PERCEPTUAL SPAN IN TURKISH READING: A STUDY ON PARAFOVEAL INFORMATION INTAKE

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PERCEPTUAL SPAN IN TURKISH READING: A STUDY ON PARAFOVEAL INFORMATION INTAKE

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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

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Perceptual span is the visual region where useful information can be collected at one fixation. This thesis investigates the size of the perceptual span of Turkish readers. Rayner (1975) found that the size of the perceptual span for English readers is about 14-15 characters to the right and 3-4 characters to the left of fixation. However, different characteristics of languages affect the size of the perceptual span. Being an agglutinative language and having shallow orthography are two features of Turkish that may have facilitative effect for readers. In an experiment using gaze contingent moving paradigm (N=48), we compared full paragraph condition with five different window size conditions (7, 11, 15, 19 and 23 characters to the right of fixation) in silent and oral reading. To imitate natural reading conditions, readers were presented paragraphs instead of single sentences. Preliminary results show a significant difference in eye movement measures (first fixation duration, first run dwell time, regression-in-count, regression-out-count) between full paragraph and window conditions. We have not observed a significant difference in reading rate. This suggests that the effect of parafoveal constraint follows a different pattern for Turkish readers, and this requires that perceptual span in Turkish should be investigated by a complementary approach.

Keywords: Eye Movements in Turkish Reading, Silent Reading, Oral Reading, Perceptual Span, Parafoveal Processing

ÖZ

TÜRKÇE OKUMADA ALGILAMA ARALIĞI: PARAFOVEAL BİLGİ ALIMI ÜZERİNE BİR ÇALIŞMA

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Algılama aralığı, bir bakışta (fixation) toplanabilecek işlevsel bilginin alındığı görsel bölgeye verilen isimdir. Bu tezde Türkçe okuyucularının algılama aralığı araştırılmıştır. Rayner (1975) İngilizce okuyucuları için algılama aralığını sağa doğru 14-15 karakter, sola doğru 3-4 karakter olarak belirlemiştir. Ancak dilin karakteristikleri algılama aralığının boyutu üzerinde etkili olmaktadır. Türkçenin sığ ortografiye sahip ve yapışkan (agglutinative) bir dil olması, okuyucuları üzerinde kolaylaştırıcı etkiler yapabilir. Bakışa bağlı hareket eden pencere paradigması kullanılan deneyde (N=48), paragrafın tamamının gösterildiği durum ile beş farklı pencere boyutu karşılaştırılmıştır (bakışın sağına doğru 7, 11, 15, 19 ve 23 karakter açılan pencereler). Doğal okuma koşullarını canlandırmak amacıyla, katılımcılara tek cümleler yerine paragraflar okutulmuştur. İlk sonuçlar birinci bakış süresi, bakış süresi, içeri regresyon sayısı, dışarı regresyon sayısı ölçütlerinde bütün paragraf durumu ile diğer beş pencere durumu arasında önemli bir farklılığa işaret etmektedir. Okuma oranında ciddi bir farklılık gözlenmemiştir. Bu durum, parafoveal kısıtlamanın Türkçe okuyucular üzerinde farklı etkiler yapabileceğini, bu nedenle, Türkçedeki algılama aralığının bütünleyici bir açıdan ele alınması gerektiğini göstermektedir.

Anahtar Sözcükler: Türkçe Okumada Göz Hareketleri, Sesli Okuma, Sessiz Okuma, Algı Aralığı, Parafoveal Bilgi Alımı

DEDICATION

To My Family

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LIST OF ABBREVIATIONS

EEG	Electro-Encephalography
EOG	Electro-Oculography
FFD	First Fixation Duration
fMRI	Functional Magnetic Resonance Imaging
FRDT	First Run Dwell Time
FRFC	First Run Fixation Count
PET	Positron Emission Tomography

CHAPTER 1

1. INTRODUCTION

Reading starts when a reader looks at a piece of text and moves her eyes on the characters in order to extract meaning from the script. The reader is expected to convert what is printed onto the page into a set of inner mental representations.

This process looks quite straightforward, but there is much more to it. Converting abstract symbols into mental representations is a complicated cognitive process. Systematic studies for understanding characteristics of reading have potential to contribute to our study of cognitive processes.

Cognitive processes are unobservable entities. Various methods of investigation such as PET, EEG and fMRI have been developed to infer cognitive processes by means of brain imaging. However, brain imaging methods have constraints for their use in reading research. Such limitations of various methods are usually overcome by *combining* and *triangulating* them, i.e. applying them in collaboration with each other (Bermúdez, 2014). For example, electro-encephalography (EEG) does not provide sufficient temporal resolution for accurate data analysis, and EEG may be used in complement with other methods such as electro-oculography (EOG) for reading research (Sereno & Rayner, 2003). On the other hand, eye tracking research is a widely used alternative to the above-mentioned methods, as eye movements comprise the major source of information intake for reading processes. The present study employs eye tracking for studying reading.

The major methodological question in using eye tracking for any study of reading and other cognitive processes is based on the assumption about the relationship between eye movements and cognitive processes (cf. the eye-mind hypothesis, Just & Carpenter, 1987). How do we know that eye movements may reflect cognitive activities?

There is evidence that eye movements in reading are reflections of on-line word processing (Rayner, 1998), and many eye movement measures can be taken as “good approximations” to cognitive activities (Rayner, Pollatsek, Ashby, & Clifton Jr., 2012). As we will describe in Section 2.2, the *eye-mind hypothesis* (Just & Carpenter, 1987) states that words are processed at the moment or after a very short delay. This approach has some shortcomings, as it has been observed that processing time of some words may *spill over* another if the word is difficult to process (Rayner & Duffy, 1986). Also, it is possible to obtain information from a word without directly fixating on it (cf. peripheral information intake). This phenomenon constitutes the basis of the present study.

1.2. Purpose

Our primary research question in this thesis is what factors would have an effect on the perceptual span in Turkish reading in adults. There are various factors that affect perceptual span. We investigate the role of window size, word length, word frequency, word predictability and reading mode on eye movement patterns of skilled adult readers of Turkish. Our ultimate aim is to make an estimate of perceptual span characteristics in Turkish reading based on our experimental findings.

1.3. Hypotheses & Motivation

Previous research on characteristics of eye movements of readers of English have largely been conducted in the past few decades for silent reading and oral reading, although silent reading has been a more predominant research topic compared to oral reading research (Buswell, 1922; McConkie & Rayner, 1975; Rayner, 1975; O'Regan & Schoen, 1987; Blanchard, Pollatsek, & Rayner, 1989; Pollatsek, Raney, LaGasse, & Rayner, 1993; Inhoff, Solomon, Radach, & Seymour, 2011; Ashby, Yang, Evans, & Rayner, 2012; Vorstius, Radach, & Lonigan, 2014). Studies on different languages and different orthographies such as Dutch (Den Buurman, Roersema, & Gerrissen, 1981), German (Kliegl, Nuthmann, & Engbert, 2006), Japanese (Ikeda & Saida, 1978) and Chinese (Huang & Ma, 2006) give insight on universal characteristics of reading, as well as language-specific ones. As of our knowledge, no systematic study have been conducted so far on eye movement characteristics of readers of Turkish, within the framework of the relationship between eye movement patterns, word frequency, word length, sentential predictability and reading mode. We employ silent and oral reading in order to draw inferences about the peripheral information intake during both reading modes.

Eye movements show different patterns in silent and oral reading. It is known since Huey (1908) that oral reading is slower than silent reading due to the need for activation of vocal system in oral reading (Ashby et al., 2012). It is also known that during reading aloud, the fixations go faster than the voice (Ashby et al.), which is a factor that limits the speed of oral reading. *Eye-voice span* is the measure of the distance between the fixation and the voice in letter characters. Inhoff et al. (2011) reported that readers do not allow their eyes to go far ahead of the voice, and keep their eye-voice span at a certain limit, hence their reading speed drops during oral reading.

In the present study, we investigate the characteristics of perceptual span in Turkish reading by employing a paradigm (viz. gaze contingent moving window) that focuses on peripheral information intake during the course of silent reading and oral reading. We make a comparison of silent reading with oral reading in varying window sizes, to investigate and compare the role of parafoveal processing in silent reading and oral reading.

Turkish has a *shallow orthography*, i.e. there is a nearly perfect one-to-one correspondence between each sound and character. In addition, Turkish is an *agglutinative* (aka. *agglutinating*) language, i.e. it forms new meanings by adding *suffixes* to word roots. English, on the contrary, has a *deep orthography*, in which pronunciations of sounds and words depend on their locations in the word, or on the context of the text.

Turkish orthography contains relatively less ambiguity in word pronunciations of words, and pronunciations do not vary depending on the context, compared to English orthography. In certain situations, the predictability of suffixes in a Turkish word may be higher than the predictability of a whole word in English, as the root word in Turkish gives cues about suffix combinations following it. These features of Turkish lead to language-specific differences that may be shared with other agglutinative languages like Finnish, besides universal similarities to other languages in gaze pattern during the course of reading.

In the present study, we examine particular characteristics of Turkish reading as such, and test the hypotheses below:

- The transparency of Turkish orthography may allow its readers to read by conducting more information intake from the periphery. Henderson and Ferreira (1990) found that increasing text difficulty leads to a decrease in the information intake from parafoveal reading. Also, Seymour, Aro, and Erskine (2003; as cited in Häikiö et al., 2009) state that Finnish children learn reading faster than English children. These two studies point out that perceptual span characteristics may exhibit variance as a function of text difficulty, as well as a function of language characteristics. In English, the readers have an average perceptual span of 3-4 characters to the left and 14-15 characters to the right of fixation (McConkie & Rayner, 1975). Häikiö et al. (2009) imply a perceptual span slightly larger than that of native reading in English. We predict that readers of Turkish may employ a larger window for peripheral information intake (i.e. perceptual span) than that of readers of English.

- Word predictability, i.e. the probability of guessing the next word correctly from the previous context, word length, and word frequency, i.e. the rate of the number of instances a word is encountered, influence eye movement patterns in reading. In particular, more predictable words are more likely to be skipped, or they are fixated for shorter durations (Ehrlich & Rayner, 1981). Similarly, the number of fixations on a word increases when a longer word is read (Rayner & McConkie, 1976). Frequent words are read faster than less frequent words (Just & Carpenter, 1987). We expect to observe similar characteristics for eye movement behaviour of readers of Turkish, since these are universal characteristics of eye movement patterns in reading.

- Varying window sizes have an effect on peripheral information intake on both silent and oral reading. Nevertheless, this effect is less conspicuous on oral reading compared to silent reading. Smaller windows disrupt the reading process in both reading modes (Ashby et al, 2012). We expect to observe similar eye movement patterns in oral reading in Turkish reading. As the limits of vocal system inhibit the speed of eye movements, we expect to observe this disruption in smaller windows more for silent reading and less for oral reading.

In the following chapter, we will summarize the start and development of eye tracking research, by emphasizing the concept of perceptual span. We will then describe basic characteristics of eye movements, the connection between eye movements and cognitive activities, the perceptual span, paradigms for studying perceptual span, and eye movement measures that are used in eye tracking.

We will describe the nature of vision in Section 2.2. The limitations of vision allow only a limited amount of information to be collected at one fixation of the eyes. This amount of information also depends on various factors such as characteristics of the writing system of a language, or its syntactic structure. In Sections 2.3 and 2.4, we will move on to the features of perceptual span and give a thorough description of studies to investigate perceptual span and measures used in eye movement research. In Chapter 3, we will introduce our study and methodology, then present our results. In the final chapter, we are going to discuss the results of our findings and propose new directions of future research.

CHAPTER 2

2. BACKGROUND

2.1. Previous studies on eye movement research and gaze contingent paradigms

Experimental methods that employ eye movements have shown major progress towards the end of the 20^{th} century and this allowed researchers to discover hitherto unknown aspects of eye movements (Wade, 2010) and cognitive processes. Rayner (1998) divides the stages of eye movement research into three eras:

The first era begins with Javal (1879) and continues up to 1920. This period is when the first basic observations led to the definitions of basic eye movements.

Hering (1879) observed the sound of muscle contractions in the eye using the friction caused by a tube attached to the eyelid, and deduced the characteristics of each eye movement depending on the particular sound it produced. He discovered saccadic movements of the eye and gave a description of fixations and saccades. It was Javal (1879) who first used the term "saccades" (Wade, 2010). Dodge (1900) describes the fixations and saccades during reading as:

> *It will be clear that when the eye moves as rapidly as possible from one fixation point to the other nothing new is seen; but it will seem that, when the eye moves more slowly, the entire line is seen very distinctly. If the observer takes the precaution to have some one watch his eyes, as recommended, he will find that what in self-observation passes for slow movements of the eyes is in reality broken by one or more clearly defined full stops* (Dodge, 1900; as quoted in Wade, 2010, pp.24-25).

Huey (1908), tackling basic questions on reading, also extensively discussed the amount of data intake during reading a text. Huey stated that eye movements make a reader think that she can see every part of a page completely, but after fixating a character, which Huey called a "reading pause", she would have limited visual clarity. Estimates of Erdmann and

Dodge (1898) on perceptual span of German readers are shown in Figure 2.1., as seen in Huey (1908).

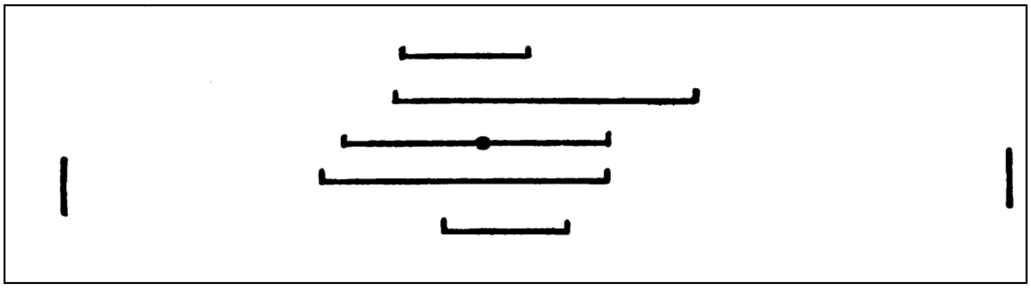

Figure 2.1 Perceptual span found in Erdmann and Dodge (1898) for German readers. Vertical lines on the left and right indicate the size of the paper. Horizontal lines indicate the size of the area that is reported to be perceived by the readers (Huey, 1908, p. 52)

Huey (1908) conducted an experiment in which a flow of text was shown to readers through a peephole in several sizes. Readers were exposed to stimulus for two seconds before the peephole was covered. The size of the peephole was manipulated, starting from 1.75 cm up to 4 cm. Readers were expected to read the whole text that could be seen through the peephole. He found that it was possible to read the whole text through a 3.7 cm peephole, but a 2.5 cm (16 characters) peephole was the largest window through which the whole text could be read by average readers. Word frequency, used today as a parameter in reading (Rayner & Duffy, 1986; Rayner, 1998; Bicknell & Levy, 2012), had an effect on readers' performance as well.

He conjectured that the readers' perceptual span is:

> *limited, in the amount that can be read during a reading pause, by the inadequacy of the retinal structure, by our inability to attend to more than a few parts of the total picture presented, and by the necessity of our attention's concerning itself with interpretations* (Huey, 1908, p.70).

On the other hand, Huey's (1908) method involved overestimations for the size of perceptual span, especially for the left of fixation (Wade, 2010). Huey reported that perceptual span extends up to 16 characters (24 mm) towards the left of fixation. Huey's methods and devices used to track the eyes were mechanical, and their accuracy was low. More generally, those methods used in the experiments in the first and second eras of eye movement research were weak in providing rigorous results. Accordingly, in this era, observation of eye movements by human eyes did not yield much success. Since eyes make small and jerky movements, in addition to large saccades, it was not possible to detect each movement and record them by appropriate means. Moreover, eye tracking devices put limitations on the subject's natural eye movements in addition to their failure in tracking small eye movements (Wade & Tatler, 2005).

