THE EFFECTS OF WORD LENGTH AND SUFFIXATION ON EYE MOVEMENT CONTROL IN TURKISH READING

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

THE EFFECTS OF WORD LENGTH AND SUFFIXATION ON EYE MOVEMENT CONTROL IN TURKISH READING

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Findings in reading research literature reveal that eyes do not move randomly during reading; instead, they follow patterns that enable studying cognitive processes underlying reading. Recent studies report the first fixation on a word as the major measure of lexical influences in reading. Subsequent fixations on a word are usually assumed to have different roles than the first fixation. In the present study, the relationship between the first fixation and subsequent fixations is investigated by taking into account the role of suffixation. The fixation strategies of readers are examined in two experiments by controlling the factors that affect eye movement patterns. The results reveal lexical effects on morphological processing for short and frequent words through the analysis of individual fixations. The study suggests that early lexical effects on words are best observed through the single fixation duration on the words whereas the subsequent fixations have potential to provide an indication of effects related to suffixation.

Keywords: Turkish reading, eye movements, word length, suffixation, first fixation duration

ÖZ

TÜRKÇE OKUMADA SÖZCÜK UZUNLUĞU VE SONEKLEMENİN
GÖZ HAREKETLERİ KONTROLÜ ÜZERİNDE ETKİLERİ

Bozkurt, Tuğçe Nur
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Okuma araştırmalarındaki bulgular, gözlerin okuma sırasında rastgele hareket etmediğini; bunun yerine okumanın altında yatan bilişsel süreçleri inceleyebilmeyi sağlayan örüntüler izlediklerini ortaya koymaktadır. Yakın zamandaki araştırmalar, okumadaki leksik etkilerin başlıca ölçütü olarak bir kelime üzerindeki ilk sabitlemeyi sunmaktadır. Kelime üzerindeki sonraki sabitlemelerin genellikle ilk sabitlemeden farklı rollere sahip oldukları varsayılmaktadır. Bu çalışmada, soneklemenin rolü göz önünde bulundurularak, ilk sabitleme ile sonraki sabitlemeler arasındaki ilişki araştırılmıştır. Okuyucuların sabitleme stratejileri, göz hareketleri örüntülerini etkileyen faktörler kontrol edilerek iki deneyde incelenmiştir. Sonuçlar, bireysel sabitlemelerin analizi yoluyla kısa ve sık kullanılan sözcükler için biçimbilimsel işlemedeki leksik etkileri ortaya koymaktadır. Çalışma, sözcükler üzerindeki erken leksik etkilerin en iyi tek sabitleme süresi üzerinden gözlemlenebileceğini, diğer yandan sonraki sabitlemelerin sonek ile ilgili etkilerin göstergesi olabileceğini önermektedir.

Anahtar Sözcükler: Türkçe okuma, göz hareketleri, sözcük uzunluğu, sonekleme, ilk sabitleme süresi

This humble effort is dedicated to
my first teachers; mom and dad,
my sweet sweet brother İlte,
and my precious Serkan.

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I have to admit how fortunate I am to have Mehtap and Pınar as my housemates and my best friends. I am sure that if it had not been for their patience at odd times, the encouragement, love, and support they provided me, and the conversations we had in our cozy living room, I would not have been able to go back to my room and continue studying. I owe them much for the great environment in our home and the invaluable friendship among us.

My deepest gratitude goes to my family: to my mom and dad, who have always loved and supported me at each turning point of my life. My grandparents have always been caring and understanding when I could not visit them often lately. I am indebted to my family for all the amazing things they have done for me throughout my life.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BOUN	Boğaziçi University
CI	Confidence Interval
EM	Expectation Maximization
FFD	First Fixation Duration
FRFC	First Run Fixation Count
GLMM	Generalized Linear Mixed Model
LMM	Linear Mixed Model
METU	Middle East Technical University
OVP	Optimal Viewing Position
SFD	Second Fixation Duration
TFD	Third Fixation Duration
TNC	Turkish National Corpus

CHAPTER 1

INTRODUCTION

1.1.The Study of Reading

In the last four decades, researchers from cognitive psychology, cognitive science and relevant fields including linguistics contributed to the study of reading and particularly to the investigation of the processes underlying reading. The major focus of reading studies is on how readers go about extracting information from the printed page during the course of comprehending the text (Rayner, et al., 2012).

The history of eye movement studies roots back to a history of more than a hundred years. Huey (1908) mentions the first observations made by Louis Émile Javal in 1879 regarding the role of the eye movements in reading; however, the methods that the reading researchers use have changed a lot since then. Currently, state of the art is mainly based on the detection of eye movements, and the assumptions about the inner processes during reading are made depending on the results of the eye movement experiments. This method of studying has more than forty years of history beginning with the original work of McConkie and Rayner (1975), and since then, many eye-movement researchers conducted their research to investigate this behavior (consult Rayner, 1998 for a substantial review). Eye movement recording is the favored method in the study of reading since eye movements have the potential to provide a moment-to-moment indication of cognitive processes during reading through the analysis of the patterns of information intake (Rayner, 2009).

One of the basic research topics in reading research has been the relation between reading patterns and relevant inner processes. Two distinct group of researchers are mentioned in the study of reading (Liversedge & Findlay, 2000). The first group bears the aim of understanding the mechanics of the eye movements behavior (viz. oculomotor processes), and their major focus is on the impact of lower-level visual (i.e., visuomotor) and linguistics factors on control of the eye movement. On the other hand, the second group is interested in higher-level psycholinguistics processes, that provides information about the comprehension of the written language. The main interests of the second group include the factors that affect the identification of the words, structural relationships between the words that compose a sentence and the meaning of a sentence; in other words, syntactic and semantic processing respectively. They are mainly concerned with the question of how different linguistic manipulations between sentences create differences in reading rather than the mechanics of how eyes move.

The question of interest in the present study is to determine which factor(s) are behind the refixation strategies of the readers. In other words, the focus is on to what degree the lexical factors such as word length, frequency, and suffixation are involved in the decision to make a single fixation or multiple fixations on a word. In the section below, the motivation of the current study will be presented.

1.2. Motivation of the Present Study

It is known from the literature that the first and subsequent fixations on a word have different roles. In the present study, the relationship of these roles with suffixation is investigated. For this, the fixation strategies of readers are examined by controlling the factors that affect eye movement patterns such as word length and frequency.

The two most frequently used eye movement measures in reading are *the first fixation duration* which is the duration of the first fixation on a word regardless of whether it is the only fixation or the first of multiple fixations on a word and *the gaze duration* on a word which is the sum of all fixations made on a word prior to a saccade to another word (Rayner, 1998). After finding that both the first fixation and gaze duration are affected by word frequency, but only the gaze duration is affected by the predictability of the word, Inhoff (1984) proposed that these two measures measure different processes.

The distinction proposed by Inhoff (1984) also involves the suggestion that while lexical access can be measured with the help of first fixation duration, gaze duration reflects text integration processes as well. Accordingly, Rayner and Pollatsek (1987) arrived at the conclusion that cognitive operation is the key factor; if the operation is very fast, the effects of it can be observed in first fixation duration. If the operation turns out to be relatively slower, the gaze duration might be affected.

First fixation duration (FFD) is assumed to be representing early word recognition processes. This measure includes two cases: First, where a word receives only one fixation and secondly, where a word is fixated more than once in the first pass reading. The first case is usually named as *single fixation duration* in which a word is most likely recognized whereas the second one is called *FFD of multiple fixations* duration in which the word has most likely not been completely recognized on the first fixation, so there occurs a need for refixation (Juhasz & Rayner, 2003). Juhasz and Rayner (2003) suggest single fixation duration as a reliable measure of word recognition time, including semantic activation by considering that most likely readers would not move off their eyes of a word before recognizing it.

There have been varying claims regarding the different roles that single fixation and first of multiple fixations play in terms of lexical access. O'Regan (1992) claims that if a word receives only one fixation, lexical and perceptual processing is completed on this

single fixation. Therefore, in case of a word only receives a single fixation, then this fixation duration is longer than another word's first or second fixation durations, given that the other word received multiple fixations. He also claims that no lexical processing occurs on the first duration of a refixated word, rather it is postponed to the second fixation in the words that received more than one fixation, thus resulting in an extended duration of this fixation.

Sereno (1992) suggested that lexical processing should be absent during the first fixation of a refixated word if the view supported by O'Regan (1992) would be confirmed. Her results revealed evidence against this interpretation: she observed the effect of frequency is significant on both single fixation duration and first fixation duration of multiple fixations whereas she did not report any significant effect on the second fixation duration of the words that are fixated more than once.

After her findings, Sereno (1992) raised the question that why readers sometimes decide to refixate a word if the lexical access is achieved in the both cases of the first fixation. One suggestion of her is that lexical access may represent an incomplete stage of word recognition: A possible cause is that readers might require more than the lexical access prior to moving onto the next word. Hence, they execute an intraword saccade to meet a certain word recognition criterion. Her second suggestion is that if the upcoming word is farther away, readers may have a tendency to make immediate intraword saccade.

While mentioning lexical access, it is also needed to mention morphological processing. In the late eighties, reading studies focusing on the morphological processing have started to be conducted (Inhoff, 1989; Lima, 1987), and one of the preliminary questions of these studies is how complex words are processed while eyes are fixated.

In the present study, the first motivation is to observe how the first and subsequent fixations differ in their roles while accessing words, especially long and morphologically complex ones. By discussing these different roles, it is aimed to gain a deeper understanding of the determining factors behind the decision of single fixation and refixation strategies of readers. To be able to realize this, in addition to First Fixation Duration and Gaze Duration, several other local eye movement measures are analyzed in the present study. In the section below, these measures and their definitions are presented.

1.3.Definitions of Relevant Eye Movement Measures

Below, the definitions of the eye movement measures which are analyzed in the present study are presented. It should be noted that **only the measurements in first pass reading** are used for the purposes of the present study.

- *First Fixation Duration (FFD)*: The duration of the first fixation on a word regardless of whether it is the only fixation on a word or the first of multiple fixations on a word.

- *Single Fixation Duration:* The duration of the one and the only fixation on a word.
- *First Fixation Duration of Multiple Fixations*: The duration of the first of multiple fixations on a word.
- *Second Fixation Duration (SFD):* The duration of the second fixation on a word.
- *Third Fixation Duration (TFD):* The duration of the third fixation on a word.
- *Gaze Duration:* The sum of all fixations made on a word prior to a saccade to another word.
- *First Run Fixation Count (FRFC)*: The number of all fixations in a trial falling in the first run of the word.

1.4. The Purpose of the Study and Hypotheses

i. The present study aims to investigate the relation between refixation strategy and first fixation duration by an experimental investigation (Experiment 1, Chapter 3).

   It is expected to observe that long words will get more than one fixation.

ii. The present study aims to examine how the measures of the subsequent fixations differ between short and long words in terms of their roles in lexical access (Experiment 1, Chapter 3).

   It is expected to observe that in long words the second and third fixations will have complementary roles.

iii. The present study aims to come with an account related to lexical access and morphological processing by comparing the findings of the two experimental investigations (Experiment 1 and Experiment 2, Chapter 3).

In the second experiment, it is expected to detect some effects which are only related to morphological complexity since different from the first experiment, in this experiment, word length and word frequency are controlled.

The present study consists of five chapters; in the next chapter (Chapter 2), the background of the study will be presented. Chapter 3 covers the methodology part, and the findings of the experiments are presented in Chapter 4. Finally, in Chapter 5 the discussion and conclusion regarding the findings is included.

CHAPTER 2

BACKGROUND

2.1. A Brief Timeline of Eye Movement Research

The history of the eye movement research goes back more than one hundred years from now; to the initial observations made by Louis Émile Javal in 1879. In his 1908 landmark volume, *The Psychology and Pedagogy of Reading*, Huey mentioned that Professor Javal was the first to note the actual role of the eye movements in reading (Huey, 1908). Javal reported that the movement of the eyes while reading was discontinuous. Huey (1908) described the same observation as follows: "…eyes do not move continuously from left to right along the line, but proceed by a succession of quick, short movements to the end, then return in one quick, usually unbroken movement to the left" (p. 15-16).

The period between 1879 and 1920 was described as the first era in the history of eye-movement research in the extensive review of Keith Rayner (1998). The concerns during that era included the issues such as *saccadic suppression* which can be summarized as the fact that information is not perceived during an eye movement, *saccadic latency* which refers to the time that it takes to initiate an eye movement, and *the size of the perceptual span* which is the region of the effective vision (Rayner, 1998).

The period following the first era up until the mid-1970s was mentioned as the second era of the eye movement research (Rayner, 1998). According to Rayner (1998), the behaviorist movement in experimental psychology led the researches of the second era to focus more on the applied research, thus to conduct less research with eye movements with the aim of investigating cognitive processes. The eye movement studies carried out in that era focused more on the eye movement itself, and less research was done between the late 1950s and the mid-1970s.

The third era in the history of eye-movement research has begun around the mid-1970s, and today's research is also included in this era. Measurements of eye movements have been more accurate and easy to be obtained with the help of the technological improvements in eye movement recording systems. The technological advancements also allowed to interface laboratory computers with eye-tracking systems which made it possible to collect and analyze larger amounts of data than before (Rayner, 1998). Rayner (1998) puts forward that with the development of general theories regarding language processing, it has become possible to examine the cognitive processes underlying reading by using eye movement records.

In sum, the first era of the eye movement research was based on the observations made by Javal regarding the discontinuity of the eye movements during reading. That

observation then, extended to the research on saccadic suppression, saccadic latency, and the size of the perceptual span. In the following era, the focus of the studies was more on the surface aspects of the reading task rather than the cognitive processes underlying reading. Finally, the third era which has been mostly influenced by the technological advances in recording systems for eye-movement and the theoretical developments regarding language processing has begun, and it still continues.

In the last twenty years, more and more researchers utilize eye movements to investigate tasks related to cognitive processing, since eye tracking techniques have become more user-friendly and readily available (Rayner, 2009). Rayner (2009) declares that a new era of eye movement research focused particularly on the domain of reading has begun. In this era, the driving force for many of the researchers is the predictions that develop from the computational models related to the control of the eye movement. In the following section, some essential features of the eye movements during information processing will be presented.

2.2. Basic Characteristics of Eye Movements in Information Processing

In the previous section, the timeline of the eye movement research is presented briefly. The current section aims to provide the basic characteristics of eye movements in information processing. For ease in describing these characteristics, an eye movement record of a hypothetical adult reader is presented in Figure 2.1. The four characteristics that this section includes are saccades, fixations, saccadic latency, and the visual field and acuity respectively.

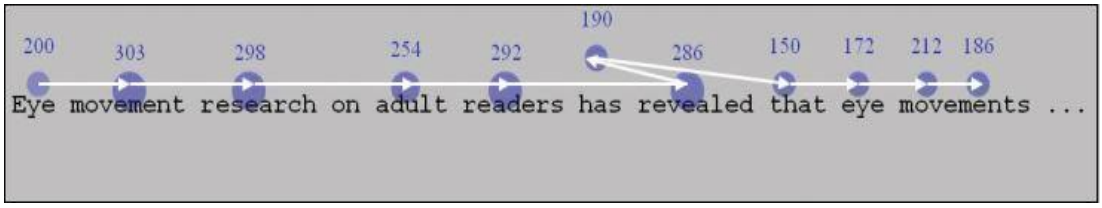

Figure 2.1: An eye movement record of an adult reader on part of a sentence. The dots represent fixations, the arrows represent saccades, and the numbers represent fixation durations. Reprinted from Bertram, R. (2011). Eye movements and morphological processing in reading. *The Mental Lexicon*, 6 (1), 83-109. https://doi.org/10.1075/ml.6.1.04ber

2.2.1. *Saccades and Fixations*

Saccades are rapid eye movements with velocities as high as 500° per second that we continually make during reading, while we are looking at a scene, or searching for an object (Rayner, 1998). After every saccade, our eyes remain relatively still for a moment on a specific location for about 200-300 ms to extract information from the text (Bertram, 2011; Rayner, 1998). The length of the saccade determines the duration of the saccade; however, in reading, the typical completion of a saccade is between 20 and 30 ms (Bertram, 2011).

During a saccade, we extract almost no information, a phenomenon that is called *saccadic suppression* (Matin, 1974). There have been many debates regarding saccadic suppression; however, Rayner (2009) puts forward that new information is not acquired during a saccade under most normal circumstances since the eyes are moving so quickly that only a blur would be perceived. Although we tend to suppress our vision during a saccade (Matin, 1974) and only during the fixations one can acquire novel information, some studies demonstrate that cognitive processing such as lexical processing continues during a saccade in most situations (Irwin, 1998; Irwin & Carlson-Radvansky, 1996).

Fixation is the period of time when the eyes remain fairly still and when the reader acquire new information from the visual array (Rayner, 2009). Fixations will be mentioned in detail in the next section (see Section 2.3) which focuses on the eye movements in reading.

2.2.2. *Saccadic Latency*

Planning eye movements and executing them takes time and this time changes depending on the nature of the task. Saccadic latency is described by Rayner (2009) as "the time needed to encode the location of a target in the visual field and initiate an eye movement" (p.1458-1459), and it is of the order of 175–200 ms (Rayner, Slowiaczek, Clifton, & Bertera, 1983). The action of moving the eyes requires some time as a function of the movement distance, and this duration is called saccadic duration (Rayner, 2009). For instance, in a typical reading situation, 30 ms is needed for a 2-deg saccade, and 40-50 ms is needed for a typical scene perception task (Abrams, Richard A. Meyer, David E. Sylvan, 1989; Rayner, 1978).

2.2.3. *The Visual Field and Acuity*

When we look straight forward, we do not see everything in front of us equally; or similarly, when we look at a page, we do not see all the words on that page equally well (Rayner et al., 2012). We frequently need to make saccades due to the anatomy of the retina and the constraints that emerge from acuity outside the fovea (Rayner, 1998).

In terms of acuity, the visual field can be considered as if it consists of three separate regions when we look straight ahead: foveal, parafoveal, and peripheral (see Figure 2.2). In the fovea, which is the center of the vision, acuity is greatest (about 2 degrees of visual angle), in parafovea, acuity is not as good as fovea (extending 5 degrees of visual angle on either side of the fixation, i.e., about 10 degrees of visual angle), and peripheral area includes the region beyond the parafovea, hence, acuity drops off markedly here (Rayner, 1998; Rayner, et al., 2012).

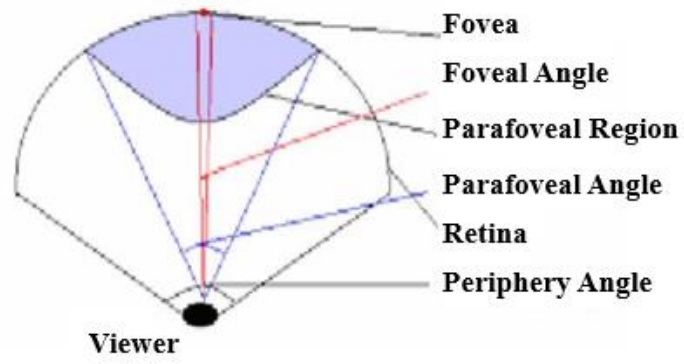

Figure 2.2: Foveal, parafoveal, and peripheral vision. Adapted from Biswas, P., Sezgin, T. M., & Robinson, P. (2008). Perception model for people with visual impairments. In *Proceedings of the 10th International Conference on Visual Information Systems (VISUAL '08), LNCS 5188,* (pp. 279–290). https://doi.org/10.1007/978-3-540-85891-1

The anatomy of retina leads us, as viewers, to move our eyes with the aim of placing the fovea on the part of the stimulus that we want to see clearly (Rayner, 1998). The limitations regarding the visual acuity differ depending on the characteristics of the stimulus presented. In other words, whether a saccade needs to be made to identify the stimulus depends on the task itself; for instance, compared to a typical reading task, in a visual search task, viewers can process more information around their fixation point (Rayner, 2009).

In this section, the basic characteristics of the eye movements in information processing are introduced. The aim of the following section is to provide readers basic knowledge about eye movements in reading.

2.3. Eye Movements in Reading

In this section, the general findings obtained from the eye movement studies which have been carried out so far is presented briefly. These general findings include average fixation durations, saccade lengths, regressions during reading, and how the stimuli influence these three main components of eye movements in reading.

For the readers of English and the readers of the other alphabetic languages, the average fixation duration is between 225-250 ms., and this duration can be as short as 50-75 ms, and as long as 500-600 ms (or more) (Rayner, 2009). Accordingly, the average saccade length is 7-9 letter spaces, and it can be as short as 1 letter space and as long as 15-20 letter spaces (or more) (Rayner, 2009). The variables such as text difficulty, reading skills of the readers, font difficulty, and the characteristics of the writing system influence the duration of fixations and the length of saccades.

It would be helpful to mention *regressions* at this point. After saccades and fixations, regressions which are the saccades that move backward in the text comes as the third important component of eye movements in reading (Rayner, 2009), and in Figure 3, these eye movements are presented. The eyes typically move from left to right which is the direction of the text in languages like English and Turkish, and right to left in languages like Arabic and Hebrew. However, approximately 10 to 15% of the saccades move the eyes in the direction opposite to word order; these saccades are called regressions (Rayner, Pollatsek, & Schotter, 2012).

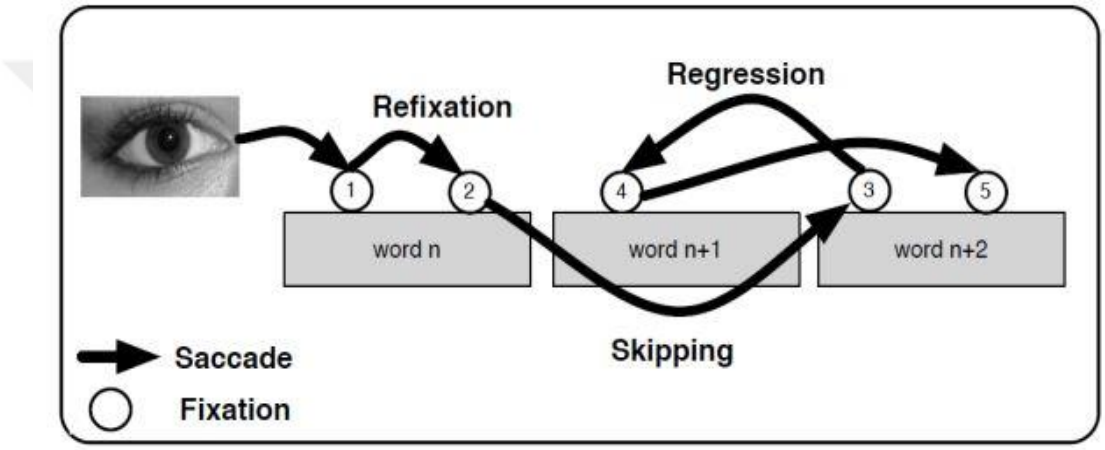

Figure 2.3: Types of saccadic eye movements. The circles 1 - 5 represent fixations in a sequential order; fixations 1, 2, and 3 are first-pass fixations, fixations 4 and 5 are second-pass fixations; the sum of fixations 1 and 2 is the first-pass gaze duration on word n (as well as its total reading time); the sum of fixations 3 and 5 is the total reading time on word n+2; fixation 3 is a regression origin fixation, fixation 4 is a single fixation regression goal; word n+1 has been skipped in first-pass reading. Reprinted from Wotschack, C. (2009). *Eye movements in reading strategies how reading strategies modulate effects of distributed processing and oculomotor control*. Potsdam: Universitätsverlag.

Regressions often occur as a response to the difficulty in comprehension, or they occur if the reader needs to do a small backward correction in order to process a particular word of interest (Rayner, Pollatsek, & Schotter, 2012). Regressions are often short, and eyes only move a few letters; however, if there is a difficulty comprehending the text such as while reading structurally ambiguous sentences (Frazier & Rayner, 1982), or syntactically complex ones (Clifton & Staub, 2011), longer regressions become necessary. Most of the time, after these long fixations, a long saccade follows because the readers are generally accurate in moving their eyes forward to the point from which they originally launched regression (Rayner, 2009; Rayner, Pollatsek, & Schotter, 2012).

Fixations, saccades and regressions respond differently according to the characteristics of the stimulus. For instance, as the text gets more difficult, fixations get longer while saccades get shorter, and readers make more regressions (Rayner, 1998). Further, Rayner, Reichle, Stroud, Williams, & Pollatsek (2006) also demonstrated that the use of different fonts influences eye movements. When the font was difficult to read, the

fixations were longer, saccades were shorter, and more regressions were made compared to the condition in which an easier to read font was used.

The eye movements are also influenced by the reading skill of the reader. Compared to skilled readers, beginning and dyslexic readers have longer fixations, shorter saccades, and they make more regressions (Rayner, 1998).

2.3.1. *Refixation and Skipping*

Eye movement data enables inferring moment-to-moment cognitive processes during reading (Rayner et al., 2012). Using eye movement data allows obtaining valuable information about the mental processes in understanding a word or a set of words whence the readers look, and how long they look there (Rayner, 1998, 2009). Regarding the question which eye movement measure provides informative estimates of this moment-to-moment process, *skipping* and *refixation* should be mentioned.

Although it seems highly intuitive to calculate the average fixation duration on a word to determine the time needed to process that particular word, two components of reading: skipping and refixation provides support against this method. Since the readers do not fixate each word and only once on each word, despite being a valuable global measure, the average fixation duration becomes inadequate in providing estimates of moment-to-moment processing time.

One of the major findings of the reading studies is that not all the words are fixated, and even when they are fixated, the duration is not the same for all words. Readers make distinction between function and content words during reading; while they fixate on the content words such as nouns, adjectives, verbs about 85% of the time, they only fixate on function words such as prepositions, conjunctions, articles about 35% of the time (Carpenter & Just, 1983; Rayner & Duffy, 1988).

When the readers fixate on the function words, they do fewer and shorter fixations than the content words (Carpenter & Just, 1983; Rayner & Duffy, 1988). Since the function words tend to be short, there is a clear relationship between the length of the word and the probability of fixating a word (Rayner & McConkie, 1976). The longer the word is, the higher the probability of fixating on it (Rayner & McConkie, 1976); and as the word length decreases, the probability of skipping it increases (Brysbaert et al., 2005). Also, the lower frequency words are fixated for longer than higher frequency words. (Rayner & McConkie, 1976).

The words with 2-3 characters are only fixated around 25% of the time while the words with 8 characters or more are almost always fixated (Rayner, 2009). Longer words are not just almost always fixated; they are often fixated more than once before leaving the word; in other words, they are refixated (McConkie, Kerr, Reddix, Zola, & Jacobs, 1989; Vergilino & Beauvillain, 2000; Vergilino, Collins, & Doré-Mazars, 2004).

These findings led the researchers to develop a number of other local measures of fixation time. Three of these alternative measures of fixation time are: first fixation duration which is the duration of the first fixation on a word, single fixation duration which addresses the cases where only a single fixation made on a word, and gaze duration which is the sum of all durations on a word before moving to another word (Rayner, 2009).

2.3.2. *Optimal Viewing Position*

In the section above, it is mentioned that most of the words are fixated once while longer words are often fixated twice (or more). In Figure 2.1, the word *movements* is dealt with two fixations which increases the overall reading time for this word (the sum of 212 ms and 186 ms). It is also possible to observe from Figure 2.1 that the short and frequent words such as the preposition *on* and the auxiliary verb *has* been skipped (then, a regression occurs from the word *revealed* to the word *has).*

Another observation from the eye movement record of a typical adult reader presented in Figure 2.1 is that fixations are often located in the middle of the word, a term called *optimal viewing position* (OVP), (O'Regan, 1992). This position is the position in which the word processing is the fastest, and this location can be in slightly left of the center in languages which have left to right direction, and right of the center in language with the right to left direction.

During reading, the eyes work in such a way that, the length of the next word can be estimated during the previous fixation. Hence, an oculomotor program is targeted to the optimal viewing position of that word (O'Regan, 1992). O'Regan (1992) proposes when leaving a word, readers attempt to saccade to just left of the middle of the next word, and when the eyes are too far from the intended position, the reader immediately makes a refixation to the other side of the word which he labels as within-word correction tactics.

