimate of reading behavior: The case of Greek. *Frontiers in Psychology*, *1*, 218-218.

Durgunoğlu, A. Y., & Öney, B. (1999). A cross-linguistic comparison of phonological awareness and word recognition. *Reading and Writing*, *11*(4), 281-299.

Forster, K. I. (1998). The pros and cons of masked priming. *Journal of Psycholinguistic Research*, *27*(2), 203-233.

Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, *35*, 116-124.

Frost, R. (1998). Toward a strong phonological theory of visual word recognition: True issues and false trails. *Psychological bulletin*, *123*(1), 71.

Frost, R., Katz, L., & Bentin, S. (1987). Strategies for visual word recognition and orthographical depth: a multilingual comparison. *Journal of Experimental Psychology: Human Perception and Performance*, *13*(1), 104.

Göksel, A. (2009). Compounds in Turkish. *Lingue e linguaggio, 8*(2), 213-236.

Göksel, A., & Kerslake, C. (2005). *Turkish: A Comprehensive Grammar*. New York: Routledge.

Güngör, T. (2003). Lexical and morphological statistics for Turkish. *Proceedings of TAINN*, 409-412.

Kabak, B., Maniwa, K., & Kazanina, N. (2010). Listeners use vowel harmony and word-final stress to spot nonsense words: A study of Turkish and French. *Laboratory Phonology*, *1*(1), 207-224.

Katz, L., & Frost, R. (1992). The reading process is different for different orthographies: The orthographic depth hypothesis. In R. Frost & L. Katz (Eds.), *Orthography, Phonology, Morphology and Meaning* (pp. 67-84). Amsterdam: The Netherlands: Elsevier Science Publishers.

Keuleers, E., & Brysbaert, M. (2010). Wuggy: A multilingual pseudoword generator. *Behavior Research Methods*, *42*(3), 627-633.

Khalilzadeh, A. (2010). Vowel harmony in Turkish. *Journal of Black Sea Studies*, *6*(24),141-150.

Korkmaz, S. U., Kirçiçegi, G., Akinci, Y., & Atalay, V. (2003). A Character Recognizer for Turkish Language. *ICDAR*, 1238-1241.

Kudret, C. (1966). *Dilleri var bizim dile benzemez: Dil üzerine denemeler tartışmalar* (6th ed.). Ankara: Bilgi Yayınevi.

Lewis, G. L. (1999). *The Turkish Language Reform: A Catastrophic Success: A Catastrophic Success*. Oxford University Press.

Lewis, G. L. (2001). *Turkish grammar* (2nd ed.). Oxford: Oxford University Press.

Lewis, M. P., Simons, G. F., & Fennig, C. D. (2014). *Ethnologue: Languages of the world* (17th ed.). Dallas, TX: SIL international.

McLeod, S., van Doorn, J., & Reed, V. A. (2001). Normal acquisition of consonant clusters. *American Journal of Speech-Language Pathology*, *10*(2), 99-110.

New, B., Brysbaert, M., Veronis, J., & Pallier, C. (2007). The use of film subtitles to estimate word frequencies. *Applied Psycholinguistics*, *28*(04), 661-677.

Rastle, K. (2007). Visual word recognition. In M. G. Gaskell (Ed.), *The Oxford Handbook of Psycholinguistics* (pp. 71-88). New York: Oxford University Press.

Slobin, D. I., & Zimmer, K. (1986). *Studies in Turkish linguistics: Typological Studies in Language* (Vol. 8). Philadelphia: John Benjamins Publishing.

Suomi, K., McQueen, J. M., & Cutler, A. (1997). Vowel harmony and speech segmentation in Finnish. *Journal of Memory and Language*, *36*(3), 422-444.

Underhill, R. (1976). Turkish grammar. Cambridge, MA: Massachusetts Institute of Technology Press.

Walker, R. (2005). Weak triggers in vowel harmony. In *Natural Language and Linguistic Theory*, *23*(4), 916- 989.

Wood, M. M. (1929). Latinizing the Turkish alphabet: A Study in the Introduction of a Cultural Change. *American Journal of Sociology*, *35*(2), 194-203.

Yates, M. (2011). How similarity influences word recognition: The effect of neighbors. In J. Guendouzi, F. Loncke, & W. J. Williams, M. J. (Eds.), *The Handbook of Psycholinguistic and Cognitive Processes: Perspectives in Communication Disorders* (pp 273-289). New York, NY: Routledge.