The second era was influenced by the advent of behaviorism in the mid 19^{th} century , resulting in a scarcity of research up to 1970s, as experimental psychology was more favored under the influence of behaviorist theory (Rayner, 1998). Still, various methods of eye tracking were developed, such as the corneal reflection based eye tracker (Buswell, 1935; as cited in Wade & Tatler, 2005) and imaging of blood vessels in the eye (Higgins & Stultz, 1953; as cited in Wade & Tatler, 2005).

The third era starts in the 1970s by the novel methods of data analysis and technological devices to collect data. In this era, two major types of eye tracking devices have been developed.

The first type of eye trackers was electro-oculographic eye trackers that exploit the potential difference between inner and outer surface of retina, and cornea. With this method, it is possible to track eye movements when the eyes are closed. Electro-oculographic devices are useful in clinical research although they are less reliable than reflection- based eye trackers (Wade & Tatler, 2005).

The second type, reflection-based eye trackers, were first used by Dodge and Cline in 1901 (Wade & Tatler, 2005). These eye trackers are based on the ability of the cornea and interior parts of the eye to reflect light. By the advent of computer technology, remote eye trackers became popular. This popularity is also due to the ease of use of such eye trackers by the subjects, without the obligation to keep the head stable. Another genre of eye trackers, which can be worn on the head, can be used in various situations such as driving, flying an aircraft or in infant studies (Wade & Tatler, 2005).

In the third era, the technological revolution led to finer observations of eye movements and allowed researchers to develop paradigms such as *gaze contingent display paradigm*, in which the stimulus is manipulated depending on the fixation location of the subject (Rayner, 1998; McConkie & Rayner, 1975). McConkie and Rayner (1975) pointed out that previous studies heavily depended on tachistoscopic methods, which were not at all natural reading conditions, hence not reliable for studying perceptual span.

We will examine several gaze contingent moving window paradigms in detail in Section 2.4. The method basically includes a window through which a limited part of text is shown to the reader, and the remaining part of the text is hidden from the reader by various types of filters. Rayner (2014) states that this method enabled researchers to set a quantitative measure for the amount of data intake during a fixation.

Eye movement research continued through decades, gathering momentum in the 20th century. Eye tracking methods give useful information about the nature of vision and reading, also contribute to our understanding of cognitive processes during reading and scene viewing. We will look at the cognitive processes carried out during reading in Section 2.2, although it is still early to clearly map an eye movement into a specific cognitive activity, i.e. infer exactly how a cognitive process is represented in dynamics of eye movements (Rayner, 1998).

2.2. Eye movements in reading

2.2.1. Eye movements

Eyes constantly move to extract information from stationary and moving targets. Rayner et al. (2012) define a set of natural eye movements as follows:

Eyes move continuously and relatively slowly when looking at a moving object. This movement is called *pursuit movement.* Micro-oscillations constantly performed by the eyes are called *nystagmus,* whose function is thought of as helping the eyes constantly gather visual intake, while they do not have much effect on reading or visual search. *Microsaccades* and *drifts* are small corrective movements of the eyes due to limitations of the nervous system, which do not have practical importance for the purposes of reading research, either and are often ignored.

2.2.2. Basic eye movements during reading

Eye movements in reading can be divided into two basic classes: a *fixation* is the landing of the eyes on a character for about 200 to 300 milliseconds or longer, while a *saccade* is a fast jumping movement up to 500 deg/sec between two fixations. The eyes can perceive information during fixations, however, during saccades, visual intake is inhibited (Rayner, 1998). *Saccadic suppression* is described as the decrease in the visual intake during a saccade (Rayner). In reading, the eyes collect most of the information during fixations, and do not see clearly during saccades (Wolverton & Zola, 1983; as cited in Rayner, Juhasz, & Pollatsek, 2005; Rayner). As we will see later, this phenomenon allows researchers to use gaze contingent methods (see Section 2.3).

Another type of eye movement performed during reading is *regression* or *regressive fixation*, during which the eyes refixate onto a previously fixated word with a backwards saccade. The direction of regressive fixations is from right to left in left-to-right orthographies such as Turkish, and vice versa. Regressive saccades comprise about 15% of all saccades in reading (Rayner, 1998), and their number increases as the difficulty of the text increases (Just & Carpenter, 1987).

In the present study, we examined the role of word length, word predictability and word frequency on eye movement patterns of readers. Our motivation was to investigate the cognitive processes underlying reading. In the next section, we summarize previous research on cognitive processes in reading.

2.2.3. What kind of cognitive processes occur during reading?

A common framework in information processing theories of cognitive processes is that basically, when the reader fixates a word, she *encodes* the word, i.e. perceives the phonological and orthographic features of the word. She then performs *lexical access,* i.e. reaches the representation of the word in her *mental lexicon.* A mental lexicon is thought to be a dictionary where all words known are situated together with their meanings and relations with other words (Taft & Forster, 1975). In the third phase, the reader semantically relates the word to the context (Just & Carpenter, 1987). Whether these processes take place sequentially or in parallel has been a matter of debate, as well as the subprocesses that form these broad descriptions. Recently, most computational models of reading assume that information processing during reading is a word-level process (Radach & Kennedy, 2013). The patterns of fixations and saccades also suggest word-based processing (Radach & Kennedy, 2004). This is a working assumption, since it is evident that cognitive processes go beyond word-level processes. In the present study, we will follow this working assumption as well, by leaving the study of processes higher than word-level processing to further research.

Experimental studies show that there is a relation between the text and the eye movements of the reader (Rayner, 1998). This phenomenon is called *eye-mind hypothesis* (Just & Carpenter, 1987), or *eye-mind span* (Morris, 1992). This hypothesis suggests that when a reader reads a text, it is possible to observe her ongoing cognitive processes by observing her eye movements. However, as stated before, eye movements do not represent a one-to-one mapping with the ongoing cognitive processes. As we have discussed in Section 1.3 and as Morris (1992) stated, readers can obtain information without directly fixating onto the word, i.e. obtain parafoveal preview benefits. There are *spillover effects* as well; processing of the previously fixated word may continue during the current fixation. This causes longer fixation durations on the current word. Therefore, it is crucial to choose eye movement measures to minimize such confounding effects. The measures we used in our experiment are presented in Section 2.5.

There are two main word-level reading models that attempt to account for reading processes. The E-Z reader model (Reichle, Pollatsek, & Rayner, 2005) presumes a strictly serial attention allocation on words. According to the E-Z reader model, parafoveal information is perceived by a process called the *familiarity check.* During this phase, basic features of the parafoveal word are extracted. As the distance from the fovea (henceforth, *eccentricity*) increases, the accuracy of word identification is reduced. Hence, word identification is assumed to be a function of word length and eccentricity. The SWIFT model (Engbert, Nuthmann, Richter, & Kliegl, 2005), assuming word processing occurs in a parallel fashion, shares many of the principles of E-Z reader such as the influence of word frequency and word length on eye movement behaviour. Similarly, in SWIFT, parafoveal information intake decreases as the eccentricity increases. SWIFT also takes into account the asymmetry in the perceptual span. Both models are able to explain the characteristic of eye movements and parafoveal processing to a successful degree.

In summary, we have described the basic eye movements that the eyes perform during reading, and ongoing cognitive processes during fixations and saccades. Current eye movement models and eye movement research assume reading as a *word-level* process, and reading models are based on this assumption as well. There is ample evidence that eye movements reflect online cognitive processes during reading and other tasks. Hence, studying eye movements is a simple way of observing simultaneous cognitive processes.

Reading processes can be investigated by means of eye movements, which are observable indicators of cognitive activities. *Perceptual span* is one of the constituents that influences reading characteristics. For this reason, we will take a closer look at the concept of perceptual span and introduce its basic properties.

2.3. The Perceptual Span

2.3.1. Basic features of perceptual span

The amount of useful visual information that can be extracted at one fixation is limited. Perceptual span is the visual area from which visual information is perceived in a single fixation. It consists of three regions:

Foveal region, where the visual acuity is highest, constitutes 2° of all visual span. Parafoveal region extends 5° from both sides of fovea, where the visual acuity is low compared to fovea. The third region that constitutes the rest of the visual span is called periphery. The acuity of vision is very low in this region compared to other regions of retina (Rayner, 1998).

The perceptual span can also be divided in three parts depending on the need to move the eyes and move the head to perceive the target: in the first region, there is no need for an eye movement, in the second region, the eye needs an eye movement, in the third, a head movement is needed (Sanders, 1993; as cited in Rayner, 1998). This classification seems compatible with foveal, parafoveal, and peripheral regions, respectively. An example of the amount of text perceived by the eye at one fixation is presented in Figure 2.2.

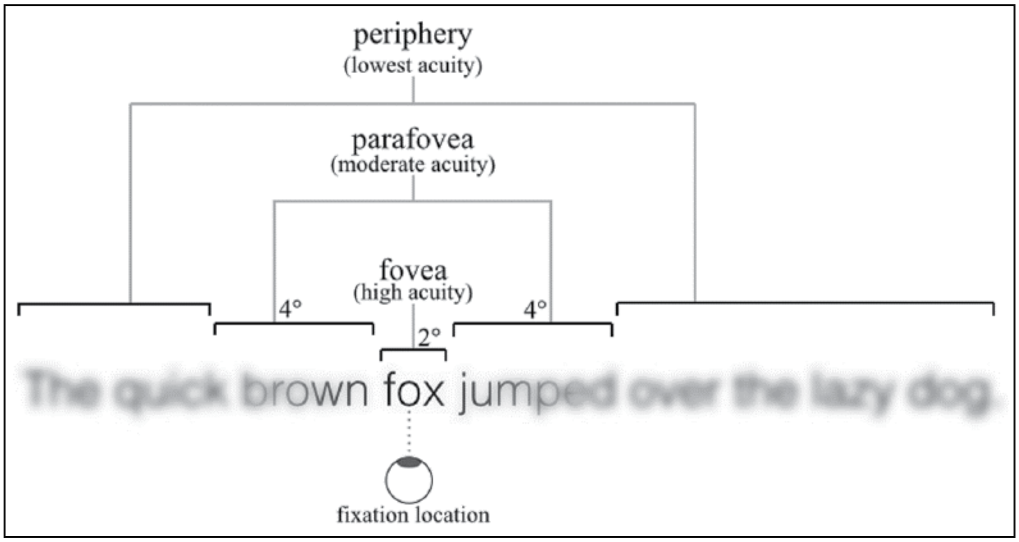

Figure 2.2 Degrees of visual acuity in the fovea, parafovea and periphery. Fixation is on the letter “o” in “fox” (Rayner, Schotter, Masson, Potter, & Treiman, 2016).

This variation in the acuity of different regions in the eye is due to the density of *cone receptors* and *rod receptors* in the retina. Cone receptors are the cells that provide acuity, and colour vision. Rods, on the other hand, are specialized in detecting vision in the dark and movement (Rayner et al., 2012). The distribution of cones and rods in the retina can be seen in Figure 2.3.

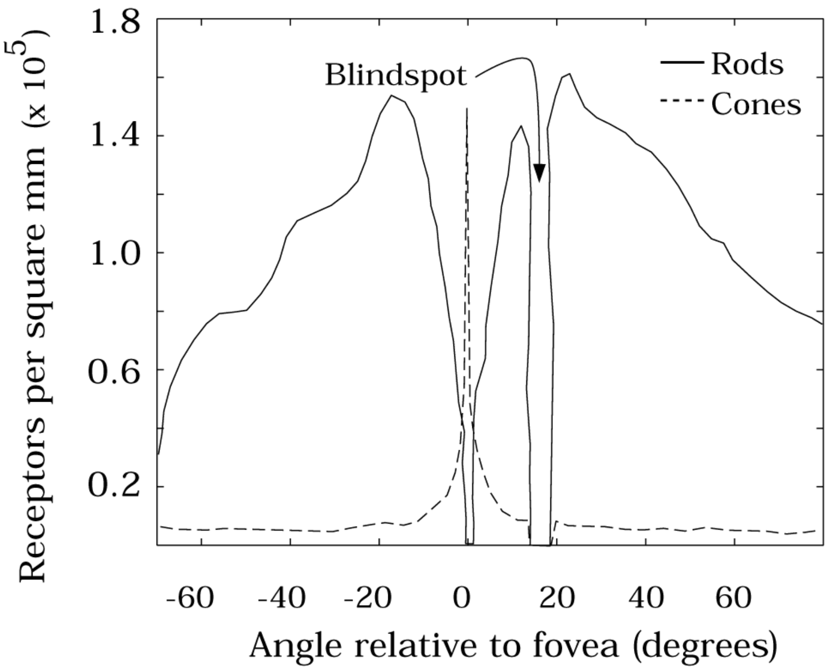

Figure 2.3 The distribution of rod cells and cone cells in retina in visual angles for the left eye. 0° indicates the fovea. As the density of cones increases, visual acuity reaches its peak. The visual acuity is reduced as the eccentricity increases. There are no rods or cones in the blindspot (from Wandell, 1995, p.6).

Although reading process is mainly conducted by the foveal region, where visual acuity is highest, parafoveal region takes part in this process as well. Variation of visual acuity in the perceptual span has an influence on the amount and features of visual information perceived during reading and scene viewing. Hence, it is meaningful to ask how much and what kind of information can be extracted at a single fixation. For this reason, we will take a closer look at the role of perceptual span in reading.

2.3.2. Perceptual span in reading

Reading process can be thought of as bringing the stimulus onto the foveal region. The amount of data that can be perceived at a fixation is limited, as visual acuity drops rapidly outside the fovea. The eyes perceive basic characteristics of letters seen from the parafovea, although this amount of information is not sufficient for identifying the word (Rayner, Well, Pollatsek, & Bertera, 1982; Rayner, 1975b; Just & Carpenter, 1987, Morris, 1992). Still, the existence of parafoveal information helps the reader decide the location of the next fixation (Leung et al., 2014; Rayner et al., 1982).

What kind of information is collected from the parafovea during reading? Rayner et al. (1982) discuss that letter features and first few letters of the next word to the fixation area help the reading process. Also, lexical access, i.e. the retrieval of the word and its basic features from the mental lexicon (Just & Carpenter, 1987), begins with the information collected from parafovea, before directly fixating onto the word (Rayner, 1998). It is under debate whether semantic preprocessing occurs with the intake of parafoveal information (Schotter, Reichle, & Rayner, 2014; Hyönä, 2011; Reichle, 2011).

In a recent study by Schotter (2013; as cited in Schotter, Reichle, & Rayner, 2014) in which the *boundary paradigm* (see Section 2.4) was used to manipulate the parafoveal word, it was observed that semantically similar words (such as *start* and *begin*) produced similar eye movement patterns to the no parafoveal change condition. She thus points out that semantic preview benefit is possible. However, in Altarriba et al.'s study (2001), conducted on bilingual Spanish-English speakers by using the same paradigm, no facilitation effect was observed when the parafoveal words were switched to English from their Spanish counterparts. Other studies on semantic preview benefits in English suggest that semantic preprocessing of words does not occur (Altarriba, Kambe, Pollatsek, & Rayner, 2001; Rayner, 1975b; Rayner, 1998; Rayner, Balota, & Pollatsek, 1986; Hyönä, 2011).

That semantic preprocessing during reading does not occur raises some questions. For instance, how would word skipping be possible without previous semantic information?

Altarriba et al. (2001) explain word skipping benefit by assuming that readers may expect to see a word in the next fixation. If this expectation is met, then the word is skipped. Hence, predictability of the coming word has an effect on word skipping (see also Rayner et al., 2012). In addition, Rayner (1975b) states that spaces between words give more effective cues than letter features and the identification of the letters. Pollatsek et al. (1992) found that switching the actual parafoveal word to a phonologically similar parafoveal word facilitates reading. Therefore, the word does not need to be processed semantically, lexical features of the word would be enough to determine it. Orthographic and phonological information is sufficient for "making a guess" of the next word.