In sum, there are some general findings in the eye movement in reading research obtained especially in the third era of the reading study, and a considerable amount of literature supports that these characteristics are valid cross-linguistically. There are some other questions that gathered attention in the last 30 years of reading study such as morphological processing in reading. In the section below, this topic will be presented with the studies which have been conducted recently. With that, it is hoped that the relevance of the current study which has been carried out in a morphologically rich language, Turkish, will be better understood.

2.4. Morphological Processing in Reading

In the sections above, the tradition of the usage of eye movements during reading is presented briefly. Although the tradition of eye movement research has a fairly long history, the studies about the role of eye movements in morphological processing have

begun in the late 1980s and gained momentum at the beginning of the 21st century (Bertram, 2011).

2.4.1. *The Eye-Contingent Boundary Paradigm*

The first studies concerning morphological processing during reading conducted by Inhoff (1989) and Lima (1987), and the aim of those studies was to investigate whether morphological information was parafoveally encoded or not. At this point, mentioning *the eye-contingent boundary paradigm* (Rayner, 1975) is needed since it was the paradigm used in those studies. The aim of developing this paradigm was to assess the type and amount of information that readers may extract from the parafovea (Rayner, 1975). In a typical design which utilizes this paradigm, there is a control condition in which nothing changes when the readers perform the reading task. In addition to the control condition, to manipulate the information in parafovea, one or more change conditions are inserted in the design (Bertram, 2011).

The boundary paradigm was used in numerous studies, and one of them was the 1986 study conducted by Rayner, Balota, and Pollatsek in which they used four conditions (three change conditions, one correct condition) in addition to a typical control condition. In the *control condition*, there was no change, and in the *correct condition*, the target word remained as it is. In the *semantically related condition*, instead of the target word, a word which has the same length and related meaning to the target word was inserted. In the *visually-orthographically related condition*, a word with the same length and with orthographically similar letters was used, and in the *unrelated condition*, only the length of the word was the same (Rayner et al., 1986).

There was an invisible boundary placed to the left of the parafoveal letter string in the change conditions. When the readers make saccade while they are crossing that invisible boundary, the letter string was changed into the correct form during that saccade (Rayner et al., 1986). As the result of that study, Rayner et al. found that a) even relatively short words in the parafovea were not processed up to semantic level b) when the final two letters changed into letters that are visually but not orthographically similar, the change did not influence the word processing negatively. The conclusion of that study was that target word processing was facilitated by orthographically related previews to some extent while semantically related previews did not influence target word processing (Rayner et al., 1986).

The findings of several other studies confirmed that the final letters of a word in parafovea are analyzed up to the visual level, but not to the orthographic level, or conversely the first two or three letters of a parafoveal word are encoded up to the orthographic level.

2.4.2. *Parafoveal Morphological Information*

Before mentioning the eye-contingent boundary paradigm, it was noted that the concern of the first studies on morphological processing was the question whether morphological information is parafoveally encoded or not (Inhoff, 1989; Lima, 1987). Although the results of those studies did not provide evidence for parafoveal information extraction, the studies conducted in Hebrew demonstrated that having a parafoveal preview of the morphological root of the word yielded significant benefits (Deutsch et al., 2000, 2003).

Kambe (2004) proposed that the reason behind obtaining different results in English and Hebrew regarding the morphological influences on parafoveal preprocessing may emerge from the difference between two languages in terms of their morphological richness (Kambe, 2004). She suggested that in the languages which have relatively limited use of morphology such as English, it may be possible that the readers' reliance on the morphological constituents during word processing may not be maximally efficient. However, she further suggested that in highly inflected languages such as Hebrew, Finnish, and Turkish where the morphological information is more informative, it may be possible to observe the morphological influences in word processing (Kambe, 2004).

The study conducted in Finnish which is a morphologically productive language demonstrated that it was not the morphological productivity of the language which determines the extraction of the morphemes parafoveally (Bertram and Hyönä, 2007). They suggested that the characteristics of a script may be more decisive. The results of the languages such as Chinese (Yen, Tsai, Tzeng, & Hung, 2008) and Hebrew (Deutsch et al., 2000, 2003) which have visually separate individual morphemes offer that in parafoveal morphological information extraction, visual segmentability of morphemes is the key factor (Bertram, 2011).

2.4.3. *Recent Studies on Morphological Processing*

Although most eye movement studies focusing on morphological processing has dealt with the processing of compound words, especially there is an extensive literature in Finnish, there are also some studies that have focused on other topics such as affixed words. Since it goes beyond the scope of the present study to review the studies which have dealt with compound nouns, several studies which manipulated the affixes on target words will be presented.

In their study, Niswander-Klement and Pollatsek (2006) manipulated the root morpheme frequency and whole word frequency, as well as the word length of the English, prefixed words. Their results demonstrated a significant effect of root morpheme frequency for longer prefixed words, but the same effect was not observed for the shorter prefixed words. They have also found that there was an effect of the whole-word frequency for shorter prefixed words, but not for longer ones (Niswander-Klement & Pollatsek, 2006). Their study is not the only one which obtained root frequency effects; the same effects

were obtained both for existing and novel English prefixed words. Root frequency effects (as well as a 100 ms novelty effect) were also obtained in Pollatsek, Slattery, and Juhasz (2008) for both existing and novel English prefixed words (Pollatsek, Slattery, and Juhasz, 2008).

In the light of their 2003 and 2008 studies in which they covered the role of agreement in Finnish inflected nouns, Vainio, Hyöna,and Pajunen concluded that the effect of agreement emerges at the level of syntactic integration but not at all levels of lexical access since they obtained a delayed effect of agreement on words (Vainio, Hyöna, & Pajunen, 2003, 2008). Since the modifiers and head nouns they utilized were relatively short ones with seven or eight characters, they reinvestigated the same issue with considerably long head nouns (Vainio, Bertram, Pajunen, & Hyönä, 2011).

The results they obtained demonstrated a facilitative agreement effect similar to the results obtained in the previous studies; however, the effect did not appear late, and it was also observed in earlier processing measures. Hence, they concluded that the benefits related to the modifier-head agreement in the processing of long words extend to the lexical identification of the head noun, rather than being constricted to post-lexical syntactic integration processes (Vainio, Bertram, Pajunen, & Hyönä, 2011).

In sum, the presented eye movement studies and many others support that root and affix properties influence the morphological processing during reading by modulating the morphological constituents.

The studies in eye movement control in Turkish reading are not at a mature stage yet, so in the present study, the experimental paradigm was kept simple (i.e., normal reading). Further, from the two approaches which are used in reading studies (Yan et al., 2014), namely the corpus-analytic and experimental control (i.e., target-based approach), the later one was adopted to conduct two controlled experiments on normal reading. In the section below (Chapter 3), the methodology of this approach will be presented.

CHAPTER 3

METHODOLOGY

In this chapter, the information regarding the participants who involved in the experiments will be presented together with the information of the materials and the apparatus used. Further, in this chapter, the design of the experiments, the data collection procedure, how the data selection was made, and the way the eye movement data analysis was conducted are explained. Since two separate experiments were conducted, the information regarding the experiments will be presented in different parts respectively.

3.1.Experiment I

3.1.1. *Participants*

Forty-eight participants who were studying at the Middle East Technical University (METU) at that time participated in Experiment 1. All the participants were native speakers of Turkish, all of them were monolingual speakers, and their ages were between 19 and 28 (M = 22.6, SD = 2.3, 24 females).

The participants were recruited through a combination of public advertisements (e.g., flyers placed around the campus and online groups). In the adverts, it was stated that the participants should not be using glasses or contact lenses in daily life since they would not be allowed to do so in the experiment. In the appointment process, the participants were reminded that they were going to participate in an eye-tracking experiment, so they arrived without any eye make-up.

The ethical approval was taken from Middle East Technical University Human Subjects Ethics Committee, and before the experiment, each participant read and signed an informed consent form. After the consent form, a demographic information form (see Appendix A) was given to the participants. In that form, the participants were asked some personal questions such as their age, gender, educational status, and contact information. In the second part of this form, there were questions related to the linguistic background of the participants. In that part, none of the participants reported that they had a language-related disorder, such as dyslexia, stuttering, rhoticism, etc. None of the 48 participants were wearing glasses or contact lenses during the experiment.

The total time for the experiment including welcoming a participant and form filling durations was 90 minutes. At the end of the experiment, each participant was paid 20 TL (approximately $7).

3.1.2. *Materials*

Target Word Selection and Properties

The target words were selected according to their frequency information and word length by using Turkish National Corpus (TNC, Aksan et al., 2012), METU Turkish Corpus (Say, Zeyrek, Oflazer, & Özge, 2002), The Dictionary of Word Frequency in Written Turkish (Göz, 2003), and Boğaziçi University (BOUN) Corpus (Bilgin, 2016).

Word length was 4 letters for short words and 10 letters for long words. The short and long words were divided into two groups according to their frequency range. So, in the full target word set, there were 16 short words with high frequency (Short-Frequent), 16 short words with low frequency (Short-Infrequent), 16 long words with high frequency (Long-Frequent), and 16 long words with low frequency (Long-Infrequent). Therefore, words were grouped under four different conditions and each word under each condition were added the suffixes "-de / -da / -te / -ta" and "-deki / -daki / -teki / -taki". A total list of 192 target words was created with the base and suffixed forms. The log10 transformation was applied to the frequency values of the words. Log10 frequency values according to the conditions are presented in the table below.

Table 3.1: Log10 frequency values of words according to conditions.

	Infrequent		**Frequent**		**Infrequent**	**Frequent**
	Short	**Long**	**Short**	**Long**	**Total**	**Total**
Mean	1.54	1.71	4.42	4.43	1.63	4.42
SD	0.44	0.53	0.40	0.41	0.49	0.40
Minimum	0.60	0.60	3.60	3.61	0.60	3.60
Maximum	2.19	2.64	5.15	5.24	2.64	5.24

- There was no statistically significant difference between the frequency values of the base forms of the short frequent words and the frequency values of the base forms of the long frequent words.

- There was no statistically significant difference between the frequency values of the base forms of the short infrequent words and the frequency values of base forms of the long infrequent words.

Stimulus Sentences Selection and Properties

The texts were taken from METU Turkish Corpus (Say et al., 2002), BOUN Web Corpus (Sak et al., 2008), and TNC (Aksan et al., 2012), including each target word and its suffixed versions. Some of the infrequent words, especially their suffixed versions

were not found from the sources mentioned, so they were quoted from various sources using the Google search engine. Some of the words were not possible to be found in a text even in that way, so their synonyms were searched in for in any context. Finally, the texts were recreated by replacing the words that are closest to the target word with the target word (see Appendix C).

A total of 192 texts were chosen based on the criteria below:

- There was no statistically significant difference between the word counts and the character counts of the texts among four conditions (see Table 3.2).
- There was no statistically significant difference in the number of characters between the lines that include the target words.
- Each text was presented at least in two lines and at most in three lines.
- The target words appeared approximately in the middle of a line to eliminate the start-of-line and end-of-line effects in reading.
- There were no punctuation marks or numbers in the immediate environment of the target words.
- The words before the target word and the words after the target word consisted of at least five characters.
- Each target word appeared once in a text and only in one text. Therefore, each target word and its suffixed versions appeared once in the entire text set.
- To prevent ambiguity, the same meaning of polysemous target words was used across all conditions.
- Some texts were composed of more than one sentence (155 single sentences, 34 with two sentences, and 3 with three sentences). In the sentences which included the target word, there were at least two words between the target word and the beginning and the end of the sentence. Similarly, in the sentences which included conjunctions, there were at least two words between the target word and the conjunctions.

Table 3.2: Word counts and number of characters in texts according to conditions.

	WORD COUNT					NUMBER OF CHARACTERS				
	Frequent		Infrequent			Frequent		Infrequent		
	Short	Long	Short	Long	TOTAL	Short	Long	Short	Long	TOTAL
Mean	15.73	15.35	15.48	14.75	15.33	124.65	131.33	121	123.54	125.13
SD	2.55	2.82	3.05	3.05	2.88	18.95	20.99	20.17	22.12	20.78
Min.	9	8	10	9	8	83	84	79	78	78
Max.	20	21	23	21	23	158	174	166	176	176

3.1.3. *Apparatus*

Experiment 1 was conducted by using an SR Research EyeLink 1000 (1000 Hz) eye tracking device, and a computer at 3.0 GHz to which a 17 inch, 1024 x 768 resolution CRT monitor (VGA) was connected and the operating system of the computer was Windows XP. Participants placed their heads on a forehead rest; a part of a tower mount. The usage of tower mount reduced the head movements during the experiments. They read the texts displayed from a distance of 62 cm from the screen. In Figure 3.1, the complete setup is demonstrated.

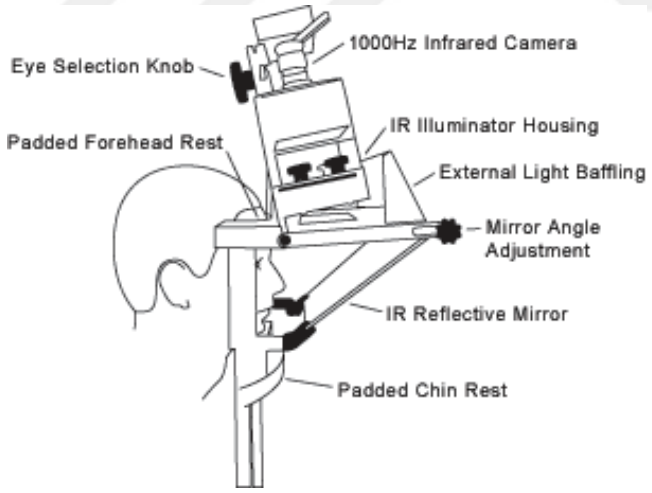

Figure 3.1: Tower Mount Setting. Reprinted from SR Research Eyelink, 2017, Retrieved from http://www.sr-research.com/mount_tower.html. Copyright 2009 SR Research Ltd.

To start and continue the experiment or to answer the questions or pass the on-screen instructions, participants used the Host PC Response Box (see Figure 3.2) by pressing any key. Using the Host PC Response Box allowed participants to be able to keep their eyes on the screen and thus prevented the calibration to be distorted while giving a response to the tasks in the experiment. While answering the questions, the participants used the left back key for the "wrong" answer and the right back key for the "right"

answer. There was a reminder regarding which key was for which answer below each question.

Figure 3.2: Host PC Response Box. Reprinted from SR Research Eyelink, 2017, Retrieved from http://www.sr-research.com/accessories_ELII_resbox.html. Copyright 2009 SR Research Ltd.

3.1.4. *Design and Procedure*

The experiment has been developed using EyeLink Experiment Builder 1.10.1630 and implemented with Tower Mount in EyeLink 1000 device. Courier New font type which allows all characters to have equal widths (monospace) and 18 font size were used. Each character had a visual angle of 0.46 degrees and 14.03 pixels. Margins are set to top 250, bottom 0, left 42, right 28 pixels, and a 1.5 line spacing is used. Each word was split using the Word Segment property provided by the experiment design software.

Experiments were initiated with a screen which presented the instructions and followed by a standard nine-point grid calibration and validation of calibration. Calibration and validation of calibration for each participant were repeated after each break during the experiment. Before the display of each text, a bullseye appeared on the left corner of the screen, and when the participant fixated on the middle of it for one second, the text appeared in a way that the first letter of the text was at the same position with the bullseye. After the participant had finished reading the text, she had to fixate on the middle of the other bullseye which was located on the lower right side of the screen for one second to be able to see the next screen. With the help of an automatic calibrating procedure inserted in the experiment, automatic re-calibration was started when the device failed to capture the one-second eye fixation on the middle of the bullseye for 10 seconds.

The original experiment was composed of two parts with the same structure, and there were two blocks in each part for oral and silent reading. Although each participant attended in both parts of the experiment, the present study focuses only on silent reading; oral reading part is beyond the scope of the present study.

There were four exercise texts and one paragraph at the beginning of each block, thus summing up 16 practice texts and four paragraphs besides the stimulus sentences. Only one text appeared on the screen at each time and texts were displayed on at least two lines (107 texts) and at most three lines (85 texts). Participants were asked to read the

texts at their normal speeds. To be able to ensure that the participants read the sentences by understanding them; after some of the texts true/false questions were asked. The questions appeared randomly so that the participants were not able to predict when the next one would come. The total number of questions was 48. There was a break after each 16 texts and another break between the blocks thus summing up 10 breaks throughout the experiment. In Figure 3.3, the distribution between the parts and the blocks is presented. Participants read half of the texts silently, and the other half was read orally. The order of the silent and oral readings was balanced between the participants, and each text was read in both ways by different participants.

After the experiment, the participants were given two tests (Corsi Block Tapping Test and Digit Span Test) to measure the visual and verbal working memory spans of the participants. Additionally, a test (Familiarity test) was completed to measure how familiar were the target words to the participants before the experiment. The application of those three tests lasted approximately 15 minutes.

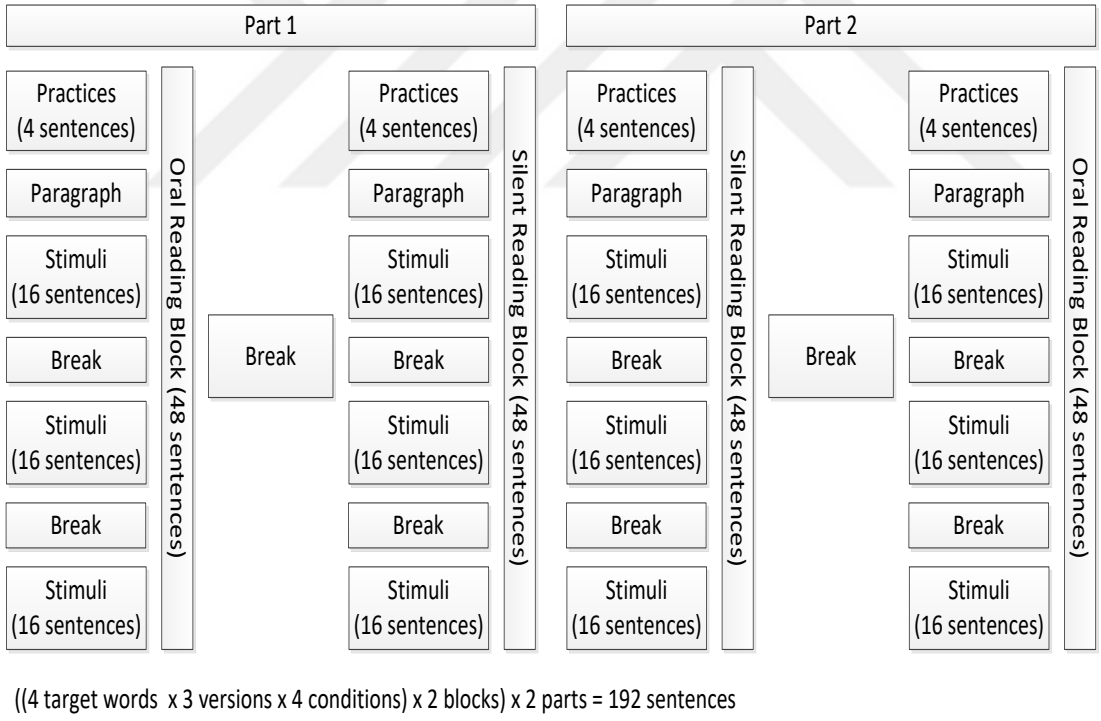

Figure 3.3: Design of Experiment I.

3.2. Experiment II

3.2.1. *Participants*

Forty people, who did not participate in Experiment 1, participated in Experiment 2. All the participants were native and monolingual Turkish speakers. The participants' ages

were between 19 and 32 (M = 23.17, SD = 3.24, 20 females). All the participants had a normal or corrected to normal vision.

The recruitment and appointment processes were the same as Experiment 1. Accordingly, the participants of the second experiment also read and signed an informed consent form similar to the one used in Experiment 1; they also filled the same demographic information form with Experiment 1 (see Appendix A). The total time for the experiment including welcoming the participant and form filling durations was 30 minutes. At the end of the experiment, each participant was paid 20 TL (approximately $7).

3.2.2. *Materials*

Target Word Selection and Properties

All the target words were chosen among the frequent words, and they all consisted of seven characters. Three conditions were created according to the number of the suffixes attached to the target words. In the first condition, the target words had seven characters in the base form, and they had no suffix attached (no suffix condition). In the second condition, the suffix -DA was attached to the target words which had five characters in their base form (one suffix condition). Finally, the third condition included the words with three characters in their base form with the suffixes -DA and -ki attached (two suffixes condition). There were 12 words in each condition; the total number of target words was 36.

- Word initial bigrams of target words were controlled; they were selected among the frequent ones.
- There were no derived words in target word set.
- The mean base (i.e., root form) and surface (i.e., suffixed form) frequency values of the words were not significantly different among the conditions for each bigram.
- Sentence frames before and after target word were the same among word initial bigrams.

Stimulus Sentences Selection and Properties

Sentences (see Appendix C) that include the target words were formed based on the following criteria:

- For each bigram, the sentence frame before the target words was the same. Similarly, for each bigram, the sentence frame after the target words was the same.

- Each sentence was presented in one line.
- Sentence lengths were 59-61 characters, sentence frame lengths before target words were 24-27 characters, and sentence frame lengths after target words were 25-27 characters.
- There were no punctuation marks or numbers in the immediate environment of the target words.
- The words before the target words and the words after the target words were consisted of at least four characters.
- Each target word appeared once in a sentence and only in one sentence.
- To prevent ambiguity, the same meaning of polysemous target words was used across all conditions.

3.2.3. *Apparatus*

Experiment 2 was conducted by using an SR Research EyeLink 1000 Plus (1000 Hz) with desktop mount eye tracking device and a computer at 3.60 GHz to which a 24 inch, 1024 x 768 resolution and 4:3 screen scale ratio monitor was connected (VGA), and the operating system of the computer was Windows 7. Participants placed their heads on a forehead rest which reduced the head movements during the experiments. They read the texts displayed from a distance of 73 cm from the screen and 66 cm from the desktop mount. (see Figure 3.4)

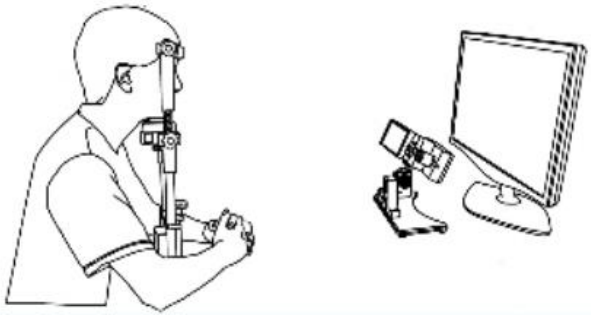

Figure 3.4: Typical EyeLink 1000 Tower Mount Configuration. SR Research Eyelink. (2013-2017). EyeLink 1000 Plus: User Manual Version 1.0.12. Retrieved from https://www.sr-support.com/forum/downloads/manuals/4475-eyelink-1000-plus-user-manual

In Experiment 2, participants used the Logitech Gamepad F310 (see Figure 3.5) to start and continue the experiment or pass the on-screen instructions. Similar to the usage of the Host PC Response Box in Experiment 1 (see Figure 3.2), the left back key was used for “wrong” while the right back key was used for the “right” answers.

Figure 3.5: Logitech F310 Gamepad. SR Research Eyelink. (2013). EyeLink 1000 Plus: Installation Guide. Retrieved from http://godzilla.kennedykrieger.org/fmri/EyeLink1000PlusInstallationGuide1.0.pdf

3.2.4. *Design and Procedure*

The development, calibration and the validation of calibration processes were the same with Experiment 1. Similarly, the original Experiment 2 was composed of two blocks for oral and silent reading. However, it is worth to remind that the present study only focuses on silent reading; oral reading part is beyond the scope of the present study.

The counterbalance in Experiment 2 was ensured in a different way. To prevent participants to read same sentence frames more than once, each participant read one sentence from each bigram group. Sentences that include target words from different suffixation conditions in each bigram group were selected for a participant in a way that each participant read at least one sentence from each suffixation condition. Accordingly, each participant read 12 sentences that include one target word from each bigram group and at least one target word from each suffixation condition. Reading modality and the suffixation conditions balanced among participants and the full sentence set was read in both modalities by different participants.

There were four practice sentences and one paragraph at the beginning of each block, and there were 6 sentences in each block. There was one break during the experiment. Only one text appeared on the screen at each time and participants were asked to read the texts at their normal speeds. There were comprehension questions after every sentence, and eight practice sentences to familiarize the participant and two paragraphs as fillers in the experiment. In Figure 3.6, the distribution between the parts and the blocks is presented.

After the experiment, the participants were given two tests (Corsi Block Tapping Test and Digit Span Test) to measure the visual and verbal working memory spans of the participants. The application of those tests took approximately 10 minutes.

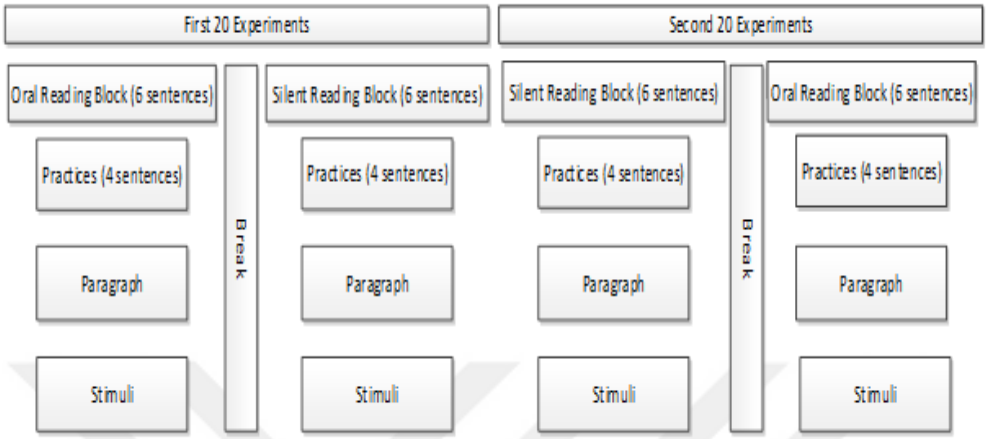

Figure 3.6: Design of Experiment II.

3.3. Eye Movement Data Selection

The software tool EyeLink Data Viewer (Data Viewer 2.3.22) was used to analyze the data. This software allows the users to view, process and filter the eye data which was taken on EyeLink, and it is possible to determine different variables according to the purposes of the studies and get reports accordingly. In the present study, Interest Area Report outputs taken from Data Viewer were used.

Despite all the precautions taken, there were some cases where the calibration deteriorated during the experiments. Those cases were determined by analyzing the reading recordings from the participants individually by using the software provided with the eye tracking device, and the drift correction process was performed.

The calibration deteriorations in eye data appeared as two different types. In the first type, the eye fixations appeared below or above the line that the participant was reading. Such defects were corrected by sliding all eye fixations up or down. In the second type, the eye fixations appeared to be sloping up or down at the end or beginning of the line. Such defects were corrected by bringing the fixations, that were determined to be done on the same line, together by using the Drift Correct function. In the cases where both types of problems were experienced together, corrections were made using the combination of the two methods.

All the corrections were conducted by shifting the eye fixations only vertically, and no fixations were moved horizontally in any correction method (x values in the coordinate plane were preserved). Data that were not possible to be corrected by any method were removed from the analyses. Further, the trials in which the target words were skipped

were also removed from the analyses. In Table 3.3 below, the information regarding the data cleansing performed in silent reading data of the two experiments is presented.

Table 3.3: Data cleansing information for both experiments.

	TRIAL NUMBER					
	Total	**Skipped Target Word**	**Drift Correction Problem**	**Both**	**After Cleansing**	**Data Loss**
Experiment 1	4606	155	5	5	4451	3.36%
Experiment 2	240	1	0	0	239	0.41%

3.4. Data Analysis

All the analyses were conducted by using the software package IBM SPSS Statistics 23.0. In order to manage missing data, the technique, EM (expectation-maximization) was used. This technique fills in missing values with estimated values using EM methods, and it is crucial in solving problems which are likely to be caused by missing data. By using that technique, it was ensured that the number of the cases analyzed for each measure was equal (N = 48 for Experiment 1, N = 40 for Experiment 2) throughout the analyses. Below the independent and dependent variables used in the present study will be presented.

3.4.1. *Independent Variables*

Experiment I:

- **Word Length**

  There were six different groups of words according to the word length: words with 4, 6, 8, 10, 12 and 14 characters respectively.