Parafoveal information intake during reading can be explained in two different theoretical approaches. The approach Altarriba et al. (2001) adopted to account for word skipping is similar to Hochberg's (1970) Hypothesis Testing Theory, in which the reader has a prediction for the parafoveal word. If the prediction is in concurrence with the actual information, reading process continues. If not, then reading is disrupted and the reader has to process the new word in order to integrate it into the previous visual information. The other approach, Direct Perception Theory, does not assume a prediction-then-comparison process. The reader only tests whether the new information is relevant to the previous data. In both theories, parafoveal information intake has crucial importance for reading process (Rayner, 1975b).

In summary, the features of information extracted from the parafovea are under debate. There are divergent results on whether semantic information is extracted from the parafovea or not. Nevertheless, we know since Huey (1908) that parafoveal information intake has a significant influence on reading. Understanding the relationship between different languages and characteristics of parafovea has the potential to contribute to our knowledge on the nature of parafoveal information intake. For this aim, the present study focuses on Turkish reading. In the next section, we will review the studies conducted on eye movements in different languages, and the variation in the size of perceptual span of the readers of those languages.

2.3.3. The size of perceptual span in reading

Gaze contingent moving paradigm is a useful tool in determining the shape and size of perceptual span of readers (McConkie &Rayner, 1975). Most generally used methods of research on perceptual span are described in Section 2.4. Perceptual span for English readers is around 14-15 characters to the right of fixation (Rayner, 1975). McConkie & Rayner (1976) reported that perceptual span is asymmetric to the right of fixation for English readers: the left boundary of the perceptual span is 3-4 characters long. However, this asymmetry is due to the direction of the writing system. The perceptual span is asymmetric in Hebrew in the reverse direction, as Hebrew is read from right to left. Hebrew readers can also switch the direction of their perceptual span when reading in English (Pollatsek, Bolozky, Well, & Rayner, 1981).

The average size and shape of perceptual span is shown in Figure 2.4.

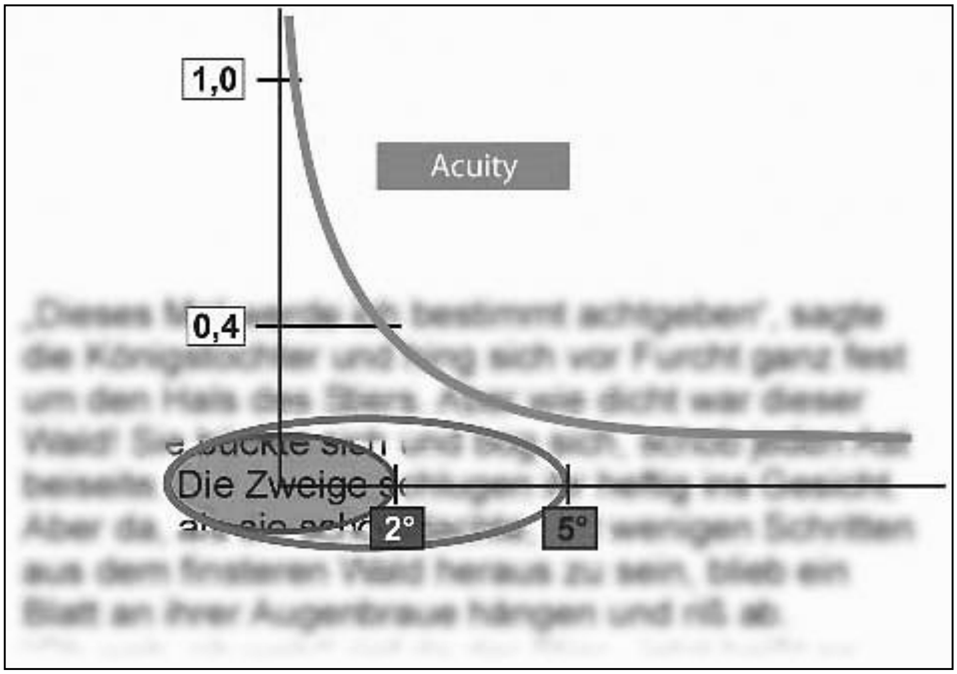

Figure 2.4 The perceptual span. Acuity is highest in 2° around the fixation. Perceptual span extends 5° to the right in left-to-right orthographies (Trauzettel-Klosinski, 2007, p. 303).

The perceptual span is determined when reading rate, i.e. the ratio of the number of words read to the total reading time (in words per minute), in two different window sizes is roughly equivalent. Reading rate is used as the main measure to infer the size of the perceptual span (Leung et al., 2014). However, there are some doubts on the reliability of this measure. Häikiö et al. (2009) state that reading rate may "obscure" particular aspects of other parameters, such as fixation duration and saccade length. We have examined various aspects of eye movement behaviours in addition to reading rate and reading speed, regarding this concern.

Studies on Dutch (Den Buurman, Roersema, and Gerrissen, 1981), French (O'Regan, 1980), and Finnish (Häikiö et al., 2009) reported similar results to English. Den Buurman et al. estimated a window size between 12-16 characters to the right. They used reading time per 100 characters, median of forward saccade length, median of fixation durations and percentage fixation time as dependent variables.

Although Finnish and Turkish have their own characteristic features and should be studied separately, the two languages bear similarities as well. Finnish has a shallow orthography and is an agglutinative language similar to Turkish. For this reason, studies on Finnish are of particular importance for both understanding of reading in Turkish, and in other languages. Hyönä, Laine, and Niemi (1995) reported an influence of morphological differences in eye movement behaviour. Readers spent more time on inflected words compared to root words or derived words. This implies that the processing of the word continues after lexical access for inflected words. In addition, having shallow orthography may have a facilitative effect on reading, increasing the size of perceptual span for readers of Finnish (Häikiö et al., 2009).

However, studies on different writing systems such as Japanese and Chinese give different results. Ikeda and Saida (1978) found a perceptual span of around 10 characters for Japanese. Inhoff and Liu (1998) found a smaller size of perceptual span for Chinese, which extends 1 character to the left and 3 characters to the right of fixation.

Yet, readers obtain similar amount of information at each fixation, regardless of the size of their perceptual span if the measure is taken as the number of words instead of characters (Rayner, 2014).

As of our knowledge, no study has been conducted so far on characteristics of peripheral information intake and perceptual span in adult Turkish reading. The present study aims at contributing to the literature on the role of perceptual span in reading by conducting experimental studies with Turkish-reading participants.

2.3.5. Factors that influence perceptual span

2.3.5.1. Writing system

The size of the perceptual span depends on the orthography and characteristics of the language. As described above, perceptual span in Japanese reading is slightly narrower than that of English reading. Chinese reading has a much smaller span compared to Japanese and English readers.

These differences in perceptual span can partly be explained by the difference in the writing systems of these languages. English has an *alphabetic* writing system, in which phonemes are represented by letters. In the *syllabic* writing system of Japanese, each character represents a syllable. For example, two different syllables “ta” and “te” are written as two different characters. Japanese also uses *logographic* characters, in which each character represents a meaningful unit called *kanji*. For example, “to play” is represented by one character. In this system, sounds and characters are independent of each other. Chinese has a totally logographic writing system (Just & Carpenter, 1987).

It has been suggested that the number of strokes in Chinese characters be thought as a parallel measure to word length in English. It has been found that Chinese readers fixate longer on characters with more strokes. Therefore, this seems like a plausible assumption. Also, a comparison of fixation durations of Chinese and English readers suggests that the lexical access mechanisms of both groups work similarly for frequent and infrequent words. Chinese readers, similar to English readers, spend more time on infrequent words (Just & Carpenter, 1987). Therefore, it can be speculated that the considerable difference between perceptual spans of two groups is mostly due to the difference between their orthographic systems.

As we have mentioned in Section 2.3, the direction of the writing system has an influence on the asymmetry of the perceptual span. Pollatsek, Raney, LaGasse and Rayner (1993) reported a negligible amount of visual information intake from lines below fixation in horizontal reading. Osaka and Oda (1991; cited in Rayner, 1998) found that Japanese readers employ 5- 6 characters of perceptual span on vertical texts, which is a similar value to the perceptual span in horizontal Japanese reading (Pollatsek et al., 1993). Israeli readers have asymmetry in the opposite direction of English readers (Pollatsek et al., 1981).

The writing system of Turkish is based on the Roman alphabet, hence, it is similar to English orthography. The similarity between the Turkish orthographic system and other orthographic systems may result in similar characteristics of reading. On the other hand, the agglutinative structure of the Turkish language may lead to language-specific reading strategies.

2.3.5.2. Visual attention

Henderson (1992) defines visual attention as "the selective use of information from one region of the visual field at the expense of other regions of the visual field" (p. 260). This definition suggests that the visual field sets priority on visual information to be perceived. Hence, visual attention influences the size of perceptual span (Pollatsek et al., 1993; as cited in Rayner, 2014). The influence of visual attention on perceptual span is empirically observed by Henderson and Ferreira (1990). They found that perceptual span decreases with increasing text difficulty. Rayner (1986) explains this phenomenon by the *foveal load hypothesis*. According to this hypothesis, when the lexical or syntactic complexity of the text increases, the reader allocates more attentional resources to the fovea, resulting in a decrease in parafoveal information intake, hence a smaller perceptual span.

Visual attention also has an effect on the shape of perceptual span, together with its size. Henderson (1992) explains the asymmetry of perceptual span by visual attention as well. For example, in English, the information on the left of fixation is not as crucial as the information on the right, since the left of fixation is already read and processed. Visual attention is directed to the new visual information, hence perceptual span is larger towards the right of fixation. This results in an asymmetry of 3-4 characters to the left of fixation and 15 characters to the right of fixation (McConkie & Rayner, 1976).

However, it is worth asking whether the decrease in the parafoveal information intake is a result of attentional factors or simply reduced visual acuity in the parafovea. To investigate this question, Miellet, O'Donnell and Sereno (2009) introduced *parafoveal magnification paradigm*, in which parafoveal characters were magnified to compensate for the decrease in the visual acuity while the fixated letters were of normal size. They found that magnified characters were still not perceived by the readers, suggesting that perceptual span depends more on attentional constraints than visual acuity. Hence, Henderson's (1992) suggestion of calling perceptual span "attentional span" seems plausible.

2.3.5.3. Reading ability (Reading skill)

It is a known fact that reading skill improves by training (Rayner, 1986). Beginning readers show characteristics of adult readers, but their processing is slower. This difference is due to several reasons: Beginning readers' speed of lexical access is lower than adults. Their familiarity of letters and words is less than adult readers as well (Just & Carpenter, 1987). Additionally, their eye movement patterns are different from skilled readers. Häikiö et al. (2009) state that automaticity of word identification has not been developed in beginning readers, also, they process words in a serial fashion.

These differences between beginning and skilled readers are apparent when their eye movement patterns are observed. Beginning readers perform longer fixation durations, their saccade length is shorter and the number of regressions is higher than adults (Rayner et al., 2012). These factors affect the perceptual span of beginning and developing readers.

Rayner (1986) investigated the perceptual span of students between the ages 8-14. He found that perceptual span is 11 characters to the right for beginning readers, which is more or less smaller than the perceptual span of adult readers, which is around 15 characters. Hence, perceptual span of less skilled readers is smaller (Rayner, 1986; Rayner et al., 2012; Häikiö et al, 2009).

Similar to adult readers, perceptual span of children in reading was found to be asymmetric to the right even after one year of reading practice (Rayner, 1998; Rayner et al., 2012). However, this changes as the age of the reader increases. Perceptual span of older readers becomes more symmetrical compared to younger readers. Their reading rate slightly decreases as well, compared to adult readers (Rayner, Castelhano, & Yang, 2009; as cited in Rayner, 2014).

2.3.5.4. Reading mode

Despite the considerable and still growing literature on silent reading, little research is conducted on oral reading compared to silent reading. Initial studies on oral reading were conducted by Buswell (1922) on developing readers.

Reading aloud shows similarity to silent reading, as the same eye movement parameters, e.g. first fixation duration, regression counts, total dwell time are used in investigation of both reading modes. However, there is another mechanism that is activated during oral reading. The activation of vocal system takes relatively longer time than cognitive activities (Ashby et al., 2012). Since activation of muscles is a slower process, it results in a slower reading rate than that of silent reading, and the eyes go ahead of the voice while reading aloud. The distance between the current fixation and voice in letter characters is called the *eye-voice span*.

Buswell (1922) examined the eye-voice span of children throughout grades. He found that good readers had a larger eye-voice span compared to poor readers. He also found a positive correlation between eye-voice span and reading rate. Vorstius et al. (2013) reported similar findings on children. Ashby et al. (2012) observed whether manipulation of parafoveal information would have an effect on eye movement patterns in oral reading in English by skilled adult readers. They reported that the size of the window has an influence on both silent and oral reading, but parafoveal constraints disrupt silent reading more. That eye movements are less influenced by window conditions in oral reading compared to silent reading may be the result of constrained eye movement patterns during oral reading (Ashby et al.). In the present experiment, we observe whether oral reading has a similar role in eye movement patterns, and at which rate constrained parafoveal information has a disruptive effect on oral reading.

2.3.6. Summary

Perceptual span is the region of perception of useful information. How much and what kind of information is collected from the parafovea is still under debate. However, gaze contingent studies are helpful in discovering many aspects of parafoveal word intake. It seems that readers can get some visual information from the parafovea, but its amount is not sufficient to determine the word completely. What is perceived from the parafovea is basic characteristics of words, like its length, and a few letters of the word. There is evidence that semantic preprocessing of parafoveal information does not occur, although there are studies that prove otherwise. Readers can skip some words, i.e. may not perform a fixation on some words and still read them, and this is still possible without semantic preprocessing. Phonological coding of the word or predictability of the word are two main factors that cause word skipping.

The size and direction of perceptual span depend on many factors together with natural limitations of eyes, including orthography, text characteristics and reading skill. Different orthographies such as Japanese and Chinese result in smaller perceptual span, as each character represents more information than alphabetic systems. Readers make longer fixations and more regressions on difficult texts. Reading skill is another important factor that determines the size of perceptual span, as younger and older readers have smaller spans than adult readers.

On the other hand, font size does not have a significant effect on the perceptual span (Rayner, Slattery, & Bélanger, 2010). Similarly, slight changes in viewing distance does not have an influence on eye movements (Morrison, 2012). We eliminated any possible effect of font size and viewing distance by keeping both variables constant for all participants.

As perceptual span is not a directly observable entity, various methods have been developed to draw inferences on the features of the readers' perceptual span. Most generally used methods for investigation of perceptual span are described in the next section.

2.4. Basic methods for measuring perceptual span

As we described in Section 2.1, earlier research on perceptual span depended on mechanical experiments such as tachistoscopic methods. However, due to the limitations and inconsistent results obtained by those methods, various approaches have been adapted. Poulton (1962; as cited in Rayner, 1975b) used a mechanical window that limited the amount of information to be seen by the reader. He changed the size and speed of the window to measure the perceptual span. Although this method inhibited natural eye movements, it was found that it was difficult to read through smaller windows.

McConkie & Rayner (1975) developed a technique, called *gaze contingent moving paradigm,* in which the reader can only see a limited amount of information on the computer screen. As the reader fixates on a character, the location she fixates and a pre-determined area around the fixation point become visible. The rest of the text is masked. In the next fixation, previously visible area is masked again and a new window is created around the new fixation point. By varying the size of the window, it is possible to control the amount of information presented to the subject and observe the limitations of perceptual span (Rayner, 1992). It is also possible to determine the features of the information collected from parafovea by manipulating masking conditions. For example, the whole text outside of the window can be replaced by Xs, including or not including word spaces. Another modification on the text would be replacing it by letters. The letters can be visually similar to the original letters (e.g. *e* can be replaced by *c*) or different. Some examples of text as seen in gaze contingent moving paradigm are shown in Figure 2.5.

Text	The vicar drew back a little further, the tranter
XS	xxx xxxxx xrew back a lixxxx xxxxxxxx xxx xxxxxxx
XF	xxxxxxxxxxxxrew back a lixxxxxxxxxxxxxxxxxxxxxxxxx
VS	Yko uloen brew back a liffio tvnfkon, fko fnorfon
VF	Ykowuloenkbrew back a liffiottvnfkongifkobfnorfon
DS	Leh eorhn lrew back a linyrk cbherka, nqh lerkiut
DF	Lehheorhnylrew back a linyrkocbherkaesnqhtlerkiut

Figure 2.5 Examples of gaze contingent paradigms. Fixation is on the underlined **b** in each case. XS, Xs with spaces preserved; XF, Xs with spaces filled; VS, similar letters with spaces preserved; VF, similar letters with spaces filled; DS, dissimilar letters with spaces preserved; DF, dissimilar letters with spaces filled. Adapted from Rayner et al. (2012).

We employed gaze contingent moving paradigm in the present study. We used the XS case shown in Figure 2.5 for our stimulus set, i.e. the text outside the window was masked by Xs with spaces filled.

In the *moving mask paradigm* (Rayner & Bertera, 1979) foveal information is masked and reading depends only on parafoveal information. This method is the reverse of the gaze contingent moving window paradigm. Rayner and Bertera found that masking the fovea has a more serious effect on reading than masking the parafovea, as reading rates of participants dropped from 332 wpm to 42 wpm with increasing mask sizes. Participants also had difficulty identifying the words they could see, and misidentified many words. The method confirmed that readers can only see the initial and last words of the word, and try to guess a suitable word to the context based on limited information they could collect.

A widely used method in the investigation of perceptual span is developed by Rayner (1975). This method is called the *boundary paradigm*. In this method, a target word in the critical word location is manipulated, e.g. replaced by a visually similar or randomly created word, or some letters in the word are altered. When a saccade of the reader passes a certain *invisible boundary*, the word at the critical word location is replaced by the original word (Rayner & Pollatsek, 1987). By changing the distance between the boundary and the critical word location, the maximum distance where information can be picked up can be determined. An example of the boundary paradigm can be seen in Figure 2.6. The method is applied based on the assumption that any display change detected by the reader will disrupt her reading, and this will cause the reader to spend more time, i.e. perform longer fixations on the word.

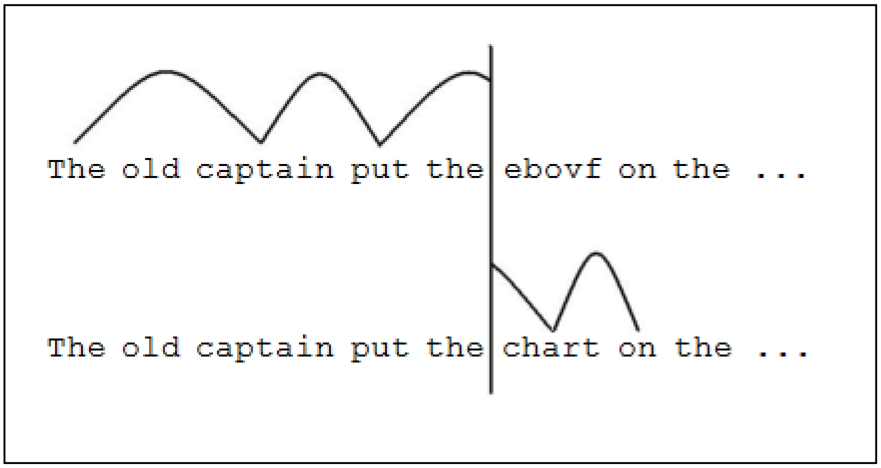

Figure 2.6 Boundary paradigm. As the fixation of the reader (denoted with the curved line) passes the boundary (the vertical line), the non-word changes into the original word (from Rayner & Pollatsek, 1989; retrieved from Larson, 2004).

Another recent method used is *parafoveal magnification paradigm* (Miellet, O'Donnell, Sereno, 2009). This method was used to investigate whether parafoveal information depends on acuity factors or attention. Therefore, characters outside of the fixation region are magnified to balance the reduction in the visual acuity. This method revealed that parafoveal constrains are due to attention factors, rather than acuity factors.

Rayner (1975b) states that there may be some limitations in gaze contingent methods. One of them is the detection of display changes by the reader would disrupt natural reading. However, these methods are used based on the assumption that display changes on the screen would not be perceived by the reader as they occur during saccades (Haber & Hershenson, 1973; as cited in Rayner, 1975b). Another possible limitation reported by Rayner (1975b) is that smaller windows may alter the attentional resources a reader usually spends on a piece of text. Therefore, normal reading pattern would not be observed. This concern should not be taken as a serious one, as it is known that reading gets slower with smaller windows (Rayner & Bertera., 1979). Hence, it is expected that reading will be disrupted in smaller windows.

The perceptual span is determined when reading rate, i.e. the ratio of words to the total reading time (in words per minute), in a window size is roughly equivalent to reading rate in no-window condition. Reading rate is used as the chief measure to infer the size of the perceptual span (Leung et al., 2014).

The methods described above are used to estimate a *maximum* value for perceptual span (Well, 1983; as cited in Rayner & Pollatsek, 1987), since there are many factors that affect the size of perceptual span, as previously discussed in Section 2.3.

In this section, we have described basic methods used in investigation and measurement of perceptual span. We will employ gaze contingent moving paradigm in the present study. The use of other paradigms described in collaboration with gaze contingent moving paradigm may lead to a deeper understanding of the characteristics of perceptual span. Nevertheless, all paradigms described above employ the same eye movement parameters. In the next section, we will review a set of most generally used eye movement parameters in reading research and in gaze contingent paradigms.

2.5. Eye movement parameters used in research

The observation of eye movements requires precise measures to be able to infer relevant information. In this section, we introduce basic parameters that are indicators of some ongoing cognitive activities, hence widely used in eye tracking research. Of course, the parameters are chosen depending on the level and method of the study.

Definitions of commonly used parameters are listed in Table 2.1.

Table 2.1 Definitions of widely used eye movements and their levels (Adapted from Inhoff & Kennedy, 2004; Hyönä, Lorch Jr., & Rinck, 2003; EyeLink Data Viewer User's Manual, 2007).

Parameter	Timing	Definition
First fixation duration	Immediate	Duration of the first fixation within a word, irrespective of whether more fixations follow
Gaze duration/first run dwell time	Immediate	Summed duration of all fixations before leaving the word (within the current pass)
Total dwell time	Immediate/Delayed	Summed duration of all fixations made on the word
Saccade amplitude	Immediate	Distance, in character positions, between the mean position of two successive fixations
Regression-in count	Delayed	Number of times the word was returned from a later word (from the right in English and Turkish)
Regression-out count	Delayed	Number of times the word was exited to an earlier word (to the left in English and Turkish)
Launch site	Immediate	Distance in characters between the location of the prior fixation and the beginning (or center) of the current word
First run fixation count	Delayed	Number of all fixations on a text performed in the first run
Reading rate	Delayed	Number of words read divided by the time it took to read the text

In our study, we have used parameters reading rate, first fixation duration, first run dwell time (gaze duration), first run fixation count, regression-in count, regression-out count and total dwell time, which are most relevant to our research question. We will now describe the parameters we employed in our experiment, together with other important parameters.

First fixation duration and first run dwell time are the most commonly used temporal parameters of eye movement research (Rayner, 1998). For an example of first fixation duration and first run dwell time, see Figure 2.7.

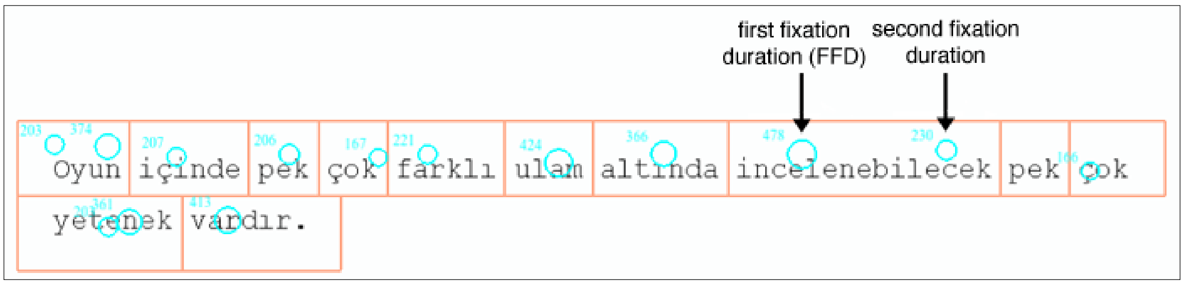

Figure 2.7 Example of first fixation duration and first run dwell time. The word “incelenebilecek” is fixated twice. First fixation duration is the duration of initial fixation (the fixation on the left) on the word. First run dwell time (gaze duration) is the sum of first and second fixation durations within the word, in the first pass. Total dwell time is the sum of all fixations on the text.

Radach and Kennedy (2013) state that first fixation duration signifies orthographic and prelexical recognition. Rayner (1998) purports first fixation duration and first run dwell time to be similar, however, Radach and Kennedy suggest that first run dwell time is an indicator of higher level processes. Inhoff (1984) states that first fixation duration is related to lexical access, and first run dwell time reflects later processing, as they are the sum of all first pass fixations on a word. First fixation duration and first run dwell time yield the same result when the word is fixated only once (Hyönä et al., 2003). However, frequency and length of the word influence first run dwell time (Liversedge & Findlay, 2000) Therefore, first run dwell time is a more appropriate measure for investigation on longer words. Total dwell time is a different measure from first run dwell time in that it indicates all fixations on a word, including refixations. It is a measure of both lexical and semantic features (Anisimov, Fedorova, & Latanov, 2013).

Regressions on a text give important cues about at which points the reader had processing difficulties (Liversedge, Paterson, & Pickering, 1998). Therefore, regression counts may be essential parameters for measuring delayed effects of the text on eye movements, such as semantic control on the word (Carpenter & Just, 1978). For this aim, we included regression-in count and regression-out count in our analyses. Similarly, the number of fixation counts reflects such difficulties that the reader deals with. First run fixation count, on the other hand, is a measure that reflects early processing of the word (Henderson & Ferreira, 1993).

Reading rate is a measure reflecting more delayed effects of the texts, compared to the other measures we used in the data analysis. Reading rate is calculated by dividing the number of words read by the time it took to read the words. It crudely gives a measure of the reading speed of the reader, as the number of words per minute. Reading rate is used as the main parameter to estimate the size of perceptual span, as it tends to decrease as the window size narrows. When the reader's reading rate in a window size does not show much difference than her reading rate with no window, the perceptual span can be estimated to be that window size (Choi, Lowder, Ferreira, & Henderson, 2015).

Additionally, forward saccade amplitude (saccade length) is another measure used in investigation of the perceptual span. It reflects immediate effects of the text on fixations. *Visual span control hypothesis* states that eye movements are a function of the visual constraints (Näsänen, Ojanpää, & Kojo, 2001). Compatible with the visual span control hypothesis, saccade length decreases as windows become smaller, i.e. as visibility constraints are employed on the text (Osaka, 1992; McConkie & Rayner, 1976; Jacobs, 1986).

In this section, we have given definitions of most commonly used eye movement measures and described the ones we used in our analysis. It is difficult to find an ideal measure that reflects all cognitive processes, so it is reasonable to use more than one measure for analysis (Rayner, 1998). This is the strategy we adopted in our study. However, first fixation duration and gaze duration are the major sources of information for prelexical and lexical processes, respectively. Regression-in count and regressive-out count are measures of later processing, while first run fixation count is a measure of early word processing. Reading rate is a rather crude measure of how much the reader is able to read in one minute. It is mainly used as the measure of perceptual span.

In the next chapter, we are going to introduce our method of experiment and present our findings.

CHAPTER 3

3. METHODOLOGY

3.1. Method

3.1.1. Participants

Forty - eight university students aged 18 to 26 (22 females, 26 males, mean age = 21.93, SD = 1.73) participated in the experiment for monetary compensation. All were native speakers and readers of Turkish. The experiment lasted 30-40 minutes. Participants had normal or corrected-to-normal vision, or could read the screen without the aid of corrective glasses or lenses. They were administered a demographic questionnaire after the experiment, followed by completion of Corsi Block and Digit Span memory tests. All participants were naïve regarding the purpose of the experiment.

3.1.2. Materials

The experiment consisted of an oral block and a silent block. Participants read one warm-up paragraph taken from the novel "Çalıkuşu" by Reşat Nuri Güntekin at the beginning of each block and answered a true/false question after both warm-up paragraphs. The warm-up paragraphs were unmasked. The experiment consisted of twelve paragraphs excerpted from various novels: "Şehir Rehberi" by Barış Bıçakçı, "Olağan İşler" by Reşat Nuri Güntekin, "Bir Dinozorun Anıları" by Mîna Urgan, "Sinekli Bakkal" by Halide Edip Adıvar and "Çocukluk Günlerim" by Hüseyin Rahmi Gürpınar.
The paragraphs had a mean log frequency of 3.994 (SD = 1.277) and mean word length of 6.570 (SD = 2.685). The average sentence length was 11. 25 words. The stimulus paragraphs consisted of 5, 6 or 7 lines. The number of words in each paragraph ranged from 40 to 53, and the number of characters (with spaces) in each paragraph ranged from 302 to 381 words.
In the *window* (i.e. *masking*) conditions, each character outside the window was replaced with Xs, including space characters. The paragraphs were shown in six different conditions: no-window, 23, 19, 15, 11 and 7 characters to the right of the fixation. The total size of a window was obtained by adding up one character for the fixated letter and