- **Word Frequency**

  There were two groups of words according to their frequency values: frequent and infrequent words respectively.

Experiment II:

- **Suffixation Condition**

  There were three groups of target words according to their suffixation conditions: no suffix condition (only the root form of the word), one suffix condition (the suffix -DA is attached to the word), and two suffixes condition (the suffixes - DA and -ki are attached to the word together).

Experiment I and II:

- **Refixation**

  This variable is only related to the First Fixation Duration measure since it is about whether there is a single fixation on a word or there is one or more subsequent fixation after the first one, and this variable was analyzed for both experiments.

3.4.2. *Dependent Variables*

The dependent variables were the same for both of the experiments. The measures which were analyzed are: First Run Fixation Count, First Fixation Duration, Second Fixation Duration, Third Fixation Duration, Gaze Duration, The Sum of First and Second Fixation Duration, and The Sum of First, Second, and Third Fixation Duration. The definitions of these measures were presented in Chapter 1 (see Section 1.3.).

In the following chapter, the results obtained from the analyses of the two experiments described in this section will be presented.

CHAPTER 4

RESULTS

This chapter consists of two main sections: In the first section, the findings of Experiment 1, and in the second section, the findings of Experiment 2 will be presented. In both of the experiments, the same eye movement measures were analyzed. Hence, it would be helpful to remember these measures. In Figure 4.1, four of the measures are presented visually, the definitions of each measure are provided in the related sections.

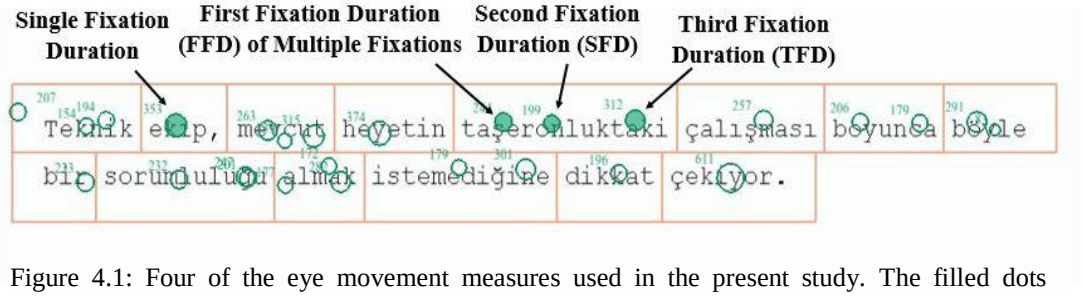

Figure 4.1: Four of the eye movement measures used in the present study. The filled dots represent the fixations.

4.1. Experiment I

This section includes the findings obtained from the analyses of Experiment 1. The order of presentation is as follows: First Run Fixation Count, First, Second, and Third Fixation Durations, Gaze Duration, Sum of First and Second Fixation Duration, and finally Sum of First, Second, and Third Fixation Duration.

4.1.1. *First Run Fixation Count (FRFC) Results*

Before reporting the findings related to fixation durations, it would be helpful to have a look at how many fixations were done on the target words. In order to examine the effects of word length and frequency on the fixation count in first pass reading, First Run Fixation Count was analyzed. In this section, findings of this measure will be presented, below the definition of this measure is provided.

- *First Run Fixation Count*: The number of all fixations in a trial falling in the first run of the word.

From Figure 4.1 above, it is possible to observe that the fixation count that the word *taşeronluktaki* received was three. Below, Table 4.1 presents the mean First Run Fixation Counts according to the related variables.

Table 4.1: Mean First Run Fixation Counts according to frequency and word length.

FIRST RUN FIXATION COUNT				
	Frequent		**Infrequent**	
Word Length	*M*	*SD*	*M*	*SD*
4 (root)	1.04	0.08	1.14	0.20
6 (one suffix)	1.25	0.21	1.50	0.50
8 (two suffixes)	1.45	0.38	1.75	0.71
10 (root)	1.57	0.41	2.27	0.78
12 (one suffix)	1.75	0.47	2.60	0.78
14 (two suffixes)	2.08	0.59	3.07	1.02

A Factorial ANOVA was conducted to compare the main effects of frequency and word length and the interaction effect between frequency and word length on First Run Fixation Count. A two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on First Run Fixation Count. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 69.83$, $p < .001$ and the interaction effect between frequency and word length, $\chi^2(14) = 69.99$, $p < .001$. In this case, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .64$ for the main effect of word length and .62 for the interaction between frequency and word length).

The main effects and the interaction are reported as significant at $p < .001$. The main effect of frequency yielded $F(1, 47) = 125.96$, $p < .001$, indicating that the mean fixation count in the first run was significantly higher for infrequent words ($M = 2.05$, $SE = 0.07$) than for frequent words ($M = 1.52$, $SE = 0.04$).

The main effect of word length yielded a significant effect, $F(3.18, 149.68) = 125.86$, $p < .001$. Pairwise comparisons (see Figure 4.2) demonstrated that the mean First Run Fixation Count was significantly the highest for the words with 14 characters, ($M = 2.57$, $SE = 0.10$) and significantly the lowest for the words with 4 characters, ($M = 1.09$, $SE = 0.01$). Accordingly, the mean First Run Fixation Count was significantly higher for the words with 12 characters, ($M = 2.18$, $SE = 0.08$) compared to the words with 10 characters, ($M = 1.92$, $SE = 0.08$). It was also higher for the words with 10 characters than for the ones with 8 characters, ($M = 1.60$, $SE = 0.07$), and for the words with 8 characters than the ones with 6 characters, ($M = 1.38$, $SE = 0.04$).

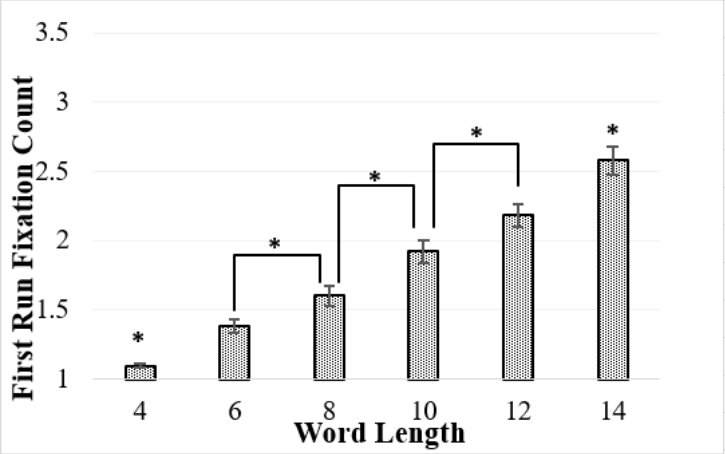

Figure 4.2: Word length effect on First Run Fixation Count. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a significant interaction effect between frequency and word length, $F(3.08, 144.82) = 24.14$, $p < .001$. Figure 4.3 presents the interaction between frequency and word length on First Run Fixation Count; it increases for both frequent and infrequent words as the words get longer.

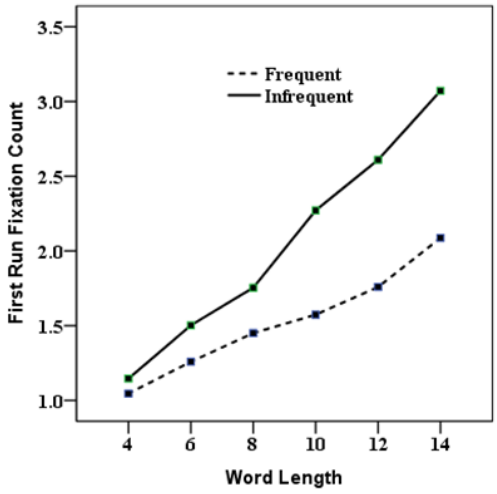

Figure 4.3: Interaction effect between frequency and word length on First Run Fixation Count

4.1.1.1. First Run Fixation Count: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on First Run Fixation Count. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the

main effect of word length, $\chi^2(14) = 68.42$, $p < .001$. So, corrected degrees of freedom were used from Greenhouse–Geisser estimates of sphericity ($\varepsilon = .63$).

The main effect of word length yielded a significant effect, F (3.16, 148.95) = 71.83, $p < .001$. Pairwise comparisons (see Figure 4.4) demonstrated that the mean First Run Fixation Count of the frequent words was significantly different ($p < .05$) among different word lengths except for the difference between the words with 6 characters, ($M = 1.45$, $SE = 0.05$) and 8 characters, ($M = 1.57$, $SE = 0.05$), and it was significantly the lowest for the words with 4 characters, ($M = 1.04$, $SE = 0.01$) and the highest for the words with 14 characters, ($M = 2.08$, $SE = 0.08$).

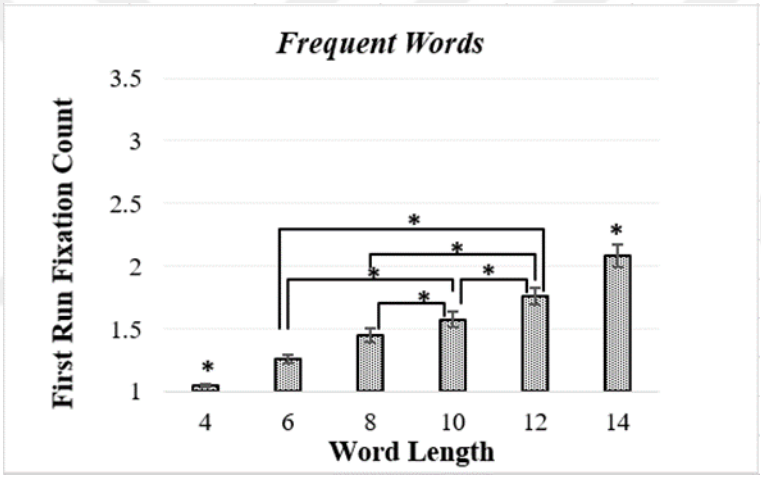

Figure 4.4: Word length effect of frequent words on First Run Fixation Count. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on First Run Fixation Count. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 55.61$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .69$).

The main effect of word length yielded a significant effect, $F(3.44, 161.97) = 94.35$, $p < .001$. Pairwise comparisons (see Figure 4.5) demonstrated that the mean First Run Fixation Count of the infrequent words was significantly the lowest for the words with 4 characters, ($M = 1.14$, $SE = 0.02$) and the highest for the words with 14 characters ($M = 3.07$, $SE = 0.14$). The difference among all word lengths was statistically significant ($p < .05$).

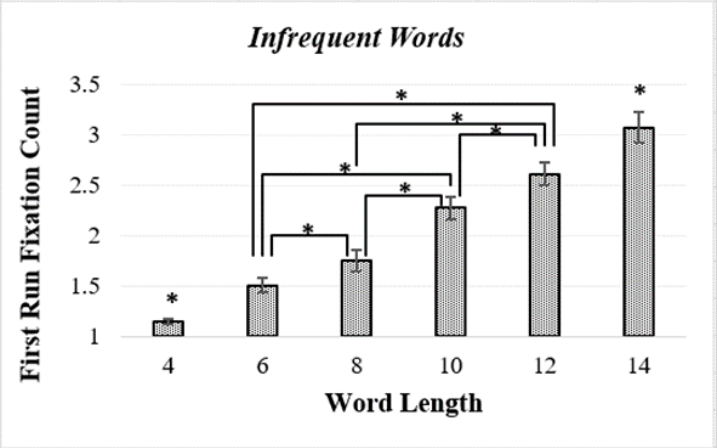

Figure 4.5: Word length effect of infrequent words on First Run Fixation Count. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.1.1.2. Summary of First Run Fixation Count Results

The mean fixation count in the first run was significantly higher for infrequent words than for frequent words. For the frequent words, it was significantly different among all word lengths except for the difference between the words with 6 and 8 characters while for the infrequent words, the difference among all word lengths was significant.

It was the lowest both for frequent and infrequent words with 4 characters and the highest both for frequent and infrequent words with 14 characters. The significant interaction between frequency and word length demonstrated that for both the frequent and infrequent words, the fixation count in the first run increased as the word length increased.

4.1.2. *First Fixation Duration (FFD) Results*

In this section, the findings regarding the First Fixation Durations on the target words will be presented. Before presenting these results, it would be helpful to provide the definitions of the measures which will be referred to in this section.

- *First Fixation Duration (FFD)*: Duration of the first fixation on a word during the first pass through the text (i.e., excluding fixations that occur after regressions)

Since FFD is the duration of the first fixation on a word regardless of whether it is the only fixation on a word or the first of multiple fixations on a word, the differentiation between these two cases will be addressed by two other local measures (see Figure 4.6):

1. Single Fixation Duration: First pass fixation duration on a word that is only fixated once.

2. FFD of Multiple Fixations: Duration of the first of multiple fixations on a word.

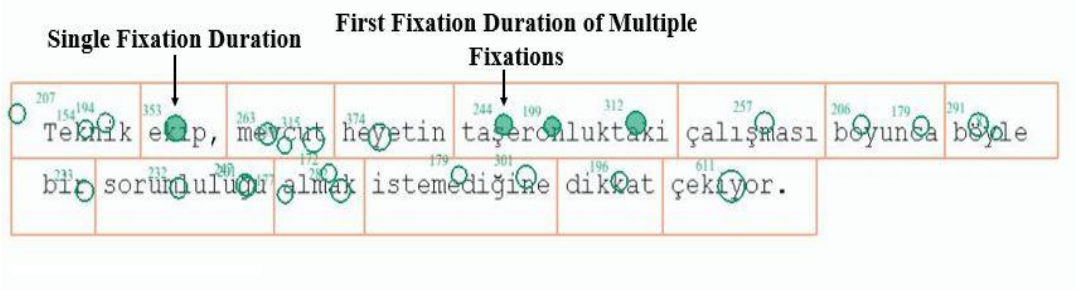

Figure 4.6: Single Fixation Duration and FFD of multiple fixations.

In other words, Single Fixation Duration is obtained when the readers pass a word by making only a single fixation, and FFD of multiple fixation cases represent the cases where the readers make second or more fixations after they fixate once on a word. It should again be noted that all the measures that will be presented in the present study are the measures of the first pass reading, (i.e., the fixations occur after regressions are excluded).

Table 4.2: Mean First Fixation Durations according to refixation, frequency, and word length.

	FIRST FIXATION DURATION (FFD) (ms)							
	SINGLE FIXATION DURATION				**FFD OF MULTIPLE FIXATIONS**			
	Frequent		**Infrequent**		**Frequent**		**Infrequent**	
Word Length	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
4 (root)	207.69	34.40	228.72	49.94	155.54	80.90	206.26	53.17
6 (one suffix)	232.52	38.09	254.22	57.35	214.46	65.02	246.08	66.75
8 (two suffixes)	251.93	73.50	284.09	68.55	208.05	73.36	252.67	68.95
10 (root)	224.92	35.67	266.97	66.97	208.51	48.85	245.04	52.02
12 (one suffix)	224.30	52.38	236.90	77.86	218.63	44.53	256.02	53.90
14 (two suffixes)	213.69	56.46	251.96	66.25	218.43	39.33	255.39	58.77

Investigating the different possible findings that will be obtained when Single Fixation Duration and FFD of Multiple Fixations are handled separately was crucial in the present study. However, before that, a Factorial ANOVA was conducted to compare the

main effects of refixation, frequency and word length and the interaction effects among them on First Fixation Duration itself.

A three-way analysis of variance was conducted to investigate the influence of three independent variables (refixation, frequency, and word length) on First Fixation Duration. Refixation included two levels (single fixation and more than one fixation), frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 24.15$, $p < .05$ and for the three interaction effects; refixation and word length, $\chi^2(14) = 34.77$, $p < .05$; frequency and word length, $\chi^2(14) = 24.41$, $p < .05$, and refixation, frequency and word length, $\chi^2(14) = 15.92$, $p < .05$. Therefore, corrected degrees of freedom from Huynh-Feldt estimates of sphericity were used ($\varepsilon = .89$ for the main effect of word length, .86 for the interaction effect between refixation and word length, .92 for the interaction effect between frequency and word length, and .97 for the interaction effect among refixation, frequency and word length).

The main effects and interaction effects are reported as significant at $p < .05$ except the interaction between frequency and word length and the interaction effect among refixation, frequency, and word length.

The main effect of refixation yielded $F(1, 47) = 13.21$, $p < .05$, indicating that the mean FFD was significantly higher for the words which were passed with a single fixation ($M = 239.83$, $SE = 4.30$) than for the ones which received more than one fixation ($M = 223.76$, $SE = 4.64$).

The main effect of frequency yielded $F(1, 47) = 68.60$, $p < .001$, indicating that the mean FFD was significantly higher for infrequent words ($M = 248.70$, $SE = 4.57$) than for frequent words ($M = 214.89$, $SE = 4.21$).

The main effect of word length yielded a significant effect, $F(4.46, 209.96) = 20.55$, $p < .001$. Pairwise comparisons (see Figure 4.7.) demonstrated that the mean FFD was significantly the lowest for the words with 4 characters ($M = 199.56$, $SE = 4.82$). The differences among the words with 6 characters, ($M = 236.82$, $SE = 5.00$), 8 characters, ($M = 249.18$, $SE = 6.31$), 10 characters, ($M = 236.36$, $SE = 4.71$), 12 characters, ($M = 233.96$, $SE = 4.92$), and 14 characters, ($M = 234.87$, $SE = 4.96$) were not significantly different.

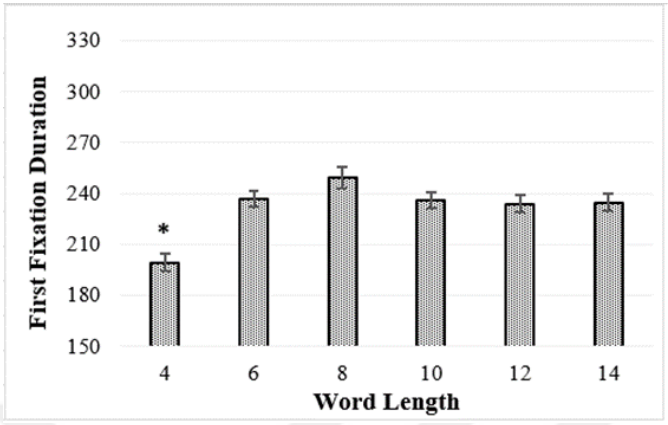

Figure 4.7: Word length effect on FFD. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a significant interaction effect between refixation and word length, $F(4.32, 203.36) = 6.78$, $p < .001$. Figure 4.8 presents the interaction between refixation and word length; in longer words, especially after the words 10 characters, FFD decreases in the cases when there is a single fixation while it increases in the cases when there is more than one fixation.

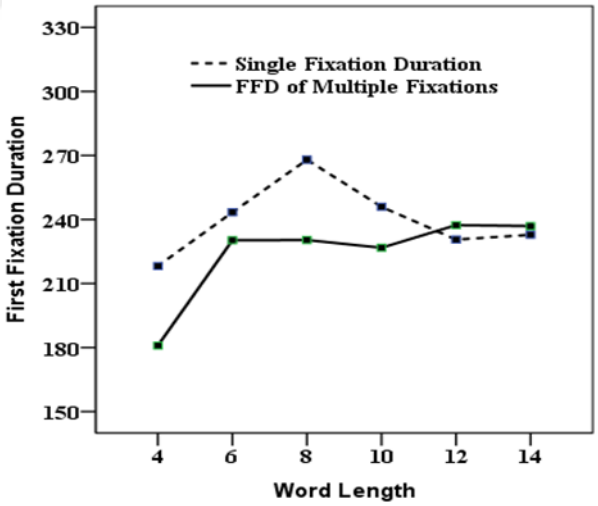

Figure 4.8: Interaction effect between refixation and word length on FFD. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

The interaction effect between frequency and word length was not significant, $F(4.63, 217.97) = 0.79$, $p = .55$. Additionally, the interaction effect among refixation, frequency and word length was not statistically significant, $F(4.87, 229.25) = 0.75$, $p = .58$.

This section has provided the general picture of First Fixation Duration. However, in order to examine the nature of the interaction between refixation and word length

accurately, Single Fixation Duration and FFD of Multiple Fixations were needed to be analyzed separately. The section below presents those analyses.

4.1.2.1 Single Fixation Duration vs. FFD of Multiple Fixations

In the section above, the general findings regarding the First Fixation Duration are reported. In the current section, the findings regarding the Single Fixation Duration and FFD of Multiple Fixations will be presented respectively.

A two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on Single Fixation Duration. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 26.68$, $p < .05$ and the interaction effect between frequency and word length, $\chi^2(14) = 58.15$, $p < .001$. Therefore, degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .90$ for the main effect of word length) and Greenhouse–Geisser estimates of sphericity ($\varepsilon = .66$ for the interaction term).

The main effect of frequency yielded $F(1, 47) = 23.63$, $p < .001$, indicating that the mean Single Fixation Duration was significantly higher for the infrequent words ($M = 253.81$, $SE = 5.90$) than for the frequent words ($M = 225.84$, $SE = 4.33$).

The main effect of word length yielded a significant effect, $F(4.50, 211.81) = 10.98$, $p < .001$. Pairwise comparisons (see Figure 4.9.) demonstrated that the mean Single Fixation Duration was significantly higher for the words with 8 characters ($M = 268.01$, $SE = 7.81$) than the words with 4 characters ($M = 218.21$, $SE = 5.36$), 10 characters ($M = 245.95$, $SE = 5.62$), 12 characters ($M = 230.60$, $SE = 7.06$), and 14 characters ($M = 232.83$, $SE = 6.18$). Additionally, the mean Single Fixation Duration was significantly higher for words with 6 characters ($M = 243.37$, $SE = 5.75$) and words with 10 characters than for the words with 4 characters. The interaction effect among frequency and word length was not statistically significant, $F(3.27, 153.83) = 1.23$, $p = .30$.

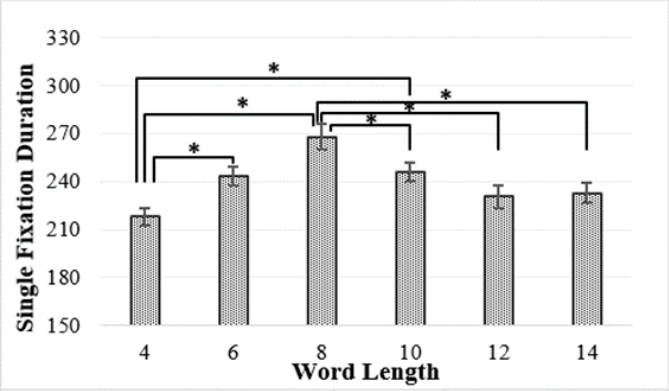

Figure 4.9: Word length effect on Single Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on FFD of Multiple Fixations. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 55.15$, $p < .001$ and the interaction effect between frequency and word length, $\chi^2(14) = 39.70$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\varepsilon = .74$ for the main effect of word length) and Huynh-Feldt estimates of sphericity ($\varepsilon = .83$ for the interaction term).

The main effect of frequency yielded $F(1, 47) = 94.31$, $p < .001$, indicating that the mean FFD of Multiple Fixations was significantly higher for the infrequent words ($M = 243.58$, $SE = 4.86$) than for the frequent words ($M = 203.94$, $SE = 5.27$).

The main effect of word length yielded a significant effect, $F(3.71, 174.38) = 16.12$, $p < .001$. Pairwise comparisons (see Figure 4.10.) demonstrated that the mean FFD of Multiple Fixations was significantly the lowest for the words with 4 characters, ($M = 180.90$, $SE = 6.89$) while the difference among the words with 6, ($M = 230.27$, $SE = 7.72$), 8, ($M = 230.36$, $SE = 7.56$), 10, ($M = 226.78$, $SE = 5.62$), 12, ($M = 237.33$, $SE = 6.12$), and 14 characters, ($M = 236.91$, $SE = 6.16$) was not statistically significant. Additionally, the interaction effect among frequency and word length was not statistically significant, $F(4.19, 197.08) = 0.38$, $p = .83$.

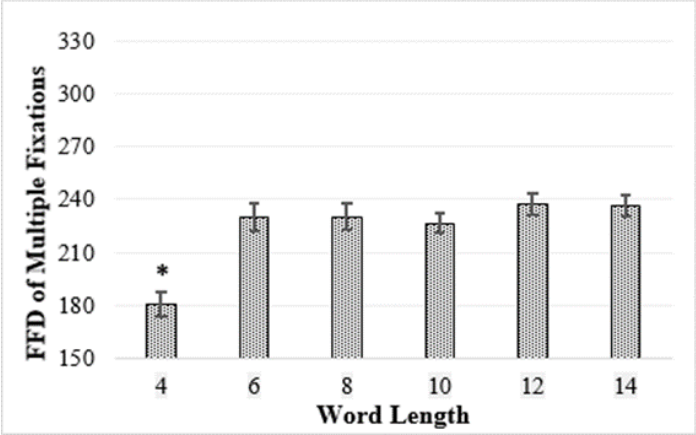

Figure 4.10: Word length effect on FFD of Multiple Fixations. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Since the main effect of frequency was always significant in the analyses above, to be able to observe only the effect of word length on Single Fixation Duration and FFD of Multiple Fixations separately, further analyses were needed. In sections, 4.1.2.2. and 4.1.2.3., those analyses are presented.

4.1.2.2 Single Fixation Duration: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on Single Fixation Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 79.56$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .65$).

The main effect of word length yielded a significant effect, $F(3.23, 152.20) = 5.88$, $p < .05$. Pairwise comparisons (see Figure 4.11) indicated that the mean Single Fixation Duration of the frequent words was significantly higher for the words with 8 characters, ($M = 251.93$, $SE = 10.60$) than the words with 4 characters ($M = 207.69$, $SE = 4.96$), and 14 characters ($M = 213.69$, $SE = 8.15$). Additionally, the words with 6 characters ($M = 232.52$, $SE = 5.49$) had a significantly higher mean Single Fixation Duration than the words with 4 characters.

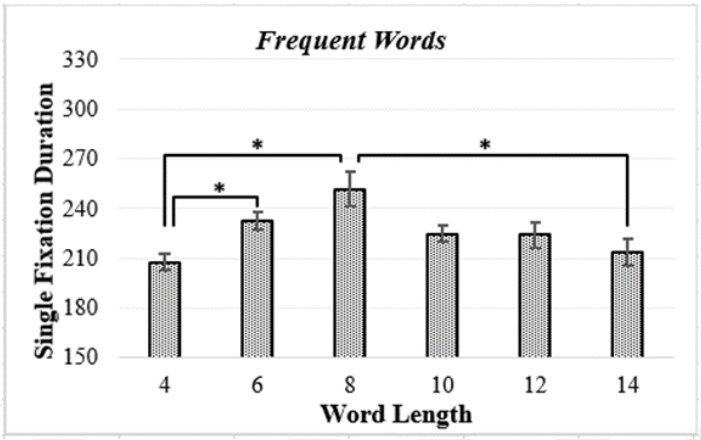

Figure 4.11: Word length effect of frequent words on Single Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on Single Fixation Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 38.01$, $p < .05$. Therefore, corrected degrees of freedom from Huynh-Feldt estimates of sphericity were used ($\varepsilon = .84$).

The main effect of word length yielded a significant effect, $F(4.22, 198.48) = 6.26$, $p < .001$. Pairwise comparisons (see Figure 4.12) indicated that the mean Single Fixation Duration of the infrequent words was significantly higher for the words with 8 characters than the words with 4 characters ($M = 228.73$, $SE = 7.20$), and 12 characters ($M = 236.90$, $SE = 11.23$). Additionally, the words with 10 characters ($M = 266.97$, $SE = 9.66$) had a significantly higher mean Single Fixation Duration than the words with 4 characters.