four characters to the left of fixation. Hence, the total window size for each window condition was 28, 24, 20, 16 and 12 characters, respectively. The number of characters to the left of fixation was 4 characters in all conditions and only the right of the fixation varied in size. A sample stimulus for six cases is shown in Figure 3.1.

```
El öpmeye giden çocukların gözleri, kendilerine para verecek olan

büyüklerin ellerindedir. Oturdukları yerde oturamazlar. Şu parayı

bir alsalar da savuşup gitseler. Büyükler de bunu bildiklerinden,

çoğu, daha kapıyı açar açmaz, kapı önünde elini öpen çocuğun eline

parayı tutuşturur. Parayı kapan çocuk fırlar gider, bir tenha yere

varıp avucundaki parayı sayar, meraktan kurtulur.



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Figure 3.1 Sample stimulus for different window conditions. The first paragraph shows the full paragraph condition. In the following paragraphs, window sizes are 23 and 19 characters, respectively. Fixation is on the letter “u” above the asterisk. The window is 4 characters to the left in each case.

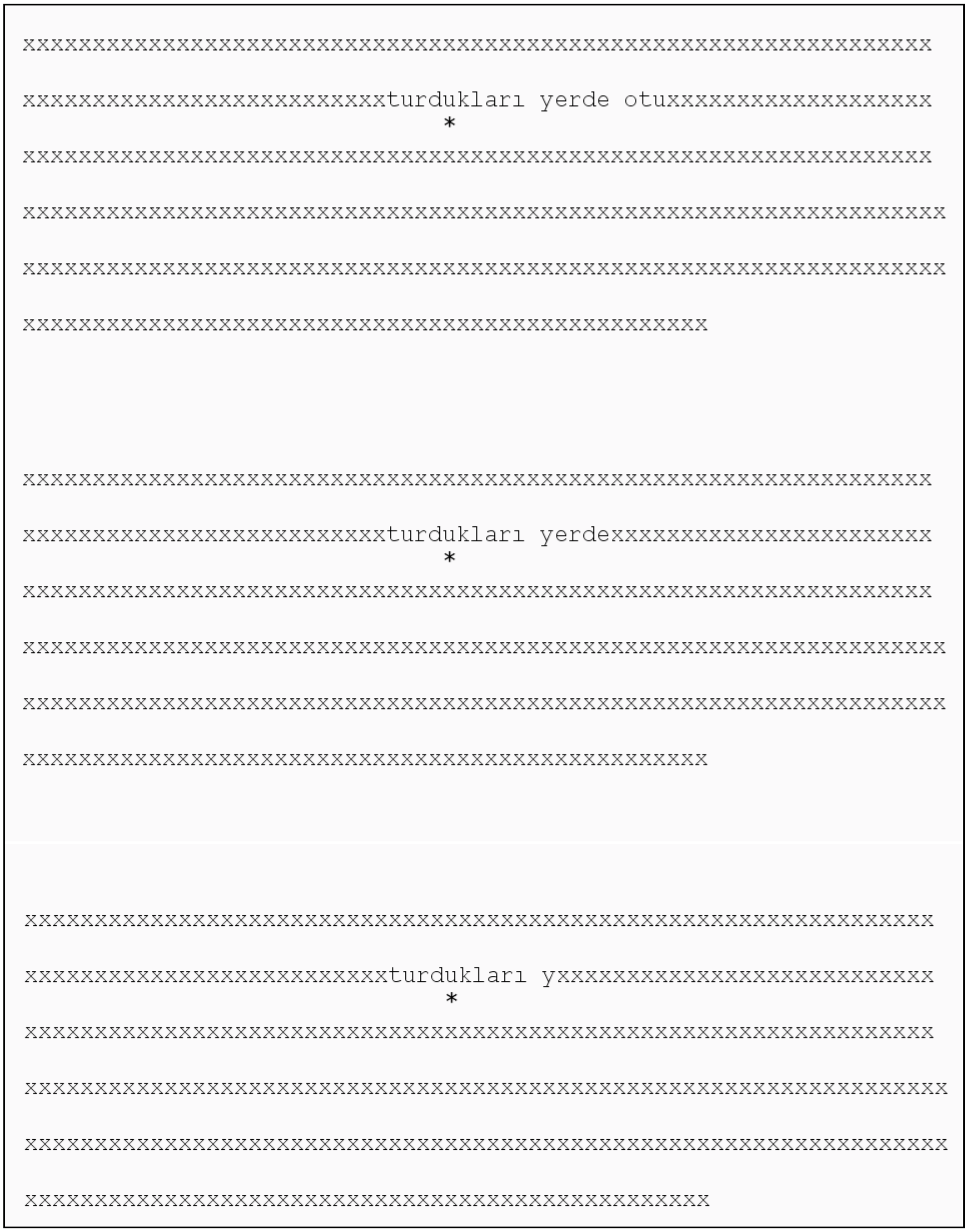

Figure 3.1 (continued) Window sizes are 15, 11 and 7 characters, respectively. Fixation is on the letter “u” above the asterisk. The window is 4 characters wide to the left in each case.

3.1.3. Apparatus

Eye movements were recorded using a tower-mount EyeLink 1000 eye tracking system with a reported sampling rate of 1000-Hz. The participants put their foreheads on a bite bar to stabilize their heads and were told not to move their heads after the calibration process. Viewing was binocular, but only the right eye was monitored. Eye movements were calibrated with a 9-point-grid at the beginning of the experiment. The setup of the eye tracker is shown in Figures 3.2 and 3.3.

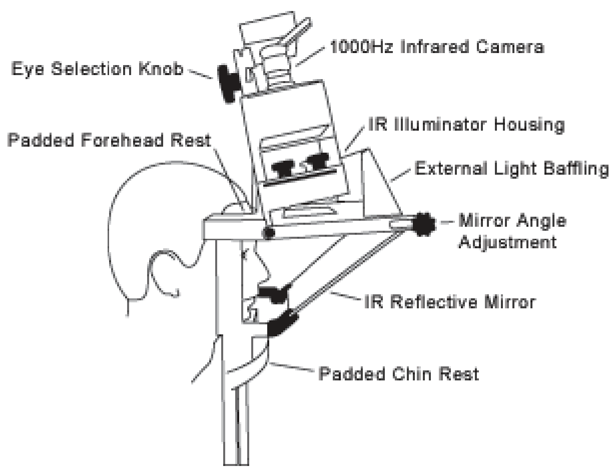

Figure 3.2 EyeLink 1000 Tower Mount setup (from http://www.sr-research.com/mount_tower.html)

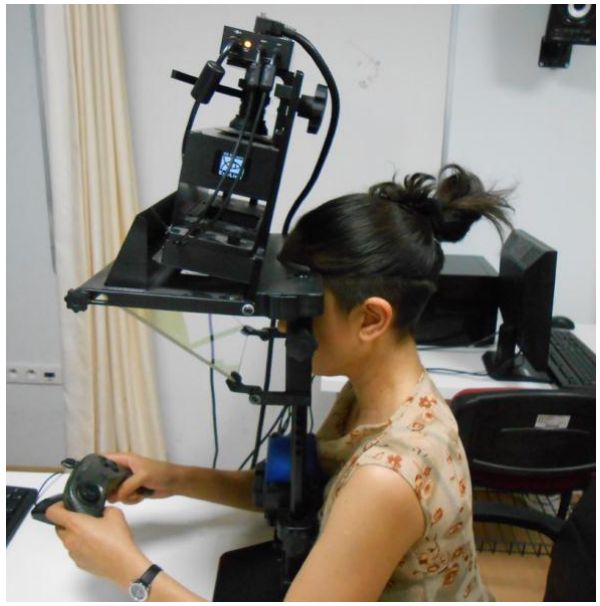

Figure 3.3 Position of a participant on the eye tracker

Paragraphs were displayed on a 24 in. monitor with a refresh rate of 60 Hz, 1024x768 pixel(s) screen resolution, and 16:9 screen scale ratio. The experiment was conducted on a computer with Windows 7 SP1 64-bit operating system.

Participants were seated approximately 70 cm away from the monitor. Paragraphs were presented in 18-pt. black Courier New, a monospace font, on white background. Each character extended 14.03 pixels to the right. 1 degree of visual angle was subtended by 1.27 characters. Double spacing was used between the lines. The stimulus paragraphs and the experiment were designed on Experiment Builder software, Version 1. 10. 1630 distributed by SR–Research. Participants answered true/false comprehension questions by using an EyeLink Button Box gamepad. For oral data collection, a uni-directional Carol Dynamic Microphone Mud-525 and an ASUS Xonar DGX Audio Device audio-card were used.

3.1.4. Procedure

Participants were informed about the procedure by an introductory screen and orally by the experimenters. They were also informed that they would see some modifications on the texts and instructed to read the texts as naturally as possible. Following the instructions, a 9-point grid calibration was run. The calibration was followed by a practice session, which involved reading a paragraph and answering a true/false question. At the beginning of each block, a different practice paragraph was presented. After the practice, the trial started. The design of the experiment is shown in Figure 3.4.

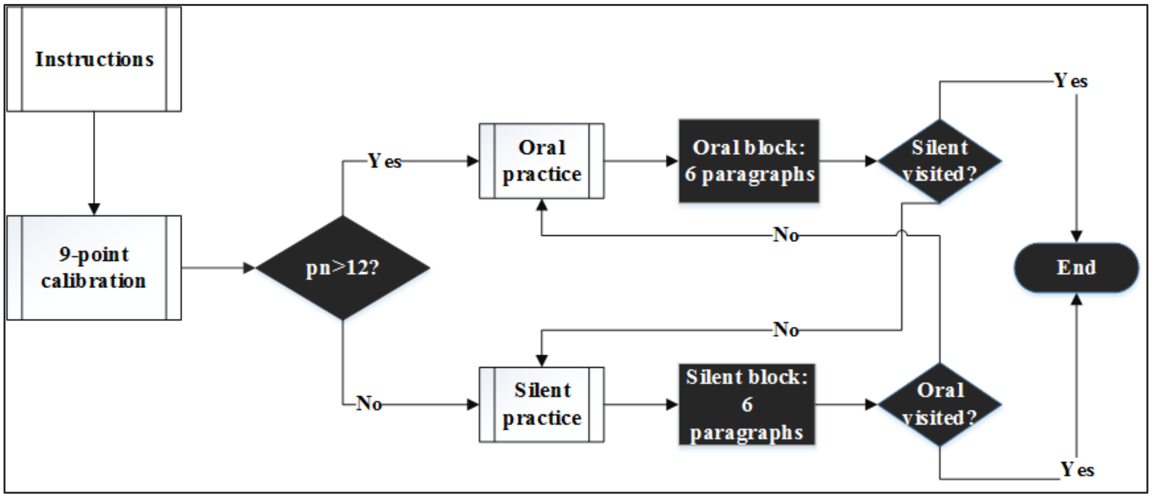

Figure 3.4 Experiment design diagram. (pn: participant number). The modality change at the 12th participant is due to the counterbalance (see Appendix A).

Each trial paragraph, including the practice-session paragraph, was triggered by a stable fixation of the participant on a circle appearing on the left of the screen. Similarly, to move on to the next screen, a stable fixation on a circle on the bottom right of the screen was needed.

Each participant read a block of six paragraphs silently and another block of six paragraphs orally. Different conditions were shown to participants counterbalanced (for the counterbalance chart, see Appendix A). The counterbalance was completed after 24 trials. Starting from the 25th participant, the counterbalance was repeated. The participant was presented each window condition in two of the twelve paragraphs, one in the silent block and one in the oral block. Twelve participants were presented the silent block first, and twelve the silent block first.

The stimulus paragraphs were shown to each participant in random order. A true/false comprehension question was presented after five of the paragraphs, which participants answered via a gamepad (with 83% accuracy). The comprehension questions were shown after the 2nd and 4th paragraph in the first block, and 8th, 11th and 12th in the second block. The true/false questions were shown in a pattern whose order could not be guessed by the participants.

The experiment required precise calibration. Therefore, performance of each participant was carefully observed by the experimenters. When the participant could not see the text at where s/he fixated, s/he was told to skip that trial and calibration process was repeated.

When the eye tracker could not detect a stable fixation on the trigger for more than 10 seconds at the beginning of a paragraph, a warning screen appeared and calibration was re-run.

3.1.5. Working memory tests

In order to measure the visual and verbal memory levels of the participants, two different memory tests were applied after the eye tracking session. In the Corsi Block Tapping Test, the participants were first shown square-shaped blocks scattered on the screen. Blocks changed colour consecutively in random order. In the second screen, the participants were asked to repeat the order of the colour change of the blocks by clicking on the squares in the right order. The sequence started with two blocks changing colour and went up to nine squares. The test finished when the participant clicked on the correct sequence or made two consecutive errors (see Figure 3.5).

In the Digit Span test, similar to the Corsi Block Tapping Test, the participants were shown numbers in random order, one at a time. Then they were asked to write down the numbers in the same order they were presented. The experiment finished when each sequence was written correctly, or when two consecutive errors were made.

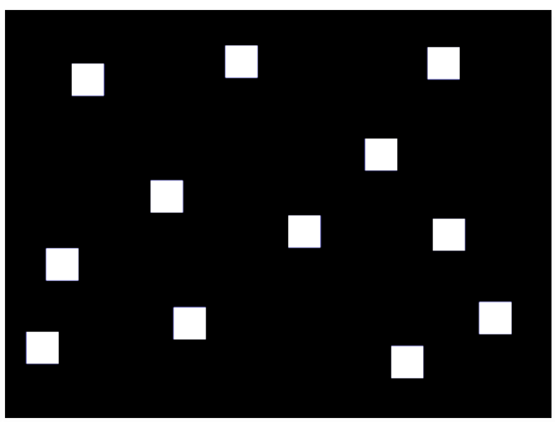

Figure 3.5 The position of the blocks on the screen in the Corsi Block test. Participants click the blocks in the same order as they changed colour.

3.2. Independent variables

Predictability:

As Balota, Pollatsek and Rayner (1985) reported, contextual constraints and predictability have a facilitative effect on parafoveal processing. Ehrlich & Rayner (1981) found that subjects performed shorter fixations on highly predictable words. To examine the predictability of the words used in the experiment, a cloze test (Taylor, 1953) was given to 19 different participants. The experiment consisted of 371 unfinished sentences of various length (see Appendix D). The participants were instructed to write a word that they thought would be the next word of the sentence. No data were recorded for the words left out of the analysis such as the words at the line-ends (see Results chapter for information on data cleansing).

Word length:

The paragraphs used in the experiment contained both short and long words. We did not consider one-letter words in our analysis. We took two to five-letter words as short words, and 6 to 15-letter words as long words.

Frequency:

Frequency values of the words were taken from the BOUN web corpus of about 200 million words (Sak, Güngör, & Saraçlar, 2008). Frequencies were transformed into their log10 values and separated into two classes: *infrequent* and *frequent*. The median of the frequencies (which is equal to 4) was used as a boundary value for classifying the frequencies.

3.3. Dependent variables

First fixation duration, first run dwell time, first run fixation count, regression- in count, regression-out count, and total dwell time were used in the analyses as dependent variables. The significance of these variables for eye tracking research and for our study is described in Chapter 2.

Reading rate:

Rayner (1998) states that perceptual span can be estimated when there is *no difference in reading* in no-window condition and a window condition as the window size is incremented. Then the window can be taken as the perceptual span. In gaze contingent studies, *no difference in reading* is measured by comparing reading rates, a composite parameter of reading duration and number of words. Reading rate is calculated by dividing the number of words by total reading duration in minutes and obtained as a words per minute (wpm) measure. The difference in reading is hence measured as the difference in reading rate.

CHAPTER 4

4. RESULTS

In this chapter, the results of our study are going to be reported. In particular, the following section presents data cleansing. Then our findings on reading rate, first fixation duration, first run dwell time (gaze duration), first run fixation count, regression-in count, regression-out count and total dwell time will follow. The last section reports a summary of the findings.

4.1. Data Cleansing

Data recordings involved invalid data due to calibration issues. Nine trials out of 576 trials were left out of the analysis. This corresponds to 1.5% of the data. Following the methodological practice in the literature, the first and the last word of each line, similarly, the first and the last word of each sentence were excluded from the analysis. The underlying reason is that sentence-initial and sentence-end words exhibit different patterns compared to middle-sentence words. Therefore, they are omitted from the analyses.

The aim of the true/false comprehension questions was to ensure that participants read each text carefully. Therefore, the accuracy rate was not taken into account in analyses. We have analyzed all trials regardless of the answer of the related comprehension question.

4.2. Analysis

Six window conditions were used in the experiment (see Table 4.1). In the full paragraph condition, participants did not see any moving window. In the 23 character window condition, a window 23 characters to the right and four characters to the left was present on each condition. Similarly, 19, 15, 11 and 7 character window conditions indicate the size of the window to the right of fixation.

Table 4.1 Window dimensions. Window sizes (in characters), window width, window height and window offset towards left (all in pixels). FP: full paragraph[1]; 23C: 23 character window; 19C: 19 character window; 15C: 15 character window; 11C: 11 character window; 7C: 7 character window. Offset value denotes the distance from the midpoint of the window so that only four letters can be seen from the left of fixation.

window size	whole window	width	height	offset
FP	-	2000	2000	-
23	28	392,84	60	-140,3
19	24	336,72	60	-112,24
15	20	280,6	60	-84,18
11	16	224,48	60	-56,12
7	12	168,36	60	-28,06

Eye movement data were analyzed by repeated measures factorial ANOVAs. We will first report the reading rate analysis, as it is the main parameter for the perceptual span. The other dependent variables are (1) first fixation duration, (2) first run dwell time, (3) first run fixation count, (4) regression in count, (5) regression out count and (6) total dwell time. We have also examined the effect of word characteristics on the dependent variables. The effects of word length, frequency and predictability were measured for the above parameters by three separate repeated measures ANOVAs.

1. Six (window size: full paragraph, 23, 19, 15, 11 or 7 characters) x two (word length: short or long),
2. Six (window size: full paragraph, 23, 19, 15, 11 or 7 characters) x two (frequency: infrequent or frequent),
3. Six (window size: full paragraph, 23, 19, 15, 11 or 7 characters) x two (predictability: unpredictable or predictable)

The window conditions, word length, word frequency and word predictability were taken as within subject measures.

[1] The full paragraph condition was obtained by making the window size large enough so that participants would not see any gaze contingent effects.

First fixation duration, first run dwell time and reading rate in six conditions were compared in oral and silent reading by three repeated measures factorial ANOVAs.

- Six (window size: full paragraph, 23, 19, 15, 11 or 7 characters) x two (modality: silent or oral)

Window conditions and modality were taken as within subject measures.

As working memory may have an influence on perceptual span, the relationship between visual and verbal memory, and reading rate was checked by correlation.

Main effects were corrected using a Bonferroni correction. We used an alpha level of .05 for all tests.

4.3. Analyses on silent reading

4.3.1. Reading rate

We examined whether there was an effect of window size on reading rate. The means for reading rate for six different window sizes is presented in Table 3.2.

Table 4.2 Means and standard deviations of reading rate in the window conditions. FP, full paragraph; C; characters to the right of fixation; standard deviations are given in parentheses; Reading Rate, in words per minute.

Measure	Group	Window Size					
		FP	23C	19C	15C	11C	7C
Reading rate	Slow er	118,87 (21,31)	142,61 (35,77)	156,98 (42,98)	135,4 (29,01)	139,62 (40,23)	144,66 (27,53)
	Faster	197,21 (24,23)	168,52 (47,79)	177,1 (38,98)	168,15 (30,7)	172,91 (26,81)	165,56 (27,63)
	Total	156,34 (45,52)	155 (43,48)	166,6 (41,91)	151,06 (33,82)	155,55 (38,02)	154,65 (29,24)

Mauchly's test indicated that the assumption of sphericity has been violated ($\chi^2(14)$ = 25.24, p = .033), therefore, degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (ε = .95). The results show that there was no effect of window size on reading rate, $F(4.77, 214{,}85) = 1.38$, $p = .234$, $\eta_p^2 = .03$.

In previous literature, reading rate analysis is usually conducted on faster readers and slower readers separately (Rayner, Slattery, & Bélanger, 2010; Choi et al., 2014; Häikiö et al., 2009). For this reason, we conducted a further analysis by classifying the participants into two groups: faster readers and slower readers.

The classification was done over the mean value of the reading rate of the participants in FP. Scores higher than the mean were labeled as faster readers and the remaining group were labeled as slower readers.

Mauchly's test indicated that the conditions for sphericity have been violated. We used a Huynh-Feldt estimate correction ($\varepsilon = .899$). The results show that there is no effect of window size on reading rate, $F(4.495, 197.793) = 1.518$, $p = .192$, $\eta_p^2 = .033$. As can be seen in Table 4.2, faster readers were faster in the FP condition and slower in the window conditions. Slower readers, on the other hand, were slower in the FP condition and faster in the window conditions.

The result is contrary to the literature that reading rate would be smallest in the smallest window condition, then it increases with increasing window size and finally reaches an asymptote at the smallest window size that is sufficient for parafoveal information intake (Rayner, 1986). These results suggest that reading rate may not be a reliable measure in the gaze contingent moving window paradigm. We will discuss our findings in the next chapter.

4.3.2. First fixation duration

First fixation duration is the duration of the first fixation on a word. First fixation duration is used as an eye movement parameter as it is assumed to reflect lower-level processes during reading.

We found that there was an effect of window size on first fixation duration, $F(5, 215) = 5.215$, $p < .001$, $\eta_p^2 = .11$. Post-hoc tests showed that first fixation duration in FP was significantly different from the four window conditions. There was no significant difference between 11C and FP ($p = .063$). The mean of first fixation duration in FP was lower than five window conditions as seen in Figure 4.1.

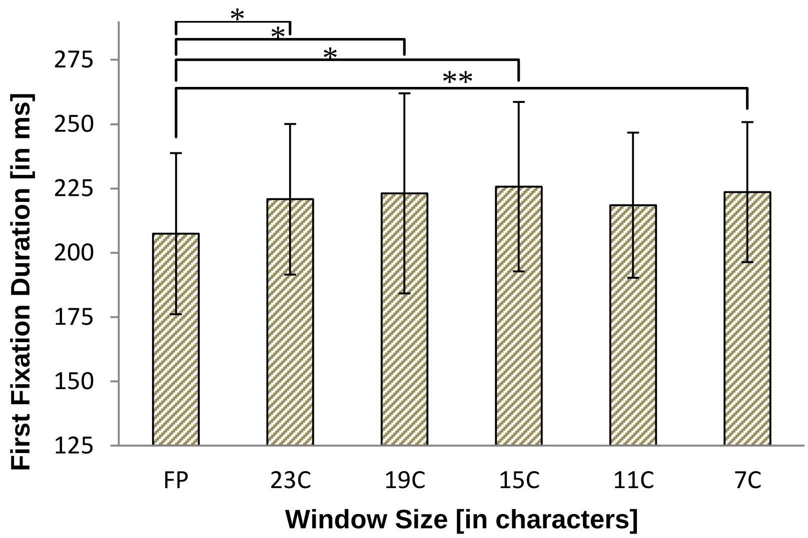

Figure 4.1 First fixation durations in six window conditions during silent reading. FP, full paragraph; C, characters to the right of fixation. Error bars indicate the standard deviations of the means. *: $p < .05$; **: $p < .01$.

Effect of word length on first fixation duration:

There was a significant effect of word length on first fixation duration, $F(1, 43) = 96.053$, $\eta_p^2 = .691$, $p < .001$. First fixation durations on longer words were longer compared to first fixation durations on shorter words. However, we did not observe an interaction between window size and word length ($p > .05$).

Effect of word frequency on first fixation duration:

There was an effect of frequency on first fixation duration, $F(1, 43) = 29.593$, $\eta_p^2 = .408$ $p < .001$. First fixation durations on frequent words were shorter compared to first fixation durations on infrequent words, but no significant interaction of window size and frequency was observed.

Effect of word predictability on first fixation duration:

We observed a strong effect of word predictability on first fixation duration, $F(1, 19) = 16.804$, $\eta_p^2 = .469$, $p < .001$. Participants fixated longer on unpredictable words compared to predictable words, which is in agreement with previous literature. We did not observe an interaction between predictability and window conditions.

4.3.3. First run dwell time

First run dwell time (gaze duration) is the total duration of fixations on a word during the first pass, i.e. excluding refixations. It is assumed to reflect both prelexical and semantic processes in reading.

Mauchly's test indicated that the sphericity has been violated (χ^2 = 28.48, p = .012). Huynh-Feldt method was used to correct estimates (ε = .902).

We found that there was an effect of window size on first run dwell time, $F(1.410, 173.686) = 4.381$, $p = .001$, $\eta_p^2 = .092$. Post-hoc analyses showed that readers spent more time on words in window conditions compared to no-window condition, although this effect was not significant. Longest dwell time was observed in the 7C condition, and it was significantly different from FP condition ($p < .001$), as seen in Figure 4.2.

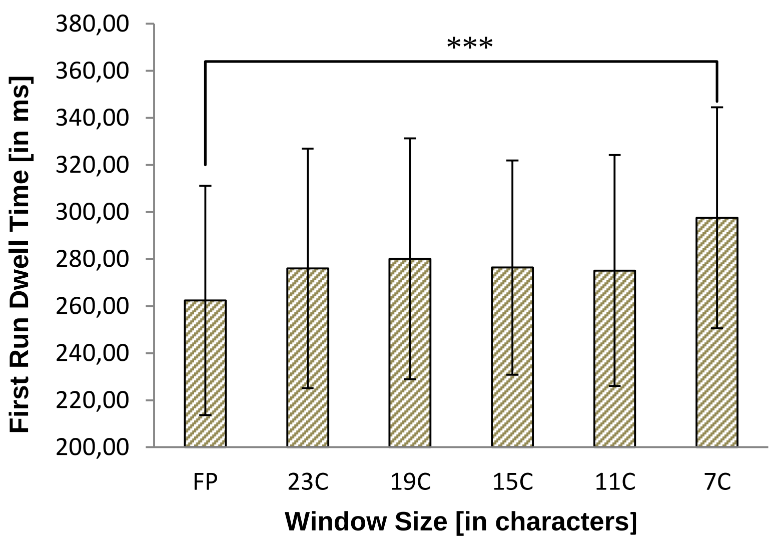

Figure 4.2 First run dwell times in six window conditions during silent reading. FP, full paragraph; C, characters to the right of fixation. Error bars indicate the standard deviations of the means. ***: $p < .001$.

Effect of word length on first run dwell time:

A Huynh-Feldt correction ($\varepsilon = .900$) determined that there was a significant effect of word length on first run dwell time, $F(4.5, 193.479) = 4.339$, $\eta_p^2 = .092$, $p = .001$. There is no interaction between window conditions and word length.

Effect of word frequency on first run dwell time:

Word frequency has a significant effect on first run dwell time. $F(1, 43) = 326.523$, $\eta_p^2 = .884$, $p < .001$. There is no interaction of window size and frequency for first fixation duration.

Effect of word predictability on first run dwell time:

There was a significant effect of predictability on first run dwell time, $F(1, 19) = 52.880$, $\eta_p^2 = .736$, $p < .001$. First run dwell time was longer on unpredictable words compared to significant words. There was no interaction between word predictability and window conditions.

4.3.4. First run fixation count

First run fixation count is the number of fixations on a word during first pass reading. There was a significant effect of window size on first run fixation count, as seen in Figure 3.3. After the Huynh-Feldt estimate correction ($\varepsilon = .925$), we have obtained $F(4.623, 198.789) = 3.730$, $\eta_p^2 = .08$, $p = .004$. We found a significant effect of word length on first run fixation count, $F(1, 43) = 255.588$, $\eta_p^2 = .856$, $p < .001$. No interaction has been found between the window size conditions and the word length.

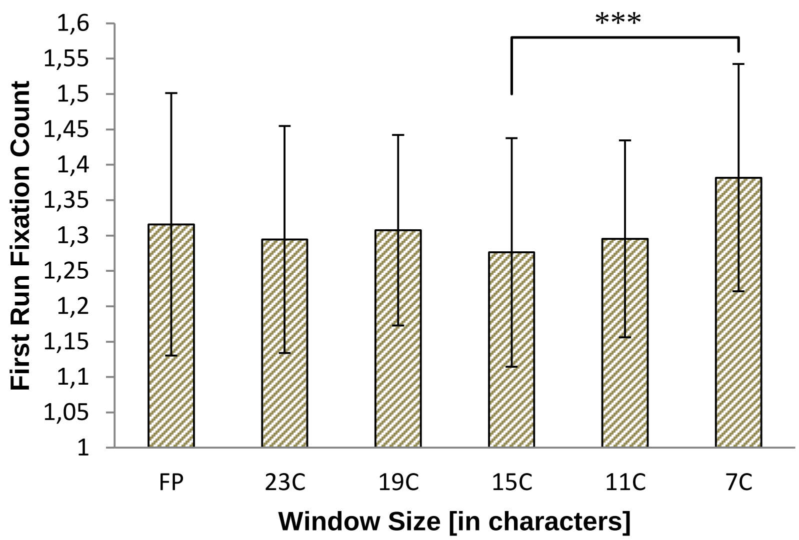

Figure 4.3 First run fixation counts in six window conditions during silent reading. FP, full paragraph; C, characters to the right of fixation. Error bars indicate the standard deviations of the means. ***: $p < .001$.

Effect of word predictability on first run fixation count:

There was a strong effect of predictability on first run fixation count, $F(1, 19) = 27.717$, $\eta_p^2 = .593$, $p < .001$. First run fixation count was less for predictable words compared to unpredictable words, as expected. There was no interaction between predictability and the window conditions.

4.3.5. Regression-in count

Regression-in count is the number of refixations made onto the word from the right (in left to right orthographies). It is a higher-level measure that is assumed to reflect semantic processes.

There was a significant effect of window size on regression-in count, $F(5, 215) = 5.762$, $\eta_p^2 = .118$, $p < .001$. Post-hoc tests revealed that there was significant difference between FP and 19C conditions ($p = .035$), FP and 11C conditions ($p = .006$), and FP and 7C conditions ($p < .001$). The mean number of regressions onto words is smallest in 7C condition. Means of regression-in count can be seen in Table 4.3.

Table 4.3 Means and standard deviations of regression-in counts for six window conditions. FP, full paragraph; C; characters to the right of fixation; standard deviations are given in parentheses.

Measure	Group	Window Size					
		FP	23C	19C	15C	11C	7C
Regression-in Count	Slower	0,18 (0,11)	0,13 (0,1)	0,14 (0,1)	0,11 (0,09)	0,12 (0,08)	0,09 (0,1)
	Faster	0,17 (0,12)	0,17 (0,16)	0,09 (0,08)	0,15 (0,12)	0,11 (0,07)	0,07 (0,08)
	Total	0,18 (0,11)	0,15 (0,13)	0,11 (0,09)	0,13 (0,11)	0,11 (0,07)	0,08 (0,09)

Effect of word length on regression-in count

No interaction has been observed between the window condition and word length, although word length has a significant effect on regression-in counts, $F(1, 43) = 5.993$, $p = .019$, $\eta_p^2 = .122$.

Effect of word predictability on regression-in count:

There was a significant effect of predictability on regression-in-count, $F(1, 19) = 9.692$, $\eta_p^2 = .338$, $p = .006$. Regression-in-count dropped for both predictable and unpredictable words, as window size became smaller. Hence, there was no interaction between predictability and window size.

4.3.6. Regression-out count

Regression-out count is the number of fixations made to previous words. Similar to regression-in count, regression out count is used as a measure of semantic processing.

There was a significant effect of condition on regression-out count, $F(5, 215) = 7.45$, $\eta_p^2 = .148$, $p < .001$. As post-hoc tests indicated, there was a significant difference between FP and 15C conditions ($p = .007$), and FP and 7C conditions ($p < .001$). There was also a significant difference between 23C and 7C conditions ($p = .011$). The number of regressions from a word, similar to regression-in count, showed a tendency to decrease with decreasing window size. This can be seen in Table 4.4.

Table 4.4 Means and standard deviations for regression-out count for six window conditions. FP, full paragraph; C; characters to the right of fixation; standard deviations are given in parentheses.

Measure	Group	Window Size					
		FP	23C	19C	15C	11C	7C
Regression-out Count	Slower	0,15 (0,09)	0,11 (0,07)	0,11 (0,08)	0,11 (0,08)	0,09 (0,05)	0,08 (0,07)
	Faster	0,13 (0,08)	0,1 (0,07)	0,08 (0,08)	0,09 (0,06)	0,11 (0,07)	0,05 (0,03)
	Total	0,14 (0,08)	0,1 (0,07)	0,09 (0,08)	0,1 (0,07)	0,1 (0,06)	0,06 (0,05)

4.3.7. Total dwell time

Total dwell time is the sum of durations of all fixations on the text, including refixations.

There was no significant effect of condition on total dwell time, $F(5, 215) = 1.300$, $\eta_p^2 = .029$, $p = .265$. Means for total dwell time in six window conditions are presented in Table 4.5.

Table 4.5 Means of total dwell time for six conditions. FP, full paragraph; C; characters to the right of fixation; standard deviations are given in parentheses.

Measure	Group	Window Size					
		FP	23C	19C	15C	11C	7C
Total Dwell Time	Slower	400,43 (138,14)	343,23 (89,49)	352,33 (96,5)	356,67 (74,6)	363,75 (111,1)	345,07 (95,92)
	Faster	347,02 (96,55)	367,59 (124,35)	318,13 (75,23)	362,64 (96,69)	316 (72,2)	345,65 (81,63)
	Total	373,73 (120,84)	355,41 (107,77)	335,23 (87,24)	359,65 (85,4)	339,87 (95,69)	345,36 (88,02)

4.4. Faster and slower readers

We have further analyzed our data by classifying it into faster readers and slower readers, to eliminate any effect of reading speed on our measures. We determined the two classes by classifying them into two groups as a function of their reading speed in FP condition. Scores above the mean were classified as faster readers, and scores below the mean were classified as slower readers.

4.4.1. First fixation duration in faster readers and slower readers

There was no significant effect of reading speed on first fixation duration, indicating that first fixation durations of both faster and slower readers were similar, $F(1, 42) = .001$, $p = .980$, $\eta_p 2 = .000$.

Table 4.6 Means and standard deviations for first fixation durations for slower and faster readers in six conditions. FP, full paragraph; C; characters to the right of fixation; standard deviations are given in parentheses; First Fixation Duration, in milliseconds.

Measure	Group	Window Size					
		FP	23C	19C	15C	11C	7C
First Fixation Duration	Slow er	209,69 (26,54)	219,54 (26,93)	223,01 (40,4)	225,39 (30,8)	221,14 (33,09)	219,68 (22,65)
	Faster	205,19 (35,97)	222,07 (31,99)	223,13 (38,32)	225,97 (35,66)	215,78 (22,81)	227,52 (31,21)

4.4.2. First run dwell time in faster and slower readers

We observed no significant effect of reading speed on first run dwell time, $F(1, 42) = 1.432$, $p = .238$, $\eta_p 2 = .033$. Means of first run dwell time for six conditions is shown in Table 4.7

Table 4.7 First run dwell times for slower and faster readers in six conditions. FP, full paragraph; C; characters to the right of fixation; standard deviations are given in parentheses; First Run Dwell Time, in milliseconds.

Measure	Group	Window Size					
		FP	23C	19C	15C	11C	7C
First Run Dwell Time	Slower	273,76 (50,61)	285,1 (59,02)	284,58 (51,78)	280,24 (46,93)	285,69 (55,73)	297,24 (45,87)
	Faster	251,07 (45,21)	267,06 (40,64)	275,67 (51,38)	272,61 (44,91)	264,61 (39,87)	297,86 (49,05)

4.4.3. First run fixation count in faster and slower readers

There was a main effect of reading speed on first run fixation count, $F(1, 42) = 6.219$, $p = .017$, $\eta_p 2 = .129$. Means of first run fixation count for six conditions is shown in Table 3.5.