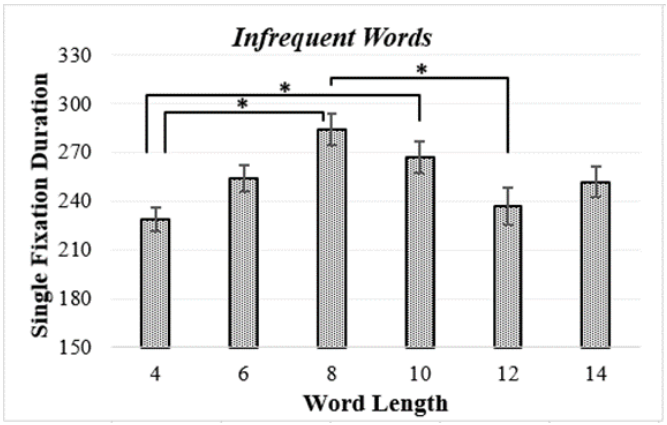

Figure 4.12: Word length effect of infrequent words on Single Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a pattern that is likely to be realized in the results of Single Fixation Duration about the relationship among the words with 4, 6, and 8. It is worth to remember that the

words with 4 and 10 characters are the root forms while the ones with 6 and 12 characters are the ones representing the roots with one suffix (-DA) attached, and 8 and 14 characters are the ones to which two suffixes (-DAki) attached. Single Fixation Duration revealed a regular increase until to the words with 8 characters, then decreased on the words the words with 10 characters, and provided mixed results regarding the words with longer than 10 characters.

4.1.2.3. FFD of Multiple Fixations: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on FFD of Multiple Fixations. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 54.01$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .74$).

The main effect of word length yielded a significant effect, $F(3.69, 173.69) = 9.96$, $p < .001$. Pairwise comparisons (see Figure 4.13) indicated that the mean FFD of Multiple Fixations of the frequent words was significantly the lowest for the words with 4 characters ($M = 155.54$, $SE = 11.67$).

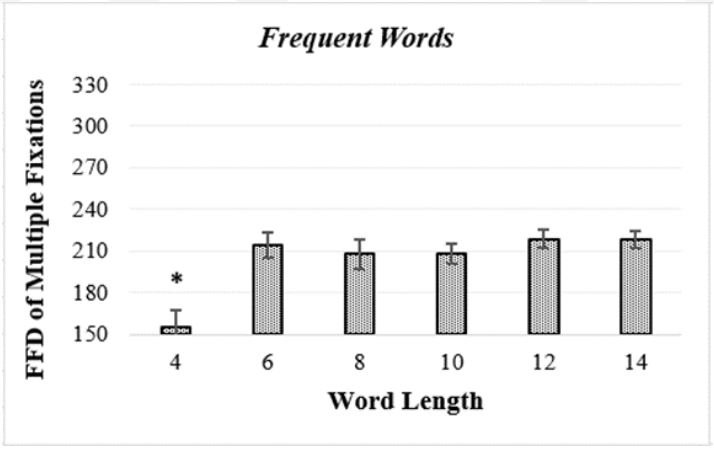

Figure 4.13: Word length effect of the frequent words on FFD of Multiple Fixations. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on FFD of Multiple Fixations. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 26.11$, $p < .05$. Therefore, corrected degrees of freedom from Huynh-Feldt estimates of sphericity were used ($\varepsilon = .93$).

The main effect of word length yielded a significant effect, $F(4.62, 217.30) = 5.97$, $p < .001$. Pairwise comparisons (see Figure 4.14) indicated that the mean FFD of Multiple

Fixations of the infrequent words was significantly the lowest for the words with 4 characters (M = 206.26, SE = 7.67).

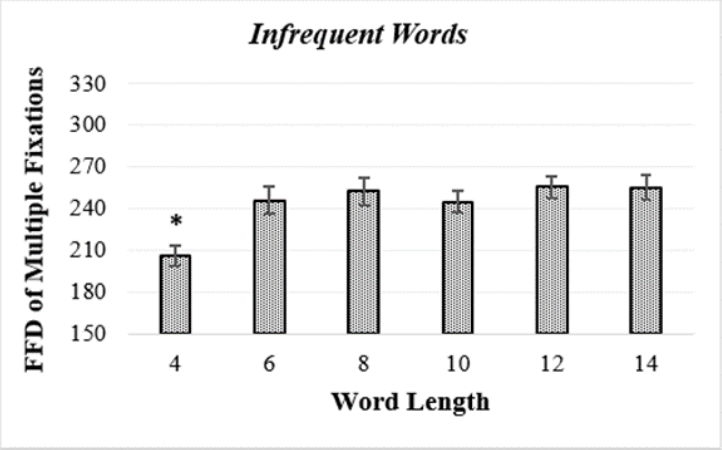

Figure 4.14: Word length effect of infrequent words on FFD of Multiple Fixations. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

The analysis regarding the FFD of Multiple Fixations revealed that when there was more than one fixation on a word, the lowest first fixation duration was on the words with 4 characters which was the shortest group in Experiment 1, and those words were in their root form. There was not a significant result regarding the other word length groups observed by looking at the FFD of Multiple Fixation Duration Results.

4.1.2.4. Summary of FFD Results

FFD is an important parameter since it is associated with lexical access. The analyses conducted so far demonstrated that FFD was higher for the words which were passed with a single fixation than for the ones which received more than one fixation and it was higher for infrequent words than for frequent words. There was an interaction between refixation and word length.

When the further analysis conducted on the two sub-local measures of First Fixation Duration, the findings that Single Fixation Duration could reveal more about relatively shorter words (up until 8 characters) while FFD of Multiple Fixations could only reveal that root forms of the short words (4 characters) received the lowest first fixation duration. Since the analyses of FFD of Multiple Fixations provided less about longer words, in the following sections, the findings regarding the subsequent fixations will be presented

4.1.3. *Second Fixation Duration (SFD) Results:*

In this section, the findings regarding the Second Fixation Duration will be presented. The definition of Second Fixation Duration and the image representing it (see Figure 4.15) are presented below.

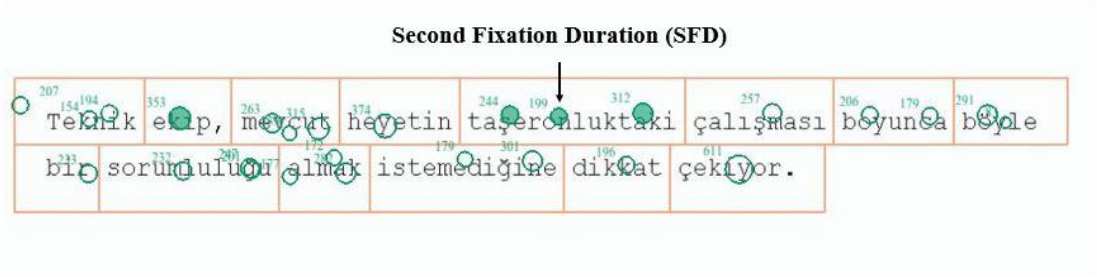

Figure 4.15: Second Fixation Duration.

- *Second Fixation Duration:* The duration of the second fixation on a word.

Table 4.3: Mean Second Fixation Durations according to frequency and word length.

SECOND FIXATION DURATION (ms)				
	Frequent		**Infrequent**	
Word Length	*M*	*SD*	*M*	*SD*
4 (root)	207.13	94.58	174.10	61.35
6 (one suffix)	174.55	47.66	231.80	59.80
8 (two suffixes)	183.65	55.91	221.66	56.32
10 (root)	171.66	43.02	199.42	41.57
12 (one suffix)	195.73	41.86	211.75	40.57
14 (two suffixes)	202.76	37.09	213.36	40.34

A Factorial ANOVA was conducted to compare the main effects of frequency and word length and the interaction effect between frequency and word length on Second Fixation Duration. A two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on Second Fixation Duration in first pass reading. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 100.75$, $p < .001$ and the interaction effect between frequency and word length, $\chi^2(14) = 70.35$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .59$ for the main effect of word length and .61 for the interaction effect between frequency and word length).

The main effects and the interaction are reported as significant at $p < .05$. The main effect of frequency yielded $F(1, 47) = 29.40$, $p < .001$, indicating that the mean SFD was

significantly higher for infrequent words (M = 208.68, SE = 5.00) than for frequent words (M = 189.25, SE = 4.82).

The main effect of word length yielded a significant effect, $F(2.94, 138.25) = 4.03$, $p < .05$. Pairwise comparisons (see Figure 4.16) demonstrated that the mean SFD was significantly higher for words with 6 characters, (M = 203.18, SE = 6.37), 12 characters, (M = 203.74, SE = 4.97) and 14 characters, (M = 208.06, SE = 4.33) than words with 10 characters, (M = 185.54, SE = 5.08).

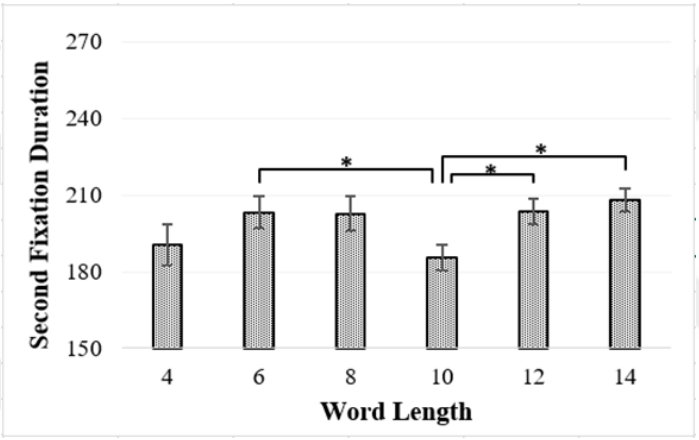

Figure 4.16: Word length effect on SFD. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a significant interaction effect between frequency and word length, $F(3.02, 142.29) = 9.576$, $p < .001$. Figure 4.17 presents the interaction between frequency and word length; starting from the words with 8 characters, frequent and infrequent words follow a similar pattern on their SFDs.

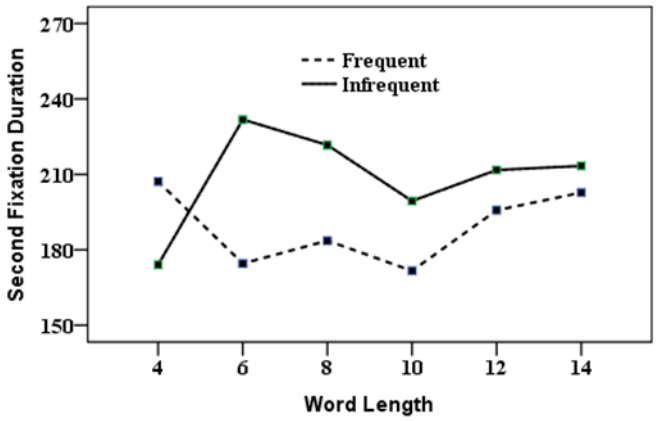

Figure 4.17: Interaction effect between frequency and word length on SFD.

4.1.3.1. Second Fixation Duration: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on Second Fixation Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 104.92$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .48$).

The main effect of word length yielded a significant effect, $F(2.37, 111.735) = 4.18$, $p < .05$. Pairwise comparisons (see Figure 4.18) demonstrated that the mean SFD of the frequent words was significantly higher for the words with 12 characters, ($M = 195.73$, $SE = 6.04$) and 14 characters, ($M = 202.76$, $SE = 5.35$) than the words with 6 characters, ($M = 174.55$, $SE = 6.88$) and 10 characters, ($M = 171.66$, $SE = 6.21$).

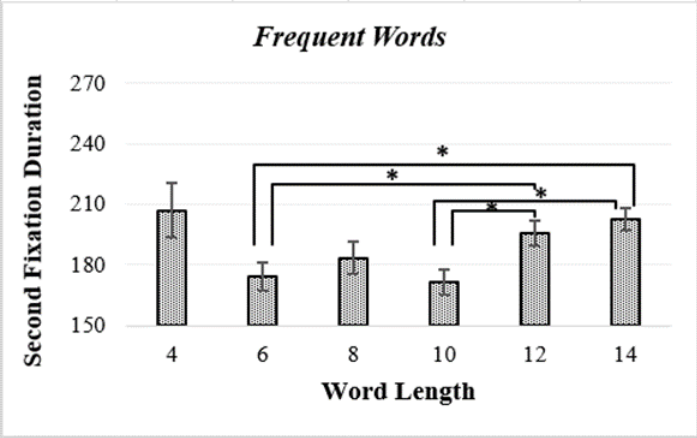

Figure 4.18: Word length effect of the frequent words on SFD. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on Second Fixation Duration. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 45.08$, $p < .001$. Therefore, corrected degrees of freedom from Huynh-Feldt estimates of sphericity were used ($\varepsilon = .85$).

The main effect of word length yielded a significant effect, $F(4.25, 199.92) = 11.65$, $p < .001$. Pairwise comparisons (see Figure 4.19) demonstrated that the mean SFD of the infrequent words was significantly higher for the words with 6 characters, ($M = 231.81$, $SE = 8.63$) than the words with 10 characters, ($M = 199.42$, $SE = 6.00$), and it was the lowest for the words with 4 characters ($M = 174.10$, $SE = 8.85$).

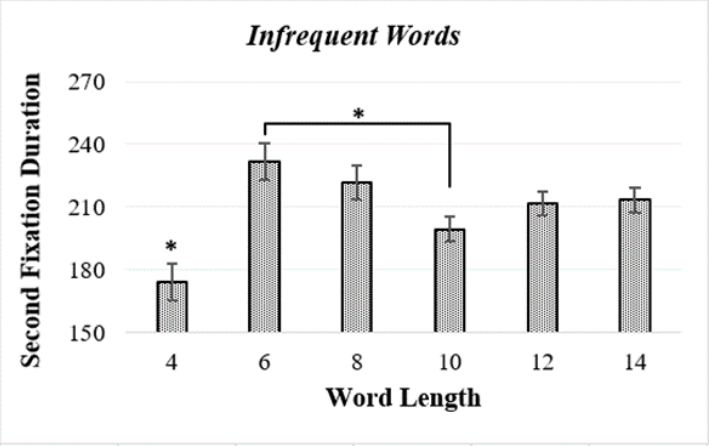

Figure 4.19: Word length effect of the infrequent words on SFD. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.1.3.2. Summary of SFD Results

The analyses on SFD demonstrated that similar to FFD, SFD was also higher for infrequent words than for frequent words. There was a significant interaction between frequency and word length. SFD of the frequent words was higher for the words with 12 and 14 characters than the words with 6 and 10 characters while SFD of the infrequent words was significantly higher for the words with 6 characters than the words with 10 characters, and it was the lowest for the words with 4 characters.

Different from the results of FFD (see section 4.1.2.), the results of SFD suggest differences between frequent and infrequent words with different lengths. Findings of Third Fixation Duration will be presented in the following section in order to examine whether there are clearer effects on this measure.

4.1.4. *Third Fixation Duration (TFD) Results*

This section includes the findings regarding the Third Fixation Duration. The definition of Third Fixation Duration and the image representing it (see Figure 4.20) are presented below.

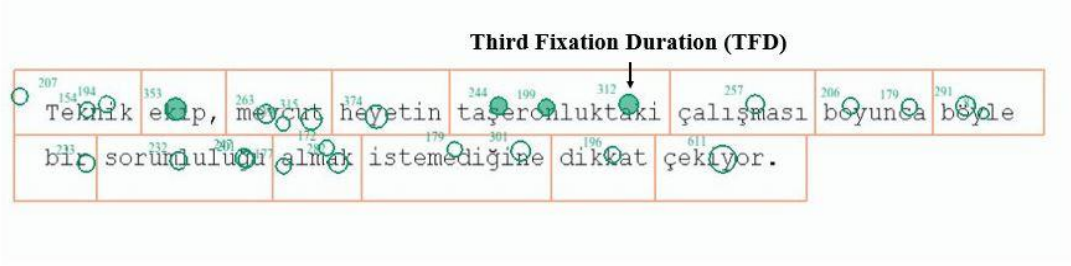

Figure 4.20: Third Fixation Duration on a word.

- *Third Fixation Duration:* The duration of the third fixation on a word.

Table 4.4: Mean Third Fixation Durations according to frequency and word length.

THIRD FIXATION DURATION (ms)				
	Frequent		**Infrequent**	
Word Length	*M*	*SD*	*M*	*SD*
4 (root)	NA	NA	230.90	143.81
6 (one suffix)	254.73	430.27	195.91	116.31
8 (two suffixes)	205.39	33.06	204.45	69.53
10 (root)	167.95	49.57	225.42	71.37
12 (one suffix)	196.71	57.60	228.50	69.29
14 (two suffixes)	193.51	35.71	222.39	50.85

A Factorial ANOVA was conducted to compare the main effects of frequency and word length and the interaction effect between frequency and word length on Third Fixation Duration. A two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on Third Fixation Duration in first pass reading. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 387.72$, $p < .001$ and the interaction effect between frequency and word length, $\chi^2(14) = 249.65$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .25$ for the main effect of word length and .30 for the interaction term).

The main effects and the interaction are reported as significant at $p < .05$. The main effect of frequency yielded $F(1, 47) = 21.67$, $p < .001$, indicating that the mean TFD was significantly higher for infrequent words ($M = 217.93$, $SE = 7.77$) than for frequent words ($M = 169.72$, $SE = 12.11$).

The main effect of word length yielded a significant effect, $F(1.25, 59.13) = 6.23$, $p < .05$. Pairwise comparisons (see Figure 4.21) demonstrated that the mean TFD was significantly higher for the words with 8 characters, ($M = 204.92$, $SE = 6.09$), 10 characters, ($M = 196.69$, $SE = 4.89$), 12 characters, ($M = 212.60$, $SE = 7.28$), and 14 characters, ($M = 207.95$, $SE = 5.30$) than the words with 4 characters, ($M = 115.45$, $SE = 10.37$).

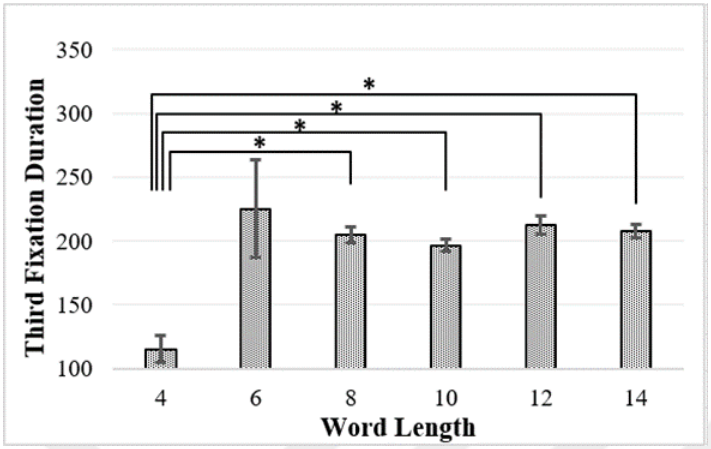

Figure 4.21: Word length effect on TFD. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a significant interaction effect between frequency and word length, $F(1.46, 69.93) = 11.77$, $p < .001$. Figure 4.22 presents the interaction between frequency and word length; between the words with 6 and 12 characters, the mean TFD of infrequent words increases while the mean TFD of the frequent words decreases between the words with 6 and 10 characters.

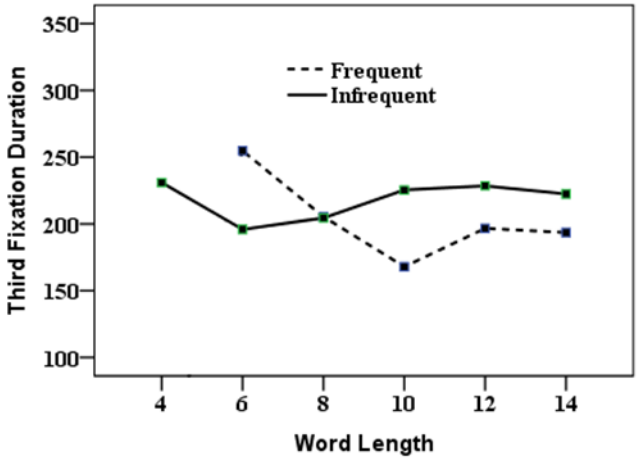

Figure 4.22: Interaction effect between frequency and word length on TFD.

4.1.4.1. Third Fixation Duration: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on Third Fixation Duration. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 557.51$, $p <$

.001. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used (ε = .21).

The main effect of word length yielded a significant effect, $F(1.06, 50) = 12.27$, $p < .05$. Pairwise comparisons (see Figure 4.23) demonstrated that the mean TFD of the frequent words was significantly higher for the words with 8 characters, (M = 205.39, SE = 4.77) than the words with 10 characters (M = 167.95, SE = 7.15). There was no third fixation on the frequent words with 4 characters.

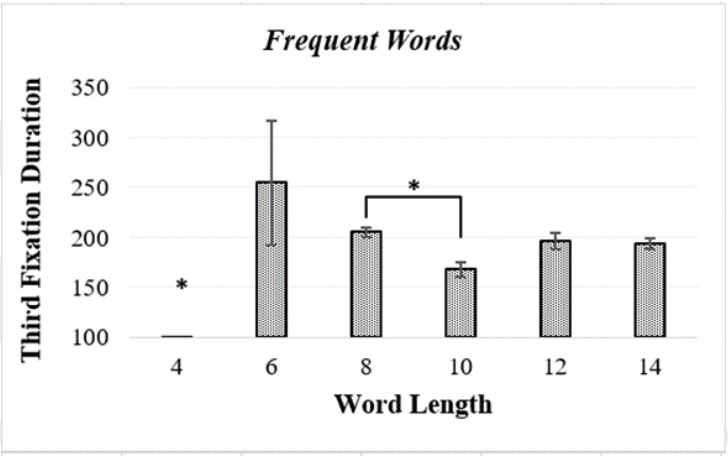

Figure 4.23: Word length effect of the frequent words on TFD. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on Third Fixation Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 132.20$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used (ε = .52).

The main effect of word length yielded $F(2.58, 121.67) = 1.43$, $p = .23$ indicating that the difference among the mean TFD on infrequent words was not significantly affected by the word length.

4.1.4.2. Summary of TFD Results

The TFD analyses revealed that TFD was higher for infrequent words than for frequent words which was the case for FFD and SFD as well. There was a significant interaction effect between frequency and word length. There was no Third Fixation Duration on frequent words with 4 characters. Additionally, while frequent words with 8 characters had a higher mean TFD than the frequent words with 10 characters, there was no significant effect of the word length on TFD for infrequent words.

4.1.5. *Gaze Duration Results*

In this section, the findings regarding the Gaze Duration will be presented. The definition of Gaze Duration and the image representing it (see Figure 4.24) are presented below.

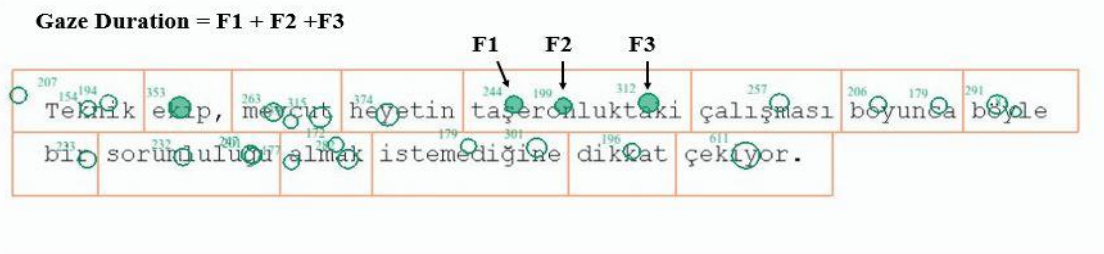

Figure 4.24: Gaze Duration.

- *Gaze Duration:* The sum of all fixations made on a word prior to a saccade to another word.

Table 4.5: Mean Gaze Durations according to frequency and word length.

GAZE DURATION (ms)				
	Frequent		**Infrequent**	
Word Length	*M*	*SD*	*M*	*SD*
4 (root)	600.15	146.23	628.52	172.29
6 (one suffix)	656.35	178.54	807.47	234.16
8 (two suffixes)	695.80	162.27	878.79	215.57
10 (root)	637.62	115.44	921.99	237.49
12 (one suffix)	690.94	119.45	965.58	207.02
14 (two suffixes)	727.11	146.70	1075.91	313.01

A Factorial ANOVA was conducted to compare the main effects of frequency and word length and the interaction effect between frequency and word length on Gaze Duration. A two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on Gaze Duration in first pass reading. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 53.47$, $p < .001$ and the interaction effect between frequency and word length, $\chi^2(14) = 31.86$, $p < .05$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\varepsilon = .71$for the main effect of word length)

and Huynh-Feldt estimates of sphericity .91 for the interaction effect between frequency and word length).

The main effects and the interaction are reported as significant at $p < .001$. The main effect of frequency yielded $F(1, 47) = 168.36$, $p < .001$, indicating that the mean Gaze Duration was significantly higher for infrequent words ($M = 879.70$, $SE = 25.22$) than for frequent words ($M = 667.99$, $SE = 15.60$).

The main effect of word length yielded a significant effect, $F(3.56, 167.56) = 38.93$, $p < .001$. Pairwise comparisons (see Figure 4.25) demonstrated that the mean Gaze Duration was significantly the lowest for the words with 4 characters, ($M = 614.33$, $SE = 18.57$). Pairwise comparisons also demonstrated that the mean Gaze Duration was significantly higher for the words with 14 characters, ($M = 901.51$, $SE = 29.56$) than the words with 10 characters, ($M = 779.80$, $SE = 22.98$), 8 characters, ($M = 787.29$, $SE = 22.19$), and 6 characters, ($M = 731.91$, $SE = 28.15$). Additionally, the words with 12 characters (M = 828.259, SE = 20.136) had a mean Gaze Duration significantly higher than the words with 6 characters.

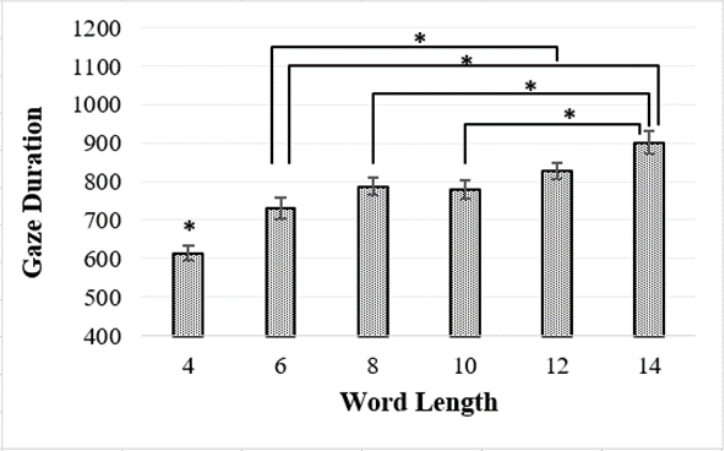

Figure 4.25: Word length effect on Gaze Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a significant interaction effect between frequency and word length, $F(4.58, 215.48) = 17.93$, $p < .001$. Figure 4.26 illustrates the interaction effect between frequency and word length on Gaze Duration; for the infrequent words, Gaze Duration increases as the words get longer. On the other hand, for the frequent words, it increases up to words with 8 characters, then decreases on the words with 10 characters, then it again increases as the words get longer.

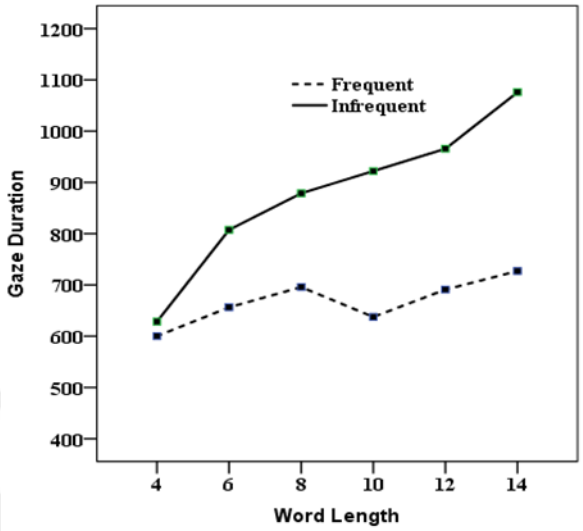

Figure 4.26: Interaction effect between frequency and word length on Gaze Duration.

4.1.5.1. Gaze Duration: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on Gaze Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 73.41$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .63$).

The main effect of word length yielded a significant effect, $F(3.19, 149.93) = 8.56$, $p < .001$. Pairwise comparisons (see Figure 4.27) demonstrated that the mean Gaze Duration of the frequent words was significantly higher for the words with 14 characters, (M = 727.11, SE = 21.17), 12 characters, (M = 690.93, SE = 17.24), and 8 characters, (M = 695.80, SE = 23.42) than the words with 4 characters, (M = 600.15, SE = 21.10). Pairwise comparisons also demonstrated that the mean Gaze Duration of the frequent words was significantly higher for the words with 12 characters than the words with 10 characters, (M = 637.62, SE = 16.66).

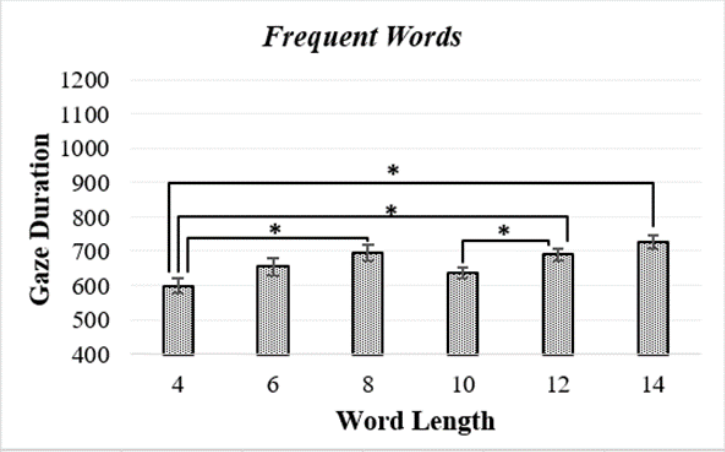

Figure 4.27: Word length effect of the frequent words on Gaze Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on Dwell Time. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 43.13$, $p < .05$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .74$).

The main effect of word length yielded a significant effect, $F(3.70, 174.33) = 38.39$, $p < .001$. Pairwise comparisons (see Figure 4.28) demonstrated that the mean Gaze Duration of the infrequent words was significantly the lowest for the words with 4 characters, ($M = 628.52$, $SE = 24.86$) and it was higher for the words with 14 characters, ($M = 1075.90$, $SE = 45.17$) than the words with 10 characters, ($M = 921.98$, $SE = 34.27$), 8 characters, ($M = 878.78$, $SE = 31.11$), and 6 characters, ($M = 807.46$, $SE = 33.79$). Additionally, the words with 12 characters, ($M = 965.58$, $SE = 29.88$) and 10 characters had a significantly higher mean Gaze Duration than the words with 6 characters.

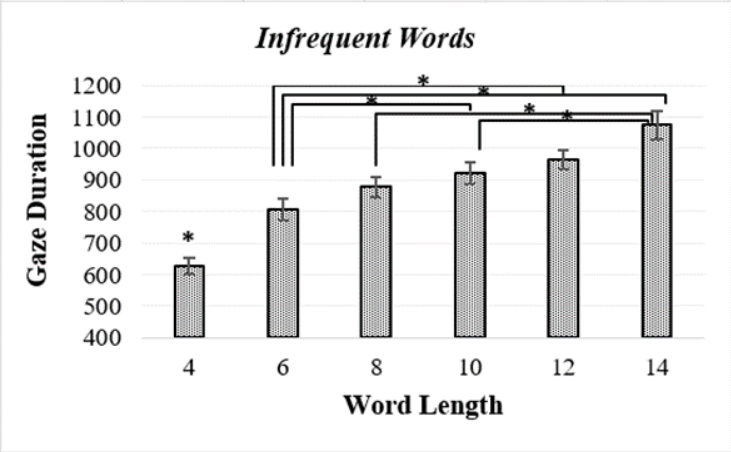

Figure 4.28: Word length effect of the infrequent words on Gaze Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.1.5.2. Summary of Gaze Duration Results

The analyses of Gaze Duration demonstrated that it was higher for the infrequent words than for the frequent words which was consistent with the results of the findings of the other measures that were reported in the above sections. There was a significant interaction effect between frequency and word length.

For the frequent words, Gaze Duration was significantly higher for the words with 14, 12, and 8 characters than the words with 4 characters; it was also higher for the words with 12 characters than the words with 10 characters. For the infrequent words Gaze Duration was the lowest for the words with 4 characters and it was higher for the words with 14 characters than the words with 10, 8, and 6 characters. The words with 12 and 10 characters had a significantly higher mean Gaze Duration than the words with 6 characters.

So far, the findings of the analyses conducted on First, Second, and Third Fixation Duration and Gaze Duration are reported. In the following section, the results of the Sum of First and Second Fixation Duration will be presented. The rationale behind this analysis is the fact that lexical access is assumed to be started in First Fixation Duration, and it is likely that for longer words, this access may take longer than the duration of the first fixation. Although this method of analyzing may not suggest much for the cases when lexical access is completed with a single fixation, there is a possibility for longer words such that this process is completed together with first and one or more subsequent fixations. In order to examine this possibility, this further analysis was conducted.

4.1.6. *Sum of First and Second Fixation Duration Results*

The Sum of First and Second Fixation Duration measure was obtained by adding the duration of the first of multiple fixations on a word to the duration of the second fixation on a word.

Table 4.6: Mean Sum of First and Second Fixation Durations according to frequency and word length.

FFD + SFD (ms)				
	Frequent		**Infrequent**	
Word Length	*M*	*SD*	*M*	*SD*
4 (root)	373.48	127.32	380.58	92.65
6 (one suffix)	392.93	83.43	482.02	102.02
8 (two suffixes)	397.28	92.07	472.01	90.53
10 (root)	380.43	70.18	444.47	66.13
12 (one suffix)	414.50	71.34	467.96	73.73
14 (two suffixes)	421.19	63.26	468.76	82.35

A Factorial ANOVA was conducted to compare the main effects of frequency and word length and the interaction effect between frequency and word length on the sum of First and Second Fixation Duration. A two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on the sum of First and Second Fixation Duration. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 58.74$, $p < .001$ and the interaction effect between frequency and word length, $\chi^2(14) = 31.13$, $p < .05$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\varepsilon = .71$ for the main effect of word length) and Huynh-Feldt estimates of sphericity ($\varepsilon = .86$ for the interaction effect between frequency and word length).

The main effects and the interaction are reported as significant at $p < .05$. The main effect of frequency yielded $F(1, 47) = 160.02$, $p < .001$, indicating that the mean Sum of First and Second Fixation Duration was significantly higher for infrequent words ($M = 452.63$, $SE = 8.62$) than for frequent words ($M = 396.63$, $SE = 8.83$).

The main effect of word length yielded a significant effect, $F(3.52, 165.65) = 14.01$, $p < .001$. Pairwise comparisons (see Figure 4.29) demonstrated that the mean Sum of First and Second Fixation Duration was significantly the lowest for the words with 4 characters, ($M = 377.03$, $SE = 13.69$) and it was significantly higher both for the words with 14, ($M = 444.97$, $SE = 9.27$) and 12 characters, ($M = 441.23$, $SE = 9.12$), than for the words with 10 characters, ($M = 412.45$, $SE = 8.33$).

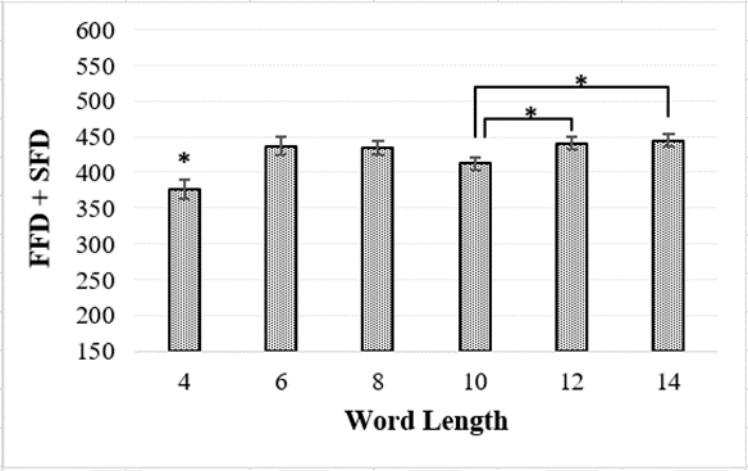

Figure 4.29: Word length effect on Sum of First and Second Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a significant interaction effect between frequency and word length, $F(4.31, 202.83) = 4.25$, $p < .05$. In Figure 4.30, the interaction between frequency and word length is presented. The frequent and infrequent words follow a similar pattern except for the duration on words with 6 characters.

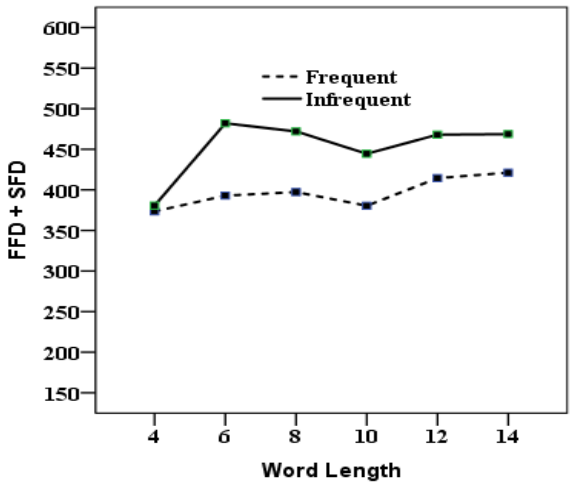

Figure 4.30: Interaction effect between frequency and word length on Sum of First and Second Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.1.6.1. Sum of First and Second Fixation Duration: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on the sum of First and Second Fixation Duration. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word

length, $\chi^2(14) = 82.82$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .57$).

The main effect of word length yielded a significant effect, $F(2.82, 132.76) = 3.58$, $p < .05$. Pairwise comparisons (see Figure 4.31) demonstrated that the mean Sum of First and Second Fixation Duration of the frequent words was significantly higher for the words with 14 characters, ($M = 421.19$, $SE = 9.13$) than the words with 4 characters ($M = 373.48$, $SE = 18.37$). Additionally, the mean Sum of First and Second Fixation Duration of the frequent words was significantly higher for the words with 14 and 12 characters, ($M = 414.50$, $SE = 10.29$) than the words with 10 characters, ($M = 380.43$, $SE = 10.13$).

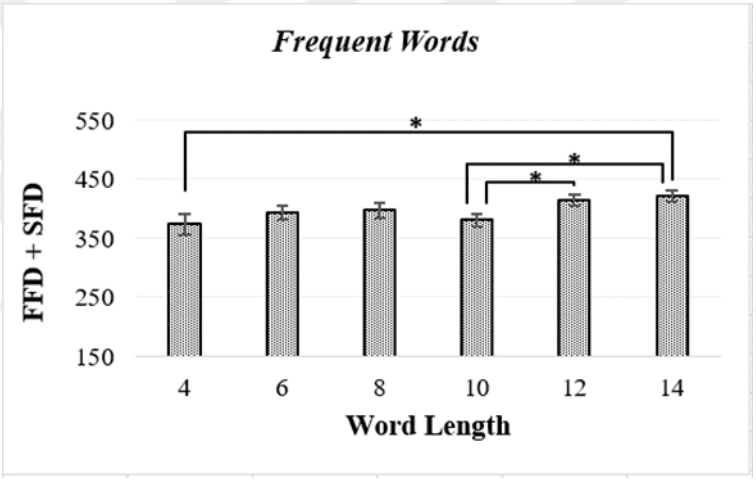

Figure 4.31: Word length effect of the frequent words on Sum of First and Second Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on the sum of First and Second Fixation Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 47.27$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .69$).

The main effect of word length yielded a significant effect, $F(3.42, 161.18) = 15.02$, $p < .001$. Pairwise comparisons (see Figure 4.32) demonstrated that the mean Sum of First and Second Fixation Duration of the infrequent words was significantly the lowest for the words with 4 characters, ($M = 380.59$, $SE = 13.37$).

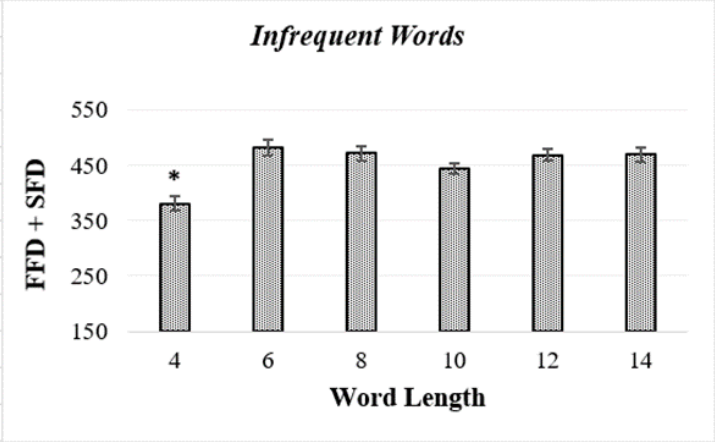

Figure 4.32: Word length effect of the infrequent words on Sum of First and Second Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.1.6.2. Summary of Sum of First and Second Fixation Results

The results of the analysis on Sum of First and Second Fixation Duration revealed that it was higher for infrequent words than for frequent words. Further, for frequent words, it was higher for the words with 14 characters than the words with 4 characters while it was higher for the words with 14 and 12 characters than the words with 10 characters. For the infrequent words, it was the lowest for the words with 4 characters.

In the following section, the findings regarding the Sum of First, Second and Third Fixation Duration will be presented in order to examine whether the lexical access can be completed in three subsequent fixations. It is especially important for longer words; although the analyses of the Sum of First and Second Fixations provided results related to long and frequent words, less is known for the long and infrequent words from the analyses reported so far.

4.1.7. *Sum of First, Second, and Third Fixation Duration Results*

The Sum of First, Second and Third Fixation Duration measure was obtained by summing up the duration of the first of multiple fixations on a word with the duration of the second and the third fixation on a word.

Table 4.7: Mean Sum of First, Second, and Third Fixation Durations according to frequency and word length.

FFD + SFD + TFD (ms)				
	Frequent		**Infrequent**	
Word Length	*M*	*SD*	*M*	*SD*
4 (root)	375.31	121.47	398.97	172.13
6 (one suffix)	462.03	338.95	566.38	181.09
8 (two suffixes)	473.18	145.69	596.83	166.84
10 (root)	450.22	132.35	647.22	132.67
12 (one suffix)	525.68	151.72	664.04	117.61
14 (two suffixes)	571.06	115.46	681.96	111.93

A Factorial ANOVA was conducted to compare the main effects of frequency and word length and the interaction effect between frequency and word length on the sum of First, Second and Third Fixation Duration. A two-way analysis of variance was conducted to investigate the influence of two independent variables (frequency, word length) on the sum of First, Second and Third Fixation Duration. Frequency included two levels (frequent, infrequent) and word length consisted of six levels (words with 4, 6, 8, 10, 12, 14 characters respectively).

When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 87.20$, $p < .001$ and the interaction effect between frequency word length, $\chi^2(14) = 41.39$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\varepsilon = .51$ for the main effect of word length) and Huynh-Feldt estimates of sphericity (.85 for the interaction effect between frequency and word length).

The main effects and the interaction are reported as significant at $p < .05$. The main effect of frequency yielded $F(1, 47) = 117.75$, $p < .001$, indicating that the mean Sum of First, Second and Third Fixation Duration was significantly higher for infrequent words ($M = 592.57$, $SE = 16.13$) than for frequent words ($M = 476.25$, $SE = 16.69$).

The main effect of word length yielded a significant effect, $F(2.42, 114.16) = 31.65$, $p < .001$. Pairwise comparisons (see Figure 4.33) demonstrated that the mean Sum of First, Second and Third Fixation Duration was significantly the lowest for the words with 4 characters, (M = 387.14, SE = 16.59) and it was significantly higher for the words with 14 characters, (M = 626.51, SE = 13.68) than for the words with 10, (M = 548.72, SE = 15.99), 8, (M = 535.01, SE = 18.41), and 6 characters, (M = 514.20, SE = 35.08). Accordingly, the mean Sum of First, Second and Third Fixation Duration was significantly higher for the words with 12 characters, (M = 594.86, SE = 15.64) than for the words with 10 and 8 characters.

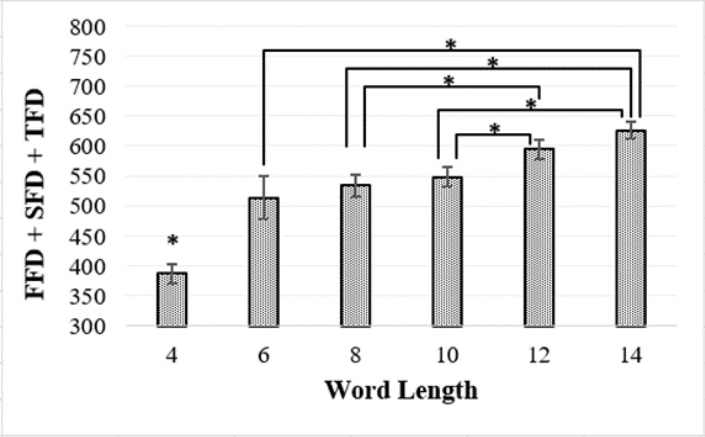

Figure 4.33: Word length effect on Sum of First, Second, and Third Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

There was a significant interaction effect between frequency and word length, $F(4.22, 198.55) = 4.78$, $p < .05$. Figure 4.34. illustrates the interaction effect between frequency and word length; the Sum of First, Second and Third Fixation Duration increases for the infrequent words as the words get longer while for the frequent words it increases up to words with 8 characters, then decreases on the words with 10 characters, then it again increases as the words get longer which is similar to the interaction effect between frequency and word length on Gaze Duration (see Figure 4.26).

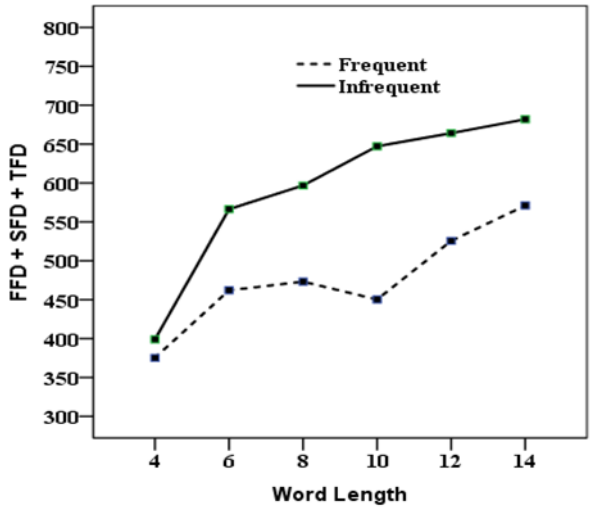

Figure 4.34: Interaction effect between frequency and word length on Sum of First, Second, and Third Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.1.7.1. Sum of First, Second and Third Fixation Duration: Frequent vs. Infrequent Words

A one-way analysis of variance was conducted to investigate the influence of the word length of the frequent words on the sum of First, Second and Third Fixation Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of word length, $\chi^2(14) = 89.97$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .49$).

The main effect of word length yielded a significant effect, $F(2.44, 115.01) = 8.68$, $p < .001$. Pairwise comparisons (see Figure 4.35) demonstrated that the mean Sum of First, Second and Third Fixation Duration of the frequent words was significantly lower for the words with 4 characters ($M = 375.31$, $SE = 17.53$) than the words with 14 characters, ($M = 571.06$, $SE = 16.66$), 12 characters, ($M = 525.68$, $SE = 21.90$), 10 characters, ($M = 450.22$, $SE = 19.10$), and 8 characters, ($M = 473.18$, $SE = 21.03$). Additionally, it was significantly higher for the words with 14 characters than the words with 8 and 10 characters. The words with 12 characters had a significantly higher mean Sum of First, Second and Third Fixation compared to words with 10 characters.

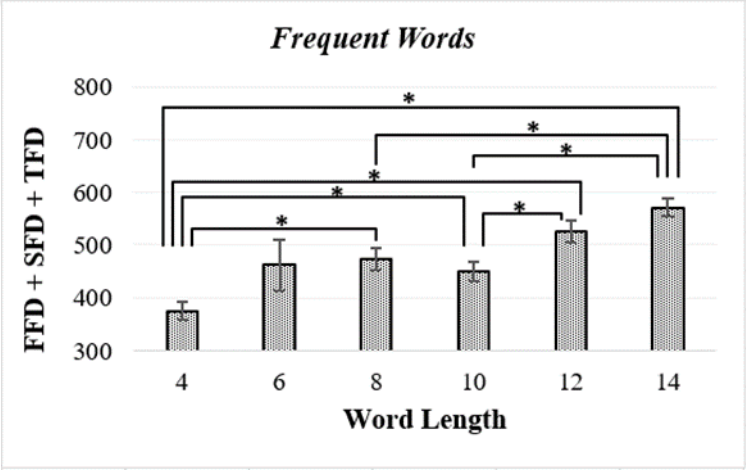

Figure 4.35: Word length effect of the frequent words on Sum of First, Second, and Third Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

Another one-way analysis of variance was conducted to investigate the influence of the word length of the infrequent words on the sum of First, Second and Third Fixation Duration. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of word length, $\chi^2(14) = 51.73$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .73$).

The main effect of word length yielded a significant effect, $F(3.62, 170.33) = 43.97$, $p < .001$. Pairwise comparisons (see Figure 4.36) demonstrated that the mean Sum of First, Second and Third Fixation Duration of the infrequent words was significantly the lowest for the words with 4 characters, ($M = 398.97$, $SE = 24.84$) and it was significantly higher for the words with 14 characters, ($M = 681.96$, $SE = 16.15$), 12 characters, ($M = 664.04$, $SE = 16.97$), and 10 characters, ($M = 647.22$, $SE = 19.15$) than for the words with 6 characters, ($M = 566.38$, $SE = 26.13$). Additionally, the words with 14 characters had a significantly higher mean Sum of First, Second and Third Fixation Duration than the words with 8 characters, ($M = 596.83$, $SE = 24.08$).

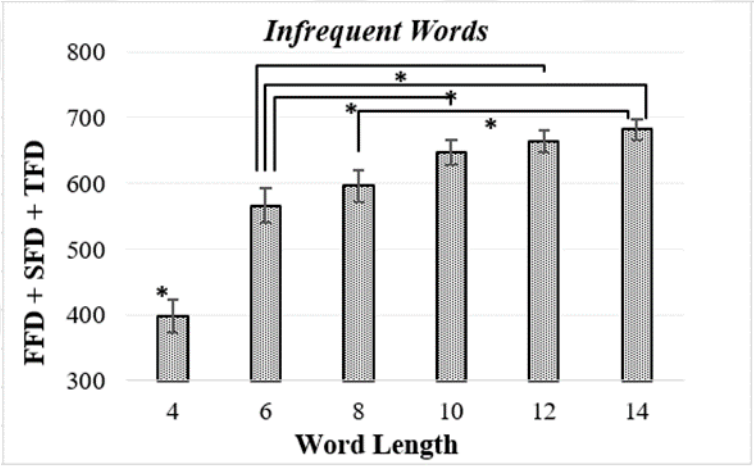

Figure 4.36: Word length effect of the infrequent words on Sum of First, Second, and Third Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.1.7.2. Summary of Sum of First, Second and Third Fixation Duration

The mean Sum of First, Second and Third Fixation Duration was significantly higher for infrequent words than for frequent words. For the frequent words, it was lower for the words with 4 characters than the words with 14, 12, 10, and 8 characters. Additionally, it was significantly higher for the words with 14 characters than the words with 8 and 10 characters. The frequent words with 12 characters had a higher mean Sum of First, Second and Third Fixation compared to words with 10 characters.

For the infrequent words Sum of First, Second and Third Fixation Duration was the lowest for the words with 4 characters and it was higher for the words with 14, 12, and 10 characters than for the words with 6 characters. Additionally, it was higher for the words with 14 characters than the words with 8 characters. The results of the Sum of First, Second, and Third Fixation Duration provided findings regarding the long and infrequent words compared to the results of the Sum of First and Second Fixation.

4.2. Experiment 2

In Experiment 1, the words were grouped according to their length and frequency values. There were two groups of words according to their frequencies: frequent and infrequent, and there were six groups of words according to their lengths: words with 4, 6, 8, 10, 12, and 14 characters respectively. Observing and understanding only the possible effects of morphological complexity was not possible solely with the results of Experiment 1 since in that experiment, word length and frequency were confounding factors. Moreover, sentence frames (i.e. the parts before and after the target words in the sentences) were not controlled in Experiment 1, and some of the target words with no suffix were derived words which were also confounding factors.

So, Experiment 2 was designed with the aim of eliminating the mentioned confounding factors by using only the frequent words with the same length, and among the target words, there were no derived ones. Further, word-initial bigrams of target words were controlled, and sentence frames before target word and after target word were the same among word-initial bigrams. The present section presents the findings of Experiment 2.

4.2.1. First Run Fixation Count (FRFC) Results

In order to examine the effects of suffixation condition on the fixation count in first pass reading, First Run Fixation Count which is the number of all fixations in a trial falling in the first run of the word was analyzed.

A Factorial ANOVA was conducted to compare the main effect of suffixes on First Run Fixation Count. A one-way analysis of variance was conducted to investigate the influence of one independent variable (condition) on First Run Fixation Count. The condition included three levels (1, 2, 3; representing words with no suffix, words with one suffix and words with two suffixes respectively).

The results show that there was no statistically significant effect of condition on First Run Fixation Count, $F(2, 78) = 1.38$, $p = .25$.

4.2.2. First Fixation Duration (FFD) Results

In this section, the findings regarding the First Fixation Durations on the target words will be presented. First Fixation Duration is the duration of the first fixation on a word during the first pass through the text. Since FFD is the duration of the first fixation on a word regardless of whether it is the only fixation on a word or the first of multiple fixations on a word, the differentiation between these two cases is needed. So, two local measures: Single Fixation Duration which is the first pass fixation duration on a word that is only fixated once and FFD of Multiple Fixations which is the duration of the first of multiple fixations on a word were used (see Figure 4.6).

Table 4.8: Mean First Fixation Durations according to the suffixation conditions.

FIRST FIXATION DURATION (FFD) (ms)				
	Single Fixation Duration		**FFD of Multiple Fixations**	
Condition	*M*	*SD*	*M*	*SD*
1-NoSuffix	218.81	49.56	217.79	52.27
2-OneSuffix	242.14	77.89	190.63	51.15
3-TwoSuffixes	248.21	71.42	219.35	43.95

A Factorial ANOVA was conducted to compare the main effects of refixation and condition (suffixes) and the interaction effect between refixation and condition on First Fixation Duration. A two-way analysis of variance was conducted to investigate the influence of two independent variables (refixation, condition) on First Fixation Duration. Refixation included two levels (single fixation and more than one fixation), and condition included three levels (1, 2, 3; representing words with no suffix, words with one suffix and words with two suffixes respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the interaction effect between refixation and condition, $\chi^2(2) = 12.04$, $p < .05$. Therefore, corrected degrees of freedom from Huynh-Feldt estimates of sphericity were used ($\varepsilon = .81$).

The main effect of refixation and the interaction effect are reported as significant at $p < .05$. The main effect of refixation yielded an F ratio of $F(1, 39) = 9.79$, $p < .05$, indicating that the mean FFD was significantly higher for the words which were passed with a single fixation ($M = 236.39$, $SE = 6.99$) than for the ones which received more than one fixation ($M = 209.26$, $SE = 5.66$).

The main effect of the suffixation condition was not statistically significant on the mean FFD $F(2, 78) = 2.44$, $p = .09$. The interaction effect between refixation and the suffixation condition was statistically significant though, $F(1.62, 63.46) = 4.90$, $p < .05$. Figure 4.37 presents the interaction between refixation and the suffixation condition; while the Single Fixation Duration increases on the words with one suffix, FFD of Multiple Fixations decreases. Additionally, they both increase on the words with two suffixes; however, the increase in FFD of Multiple Fixations is larger.

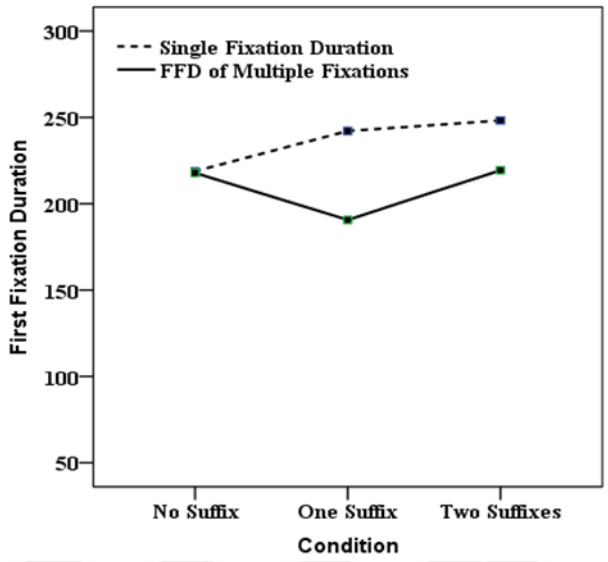

Figure 4.37: Interaction effect between refixation and suffixation condition on First Fixation Duration.