Table 4.8 First run fixation counts for slower and faster readers in six conditions. FP, full paragraph; C; characters to the right of fixation; standard deviations are given in parentheses.

Measure	Group	Window Size					
		FP	23C	19C	15C	11C	7C
First Run Fixation Count	Slower	1,37 (0,2)	1,34 (0,17)	1,34 (0,15)	1,3 (0,16)	1,34 (0,15)	1,41 (0,17)
	Faster	1,26 (0,16)	1,24 (0,14)	1,27 (0,11)	1,25 (0,16)	1,25 (0,12)	1,36 (0,15)

4.4.4. Regression-in count in faster and slower readers

We have not observed a significant effect of reading speed on regression-in count, $F\ (1, 42) = .008$, $p = .930$, $\eta_p 2 = .000$.

4.4.5. Regression-out count in faster and slower readers

There was no significant effect of reading speed on regression-out count, $F\ (1, 42) = 1.210$, $p = .278$, $\eta_p 2 = .028$.

4.4.6. Total dwell time in faster and slower readers

There was not a strong effect of reading speed on total dwell time, F (1, 42) = .840, p = .345, η_p2 = .020.

4.5 Summary of the results for silent reading

We found that reading rate did not follow a systematic pattern as the window sizes narrowed. First fixation duration in FP was significantly different from the four window conditions. We observed a significant difference between FP and 7C for first run dwell time. Participants' first run dwell time was longer in window conditions. First run fixation count in the window conditions were also significantly different. Regression-in count and regression-out count decreased with decreasing window size. We did not observe a significant effect of window size on total dwell time. We observed the role of word predictability and word length on first fixation duration, first run dwell time, first run fixation count and regression-in count. Word frequency had an influence on first fixation duration and first run dwell time.

We did not observe a significant difference between the slower readers and the faster readers.

4.6. Oral reading

We have compared oral reading and silent reading in three dependent variables: reading rate, first fixation duration, and first run dwell time.

4.6.1. Reading rate

There was a significant effect of modality (silent-oral) on reading rate, F (1, 39) = 76.441, p <.001, η_p2 = .662, as seen in Figure 4.4. Reading rate was higher during silent reading compared to oral reading. No interaction was observed between modality and the window conditions.

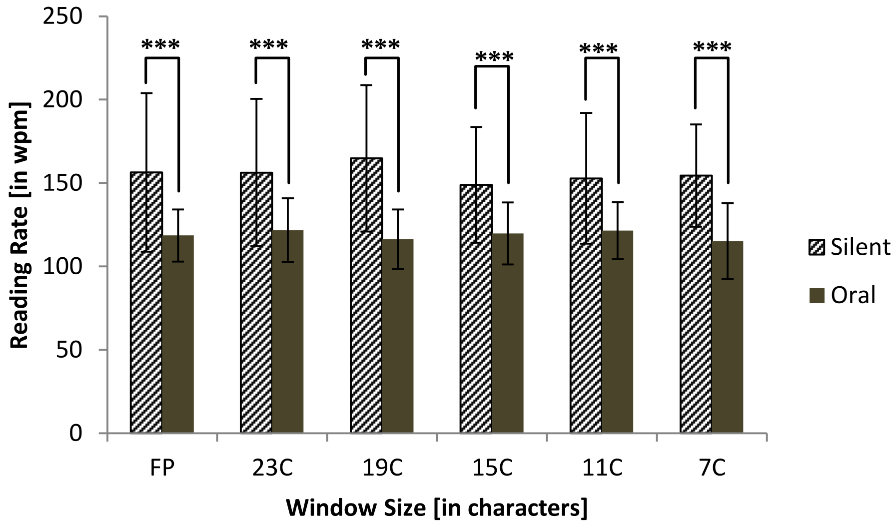

Figure 4.4 Reading rate in six window conditions for oral and silent reading. FP, full paragraph; C, characters to the right of fixation. Error bars indicate the standard deviations of the means. ***: $p < .001$.

4.6.2. First fixation duration

There was a significant effect of modality (silent-oral) on first fixation durations, F (1, 37) = 40.935, p <.001, $\eta_p 2$ = .525. First fixation durations were longer in oral reading compared to silent reading. A paired samples t-test was conducted to compare silent and oral reading in each condition. There was a significant difference between silent and oral reading in each window condition (see Figure 4.5).

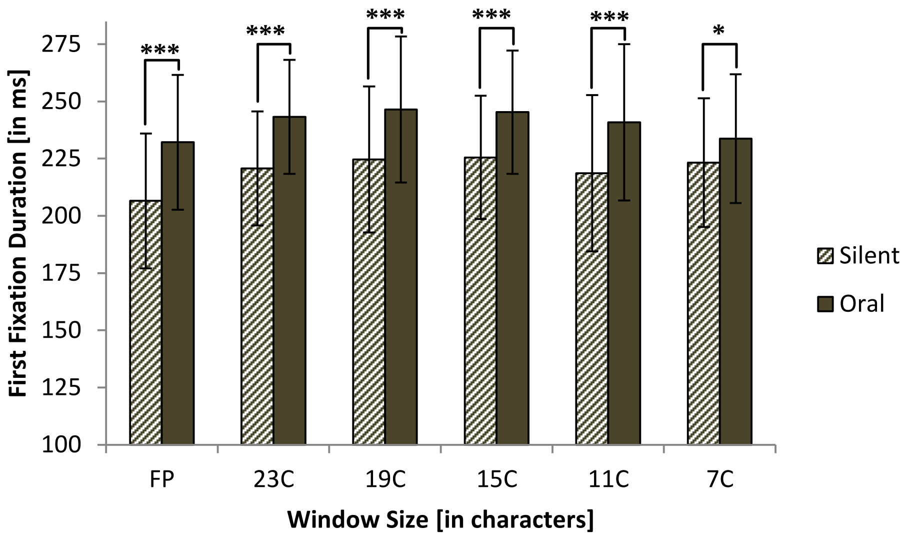

Figure 4.5 First fixation duration in six window conditions for silent and oral reading. FP, full paragraph; C, characters to the right of fixation. Error bars indicate the standard deviations of the means. ***: p < .001; *: p < 0.05.

4.6.3. First run dwell time

We observed a significant effect of modality on first run dwell time, F (1, 37) = 205.396, p <.001, $\eta_p 2$ = .847. First run dwell times of oral readers were significantly longer than silent readers in all window conditions. Comparison of first run dwell times in silent and oral reading in each condition showed that first run dwell time in oral reading was significantly higher compared to silent reading (see Figure 4.6).

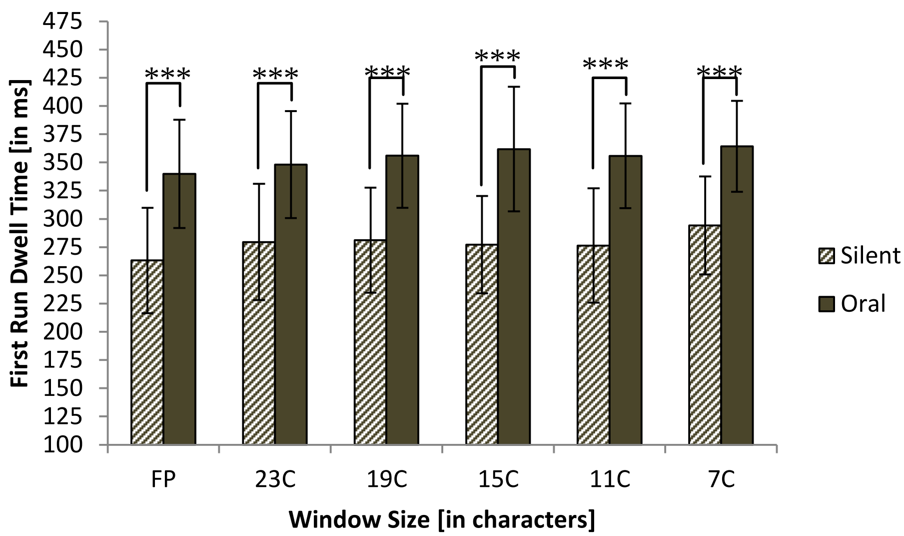

Figure 4.6 First run dwell time in six window conditions for silent and oral reading. FP, full paragraph; C, characters to the right of fixation. Error bars indicate the standard deviations of the means. ***: $p < .001$.

In summary, we observed that there was a significant effect of modality on reading rate, first fixation duration and first run dwell time. In oral reading, reading rate was slower compared to silent reading. First fixation durations and first run dwell times were longer in oral reading compared to silent reading.

4.7. Working memory tests

As described above, we conducted two more tests on each participant after the eye tracking session. Corsi Block Tapping Test and Digit Span Test aimed to assess visual and verbal memory levels of participants, respectively. The average success rate is 5 for Corsi Block Tapping Test (Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000), and 7 for Digit Span Test (Miller, 1956). We examined the correlation between visual span and reading rate, also between verbal span and reading rate. We applied correlation on standardized values of all variables.

There was no significant relationship between visual span and reading rate, $r = .049$, $p = .740$. Similarly, we did not observe a relationship between verbal span and reading rate, $r = -.079$, $p = .595$.

CHAPTER 5

5. DISCUSSION

In this thesis, our main purpose was to investigate the characteristics of perceptual span in Turkish reading. We also analyzed the effects of word frequency, word length and word predictability on first fixation duration, first run dwell time (gaze duration), first run fixation count, regression-in count, regression-out count and total dwell time under different window-size conditions of the gaze contingent moving window paradigm. We compared oral reading and silent reading for reading rate, first fixation duration and first run dwell time.

Additionally, we analyzed the effect of working memory (visual and verbal) on reading rate. We conducted analyses of reading patterns in Turkish for various measures. We obtained cues on the characteristics of perceptual span in Turkish reading. We will first summarize our results in Section 3.1. In Section 3.2, we will evaluate our results. In the last section, we will state the limitations of the experiment and suggest new directions for future research.

5.1. Summary of the results

We observed that reading rate, the main measure for estimating a perceptual span, may not be an appropriate measure for determining the perceptual span. We found divergent results for faster and slower readers. However, for other parameters, we observed significant effects that are similar to the findings in previous studies. First fixation duration in the full paragraph (i.e. normal reading) condition was significantly lower than the other conditions. Similarly, first run dwell time was affected by the smallest window size, 7C condition (7 character window to the right of fixation). However, this effect did not exhibit a regular change as a function of window size.

We also observed a significant effect of window size on regression-in count and regression-out count. We did not observe a correlation between reading rate and levels of working memory. There was also no significant effect of conditions on total dwell time.

We compared oral reading with silent reading for three measures: reading rate, first fixation duration, and first run dwell time. We found that reading was slower in oral reading compared to silent reading. First fixation durations and first run dwell times were longer in oral reading compared to silent reading, which is compatible with previous studies (e.g. Inhoff, & Radach, 2014).

5.2. Discussion

Reading studies have become a major source of information for cognitive scientists, as eye movements able to reflect basic characteristics of on-line cognitive activities (see Chapter 1 for detailed discussion). We used a reading paradigm (i.e. gaze contingent moving window paradigm) to investigate characteristics of Turkish reading and perceptual span of readers of Turkish.

The effect of word characteristics were compatible with the findings obtained in previous literature. We found a significant effect of word length, word frequency and word predictability on first fixation duration and first run dwell time, also an effect of word predictability on first run fixation count, and effect of word length and word predictability on regression-in count. We did not observe an interaction effect of window size and word characteristics on eye movement measures, however.

We also observed that reading mode has a significant effect on first fixation duration, first run dwell time and reading rate. Participants' first fixation durations and first run dwell times were longer during oral reading compared to silent reading, as observed by Ashby et al. (2012). Similarly, reading rate in oral mode was slower than reading rate in silent mode (Ashby et al.). Our findings were compatible with previous studies on oral reading.

Reading rate is reported as a basic measure used to estimate a perceptual span in previous studies (e.g. Leung et al., 2014). We observed that faster readers and slower readers had different reading rates and different reading patterns, as expected. The pattern found in overall results is preserved for slower readers, however, it is lost for faster readers. Reading rate for faster readers tend to decrease together with the decrease in window size.

This shows that reading rate may not be a precise measure for determining the size of perceptual span in Turkish reading. A study with a more controlled stimulus set would reveal the reliability of reading rate as a measure of perceptual span for Turkish.

It could be misleading to make deductions based on a single variable (see Section 2.5), as each variable reflects different properties of eye movements. For this reason, we will also discuss the significance and reliability of the other measures we used in the experiment.

We observed that first run dwell time was highest in 7C for both faster and slower groups. This implies that regardless of reading speed, parafoveal processing was disrupted for both groups in 7C, resulting in longer dwell times to obtain missing parafoveal information. Hence, it can be suggested that 7C was small enough to cause a disruption on reading process. Therefore, it is safe to assume that perceptual span should be larger than seven characters to allow natural reading. As previous literature established a perceptual span around 14-15 characters, it is safer to suggest that a window size between 7-11 windows can be considered as a *minimum* window size for undisrupted reading.

It is clear that first fixation duration of participants was disrupted by window conditions. This may be due to the fact that limited parafoveal information prevented them from parafoveal preprocessing of words, hence they performed longer first fixation durations on the current word to recognize it. Looking at overall results, we see that there was a slight but steady decrease of first fixation durations, starting from 15C. The same pattern follows for faster and slower readers in first fixation durations (see Table 3.6). This systematic decrease in first fixation duration may suggest a window size greater than 15 characters. Similar results were obtained from first run dwell time and first fixation duration, since they reflect similar characteristics of eye movements, as discussed in Chapter 2.

First run fixation count of both faster and slower readers showed similar patterns. There was a significant difference between full paragraph (henceforth, FP) and 7C, similar to the results for first fixation duration. We can see that reading is significantly disrupted in 7C compared to other conditions.

For regression-in counts, contrasts showed that there was no difference between 23C and FP, and all other conditions were significantly different from FP. Similarly, for regression-out count, we observed a similar pattern. All window conditions were significantly different from FP.

We pointed out in Section 2.5 that regression-in count and regression-out count reflect higher cognitive processes such as semantic comprehension (Carpenter & Just, 1978). As we keep our analysis at word level, we simply state that regression patterns in window conditions show significantly different patterns than FP. Regression-in count and regression-out count significantly decrease as window size decreases. Further experiments with more controlled designs are needed to understand the relationship between window size and regression counts. Hence, we will adopt a cautious approach and avoid an estimation of perceptual span depending on regression counts.

We did not observe any significance of condition on total dwell time. Total dwell time is a higher-level measure usually assumed to reflect semantic processing and comprehension (Anisimov et al., 2013). The insignificance of our results suggests that comprehension processes interfered with early processing of words. As we discussed above, total dwell time may not reflect the true nature of eye movements without the interference of higher level cognitive activities. Additional experiments with more controlled stimulus are needed to reduce this confounding effect.

5.3. Limitations & Future work

We can make a plausible estimate of the size of perceptual span in Turkish, depending on our parameters and results. However, there were limitations of the study that need to be considered for future work.