4.2.2.1 Single Fixation Duration vs. FFD of Multiple Fixations

A one-way analysis of variance was conducted to investigate the influence of the condition on Single Fixation Duration. The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of condition, $\chi^2(2) = 8.33$, $p < .05$. Therefore, corrected degrees of freedom from Huynh-Feldt estimates of sphericity were used ($\varepsilon = .87$).

The main effect of the suffixation condition yielded an F ratio of $F(1.73, 67.74) = 2.48$, $p = .10$, indicating that the mean Single Fixation Duration was not statistically different among the suffixation conditions.

Another one-way analysis of variance was conducted to investigate the influence of the condition on FFD of Multiple Fixations. When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of condition, $\chi^2(2) = 9.18$, $p < .05$. Therefore, degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .86$).

The results show that the mean FFD of Multiple Fixations was significantly affected by the suffixation condition $F(1.71, 66.67) = 6.07$, $p < .05$. Pairwise comparisons (see Figure 4.38) demonstrated that the mean FFD was significantly higher for the words with two suffixes, ($M = 219.35$, $SE = 6.95$) and for the ones with no suffix, ($M = 217.79$, $SE = 8.26$) than the words with one suffix, ($M = 190.63$, $SE = 8.08$).

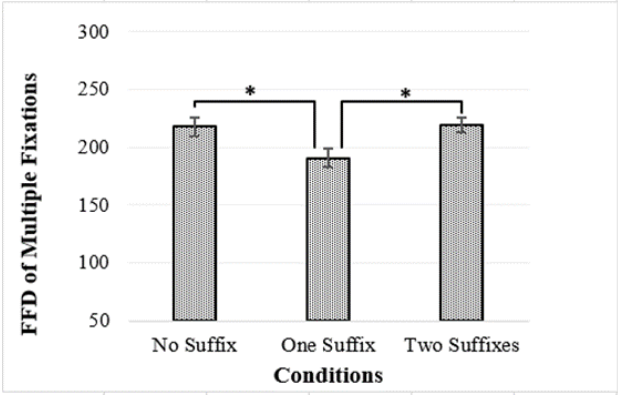

Figure 4.38: Suffixation Condition effect on FFD of Multiple Fixations. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.2.3. Second Fixation Duration (SFD) Results:

In the section above, the findings of FFD analyses are reported. Since Single Fixation Duration was not statistically different among the suffixation conditions, but FFD of Multiple Fixations was significantly affected by the suffixation condition, Second Fixation Duration analyses will be reported in this section. Second Fixation Duration is the duration of the second fixation on a word (see Figure 4.15).

Table 4.9: Mean Second Fixation Durations according to the suffixation conditions.

SECOND FIXATION DURATION (ms)		
Condition	*M*	*SD*
1-NoSuffix	173.10	34.15
2-OneSuffix	215.33	44.36
3-TwoSuffixes	157.44	53.43

A Factorial ANOVA was conducted to compare the main effect of condition (suffixes) on Second Fixation Duration. A one-way analysis of variance was conducted to investigate the influence of one independent variable (condition) on Second Fixation Duration in first pass reading. The condition included three levels (1, 2, 3; representing words with no suffix, words with one suffix and words with two suffixes respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of condition, $\chi^2(2) = 47.23$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .58$).

The results show that Second Fixation Duration was significantly affected by the suffixation condition, $F(1.16, 45.57) = 31.51$, $p < .001$. Pairwise comparisons (see Figure 4.39) demonstrated that the mean SFD was significantly the highest for the words

with one suffix, (M = 215.33, SE = 7.01), and the lowest for the words with two suffixes, (M = 157.44, SE = 8.44). Additionally, the mean SFD was significantly higher for the words with no suffix, (M = 173.10, SE = 5.40) than for the words with two suffixes.

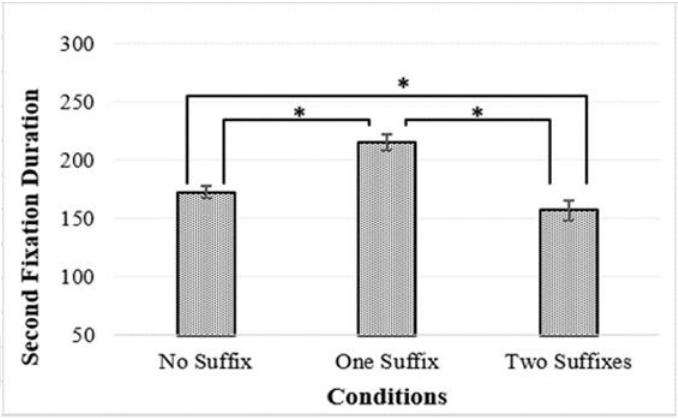

Figure 4.39: Suffixation Condition effect on Second Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.2.4. Third Fixation Duration (TFD) Results

The results of Second Fixation Duration revealed that the mean SFD was the lowest for the words with two suffixes. In order to examine the access of the word with two suffixes, Third Fixation Duration results may be needed. Hence, the findings of this measure will be presented in this section. Third Fixation Duration is the duration of the third fixation on a word (see Figure 4.20).

Table 4.10: Mean Third Fixation Durations according to the suffixation conditions.

THIRD FIXATION DURATION (ms)		
Condition	*M*	*SD*
1-NoSuffix	132.52	7.81
2-OneSuffix	148.00	27.29
3-TwoSuffixes	206.64	16.98

A Factorial ANOVA was conducted to compare the main effect of suffixes on Third Fixation Duration. A one-way analysis of variance was conducted to investigate the influence of one independent variable (condition) on Third Fixation Duration in first pass reading. The condition included three levels (1, 2, 3; representing words with no suffix, words with one suffix and words with two suffixes respectively).

When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of condition, $\chi^2(2) = 25.71, p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .67$).

The results show that Third Fixation Duration was significantly affected by the suffixation condition, $F(1.34, 52.29) = 177.84$, $p < .001$. Pairwise comparisons (see Figure 4.40) demonstrated that the mean TFD was significantly the highest for the words with two suffixes, ($M = 206.64$, $SE = 2.68$), and the lowest for the words with no suffix, ($M = 132.52$, $SE = 1.23$). Accordingly, the mean TFD was significantly higher for the words with two suffixes than for the words with one suffix, ($M = 148.00$, $SE = 4.31$) for which the mean TFD was significantly higher than the words with no suffix.

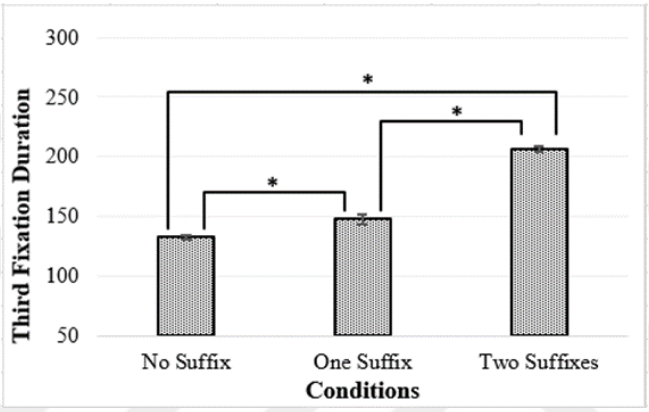

Figure 4.40: Suffixation Condition effect on Third Fixation Duration. Error bars indicate CI for the mean at 95% significance level and asterisk (*) shows significance.

4.2.5. Gaze Duration Results

A Factorial ANOVA was conducted to compare the main effect of suffixes on Gaze Duration which is the sum of all fixations on a word prior to a saccade to another word (see Figure 4.24). A one-way analysis of variance was conducted to investigate the influence of one independent variable (condition) on Gaze Duration in first pass reading. Condition included three levels (1, 2, 3; representing words with no suffix, words with one suffix and words with two suffixes respectively).

The chi-square test statistic from Mauchly's test revealed that the assumption of sphericity had been violated for the main effect of condition, $\chi2(2) = 9.72$, $p < .05$. Therefore, corrected degrees of freedom from Huynh-Feldt estimates of sphericity were used ($\varepsilon = .85$).

The results show that there was no statistically significant effect of the suffixation condition on Gaze Duration, $F(1.69, 66.02) = 2.93$, $p = .06$.

4.2.6. Sum of First and Second Fixation Duration and Sum of First, Second, and Third Fixation Duration Results

The results of the Gaze Duration analysis revealed that Gaze Duration was not affected by the suffixation condition. However, FFD of Multiple Fixations and Second and Third Fixations were affected by the suffixation condition, so the Sum of First and Second

Fixation Duration and the Sum of First, Second, and Third Fixation Durations were also analyzed.

First, a one-way analysis of variance was conducted to investigate the influence of one independent variable (condition) on the sum of First and Second Fixation Duration. Condition included three levels (1, 2, 3; representing words with no suffix, words with one suffix and words with two suffixes respectively).

When Mauchly's test is applied to investigate whether the assumption of sphericity had been violated, the chi-square test statistic yielded that it is violated for the main effect of condition, $\chi^2(2) = 19.69$, $p < .001$. Therefore, corrected degrees of freedom from Greenhouse–Geisser estimates of sphericity were used ($\varepsilon = .71$). The results show that there was no statistically significant effect of the suffixation condition on Sum of First and Second Fixation Duration, $F(1.42, 55.53) = 3.29$, $p = .06$.

Then, another one-way analysis of variance was conducted to investigate the influence of one independent variable (condition) on the sum of First, Second and Third Fixation Duration. The results show that there was no statistically significant effect of the suffixation condition on the sum of First, Second, and Third Fixation Duration, $F(2, 78) = 1.30$, $p = .28$.

4.3. Overall Summary of Results

In this section, findings that are presented in the previous sections of the present chapter (Chapter 4) will be summarized. Since the eye movement measures under investigation were the same for both experiments, the results of eye movement measures will be included together. Thus, it would be possible to compare the findings for Experiment 1 and 2.

4.3.1. First Run Fixation Count (FRFC)

Experiment I

There was a significant main effect of word length both for frequent and infrequent words which was qualified by the interaction between frequency and word length. The mean fixation count was significantly higher for infrequent words than for frequent words. Nevertheless, for both frequent and infrequent words, there was a regular increase in the fixation count in the first run which was parallel to the increase in the word length.

Experiment II

The results of Experiment 2 demonstrated that there was no statistically significant effect of the suffixation condition on First Run Fixation Count.

4.3.2. First Fixation Duration (FFD)

Experiment I

Single Fixation Duration analyses revealed that there was a regular increase in the durations of the words according to their word length up until the words with 8 characters. However, the decrease on the words with 10 characters which are the roots forms could suggest that the given increase in the durations might be due to the suffixation in the case of the words with 6 and 8 characters. Nevertheless, it still might be the case that word length effect on Single Fixation Duration was more observable in shorter words since the distinction of the word length and suffixation effect is difficult to make for Experiment 1. On the other hand, when the FFD of Multiple Fixations were analyzed, the only findings that could be reached that it was the lowest for the words with 4 characters.

Experiment II

This experiment revealed different results than the first one regarding FFD. The suffixation condition did not have a significant main effect either on First Fixation Duration or on Single Fixation Duration. However, FFD of Multiple Fixations was significantly affected by the suffixation condition which revealed that it was significantly higher for the words with two suffixes and for the ones with no suffix than the words with one suffix.

4.3.3. Second Fixation Duration (SFD)

Experiment I

Second Fixation Duration analyses demonstrated that it was significantly higher for the words with 6, 12, and 14 characters than words with 10 characters. This finding is interesting because normally we would expect the words with 10 characters to receive longer second fixation than the words with 6 characters. However, when it is considered that the words with 10 letters were actually in their base forms, it could imply that the words with 6 characters received longer fixations because of the suffix attached to them. Moreover, despite not yielding a significant difference, the words with 8 characters (two suffixes attached) also received longer SFDs than the ones with 10 characters.

There was also a significant interaction effect between frequency and word length. The mean SFD of the frequent words was significantly higher for the words with 12 (one suffix) and 14 (two suffixes) characters than the words with 6 (one suffix) and 10 (root) characters. Besides, the mean SFD of the infrequent words was significantly higher for the words with 6 (one suffix) characters than the words with 10 (root) characters, and it was the lowest for the words with 4 (root) characters.

Experiment II

In Experiment 2, the mean SFD was significantly the highest for the words with one suffix, and the lowest for the words with two suffixes. Additionally, the mean SFD was significantly higher for the words with no suffix than for the words with two suffixes. These results of Experiment 2 may suggest that readers could complete the processing of the words with one suffix, and the words with no suffix with the Second Fixations they made on the word.

It should be noted that the mean FFD of Multiple Fixations was significantly higher for the words with two suffixes and the ones with no suffix than the words with one suffix. As a complement, in the Second Fixation Duration, the words with one suffix had a longer Second Fixation Duration than the ones with two suffixes which may allow arguing that Second Fixation had a complementary role for the words with one suffix.

4.3.4. Third Fixation Duration (TFD)

Experiment I

There was a significant interaction effect between frequency and word length. Furthermore, the mean TFD of the frequent words was significantly higher for the words with 8 characters than the words with 10 characters. There was not any third fixation on the frequent words with 4 characters. Hence, the difference between this group and words with other lengths was significant.

The evidence that there was not any third fixation on the words with 4 characters may suggest that the processing of these words was completed either with one fixation or with two fixations (a shorter FFD of multiple fixations and a longer SFD). The mean TFD on infrequent words was not informative since it was not significantly affected by the word length.

Experiment II

The mean TFD was significantly the highest for the words with two suffixes and the lowest for the words with no suffix. Accordingly, the mean TFD was significantly higher for the words with two suffixes than for the words with one suffix for which the mean TFD was significantly higher than the words with no suffix. The findings of the TFD in Experiment 2 support the argument regarding the role of SFD in the processing of the words with one suffix. This may suggest that the processing of the words with no suffix was less related to the Third Fixation on the word than the processing of the words with one suffix. Moreover, the words with two suffixes benefited from the Third Fixation on the word the most.

4.3.5. Gaze Duration

Experiment I

The mean Gaze Duration of the frequent words was significantly higher for the words with 14, 12, and 8 characters than the words with 4 characters. The mean Gaze Duration of the frequent words was significantly higher for the words with 12 characters than the words with 10 characters.

The mean Gaze Duration of the infrequent words was significantly the lowest for the words with 4 characters, and higher for the words with 14 characters than the words with 10, 8, and 6 characters. Additionally, the words with 12 and 10 characters had a significantly higher mean Gaze Duration than the words with 6 characters.

Experiment II

In the second experiment, the results demonstrated that there was no statistically significant effect of the suffixation condition on Gaze Duration. This finding might lead one to consider the possibility by looking at the results of Experiment 1 and 2 together that Gaze Duration seems to be affected by the length of the word rather than the suffixation.

4.3.6. Sum of First and Second Fixation Duration

Experiment I

The mean Sum of First and Second Fixation Duration of the frequent words was significantly higher for the words with 14 characters than the words with 4 characters. For the frequent words, it was significantly higher for the words with 14 and 12 characters than the words with 10 characters. These findings may suggest that the processing that was not observable in the First and the Second Fixation Durations separately for the long words could be observable in the sum of these two fixations on the word.

The mean Sum of First and Second Fixation Duration of the infrequent words was significantly the lowest for the words with 4 characters which was also not informative enough to speculate on the processing of the long and infrequent words.

Experiment II

The results demonstrated that there was no statistically significant effect of the suffixation condition on Sum of First and Second Fixation Duration.

4.3.7. Sum of First, Second, and Third Fixation Duration

Experiment I

The mean Sum of First, Second, and Third Fixation Duration of the frequent words was significantly lower for the words with 4 characters than the words with 14, 12, 10, 8 characters. Additionally, it was significantly higher for the words with 14 characters than the words with 8 and 10 characters. The words with 12 characters had a significantly higher mean Sum of First, Second, and Third Fixation compared to words with 10 characters.

The mean Sum of First, Second, and Third Fixation Duration of the infrequent words was significantly the lowest for the words with 4 characters, and it was significantly higher for the words with 14, 12, and 10 characters than for the words with 6 characters. Additionally, the words with 14 characters had a significantly higher mean Sum of First, Second, and Third Fixation Duration than the words with 8 characters.

The Sum of First, Second, and Third Fixation Duration may suggest an explanation both for frequent and infrequent words regarding particularly the online processing of the long words. The process in question can be described more reliably with the sum duration of these three fixations rather than the individual fixation durations.

Experiment II

The results of the second experiment revealed that there was no statistically significant effect of the suffixation condition on the Sum of First, Second, and Third Fixation Duration which is compatible with the argument above that the sum of the first three fixations might be more informative for the processing of long words.

CHAPTER 5

DISCUSSION AND CONCLUSION

The present study was conducted bearing the aim of investigating the word length and suffixation on eye movement control in Turkish reading. The motivation behind the present study was to contribute to the existing literature on lexical access and morphological processing in reading by studying in a morphologically rich language. However, the broader motivation was getting closer to the underlying mechanisms of reading as a cognitive process. Although studies on reading have a longer history than the cognitive science, origins of which can be traced to the mid-1950s, cognitive science offers theories and methodologies that promise progress in the reading research in the years to come.

Cognitive science, which can be defined as the scientific study of mind from an interdisciplinary perspective, makes use of various methods such as thinking and discussing the mind, collecting, reporting human behavior data and engineering. However, none of these methods is enough in isolation to come with an account regarding how the mind works according to the cognitive scientists. At this point, as a field which studies how people extract information from the written text, reading is one of the relevant fields of cognitive science. The present study was conducted as a part of a more comprehensive project which initiated the investigation of eye movement control modeling in Turkish reading. The evaluation of the results obtained, the limitations of the present study, possible future work, and the conclusion will be introduced in this chapter.

5.1. Evaluation of Results

Before starting evaluating the results, it would be helpful to remember the motivation behind the present study. It was to observe how the first and subsequent fixations differ in their roles while accessing words, especially long and complex ones. By discussing these different roles, it was aimed to gain a deeper understanding of the determining factors behind the decision of single fixation and refixation strategies of the readers.

The first run fixation count results provided evidence regarding one of the determining factors of the refixation strategy of the readers. In Experiment 1, both frequency and word length had a significant effect on First Run Fixation Count. However, the interaction effect between frequency and word length demonstrated that for both frequent and infrequent target words, there was a regular increase in the fixation count in the first run which was parallel to the increase in the word length. On the other hand, the results of Experiment 2 revealed that there was no significant effect of the suffixation condition on First Run Fixation Count.

At this point, it is needed to remember that in Experiment 2, the target words had the same length (seven characters), and they were all frequent words. The only difference among the words was regarding the suffixation conditions they belong to. The findings of the two experiments regarding the First Run Fixation Count suggest that this measure is related to word length rather than suffixation. So, it is legitimate to argue that as a strategy, refixation is determined not by the suffixation but by the word length.

The evaluation regarding the first fixation duration includes two cases: fixation of a singly fixated word and first fixation of a refixated word. The results of Experiment 1 demonstrated that lexical effects such as frequency, word length, and suffixation could be best observed through the Single Fixation Duration analyses while the results of the FFD of Multiple Fixation analyses did not reveal much about the lexical access of the words. Here, it should be noted whether the suffixation or word length effects were observed in Single Fixation Duration analyses in Experiment 1 is not certain due to the design of the experiment. However, the result of Experiment 2, in which only the suffixation conditions were manipulated revealed no significant effect of conditions on the Single Fixation Duration. Therefore, it is reasonable to argue that lexical effects such as frequency and word length are best represented by the measure of Single Fixation Duration in the present study at least for the short words, which are up to 8 characters.

The findings of the subsequent fixations obtained from both experiments provided mixed results to discuss. Since the finding that the fixation count in the first run is related to word length rather than suffixation or frequency is obvious as a result of the present study, what Sereno (1992) suggested to explain the refixations in the words are worth to remember. Her first explanation was that a deeper level of word recognition is required for a decision to move the eyes to the next word. The other one was that if the upcoming word is farther away, readers may have a tendency to make immediate intraword saccade. Although the launch sites and landing positions were not analyzed in the present study, the findings favor the second suggestion since it seems more related to the word length effect. In other words, since for long words, the upcoming word is farther away compared to shorter ones, it is likely that readers tend to make refixations on the long ones.

O'Regan (1992) suggests that only oculomotor factors determine when to move the eyes. According to his interpretation, lexical variables should only influence the duration of single fixations on a word but only the second fixation the words which received more than one fixation. However, in the present study word frequency had a significant effect on all fixation duration measures, thus revealing its importance in all aspects of the word recognition processes.

In terms of morphological processing, the results can be evaluated within the theoretical framework of the dual-route model (Pollatsek & Hyönä, 2006). This framework assumes that there are two routes to encode words which are made of multiple morphemes (i.e. polymorphemic), namely the compositional and the holistic route. The compositional route involves accessing the morphemic components first, and putting them together

afterward while the holistic route involves accessing the word as a whole (Pollatsek & Hyönä, 2006).

Since there are some other models which assume dual routes to lexical access, it should be noted that the one referred here is the dual-route theory of the type Pollatsek & Hyönä (2006) advocated. As they made clear earlier, the framework they support does not assume a holistic route which accesses words like visual templates; rather they argue that the inputs that holistic route takes are not morphemes. They support that the holistic and compositional route work in parallel; however, success in one route may inhibit the other (Pollatsek & Hyönä, 2006).

Pollatsek & Hyönä (2006) argues that since the short words fall within the fovea on a fixation, accessing the word via holistic route is more efficient than trying to find the component boundaries and then encoding them. Hence, it is legitimate to argue that the effect of suffixation may be emerging in the durations of the fixations. The results of the second experiment demonstrated that the duration of the first three fixations changed according to the suffixation conditions; however, no significant effect of the suffixation condition found on Gaze Duration and the Sum of First and Second Fixation Duration and Sum of First, Second, and Third Fixation Duration. On the other hand, in Experiment 1, the first three fixation durations were informative for the short words (up until 8 characters), but to be able to observe the situation of the long words Sum of First, Second and Third Fixation Durations and Gaze Duration were needed.

The dual-route model argues that for short words, the holistic route is more efficient, and since the inputs in this route are not morphemes, the readers access the words as a whole. When this argument and the results of the present study are taken into account, it is likely that the short words might be accessed via the holistic route, and the suffixation conditions they were in might determine the fixation durations of the words. For the first experiment, it is challenging to talk about the effect of suffixation solely; however, in the results of the second experiment, there may be implications for the effects of suffixation conditions on the individual fixation durations namely the First, Second, and Third Fixation Durations.

For the long words in the first experiment, the first three individual fixations did not reveal much. However, especially, the Sum of First and Second Fixation and Sum of First, Second, and Third Fixation Duration analyses demonstrated similar patterns obtained for the short words from the analysis of First, Second and Third Fixation Durations. Hence, a reasonable argument to explain it may be that there occurred a componential process involving morphemes for the long words which would be compatible with the argument of the dual-route regarding the compositional route used in the access of long words.

5.2. Limitations and Future Research

A general limitation of the present study is that it is almost impossible to understand the mechanisms underlying an information processing such as reading, solely by collecting and reporting human data, computational models are needed to provide a nearly full account of this process. However, the studies in Turkish reading are not mature enough, and the present study and similar others bear the aim of collecting data and reporting preliminary results which possibly shed light on the discussions regarding the eye movement control modeling in Turkish.

Moreover, the present study has dealt with reading at the level of word recognition by making important, yet incomplete assumptions since reading is not just an orthographic process. Although the cognitive processes underlying reading are much more complex, the systematic findings obtained as a result of the present study contribute to our knowledge about reading.

Additionally, as the individual differences and despite being controlled, the items (target words in the case of the present study) are random effects in most of the studies, statistical analysis could be further extended with results from a Linear Mixed Model (LMM) or a Generalized Linear Mixed Model (GLMM). However, the kind of analysis reported in Chapter 4 still served well to the purposes of the present study.

Finally, and perhaps more fundamentally, the fact that the evaluations made in Section 5.1. are based on only 2 suffixes, more empirical justification is needed to build on these conclusions. The question that would the same or similar results be obtained if different suffixes were used instead of the ones used in the present study is a one difficult to answer. The reason for the difficulty is that there might be spillover effects which are not covered in the scope of the present study. When readers start to look at the next word (N+1) while completing the procession of the previous word (N), there assumed to be some influence, which is called “spillover effect,” of the properties of word N on the duration time on N+1 (Just et al., 1982). In the case of the present study, durations on the next word (N+1) were not investigated, hence not reported. Nevertheless, it would still be assertive to answer this question. The words with the suffix -ki attached and the words ending with another suffix like -DIK which is a multifunctional subordinating suffix in Turkish might or might not differ in their procession which would be a real investigation topic for future search.

As a future experimental investigation in Turkish reading, an experiment in which word length and frequency are controlled similar to Experiment 2, but with a target word set with longer words (i.e., more than 7 characters) can reveal more about the effect of suffixation in long words. Furthermore, it would be helpful to gain a deeper understanding regarding the role of suffixation in the morphological processing in Turkish when the present and further studies are extended by making use of the derivational morphemes in the experiments.

Further, the suffixes used in the present study were -DA, and -DAki. -DA is the marker of the locative case, and it is unproductive whereas -DAki is formed by adding the suffix -ki to the locative marked noun phrase, and this is a productive construction (Göksel & Kerslake, 2005). The words with unproductive suffixes are argued to be always stored and never parsed while the ones with productive suffixes are argued to be always parsed and never stored (Anshen & Aronoff, 1988, 1997). However, especially the results of the second experiment revealed that the unproductive suffix -DA may not be stored or may be parsed as well. Experimental investigations with different productive and unproductive affixes can contribute to the literature regarding the morphological processing in reading.

5.3. Conclusion

The results of the present study show the effects of word length, frequency, and suffixation on eye movement control in Turkish reading. The results are also evaluated within the theoretical framework of the dual-route model; however, as Pollatsek & Hyönä (2006) indicated themselves; this theory is a vague one from many perspectives. For instance, how the effect of suffixation and in what way it can be observed in the holistic or compositional route is not clear. Thus, the present study is an important one since it provided an alternative way of searching for the effects of suffixation by looking at several other within word measures in addition to First Fixation and Gaze Duration.

The finding that First Run Fixation Count is an orthographical measure which is not related to suffixation but to the word length is an important one since it suggested that refixation strategy is related to word length. However, the modulating effects of word length on lexical access; especially when it is manipulated together with other variables as done in Experiment 1 are still not trivial to be understood. The other major findings of the present study are that (i) it revealed that the Single Fixation Duration provides the best chance to observe the lexical effects on words (ii) subsequent fixations on the words reveal effects related to suffixation conditions of the words as reported in the results of Experiment 2.

In sum, this study in Turkish reading offers that to be able to gain a deeper understanding of the lexical access, the cases when Single Fixation occur need to be investigated. Languages which have morphological systems with productivity in segmental morphology like Turkish may contribute more to the debate of lexical access and research on reading. However, more experimental investigations in a wider range of languages are needed to come with a coherent cross-linguistics theory of morphological processing.

REFERENCES

Abrams, Richard A. Meyer,David E. Sylvan, K. (1989). Speed and accuracy of saccadic eye movements: Characteristics of impulse variability in the oculomotor system., 15(3), 529–543.

Aksan, Y., Aksan, M., Koltuksuz, A., Sezer, T., Mersinli, Ü., Ufuk, U., … Yıldız, I. (2012). Construction of the Turkish National Corpus (TNC). Lrec 2012, 3223-3227.
Retrieved from http://www.lrec-conf.org/proceedings/lrec2012/papers.html

Anshen, E, & Aronoff, M. (1988). Producing morphologically complex words. Linguistics, 26, 641-655

Bertram, R. (2011). Eye movements and morphological processing in reading. The Mental Lexicon, 6 (1), 83-109. https://doi.org/10.1075/ml.6.1.04ber

Bertram, R., & Hyönä, J. (2007). The interplay between parafoveal preview and morphological processing in reading. Eye movements: A window on mind and brain, 391-407.

Bilgin, O. (2016). Frequency Effects in the Processing of Morphologically Complex Turkish Words (Unpublished master's thesis). Bogaziçi University, Istanbul, Turkey. Retrieved from http://st2.zargan.com/public/resources/turkish/frequency_effects_in_turkish.pdf

Biswas, P., Sezgin, T. M., & Robinson, P. (2008). Perception model for people with visual impairments. In Proceedings of the 10th International Conference on Visual Information Systems (VISUAL '08), LNCS 5188, (pp. 279–290). https://doi.org/10.1007/978-3-540-85891-1

Brysbaert, M., Drieghe, D., & Vitu, F. (2005). Word skipping: Implications for theories of eye movement control in reading. In G. Underwood (Ed.), Cognitive processes in eye guidance (pp. 53–78). Oxford, UK: Oxford University Press

Clifton, C. J., & Staub, A. (2011). Syntactic influences on eye movements during reading BT - The Oxford Handbook of Eye Movements. The Oxford Handbook of Eye Movements, 895–909. Retrieved from papers2://publication/uuid/FE5DD9FB-B236-46F0-A48E-E6534194280E

Deutsch, A., Frost, R., Pollatsek, A., & Rayner, K. (2000). Early morphological effects in word recognition in Hebrew: Evidence from parafoveal preview benefit. Language and Cognitive Processes, 15, 487–506. https://doi.org/10.1080/01690960444000115

Deutsch, A., Frost, R., Pollatsek, A., & Rayner, K. (2003). Early morphological effects in reading: Evidence from parafoveal preview benefit in Hebrew. Psychonomic Bulletin& Review, 10(2), 425–422. https://doi.org/10.1080/01690960444000115

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. Cognitive Psychology, 14(2), 178–210. https://doi.org/10.1016/0010-0285(82)90008-1

Göksel, A., & Kerslake, C. (2005). Turkish: A Comprehensive Grammar. https://doi.org/10.4324/9780203340769

Göz, İ., (2003). Yazılı Türkçenin Kelime Sıklığı Sözlüğü [The Dictionary of Word Frequency in Written Turkish]. Ankara: Turkish Language Association Publications.

Huey, E. B. (1908). The Psychology and Pedagogy of Reading. New York: The MacMillan Company.

Inhoff, A. W. (1984). Two stages of word processing during eye fixations in the reading of prose. Journal of Verbal Learning and Verbal Behavior, 23(5), 612–624. https://doi.org/10.1016/S0022-5371(84)90382-7

Inhoff, A. W. (1989). Lexical access during eye fxations in reading. Are word access codes used to inegrate information across interword fxations? Journal of Memory & Language, 28, 444–461

Irwin, D. E. (1998). Lexical processing during saccadic eye movements. Cognitive Psychology, 36(1), 1–27. https://doi.org/10.1006/cogp.1998.0682

Irwin, D. E., & Carlson-Radvansky, L. A. (1996). Cognitive Suppression during Saccadic Eye Movements. Psychological Science, 7(2), 83–88. https://doi.org/10.1111/j.1467-9280.1996.tb00334.x

Juhasz, B. J., & Rayner, K. (2003). Investigating the effects of a set of intercorrelated variables on eye fixation durations in reading. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *29*(6), 1312–1318. https://doi.org/10.1037/0278-7393.29.6.1312

Just, M.A., Carpenter, P. A. (1983). What your eyes do while your mind is reading. In: Rayner, K., Ed., Eye Movements in Reading: Perceptual and Language Processes, Academic, New York.

Just, M. A., Carpenter, P. A., & Woolley, J. D. (1982). Paradigms and processes in reading comprehension. Journal of experimental psychology: General, 111(2), 228.

Kambe, G. (2004). Parafoveal processing of prefixed words during eye fixations in reading: evidence against morphological influences on parafoveal preprocessing. Perception & Psychophysics, 66(2), 279–92. https://doi.org/10.3758/BF03194879

Lima, S. (1987). Morphological analysis in sentence reading*1. Journal of Memory and Language. https://doi.org/10.1016/0749-596X(87)90064-7

Liversedge, S. P., & Findlay, J. M. (2000). Saccadic eye movements and cognition. Trends in Cognitive Sciences, 4(1), 6–14. https://doi.org/10.1016/S1364-6613(99)01418-7

Matin, E. (1974). Saccadic suppression: a review and an analysis. Psychological Bulletin, 81(12), 899–917. https://doi.org/10.1037/h0037368

McConkie, G. W., Kerr, P. W., Reddix, M. D., Zola, D., & Jacobs, a M. (1989). Eye movement control during reading: II. Frequency of refixating a word. Perception & Psychophysics, 46(3), 245–253. https://doi.org/10.3758/BF03208086

McConkie, G. W., & Rayner, K. (1975). The span of the effective stimulus during a fixation in reading. Perception & Psychophysics, 17, 578-586.

Niswander-Klement, E., & Pollatsek, A. (2006). The effects of root frequency, word frequency, and length on the processing of prefixed English words during reading. Memory & Cognition, 34(3), 685–702. https://doi.org/10.3758/BF03193588

O'Regan, J. K. (1992). Optimal viewing position in words and the strategy-tactics theory of eye movements in reading. In K. Rayner (Ed.), Eye movements and visual cognition: Scene perception and reading (pp. 333–354). New York: Springer-Verlag

Pollatsek, A., & Hyönä, J. (2006). Processing of Morphemically Complex Words in Context: What Can be Learned from Eye Movements. In S. Andrews (Ed.), From inkmarks to ideas: Current issues in lexical processing (pp. 275–298). Hove: Psychology Press.

Pollatsek, A., Slattery, T. J., & Juhasz, B. (2008). The processing of novel and lexicalised prefixed words in reading. Language and Cognitive Processes, 23(7-8), 1133-1158.

Rayner, K. (1975). The perceptual span and peripheral cues in reading. Cognitive Psychology, 7(1), 65-81.

Rayner, K. (1978). Eye movement latencies for parafoveally presented words. Bulletin Of The Psychonomic Society, 11(1), 13–16. https://doi.org/10.3758/BF03336753

Rayner, K. (1998). Eye movements in Reading and Information Processing: 20 Years of Research. Psychological Bulletin, 124(3), 372–422. https://doi.org/10.1037/0033-2909.124.3.372

Rayner, K. (2009). The 35th Sir Frederick Bartlett Lecture: Eye movements and attention in reading, scene perception, and visual search. Te Quarterly Journal of Experimental Psychology, 62, 1457–1506.

Rayner, K., Balota, D. A., & Pollatsek, A. (1986). Against parafoveal semantic preprocessing during eye fixations in reading. Canadian Journal of Psychology, 40(4), 473–483. https://doi.org/10.1037/h0080111

Rayner, K., & Duffy, S. A. (1988). On-line comprehension processes and eye movements in reading. In M. Daneman, G. E. MacKinnon, & T. G. Waller (Eds.), Reading research: Advances in theory and practice (pp. 13-66). New York: Academic Press.

Rayner, K., & McConkie, G. W. (1976). What guides a reader's eye movements? Vision Research, 16, 829–837.

Rayner, K., & Pollatsek, A. (1987). Eye movements in reading: A tutorial review. In M. Coltheart (Ed;), Attention and performance (Vol. 12, pp. 327-362). London: Erlbaum

Rayner, K., Pollatsek, A., Ashby, J., & Clifton C., J. (2012). Psychology of reading, second edition. Psychology of Reading, Second Edition (Vol. 9780203155). https://doi.org/10.4324/9780203155158

Rayner, K., Pollatsek, A., & Schotter, E. R. (2012). Reading: Word Identification and Eye Movements. Handbook of Psychology, Volume 4: Experimental Psychology, 548–577.

Rayner, K., Reichle, E. D., Stroud, M. J., Williams, C. C., & Pollatsek, A. (2006). The effect of word frequency, word predictability, and font difficulty on the eye movements of young and older readers. Psychology and Aging, 21(3), 448-465.

Rayner, K., Slowiaczek, M. L., Clifton, C., & Bertera, J. H. (1983). Latency of sequential eye movements: Implications for reading. Journal of Experimental Psychology: Human Perception and Performance, 9, 912–922.

Sak, H., Tunga, G., Saraçlar, M.. (2008) Turkish Language Resources: Morphological Parser, Morphological Disambiguator and Web Corpus. GoTAL 2008: p417-427.

Say, B., Zeyrek, D., Oflazer, K., & Özge, U. (2002). Development of a Corpus and a Treebank for Present day Written Turkish. Current Research in Turkish Linguistics (Proceedings of the Eleventh International Conference of Turkish Linguistics, 2002), 182–192.

Sereno, S. C. (1992). Early lexical effects when fixating a word in reading. In K. Rayner (Ed.), Eye movements and visual cognition: Scene perception and reading (pp. 304–316). New York: Springer-Verlag.

SR Research Eyelink, 2017, Retrieved from http://www.sr-research.com/accessories_ELII_resbox.html. Copyright 2009 SR Research Ltd.

SR Research Eyelink, 2017, Retrieved from http://www.sr-research.com/mount_tower.html. Copyright 2009 SR Research Ltd.

SR Research Eyelink. (2013). EyeLink 1000 Plus: Installation Guide. Retrieved from http://godzilla.kennedykrieger.org/fmri/EyeLink1000PlusInstallationGuide1.0.pdf

SR Research Eyelink. (2013-2017). EyeLink 1000 Plus: User Manual Version 1.0.12. Retrieved from https://www.sr-support.com/forum/downloads/manuals/4475-eyelink-1000-plus-user-manual

Vainio, S., Hyönä, J., & Pajunen, A. (2003). Facilitatory and inhibitory effects of grammatical agreement: Evidence from readers' eye fixation patterns. Brain and Language, 85(2), 197–202. https://doi.org/10.1016/S0093-934X(03)00029-4

Vainio, S., Hyöna, J., & Pajunen, A. (2008). Processing modifier-head agreement in reading: evidence for a delayed effect of agreement. Memory & Cognition, 36(2), 329–40. https://doi.org/10.3758/MC.36.2.329

Vainio, S., Bertram, R., Pajunen, A., & Hyönä, J. (2011). Processing modifier-head agreement in long Finnish words: Evidence from eye movements. Acta Linguistica Hungarica, 58(1–2), 134–156. https://doi.org/10.1556/ALing.58.2011.1

Vergilino, D., & Beauvillain, C. (2000). The planning of refixation saccades in reading. Vision Research, 40(25), 3527–38. https://doi.org/10.1016/S0042-6989(00)00192-9

Vergilino, D., Collins, T., & Doré-Mazars, K. (2004). Decision and metrics of refixations in reading isolated words. Vision Research, 44(17), 2009–2017. https://doi.org/10.1016/j.visres.2004.03.012

Wotschack, C. (2009). *Eye movements in reading strategies how reading strategies modulate effects of distributed processing and oculomotor control*. Potsdam: Universitätsverlag.

Yan, M., Zhou, W., Shu, H., Yusupu, R., Miao, D., Krügel, A., & Kliegl, R. (2014). Eye movements guided by morphological structure: Evidence from the Uighur language. *Cognition, 132*(2), 181-215.

Yen, M.-H., Tsai, J.-L., Tzeng, O. J.-L., & Hung, D. L. (2008). Eye movements and parafoveal word processing in reading Chinese. Memory & Cognition, 36(5), 1033–1045. https://doi.org/10.3758/MC.36.5.1033ais, M. (1953). Le Comportement de l'Homme Rationnel devant le Risque: Critique des Postulats et Axiomes de l'Ecole Americaine. *Econometrica, 21*(4), 503-546

APPENDICES

APPENDIX A

Dilbilgisel Artalan Anketi

Table A.1: Demographic information form used in both experiments.

Kişisel Bilgiler (Bu formdaki kimlik bilgileri verilerle eşleştirilmemektedir.)		Kod:	
Soyadı	Adı		Bugünün Tarihi
Doğum Yılı	Kadın ( )		Erkek ( )
Telefon Numarası		E-posta Adresi	
Şu anki mesleğiniz?			
En yüksek tahsiliniz (veya muadili) (lütfen yuvarlağa alınız)	Ortaokul	Lise	Üniversite Derecesi
	Mesleki Eğitim	Diğer?	
Fakülteniz			
Bölümünüz			
Sınıfınız	Hazırlık ( ) 1. Sınıf ( ) 2. Sınıf ( ) 3. Sınıf ( ) 4. Sınıf ( )		
Lisede hazırlık okunuz mu?	Evet ( ) Hayır ( )		
Üniversitede hazırlık okudunuz mu?	Evet ( ) Hayır ( )		

Genel Sağlık Durumunuz			
Yazarken hangi elinizi kullanıyorsunuz?	Sağ ( )	Sol ( )	
Tanısı konmuş herhangi bir dil bozukluğunuz var mı (disleksi, kekemelik gibi)?	Hayır ( )	Evet ( )	Varsa, lütfen ayrıntılandırınız.
Çalışma sırasında gözlük kullandınız mı?	Hayır ( )	Evet ( )	
Çalışma sırasında lens kullandınız mı?	Hayır ( )	Evet ( )	

Hangi dil(ler)i, hangi sırayla öğrendiniz? (anadiliniz dahil)			
Dil	Hangi yaştan itibaren?	Ne kadar süreyle?	Öğrendiğiniz yer? (evde, okulda, başka) Lütfen belirtiniz.
1.			
2.			
3.			

Türkiye dışında başka ülkelerde yaşadınız mı?	Nekadar süreyle?	Hangi sebeple? (okul, eğitim, vs.)
1.		
2.		
3.		

APPENDIX B

Stimulus Texts for Experiment I

Table B.1: Stimulus Texts used in Experiment 1. Texts are presented according to the conditions that target words belong to.

Short and Frequent Words

Suffix	Word	Sentence
-	asit	Kapakçık ters çalışıyor ve midenin salgıladığı asit yemek borusunu tahriş ediyor, siz de sürekli öksürüp tıksırıyorsunuz.
-DA	asitte	Zaman kapsülünün içindeki eşyalar asitte yıkanmalarının ardından pirinç bir kutuya yerleştirilmişlerdi.
-DAki	asitteki	Tuz, kimyada, bir tepkime neticesinde oluşan maddedir ve bazdaki pozitif yüklü iyonla asitteki negatif yüklü iyondan meydana gelir.
-	depo	Teknenin taşıyabileceği tatlı su miktarı belirlenirken teknenin tasarımcısının planlarında hangi miktar depo hacimleri öngördüğü incelenmelidir.
-DA	depoda	Uzun yıllar boyunca depoda bekleyen geçmişim, bana dünyayla arasına duvarlar ören bir ülkeyi hatırlattı.
-DAki	depodaki	Kitle içindeki her birey depodaki farklı bir bilgiyi seçip ulaşabilir ve yayıncı kuruluşa gönderebilir.
-	doku	Üretim ortamları hazırlanarak alınan doku parçalarının bu ortamlara konulmasıyla köklendirme işlemleri gerçekleştirilmektedir.
-DA	dokuda	Hastanın hormon tedavisinden faydalanıp faydalanamayacağını görmek için alınan kanserli dokuda östrojen ve progesteron reseptörlerini tayin etmek gereklidir.
-DAki	dokudaki	Erişkin kök hücreler her yaştaki insanda bulunmakta ve ihtiyaç duyulduğunda bulundukları dokudaki değişik hücre türlerine dönüşebilmektedirler.
-	etüt	Haftada bir gün, cuma öğlenleri okulun etüt salonunda toplanıp, mısır - çıtır atardık birbirimize.
-DA	etütte	Heyecanlıydım çünkü bir gün önceki etütte kartlarını alamayan ve kartsız kalan çocuklar o gün öğle yemeğine çıkamayacaktı.
-DAki	etütteki	Öğrencilerin okuldaki durumlarından etütteki başarılarına kadar çeşitli konularda öğrencileri takip etmenizi sağlayan bir sistemdir.
-	fuar	Merkez bu yıl da çocukların sosyal ve toplumsal değerine katkıda bulunmak amacıyla fuar boyunca elde edeceği geliri çocuk yuvasına bağışlayacak.
-DA	fuarda	Şehir ekonomisine katkı sağlamak ve ticari hayatı hareketlendirmek amacıyla düzenlenen fuarda ziyaretçiler aradıkları tüm materyalleri bulabilecekler.
-DAki	fuardaki	Farklı ülkelerden gelen ziyaretçilerin fuardaki mevcut firmalarla markalarını buluşturmaları sağlanarak yeni iş fırsatları ortaya çıkmıştır.
-	gişe	Maddenin aslıyla muhatap olunup olunmadığı bilinemez. Açıkçası konu hakkında gişe rekorları kıran filmler bile çekilmişken bu teoriye kulak kabartmamak olmaz.

Suffix	Word	Sentence
-DA	gişede	Onda şeytan tüyü var: Çevirdiği filmler gişede başarılı oluyor, daha önemlisi, özel hayatını filmlerinin önüne geçirmiyor.
-DAki	gişedeki	Eski klişeye uygun olarak, bilet almak için sırada bekleyen müşterilere rağmen gişedeki bütün memurlar o anda moladaydı.
-	jüri	Rock müziğin önemli isimlerinden oluşan jüri tarafından yapılacak elemelerin ardından finale katılma hakkı kazanan gruplar, canlı performanslarıyla yarışacak.
-DA	jüride	Fotoğraf Sanatı Kurumu üyelerinin jüride bulunmaları tamamen iradeleri dışında gelişmiştir.
-DAki	jürideki	Hemen rezervasyon defterlerine bakıp jürideki isimleri arıyorlar ve 68 kişilik ekipten sadece 8 kişinin geldiğini öğreniyorlar.
-	kıta	Asya'nın en çok nüfus barındıran kıta olması özelliği korunmaktadır. Üstelik toplam nüfus içindeki payı da artmıştır.
-DA	kıtada	Güneşe tapmak, bir zamanlar egemen olduğu kıtada kutsallığını kaybetmiş olsa da etkisini yeni yöntemlerle sürdürüyor.
-DAki	kıtadaki	Avustralya onbinlerce yıldır kıtadaki yerliler tarafından yurt edinilmiş olmakla birlikte, yakın zamana kadar diğer ülkelerce bilinmiyordu.
-	kıyı	Kalenin denize hakim oluşu ve ticaret yollarının birleştiği noktada bulunuşu kıyı kontrolü amaçlı bir yapı olduğunu göstermektedir.
-DA	kıyıda	Merdivenlerden inin ve masmavi denizin kıyıda turkuaza dönüştüğü bu minik sahildeki dalgaların keyfini çıkarmadan sakın buradan ayrılmayın.
-DAki	kıyıdaki	Özellikle baskın avlarında kıyıdaki dalgaların hareketliliği dengemizi bozabileceği için ağırlık seçimini uygun ayarlamalıyız.
-	masa	Bu çare arayışında ben biliyorum anlayışı yok. Diyalog var. Burada en önemlisi masa etrafında sorunları tartışabilmek.
-DA	masada	Bu tozlu baraka senelerdir önemli bir bilgi akış noktası olmuştu. Dolayısıyla birazdan masada duran zarfın içinden çıkacaklar da önemli görünüyordu.
-DAki	masadaki	Kasabaya yakın olmanın avantajından masadaki çilek reçelini tadarak yararlanıyoruz.
-	ofis	Saatlerce oturarak çalışan bir kişinin ofis şartları ergonomik değilse bu kişi sağlık problemlerine gebedir.
-DA	ofiste	İki yılı bulan ekonomi muhabirliği görevinden sonra vaktinin büyük bir kısmını ofiste geçirmesinin nedeni olan editörlük süreci başlar.
-DAki	ofisteki	Çalışanlarla birlikte kendi sosyal komünlerini kuran kediler mekana yeni bir düzen getirirken ofisteki günlük hayatın tüm süreçlerine katıldılar.
-	öykü	Anlatının derin yapısı üstünde dururken bu tür sorulara yönelmek, tüm ilgiyi belli başlı öykü kişileri arasındaki ilişkiler üstünde topluyor.
-DA	öyküde	Etrafına çizilen daireden çıkamayan adamın azınlıkta kalan bireylerin simgesine dönüştüğü öyküde tarihsel bir arka plan varlığını duyuruyor.
-DAki	öyküdeki	Sonunda adet olduğu üzere mutlu sona ulaşıldığında sarışın kız kardeş öyküdeki büyük ödüle kavuşurken esmer kız kardeşe düşen ölüp gitmektir.

Suffix	Word	Sentence
-	saha	Eğer kaleci topu yumruklayıp saha dışına atarsa veya topu yakalayıp durdurursa şutu çeken kaleye geçiyor.
-DA	sahada	Sayı almak için vuruş yapılan topun sahada rakip oyuncu topa vuramadan iki kere sıçraması gerekir.
-DAki	sahadaki	Herhangi bir erteleme halinde, aksi kararlaştırılmaz ise, önceki skor ve oyuncuların sahadaki duruş yerleri muhafaza edilir.
-	uçak	İlk belirlemeye göre kayıp uçak bulunmadığı halde yetkililer ihbarın yine de araştırıldığını bildirdi.
-DA	uçakta	New York seferini yapan uçakta yaşananlar şu sıralarda sosyal medyada büyük bir çalkantıya sebep oldu.
-DAki	uçaktaki	Motor, havayı çektiği için, kullanılan motor gücünü düşürüyor. Sıcakta ve basınç altında uçaktaki titanyum borularla hava dışarı veriliyor.
-	uyku	Karnını doyurup kapıdan çıkınca, neredeyse tüm kasabanın gözüne o gece boyunca uyku girmediğini gördü: Millet sokağa dökülmüştü.
-DA	uykuda	Her günün en fazla altı saatini uykuda geçirdiği için, geri kalan on sekiz saat, haksız bir işkence haline geliyordu.
-DAki	uykudaki	Yakınında bulunan çocukları uykudaki küçük köylünün yanına getiriyor ve gene bir şeyler söylüyordu.
-	üzüm	Üreticiler, talep baskısı sayesinde fazladan üzüm satarak daha çok para kazanmak amacıyla olabildiğince fazla verim almaya çalışıyor.
-DA	üzümde	Dalıyla birlikte ezilen üzümde bulunan bir maddenin kanı sulandırıcı etkisi var, her yerde satılıyor.
-DAki	üzümdeki	Son zamanlarda yapılan çalışmalar üzümdeki aroma maddelerinin büyük kısmının kabukta toplandığını göstermektedir.

Long and Frequent Words

Suffix	Word	Sentence
-	alternatif	Olası senaryolar, bunlar karşısında uygulanılacak eylem planları, birbirlerini destekleyecek alternatif uygulamalar ve tercih sıralamaları karar aşamasının ürünleri.
-DA	alternatifte	Bu kumsalda hafta sonu tatili geçirmek isteyenler için çeşitli alternatifte konaklama olanakları bulunmaktadır.
-DAki	alternatifteki	Geçen sezonda belli renklerde sunulan kalem etekler, bu yıl yüzlerce farklı alternatifteki renkleri ile satışa çıkarılıyor.
-	bilgisayar	Çocukla, evle ilgili bir iş yapmak şartıyla bilgisayar kullanma süresi kazanması konusunda bir sözleşme yapılabilir.
-DA	bilgisayarda	Çalışmalarım, elektriksel işaretlerin bilgisayarda modellenmesine ve simülasyonuna dayanıyor.

Suffix	Word	Sentence
-DAki	bilgisayardaki	Okuma ve yazma izni olduğunda bilgisayardaki dosyalara erişim sağlanarak değişiklik veya dosya silme yapılabilir.
-	cumhuriyet	Fransız ulusu, büyük bir endişeyi geride bıraktı ve bu seçim sonuçlarıyla cumhuriyet değerlerine güvenoyu verdi.
-DA	cumhuriyette	Her yurttaş istediği federe cumhuriyette yaşama hakkına sahiptir. Bu hakka hiçbir şekilde müdahale edilemez.
-DAki	cumhuriyetteki	Bağımsızlıktan önce azınlıklar cumhuriyetteki çoğunluğa karşı, çoğunluklar Sovyet sistemine karşı kültürel ve siyasal hak talep etmişlerdir.
-	eleştirmen	Bazı hesaplaşmalar belki eleştirmen cephesinde daha fazladır ama doğrusu modern sinema seyircisi de farklı davranmaz ve aşağı yukarı aynı güzergâhta ilerler.
-DA	eleştirmende	Belirtilenlerden anlaşılacağı üzere, nesnel bir çeviri eleştirisi yapabilmek eleştirmende birtakım birikimlerin bulunmasını gerektirmektedir.
-DAki	eleştirmendeki	Yazar, modern kültürü ve yüzyılların düşüncelerini yeniden kendilerine mal eden birçok eleştirmendeki bilindik yerel içgüdüleri, parodileştirme yoluyla ifade etmektedir.
-	enfeksiyon	Sağlığını kaybedenler hastanelerde enfeksiyon tehlikesiyle de karşı karşıya kalıyor.
-DA	enfeksiyonda	Ama ateşi her yükselen hastanın mutlaka antibiyotik kullanması gerekmez. Her gribal enfeksiyonda hastanın ateşi zaten yükselir.
-DAki	enfeksiyondaki	Kalp hastalığını tetikleyen enfeksiyondaki bakteriler diş etinde de kanama, ağrı ve kokuyla kendini gösteriyor.
-	ilköğretim	Eğitim fakülteleri ilköğretim okullarına öğretmen yetiştirmeyi temel görev olarak üstlenirlerse bu alandaki açık kolaylıkla kapanacaktır.
-DA	ilköğretimde	Okullar geleceği şekillendirecek yeni nesillerin yetiştirildiği yerlerdir. Bireyin eğitiminde ilköğretimde görevli öğretmenlerin işlevi çok önemlidir.
-DAki	ilköğretimdeki	Kurumların işbirliği sayesinde ilköğretimdeki trafik konulu derslere trafik birimlerinde görevli yüksek öğrenim görmüş personelin girmesi sağlanmıştır.
-	istatistik	Binlerce eğitimli anketör, onları her ay ziyaret edecek ve defterlerdeki sonuçları istatistik normlara göre analiz yapılması için toplayacaklardı.
-DA	istatistikte	Girdi katmanı dışarıdan gelen verilerin yapay sinir ağına alınmasını sağlar. Bu veriler istatistikte bağımsız değişkenlere karşılık gelmektedir.
-DAki	istatistikteki	Bu soruyu yanıtlamadıkça veya bir tercih yapmadıkça diğer planlar maalesef kendilerini istatistikteki negatif sonuçla yüzleşmekten koruyamayacaktır.
-	istihbarat	Eksik, belgesiz, delilsiz denemez çünkü hepsinin delili var. Örneğin bankanın istihbarat raporlarında kredi verilemez nitelikte bulunan firmalara kredi verilmiş.
-DA	istihbaratta	Üç yıldır telefonlarının dinlendiği anlaşılan bir gazetecinin bütün kayıtları istihbaratta bulunuyor olsa da belli ki kafaları karıştırmamak için içlerinden özenle seçiliyor.
-DAki	istihbarattaki	Acaba onun defteri istihbarattaki karanlık çalışmaları gibi siyah mı, yoksa farklı renkte mi olacak onu ise biz bilemeyiz.