Our aim was to estimate a perceptual span in *natural reading conditions*. That is, we presented to participants paragraphs excerpted from different types of novels without making any modifications on the paragraphs, or controlling them. Using original paragraphs from novels enabled us to imitate natural reading conditions, but reduced the amount of control we had on the texts at the same time. Although we can still observe the effect of word length, word frequency and word predictability on our eye movement measures in first pass reading such as first fixation duration and first run dwell time, these effects were distributed randomly in the texts. This also made it difficult to estimate the size of perceptual span depending on measures like reading rate and regression counts, which might be related to reading processes of higher-level such as comprehension.

As we mentioned in Section 2.3, FP was not a no-window condition in the literal sense. The window size was large enough so that the participants did not see a moving window on the screen. However, when they blinked and the eye tracker did not detect their fixation, the mask returned to the screen for a very brief moment. Participants reported that they have not noticed any flicker or change during reading, but this may have had a subliminal effect on the participants even if they did not recognize the mask.

The insignificance of the results for faster and slower readers may be due to the similarity between the age and background of the participants. All participants were college students of ages between 18-26. This constrain made it difficult to classify readers as fast readers and slow readers. Similar results for both groups may stem from this constrain.

Hyönä, Lorch and Kaakinen (2002) classified readers not by their reading speed, but by their reading strategy. They divided readers as *fast linear readers*, *nonselective reviewers*, *slow linear readers* and topic structure *processors*. Fast linear readers performed shorter forward fixations and fewer regressions, while nonselective reviewers performed more regressions in contrast to other groups, regardless of the sentence type. Slow linear readers fixated longer on words, but they used a similar reading strategy to faster readers. Topic structure processors spent more time on headings and final sentences compared to the sentences in the text. Reading strategies may have an influence on the perceptual span of the readers, as well. We did not intend our stimulus set to induce participants to use reading strategies. The stimulus paragraphs were short and easily readable by adult readers. Nevertheless, a more extensive research concerning the diversity in the participant group and the type of the stimulus text may improve the representativeness of the findings for a broader range of readers.

In conclusion, this thesis was an initial study to investigate characteristics of perceptual span in readers of Turkish for silent reading and oral reading, and aimed to estimate a size for the perceptual span of the readers in natural reading conditions. We showed that differences in languages may require different approaches to investigate them. We inferred that characteristics of readers of Turkish show similarity to readers of other languages, however, the measure of reading rate may not be a suitable representation of perceptual span for Turkish reading. Further experiments on the perceptual span of readers of Turkish may be conducted with more controlled paragraphs to observe more systematic effects of word characteristics and interactions between word characteristics and window size. The analyses can also be conducted by using linear mixed effects models, as more data are collected on reading patterns in different window conditions. The present study does not aim at developing a computational model of eye movement control in reading. However, it provides the background about the characteristics of perceptual span in reading, thus presenting a potential contribution to the development of future computational models.

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APPENDICES

APPENDIX A

Table A.1 Counterbalance chart for the experiment. Each participant is presented each window condition twice, once in silent block and once in oral block. The counterbalance is completed after 24 trials. p(number), participant number; 1, full paragraph; 2, 23 character window; 3, 19 character window; 4, 15 character window; 5, 11 character window; 6, 7 character window.

	Participants						
Paragraphs	p1	p2	p3	p4	p5	p6	
1	2	3	4	5	6	1	silent
2	3	4	5	6	1	2	
3	4	5	6	1	2	3	
4	5	6	1	2	3	4	
5	6	1	2	3	4	5	
6	1	2	3	4	5	6	
7	2	3	4	5	6	1	oral
8	3	4	5	6	1	2	
9	4	5	6	1	2	3	
10	5	6	1	2	3	4	
11	6	1	2	3	4	5	
12	1	2	3	4	5	6	

Table A.1 (continued). p(number), participant number; 1, full paragraph; 2, 23 character window; 3, 19 character window; 4, 15 character window; 5, 11 character window; 6, 7 character window.

	Participants						
Paragraphs	p7	p8	p9	p10	p11	p12	
7	2	3	4	5	6	1	silent
8	3	4	5	6	1	2	
9	4	5	6	1	2	3	
10	5	6	1	2	3	4	
11	6	1	2	3	4	5	
12	1	2	3	4	5	6	
1	2	3	4	5	6	1	oral
2	3	4	5	6	1	2	
3	4	5	6	1	2	3	
4	5	6	1	2	3	4	
5	6	1	2	3	4	5	
6	1	2	3	4	5	6	

	Participants						
Paragraphs	p13	p14	p15	p16	p17	p18	
1	2	3	4	5	6	1	oral
2	3	4	5	6	1	2	
3	4	5	6	1	2	3	
4	5	6	1	2	3	4	
5	6	1	2	3	4	5	
6	1	2	3	4	5	6	
7	2	3	4	5	6	1	silent
8	3	4	5	6	1	2	
9	4	5	6	1	2	3	
10	5	6	1	2	3	4	
11	6	1	2	3	4	5	
12	1	2	3	4	5	6	

Table A.1 (continued). p(number), participant number; 1, full paragraph; 2, 23 character window; 3, 19 character window; 4, 15 character window; 5, 11 character window; 6, 7 character window.

Paragraphs	p19	p20	p21	p22	p23	p24	
7	2	3	4	5	6	1	oral
8	3	4	5	6	1	2	
9	4	5	6	1	2	3	
10	5	6	1	2	3	4	
11	6	1	2	3	4	5	
12	1	2	3	4	5	6	
1	2	3	4	5	6	1	silent
2	3	4	5	6	1	2	
3	4	5	6	1	2	3	
4	5	6	1	2	3	4	
5	6	1	2	3	4	5	
6	1	2	3	4	5	6	

APPENDIX B

Table B.1 Stimulus paragraphs. Note: number of sentences/number of words/number of characters (spaces included).

1) El öpmeye giden çocukların gözleri, kendilerine para verecek olan büyüklerin ellerindedir. Oturdukları yerde oturamazlar. Şu parayı bir alsalar da savuşup gitseler. Büyükler de bunu bildiklerinden, çoğu, daha kapıyı açar açmaz, kapı önünde elini öpen çocuğun eline parayı tutuşturur. Parayı kapan çocuk fırlar gider, bir tenha yere varıp avucundaki parayı sayar, meraktan kurtulur. 5/52/381
2) Sağımızdaki konağın bahçesinde, pembe manolyalar veren bir ağaç vardı. Mayısta açan o pembe manolyalar öyle güzeldi ki, bana konuk gelenleri, onları görmeye götürürdüm. Kimi zaman zorla götürürdüm. Çünkü insanların gözü vardır, bakarlar, ama görmezler. O ağacın önünden geçmişlerdi; bakmışlar ama görmemişlerdi. Bense, ille görmelerini istiyordum o pembe manolyaların güzelliğini. 6/49/380
3) Bence yüzde yüz sevgi, sevgilerin en katıksızı, bir annenin ya da anne durumunda bir kadının bir bebeğe duyduğu sevgidir. Çünkü o bebeğin henüz bir kişiliği olmadığı için, bir kusuru da yoktur. Dağ selleri gibi gürül gürül akan bir aşk duyarsınız bu dünya güzeli et parçasına. Bebekler, bebek kaldıkları sürece, salt mutluluk verirler annelerine. 4/53/345
4)Burası dünyanın herhangi yerindeki bir fukara mahallesinden çok farklı değildir. Bir geçitten çok, toplantı yeri: Mahalleli orada muhabbet eder, konuşur, kavga eder, eğlenir. Hayatın orada geçmeyecek bir bölümü yok gibidir. İhtiyarlar, çeşme başında doğuran kadın bile olduğunu gülerek rivayet ederler. 4/40/302
5) Zavallı Haydar Efendi, malın en temizini, aşçının en ustasını kullandığı halde, umduğunun onda biri kadar iş yapamadı. Gün oldu ki, ailesinden ve günden güne artan misafir akrabalardan başka, yemeğini yiyen, vergi memurlarından başka kapısını çalan olmadı. Bütün boya ameleleri, memurlar ve hatta bütün şehir onu batırmak için söz birliği etmiş gibiydi. 3/51/353
6) Herkeste bir hayret! Kanepelerde bu kadar kişi oturduğu halde, hiç kimse yerini bu ihtiyara ikram etmeyi düşünmemişti. Bir genç kızın gösterdiği bu nezaket –medeniyet namına- hepimizi utandıracak bir şeydi. İhtiyar beyle genç matmazel arasında bir nezaket mücadelesidir başladı. İhtiyar, verilen yeri kabul etmiyor; Matmazel, fevkalade bir nezaketle ısrar ediyordu. 5/49/365
7) Bu kendi haline bırakılmış ihtiyar eşek, pörsük, siyah ağzını taze bitmiş çimenlere yapıştırarak karşımda gezinir durur. Dinlenir, ağır ağır gene gezinir. Bazen sonbaharın altın güneşi onun yaşlı kafasını, sakat gövdesini yaldızlar. Besbelli bu ışıkta biraz keyiflenir, o hafif sıcaklıktan bir yaşama umudu duyar… Öylece sakin sakin saatlerce düşünür. 5/48/352
8) Şehrimizdeki veznedarların en büyük tutkusu, resim galerilerinin açılış kokteyllerine gidip bedava içki içmektir. İşyerlerinin panosuna iğnelenmiş veya amirlerinin masalarının üzerine bırakılmış sergi davetiyelerini titizlikle takip eder, ne zaman nerede kokteyl olduğunu çok iyi bilirler. Boş zamanlarında da, bıyıklarını çekiştirerek, davetiyelerdeki yazıları okurlar. 3/42/369

Table B.1 (continued). Stimulus paragraphs. Note: number of sentences/number of words/number of characters (spaces included).

9) Bu berbat şehirde görüp görebileceğiniz en güzel şeyin terk edilmiş bir fabrikanın kara yıkıntısı olması saçma ya da gülünç mü? Değil! İnsana özgü bir yavaşlığı, sakarlığı hatırlatan tek şey bu yıkıntı çünkü. Şehirde otomobiller, yollar ve binalar, sonunda bütün sıcaklıkların evrenin ölgün sıcaklığıyla aynı olacağı bir geleceğe doğru son hızla gidiyor, uzanıyor, yükseliyor. 4/53/378
10) Günümüzden yaklaşık bin altı yüz yıl önce, bir Roma imparatorunun şehrimizi ziyaret etmesi vesilesiyle dikilen sütunun üzerinde bugün bir leylek yuvası var. O sütunu görünce insan ister istemez bazı yapılara bin yıl sonra üzerine leyleklerin yuva yapacağı beton yığınları gözüyle bakıyor. Hangisine yuva yapacak acaba leylekler? 3/46/330
11) Şehrin yüksek binalarından birine çıkıp aşağıya bakıyorum, her şehirde rastlanabilecek bir manzarayla karşılaşıyorum: Yüzlerce insan, bazen birbirlerinin yolunu keserek oradan oraya gidip geliyor… Ölümsüz gibi görünüyorlar. “Nedir bu?” diye soruyorum kendi kendime, anlamlandırmak gerekiyor, “Kâbus mu, şenlik mi?” Arka arkaya bir sürü karşıt anlamlı sözcük geçiyor aklımdan. 4/47/375
12) Kamaradan çıktığım vakit evvela arkaya baktım. Nihayetsiz bir deniz… İstanbul kimbilir ne kadar zaman evvel ufuktan silinip gitmişti. Buna mukabil sol tarafımızda fevkalade yakın bir sahil vardı. O kadar ki deniz kenarındaki kayalara tırmanmış keçiler bile fark ediliyordu. Gözlerimi bu topraklardan dakikalarca ayıramadım. 6/43/323

APPENDIX C

Table C.1 Demographic questionnaire filled by the participants.

<table>
<tr><td colspan="3">Kişisel Bilgiler

(Bu formdaki kimlik bilgileri verilerle eşleştirilmemektedir.)</td><td colspan="4">Kod:</td></tr>
<tr><td colspan="2">Soyadı</td><td colspan="3">Adı</td><td colspan="2">Bugünün Tarihi</td></tr>
<tr><td colspan="2">Doğum Yılı</td><td colspan="3">Kadın ( )</td><td colspan="2">Erkek ( )</td></tr>
<tr><td colspan="3">Telefon Numarası</td><td colspan="4">E-posta Adresi</td></tr>
<tr><td colspan="7">Şu anki mesleğiniz?</td></tr>
<tr><td>En yüksek tahsiliniz (veya muadili)
(lütfen yuvarlağa alınız)</td><td colspan="3">Ortaokul</td><td colspan="2">Lise</td><td>Üniversite Derecesi</td></tr>
<tr><td></td><td colspan="3">Mesleki Eğitim</td><td colspan="3">Diğer?</td></tr>
<tr><td colspan="7">Fakülteniz</td></tr>
<tr><td colspan="7">Bölümünüz</td></tr>
<tr><td>Sınıfınız</td><td colspan="6">Hazırlık ( ) 1. Sınıf ( ) 2. Sınıf ( )
3. Sınıf ( ) 4. Sınıf ( )</td></tr>
<tr><td>Lisede hazırlık okunuz mu?</td><td colspan="6">Evet ( )
Hayır ( )</td></tr>
<tr><td>Üniversitede hazırlık okudunuz mu?</td><td colspan="6">Evet ( )
Hayır ( )</td></tr>
</table>

Table C.1 (continued). Demographic questionnaire filled by the participants.

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?	Ne kadar süreyle?	Hangi sebeple? (okul, eğitim, vs.)
1.		
2.		

APPENDIX D

Table D.1. Sample of predictability sentences for a paragraph.

Tahmin edilecek kelime	Gösterilen cümle parçası
bu	Kanepelerde
kadar	Kanepelerde bu
kişi	Kanepelerde bu kadar
oturduğu	Kanepelerde bu kadar kişi
halde	Kanepelerde bu kadar kişi oturduğu
yerini	Kanepelerde bu kadar kişi oturduğu halde, hiç kimse
bu	Kanepelerde bu kadar kişi oturduğu halde, hiç kimse yerini
ihtiyara	Kanepelerde bu kadar kişi oturduğu halde, hiç kimse yerini bu
ikram	Kanepelerde bu kadar kişi oturduğu halde, hiç kimse yerini bu ihtiyara
etmeyi	Kanepelerde bu kadar kişi oturduğu halde, hiç kimse yerini bu ihtiyara ikram
bu	Bir genç kızın gösterdiği
nezaket	Bir genç kızın gösterdiği bu
medeniyet	Bir genç kızın gösterdiği bu nezaket
namına	Bir genç kızın gösterdiği bu nezaket –medeniyet
hepimizi	Bir genç kızın gösterdiği bu nezaket –medeniyet namına-
utandıracak	Bir genç kızın gösterdiği bu nezaket –medeniyet namına- hepimizi
beyle	İhtiyar
genç	İhtiyar beyle

Table D.1. Sample of predictability sentences for a paragraph.

Tahmin edilecek kelime	Gösterilen cümle parçası
matmazel	İhtiyar beyle genç
arasında	İhtiyar beyle genç matmazel
bir	İhtiyar beyle genç matmazel arasında
verilen	İhtiyar,
yeri	İhtiyar, verilen
kabul	İhtiyar, verilen yeri
fevkalade	İhtiyar, verilen yeri kabul etmiyor; Matmazel,
bir	İhtiyar, verilen yeri kabul etmiyor; Matmazel, fevkalade
nezaketle	İhtiyar, verilen yeri kabul etmiyor; Matmazel, fevkalade bir
ısrar	İhtiyar, verilen yeri kabul etmiyor; Matmazel, fevkalade bir nezaketle