Suffix	Word	Sentence
-	karşılaşma	Yoğun yağmur yağışı nedeniyle özellikle asansör ve yürüyen merdivende meydana gelen arızalar karşılaşma öncesi yapılan çalışmalarla giderildi.
-DA	karşılaşmada	Bu yönetimin görev almasından sonra oynanan karşılaşmada camianın beklentisi galibiyetti. Fakat takım, bir dağınıklık içinde maça başladı.
-DAki	karşılaşmadaki	Maçtan önce bir bahis bürosunda görüntülenmesinin ardından karşılaşmadaki şüpheli hareketleri de dikkat çekmişti.
-	koleksiyon	Mezuniyet gecelerine özel olarak koleksiyon hazırlayan ünlü giyim markası, özel fiyatlar ve taksit olanakları da sunuyor.
-DA	koleksiyonda	Yıllar boyunca topladığı koleksiyonda yılların yaşanmışlığı olan figürlerin dantel duygusu ile işlenmiş eserler olduğunu vurguluyor.
-DAki	koleksiyondaki	Şık elbiselerin yer aldığı koleksiyondaki parçalar bağcıklı ve boncuklarla örülmüş kemerlerle tamamlanıyor.
-	komutanlık	Çeşitli karargâhlarda ve alaylarda komutanlık görevi yaptı. Bu yarı akademisyen subayı görev aldığı birliklerde herkes seviyordu.
-DA	komutanlıkta	Bayram dolayısıyla sınırın sıfır noktasında bulunan komutanlıkta askeri tören düzenlendi.
-DAki	komutanlıktaki	Alınan Dersler Şube Müdürlüğü'nün yaptığı görevi duyunca çok şaşırdım. Çünkü bu görev komutanlıktaki önemli görevlerden biriydi bana göre.
-	kooperatif	Arabam, taksitlerini ödediğimiz kooperatif evimiz ve birlikte aldığımız gayri menkullerden payımızı almak için gerekli başvuruyu yaptık.
-DA	kooperatifte	Uygulamaya geçildi ama sorunun devam ettiği bölgeler var. İzmit ile Gölcük arası taşımacılık yapan kooperatifte yaşananlar buna bir örnek.
-DAki	kooperatifteki	Ortakların sorumlu olacakları miktar kooperatifteki paylarının tutarı ile orantılı olarak da gösterilebilir.
-	perspektif	Devlet Bakanı, uzun vadeli perspektif içinde siyasal güven, toplumsal güven ile ekonomik ve finansal güvenin birlikte olduğunu savundu.
-DA	perspektifte	Diğer disiplinlerle de bağlarını kurar; müzik sanatını eğitim, estetik, tarih gibi birçok perspektifte inceleyerek sonuçlara varır.
-DAki	perspektifteki	Tüm dünyadaki tarih yazımında çok önemli etkiler yapmışlar ve bunun karşılığında tarihsel perspektifteki değişimlere de katkıda bulunmuşlardır.
-	psikiyatri	Psikolog, bu rahatsızlığı taşıyanların psikiyatri uzmanlarına başvurması gerektiğini söyledi.
-DA	psikiyatride	Diğer uzmanlık alanlarında daha ayrıntılı değerlendirmelere yer verilmişken psikiyatride ayrıntılı hekim değerlendirmeleri sınırlı kalmıştır.
-DAki	psikiyatrideki	Çoğu sosyal temsil araştırmasında psikiyatrideki klasik araştırma metotlarının kullanılıyor olması eleştirilere yol açmaktadır.
-	referandum	İki ülkenin başbakanları görüşlerini, niyetlerini, temennilerini söylediler. Bundan sonra tamamıyla referandum sonuçlarını karşılıklı olarak beklemek lazım.
-DA	referandumda	Bugüne kadarki süreç şunu gösteriyor: Pazar günü yapılacak referandumda partilerin kimi mensupları kararlarını verirken kendilerini baskı altında hissediyorlar.

Suffix	Word	Sentence
-DAki	referandumdaki	Neredeyse tüm yazarlarımız referandumdaki oylarını açıkladılar ve şaşırtıcı bir biçimde hepsinin de oylarının rengi aynıydı.
-	yönetmelik	Bizim amacımız bu şirketlerin önündeki engelleri kaldırmaktır. Bununla ilgili yönetmelik çalışmamız var. Gelecek ay çıkartmayı düşünüyoruz.
-DA	yönetmelikte	Trafik kazalarında hayat kurtaran emniyet kemerinin arka koltuklarda da takılması zorunluluğu yönetmelikte olmasına karşın uygulanamıyor.
-DAki	yönetmelikteki	Orduya katılması için çağrının bildirilmesine rağmen buna uymayan kişilere yönetmelikteki ordudan kaçma hükümleri uygulanır.

Short and Infrequent Words

Suffix	Word	Sentence
-	akaç	Kemerlerin üzerinde suyu taşıyan akaç delikleri bulunan kanalların izleri yıkıntılar arasındaki parçalarda görülmektedir.
-DA	akaçta	Binlerce çocuk, onların açtığı akaçta didiklemişlerdi dünyayı. Halkın yüreğine vurulan kara mührü kazımışlardı.
-DAki	akaçtaki	Vücut ısısı saat başı 1,5 derece düşürülür ve hedeflenen hipotermi düzeyine ulaşılana kadar akaçtaki soğuk su akımı devam eder.
-	çıma	Yüzme molası için durulabilecek yerlerdir fakat deniz derindir. İki koyun arasındaki kayalara çıma tutulup geçici olarak kalınabilmektedir.
-DA	çımada	Çoğu aday gibi uzun zaman çımada asılı kalan ve yardımla aşağıya indirilen adayın bacakları yaralanmıştı.
-DAki	çımadaki	Alanya'da balık ağlarını toplarken kopan çımadaki demir makaranın üstüne düşen balıkçı hayatını kaybetti.
-	cura	Sempozyumun konusu isabetli olup, üzerine gidilerek sanatçılarla ve özellikle cura sanatçılarıyla ortak çalışmalar yapılmalıdır.
-DA	curada	Ustası, kalfanın çaldığı curada yerine getiremediği tavır ve eda ile ilgili olarak bir takım düzeltmeler yapar ve ona yol gösterir.
-DAki	curadaki	O dönemde yazının gramer kurallarının yapılmadığı bilinmektedir. Bundan dolayı curadaki yazının beşinci yüzyıla ait olduğunu düşünmekteyiz.
-	eviç	Yeden kullanmadan yapılan segâh çeşnili kararlar tam bir bitiş hissi vermediğinden eviç perdesindeki segâh çeşnili kararlarda yeden kullanılmalıdır.
-DA	eviçte	Hüzzam makamı seyri esnasında yukarıda zikredilen dizi ve çeşnilere ilave olarak zaman zaman eviçte segâh dörtlüsüne de yer verildiği görülmektedir.
-DAki	eviçteki	Irakta meydana gelen hicaz dörtlüye eviçteki hicaz dörtlüsünün simetriği de denilmektedir.
-	inak	Fransız yazarlarının özelliği, kutsallaştırılmış her türlü tabuya karşı çıkmaları; her türlü donmuş inak kalıplarının üstüne yürümeleridir.
-DA	inakta	Geçmiş çağlarda bilimciler dünyanın düz ve evrenin merkezi olduğunu söyleyen inakta yüzyıllar boyunca ısrar etmişlerdi.

Suffix	Word	Sentence
-DAki	inaktaki	Tiyatro idolü felsefi inaktaki tarafgirlikten kaynaklanır. En tehlikelisi, insanın kavrayışına en büyük darbeyi vuranı budur.
-	irap	Çünkü şekilcilik var. "Merak ettim biraz oku bana." dedim. Adam okumaya başladı ama cümleyi okuyuşu irap hatalarıyla doluydu.
-DA	irapta	Burada diyaframatik solumanın irapta etkili şekilde kullanılması amacıyla alıştırmalar verilecektir.
-DAki	iraptaki	İlk görevi çocuğun düzgün beslenmesi olan süt dişlerinin sağlığı çocukların iraptaki gelişimini de büyük ölçüde etkilemektedir.
-	ışkı	Görüntülemekte olduğunuz resim ışkı kategorisinde yer almaktadır. Bu kategoride toplam 15 resim bulunmaktadır.
-DA	ışkıda	Sınırlı ölçülerde Orman Bakanlığımızdan satın alabildiğimiz geyik boynuzu özellikle ışkıda görselliğe önem veren kullanıcılar tarafından tercih edilmektedir.
-DAki	ışkıdaki	Olaya karışan iki kişi mahkemeye çıkarıldı. Tutuklanan iki kişinin üzerinde bulunan ışkıdaki izlerin sonuçlarının kriminalden gelmesi bekleniyor.
-	ivgi	Doğrama işlerini yaparken ivgi aşağı dönük olarak ürünün içine yerleştirilir. Dilimleme içinse tam tersi yapılmalıdır.
-DA	ivgide	Aynı boydaki yapay bileme taşının ivgide oluşturduğu yüzey ile kösüre taşının oluşturduğu yüzey kesinlikle aynı değildir.
-DAki	ivgideki	Ne yazık ki tüm şüpheler onun üzerinde toplanıyordu. Biricik umudu ivgideki parmak izleriyle onunkilerin uyuşmamasıydı.
-	kete	En üstteki bezeyi de yağladıktan sonra kete yaparken olduğu gibi her tarafından katlayarak dikdörtgen yapın.
-DA	ketede	Bu yöntemi her türlü ketede kullanarak geliştirebilirsiniz. Fotoğraflardan da anlayacağınız üzere gerçekten işe yarıyor.
-DAki	ketedeki	Hazırlanan bu malzeme ketedeki kıyma yerine yufkanın içine konularak sac üstünde pişirilir.
-	loça	Ülkedeki iç savaştan kaçan dört genç, yurt dışına giden şilebe gizlice binerek loça deliğine saklanmış ve okyanusu geçmişti.
-DA	loçada	Salih denen bu adamın, yorgun bedenini serin suların kollarına bırakması uzun sürmemişti. Geminin motorları durdu ve boşalan zincir loçada dayanılmaz bir ses bıraktı.
-DAki	loçadaki	Az önce vira edilen çapanın loçadaki yerine oturmasıyla komutan emri verdi ve zincir denize bırakıldı.
-	maun	Kısa zamanda el yapımı maun mobilya alanında dünyanın önde gelen üreticilerinden birine dönüştüler.
-DA	maunda	Ağır bir ağaç olarak değerlendirilen maunda özgül ağırlık, türlerine göre değişiklik gösterir.
-DAki	maundaki	Dikimini izleyen üç yıl içinde şekil budaması uygulanır. Daha sonraki yıllarda maundaki çatal ve obur dallar ile çok zayıf sürgünler çıkarılıp atılır.
-	pişi	Hamur kızartması ya da diğer adıyla pişi bizde genellikle mayalı yapılırdı. Hatta ben çoğunlukla fırından aldığım ekmek hamurunu kızartmayı severdim.

Suffix	Word	Sentence
-DA	pişide	Hamurun üçte birini pişide kullandıktan sonra çoğundan börek yaptık. Aynı hamurdan açma börek yapmak isterseniz diğer tarife bakabilirsiniz.
-DAki	pişideki	Sotelenmiş kırmızı biberle peynirin pişideki buluşması tadanlara mükemmel bir lezzet sunuyor.
-	şose	Asfaltlanma çalışmaları öncesinde şose olduğu için birçok kazaya neden olan yolun asfaltlanması köy sakinlerini sevindirmişti.
-DA	şosede	İleride, Ahı Dağı'nın yamaçlarından kıvrıla kıvrıla inerek uzanan şosede keskin bir ışık huzmesi belirip kayboldu.
-DAki	şosedeki	Evlerin açık kapısından sızan sarı huzmeler eğer az biraz aydınlık saçmasaydı köhne şosedeki deliklerde sendelemek işten bile değildi.
-	süje	Estetik olaylar da, tıpkı bilgi olaylarında olduğu gibi bizlere süje hakkında bilgi verir ve onun objeyle arasındaki ilişkiyi gösterir.
-DA	süjede	Ekminezi, psikolojik ayrışma içindeki süjede geçmiş yaşamlarında yer alan izlenimlerin tekrar canlanmasını sağlayan yöntemdir.
-DAki	süjedeki	Bu, sekreterin işini en çok kesen unsurdur. Bir önceki süjedeki unsura göre halledilmesi daha güçtür.
-	tapa	Koyun ve kuzu yününden yapılan keçeleri avcılar tapa olarak veya çobanlar kepenek olarak kullanırlar.
-DA	tapada	Emniyet gözlüklerinizi takın; çekiç, çivi ve tahta yardımıyla plastik tapada dikkatlice bir delik açın.
-DAki	tapadaki	Top mermisi, fünyesi takılı olduğu halde yere düşse bile patlamaz ki! Patlaması için kovanın ateşlenip tapadaki mekanizmayı harekete geçirmesi lazım.
-	ulam	Oyun içinde pek çok farklı ulam altında incelenebilecek pek çok yetenek vardır.
-DA	ulamda	Yazarın yapıtında metinlerarası ulamda değerlendirilebilecek çok sayıda olgu bulmak olasıdır.
-DAki	ulamdaki	Yarışmaya katılan maketçilerin maketlerinden sadece en yüksek dereceyi aldığı ulamdaki maketi ödüllendirilecektir.

Long and Infrequent Words

Suffix	Word	Sentence
-	anakronizm	Bugünün ihtiyaçlarının, sorunlarının ve yaklaşımlarının tarih yazımına yansıması anakronizm hatalarını kolaylaştırmaktadır.
-DA	anakronizmde	Prens Igor operasının bu bölümünün doğru çevrilmiş hali, Rusların yaptığı anakronizmde ısrar edilecek olunursa Peçenek danslarıdır.
-DAki	anakronizmdeki	Felsefesinden yola çıktığım anakronizmdeki biçimiyle farklı zaman dilimleri arasında zıplamalar yapmak bana heyecan veriyor.

Suffix	Word	Sentence
-	endüksiyon	Motorlarda devir sayaçları endüksiyon bobinine bağlanıyor ve ateşleme sayısından yola çıkarak dakikadaki devir sayısını görüyoruz.
-DA	endüksiyonda	Bobinin hareketi sayesinde oluşan endüksiyonda şiddet sürekli değişir yani artar veya azalır.
-DAki	endüksiyondaki	Magnetik dedektörler metalik varlıklara karşı duyarlı olup, oluşan bir magnetik endüksiyondaki değişim bunların çalışma prensibini oluşturur.
-	hipnotizma	Hiç çalışmadan, hatta uyurken dersleri dijital hipnotizma metodu ile öğrenip sınıf birincisi olmak mümkün.
-DA	hipnotizmada	En basit olarak ağrı kesicinin bile çok yan etkisi vardır. Bugüne kadar hipnotizmada herhangi bir komplikasyon veya bu metoda bağımlılık görülmemiştir.
-DAki	hipnotizmadaki	Gevşeme halinin konforu nedeniyle hipnotizmadaki kişiler bu keyifli ortamdan çıkmama konusunda tercih kullanırlar.
-	jeodinamik	Raporda, bölgenin imarında jeodinamik karakterinin de dikkate alınması uyarısında bulunuldu.
-DA	jeodinamikte	Atmosfer adı verilen hava küresi jeodinamikte önemli bir etken olarak bilinir.
-DAki	jeodinamikteki	Bu yenilemenin sebebi tarihsel jeodinamikteki bilgi birikiminin daha anlamlı ve güvenilir hale gelmesindendir.
-	kançılarya	O yıl ikametgahın bahçesinde yeni bir bina inşa edilene kadar ikametgah binası kançılarya olarak da kullanılmaya devam etmişti.
-DA	kançılaryada	Bünyesinde Askeri Ataşelik de bulunan Büyükelçiliğimiz, Temmuzda yeni taşınılan adresindeki kançılaryada hizmet vermektedir.
-DAki	kançılaryadaki	Temizlikçi bir annenin yetiştirdiği Alman Başbakanı, kent merkezinde bulunan kançılaryadaki küçük daireye taşınabilir.
-	mazhariyet	Çağdaş uygarlık düzeyine mazhariyet çabamızda bilim, teknoloji ve insan kaynağına yapılan yatırımlar büyük önem taşımaktadır.
-DA	mazhariyette	Varlık ve hayat şerefine mazhariyette aralarında gölge ile asıl arasındaki fark kadar fark var. Bunun bir misalini rüyada yaşamıyor muyuz?
-DAki	mazhariyetteki	Engelli kişilerin bilgiye mazhariyetteki sıkıntılarını azaltmayı amaçlayan proje, engelli vatandaşlar için büyük kolaylık sağlıyor.
-	müphemiyet	Irak ve IMF görüşmeleri, piyasaların gündemindeki iki önemli konu. Ve bu iki önemli konudaki müphemiyet devam ediyor.
-DA	müphemiyette	Küreselleşme süreciyle ilişkili yapısal değişiklikler, para politikasını kuşatan müphemiyette artışa ve kargaşanın genişlemesine neden olur.
-DAki	müphemiyetteki	Bundan dolayı siyasi belirsizlik arttı ve işin teorisinden bildiğimiz gibi siyasi müphemiyetteki artış faizlerde mutlaka karşılık bulur.

Suffix	Word	Sentence
-	murakıplık	Kanun taslağı çalışmalarıyla gündeme gelen ve tartışmalara neden olan yeminli murakıplık sisteminin kaldırılmasının denetim sisteminde risk oluşturacağı belirtildi.
-DA	murakıplıkta	Mali müşavirlikten bağımsız sayılabilecek olan ve hatta yeni bir meslek olarak kabul edilen murakıplıkta avukatlar için de bir olanak yaratılabilirdi.
-DAki	murakıplıktaki	Denetçilerin çoğunluğunun murakıplıktaki kıdemlerinin fazla olması denetime daha çekingen yaklaşmalarına neden olabilir.
-	müsakkafat	Müdürlüğün uygulamaya itiraz nedeni müsakkafat olarak kabul edilen mülkün kendilerine devrini istemesidir.
-DA	müsakkafatta	Daha sonraları vakıfların elindeki müsakkafatta gayrimüslimlerin oturması dikkat çeker.
-DAki	müsakkafattaki	Yeni kazanç kanununun müsakkafattaki iradı gayrisafilerin esas tutulacağı dikkate alınarak tanzim edildiğine şüphe yoktur.
-	ornitorenk	Yeni Zelanda asıllı Amerikalı bir aktrist, sette yemek yediği sofrada mutlaka haşlanmış ornitorenk bulunmasını şart koşuyormuş.
-DA	ornitorenkte	Yavrularda bulunan dişler ergin ornitorenkte yerini kemiksi çıkıntılara bırakır.
-DAki	ornitorenkteki	Yapılan bir araştırmaya göre, insan beyninde yaşlanmayı yavaşlattığı bilinen ornitorenkteki faydalı yağların kilo vermeye de yardımcı olduğu belirlendi.
-	sarfınazar	Avrupalı tarihçilere müracaat edildi ama bazıları makalelerini gönderdikleri halde sarfınazar ederek geri çektiler, tehdit aldıklarını söylediler.
-DA	sarfınazarda	Yasayla, tarafların arabulucuya başvurma, süreci devam ettirme, sonuçlandırma veya bu süreçten sarfınazarda serbest olması güvenceye alındı.
-DAki	sarfınazardaki	Sınırlayıcı faktör ancak bizim kendi inancımız ve kötü alışkanlıklarımızdan sarfınazardaki niyet ve azmimiz olacaktır.
-	senatörlük	Ülkenin önünde, başkanın icraatları nedeniyle yargılanmasına engel olan düzenleme ve kendisini dokunulmazlık zırhı ile saran, hayat boyu sürecek senatörlük engelleri bulunuyor.
-DA	senatörlükte	Efsane başkan, başında olduğu kurumu soyup soğana çeviren sonra da kurtuluşu senatörlükte arayıp dokunulmazlığa sığınan değildir.
-DAki	senatörlükteki	Üstelik, programa davet edildikten sonra hayli tedirgin olan kişinin senatörlükteki çalışma alanı uyum ve sivil toplum.
-	stronsiyum	Doğal deniz suyunda bulunan stronsiyum seviyelerini akvaryum içerisinde dengeye getiren araç, bu seviyeyi korumaktadır.
-DA	stronsiyumda	Piyasadan alacağınız hiçbir stronsiyumda ürünün yapısı gereği tam standardı tutturmak mümkün değildir.
-DAki	stronsiyumdaki	Modifiye olmadığı durumlarda gaz seviyesi önemli ölçüde değişmez. Sodyum ile modifiyede stronsiyumdaki kadar şiddetli olmasa da gaz absorbesini biraz yükselttiği gözlenmiştir.

Suffix	Word	Sentence
-	tahtırevan	İstanbul'un dar sokaklarında hanımlar ancak sedan sandalyesi adı verilen bir çeşit tahtırevan aracılığıyla dolaşabilirlerdi.
-DA	tahtırevanda	Örneğin, elçinin kızını tahtırevanda betimleyen eserinde olduğu gibi yabancı elçiler ve elçilik çevrelerinden de siparişler almıştır.
-DAki	tahtırevandaki	Yanlarında bir de beyaz giysili kadın var. İyi giyimli dört atlı ise atlarından inerek tahtırevandaki kadını indirmeye gittiler.
-	taşeronluk	Teknik olarak ehil olmayan kişiler taşeronluk yaptığı için müşteri mağduriyeti yaşanıyor.
-DA	taşeronlukta	Bu kazanım hükümeti düzenleme yapmaya sevk etti. Dolayısıyla, şimdi gündemde taşeronlukta yapılacak yeni düzenlemeler var.
-DAki	taşeronluktaki	Teknik ekip, mevcut heyetin taşeronluktaki çalışması boyunca böyle bir sorumluluğu almak istemediğine dikkat çekiyor.
-	tekdüzelik	Yaşamın halihazırda tekdüzelik kıskacında kıvrandığı ülkelerde futbol, ekranlarda keyifle hüküm sürmektedir.
-DA	tekdüzelikte	Her birimiz, her sabah aynı sıkıcı tekdüzelikte çalıştığımız bu büyük binalara geliyoruz.
-DAki	tekdüzelikteki	Medeni insanın genişleyen dünyasında estetik değerler, sanayi devriminin getirdiği tekdüzelikteki bunalımlı durumun da tedavisini sağlıyor.

APPENDIX C

Stimulus Sentences for Experiment II

Table C.1: Stimulus Sentences used in Experiment 2. Sentences are presented according to the conditions that target words belong to.

Two Suffixed Forms (-DAki)

Root length	Bigram	Root	Word	Sentence	Before target	After target
3	ba	baş	baştaki	Emekli adamın küçük çocuğu baştaki muhabbetini bırakıp gitti.	Emekli adamın küçük çocuğu	muhabbetini bırakıp gitti.
3	be	ben	bendeki	Bu şekilde yararlı olsaydı bendeki etkileri daha çok olurdu.	Bu şekilde yararlı olsaydı	etkileri daha çok olurdu.
3	ça	çap	çaptaki	Söylediğiniz kadar büyük çaptaki halatı taşımak zor olmalı.	Söylediğiniz kadar büyük	halatı taşımak zor olmalı.
3	di	dil	dildeki	Gereken özen gösterilirse dildeki etkiler iyi gözlenebilir.	Gereken özen gösterilirse	etkiler iyi gözlenebilir.
3	ha	hat	hattaki	Burada bekliyordunuz fakat hattaki diğer bölgeden olur dendi.	Burada bekliyordunuz fakat	diğer bölgeden olur dendi.
3	ka	kan	kandaki	Olayı doğru anlamak için kandaki analizi yapmak gereklidir.	Olayı doğru anlamak için	analizi yapmak gereklidir.
3	ku	kur	kurdaki	Önemli olduğunu bilmeseydim kurdaki zamanına dikkat etmezdim.	Önemli olduğunu bilmeseydim	zamanına dikkat etmezdim.
3	li	lig	ligdeki	Durum konuşulduktan sonra ligdeki sorunumuz çözüldü sayılır.	Durum konuşulduktan sonra	sorunumuz çözüldü sayılır.
3	ma	maç	maçtaki	Çok çalıştığı için şimdi maçtaki başarıları saymakla bitmez.	Çok çalıştığı için şimdi	başarıları saymakla bitmez.
3	or	ora	oradaki	Öyle hassas konularda asla oradaki üretim hataları yapılmaz.	Öyle hassas konularda asla	üretim hataları yapılmaz.

3	sa	sağ	sağdaki	Okulun topluluğu yıllarca sağdaki başarısıyla adını duyurdu.	Okulun topluluğu yıllarca	başarısıyla adını duyurdu.
3	so	sol	soldaki	Bugün katıldığımız davette soldaki konuklar açıkça konuşmadı.	Bugün katıldığımız davette	konuklar açıkça konuşmadı.

One Suffixed Forms (-DA)

Root length	Bigram	Root	Word	Sentence	Before target	After target
5	ba	bahçe	bahçede	Emekli adamın küçük çocuğu bahçede muhabbetini bırakıp gitti.	Emekli adamın küçük çocuğu	muhabbetini bırakıp gitti.
5	be	beden	bedende	Bu şekilde yararlı olsaydı bedende etkileri daha çok olurdu.	Bu şekilde yararlı olsaydı	etkileri daha çok olurdu.
5	ça	çanta	çantada	Söylediğiniz kadar büyük çantada halatı taşımak zor olmalı.	Söylediğiniz kadar büyük	halatı taşımak zor olmalı.
5	di	diyet	diyette	Gereken özen gösterilirse diyette etkiler iyi gözlenebilir.	Gereken özen gösterilirse	etkiler iyi gözlenebilir.
5	ha	haber	haberde	Burada bekliyordunuz fakat haberde diğer bölgeden olur dendi.	Burada bekliyordunuz fakat	diğer bölgeden olur dendi.
5	ka	kayıt	kayıtta	Olayı doğru anlamak için kayıtta analizi yapmak gereklidir.	Olayı doğru anlamak için	analizi yapmak gereklidir.
5	ku	kulüp	kulüpte	Önemli olduğunu bilmeseydim kulüpte zamanına dikkat etmezdim.	Önemli olduğunu bilmeseydim	zamanına dikkat etmezdim.
5	li	liste	listede	Durum konuşulduktan sonra listede sorunumuz çözüldü sayılır.	Durum konuşulduktan sonra	sorunumuz çözüldü sayılır.
5	ma	makam	makamda	Çok çalıştığı için şimdi makamda başarıları saymakla bitmez.	Çok çalıştığı için şimdi	başarıları saymakla bitmez.
5	or	orman	ormanda	Öyle hassas konularda asla ormanda üretim hataları yapılmaz.	Öyle hassas konularda asla	üretim hataları yapılmaz.
5	sa	sanat	sanatta	Okulun topluluğu yıllarca sanatta başarısıyla adını duyurdu.	Okulun topluluğu yıllarca	başarısıyla adını duyurdu.
5	so	sofra	sofrada	Bugün katıldığımız davette sofrada konuklar açıkça konuşmadı.	Bugün katıldığımız davette	konuklar açıkça konuşmadı.

Root Forms

Root length	Bigram	Root	Word	Sentence	Before target	After target
7	ba	barbekü	barbekü	Emekli adamın küçük çocuğu barbekü muhabbetini bırakıp gitti.	Emekli adamın küçük çocuğu	muhabbetini bırakıp gitti.
7	be	beraber	beraber	Bu şekilde yararlı olsaydı beraber etkileri daha çok olurdu.	Bu şekilde yararlı olsaydı	etkileri daha çok olurdu.
7	ça	çamaşır	çamaşır	Söylediğiniz kadar büyük çamaşır halatı taşımak zor olmalı.	Söylediğiniz kadar büyük	halatı taşımak zor olmalı.
7	di	dinamik	dinamik	Gereken özen gösterilirse dinamik etkiler iyi gözlenebilir.	Gereken özen gösterilirse	etkiler iyi gözlenebilir.
7	ha	hareket	hareket	Burada bekliyordunuz fakat hareket diğer bölgeden olur dendi.	Burada bekliyordunuz fakat	diğer bölgeden olur dendi.
7	ka	kalıtım	kalıtım	Olayı doğru anlamak için kalıtım analizi yapmak gereklidir.	Olayı doğru anlamak için	analizi yapmak gereklidir.
7	ku	kuluçka	kuluçka	Önemli olduğunu bilmeseydim kuluçka zamanına dikkat etmezdim.	Önemli olduğunu bilmeseydim	zamanına dikkat etmezdim.
7	li	limuzin	limuzin	Durum konuşulduktan sonra limuzin sorunumuz çözüldü sayılır.	Durum konuşulduktan sonra	sorunumuz çözüldü sayılır.
7	ma	manevra	manevra	Çok çalıştığı için şimdi manevra başarıları saymakla bitmez.	Çok çalıştığı için şimdi	başarıları saymakla bitmez.
7	or	organik	organik	Öyle hassas konularda asla organik üretim hataları yapılmaz.	Öyle hassas konularda asla	üretim hataları yapılmaz.
7	sa	satranç	satranç	Okulun topluluğu yıllarca satranç başarısıyla adını duyurdu.	Okulun topluluğu yıllarca	başarısıyla adını duyurdu.
7	so	sosyete	sosyete	Bugün katıldığımız davette sosyete konuklar açıkça konuşmadı.	Bugün katıldığımız davette	konuklar açıkça konuşmadı.