YABANCI DİL OLARAK İNGİLİZCE ÖĞRENENLERİN IELTS GENEL OKUMA SEVİYELERİ AÇISINDAN GÖZ HAREKETİ DAVRANIŞLARININ VE FARKLILIKLARININ TANIMLANMASI

IDENTIFYING EYE MOVEMENT BEHAVIORS AND DISCREPANCIES OF LEARNERS OF ENGLISH AS A FOREIGN LANGUAGE AT DIFFERENT IELTS GENERAL READING LEVELS

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This work named " Identifying Eye Movement Behaviors and Discrepancies of Learners of English as a Foreign Language at Different IELTS General Reading Levels" by Emrah DOLGUNSÖZ has been approved as a **Dissertation for Phd. Degree** in the program of **English Language Teaching** by the below mentioned Examining Committee Members.

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YABANCI DİL OLARAK İNGİLİZCE ÖĞRENENLERİN IELTS GENEL OKUMA SEVİYELERİ AÇISINDAN GÖZ HAREKETİ DAVRANIŞLARININ VE FARKLILIKLARININTANIMLANMASI

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ÖZ

Bu çalışma bir gelişim-gözlemleme aracı olarak göz izleme tekniğinin dikkat mekanizmalarını da göz önüne alarak farklı seviyelerdeki yabancı dil olarak İngilizce öğrenen öğrencilerin okuma davranışlarının izlenmesinde nasıl bir rol oynayabileceğini açıklamayı amaçlamaktadır. Robinson'ın (1995, 2003) hiyerarşik hafıza modeline ve Schmidt'in (1990) noticing hipotezine dayanarak, öğrenci dil seviyeleri, kelime öğrenim kazanımları ve dikkat arasında yakın bir ilişki olması beklenmektedir. Bir ön kelime sınavından sonra, okuma seviyeleri *IELTS Genel Okuma Sınavı*na göre belirlenmiş 75 öğrenci tek tek göz izleme oturumuna katılmış olup, sonrasında ise bir art kelime sınavına girmişlerdir. Sonuçlara göre göz hareketlerinin okuma seviyelerine göre farklılık gösterdiği bulunmuş; düşük seviyedeki öğrencilerin göz hareketi değerleri yüksek olurken, aynı değerlerin daha yüksek seviyedeki öğrenciler için normal düzeyde olduğu gözlemlenmiştir. Bunun yanısıra sonuçlar öğrencilerin bilinmeyen kelimelerde bilinenlere oranla daha fazla dikkat yükü harcadığını göstermektedir. Ayrıca dikkat ve kelime öğrenim kazanımları doğrudan bağlantılıdır; bilinmeyen kelimeler üzerindeki fazla dikkat yükü o kelimenin daha sonra hatırlama ihtimalini artırmaktadır.

Anahtar sözcükler: Sözcük gelişimi, göz hareketi davranışları, yabancı dil olarak İngilizce, IELTS

Danışman: Doç. Dr. Arif SARIÇOBAN, Hacettepe Üniversitesi, İngiliz Dili Eğitimi Anabilim Dalı, Yabancı Diller Eğitimi Bilim Dalı

IDENTIFYING EYE MOVEMENT BEHAVIORS AND DISCREPANCIES OF LEARNERS OF ENGLISH AS A FOREIGN LANGUAGE AT DIFFERENT IELTS GENERAL READING LEVELS

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ABSTRACT

This study aims to elaborate the use of eye tracking technique as a developmental tool to track EFL learner reading behavior in different proficiency levels by scrutinizing attentional mechanisms. Relying on Robinson's (1995, 2003) hierarchical memory model and Noticing hypothesis by Schmidt (1990), it is hypothesized that proficiency levels, vocabulary learning gains and attention are closely associated. After a vocabulary pre-test, seventy-five learners of English of whom reading levels were defined by an IELTS General Reading Exam read a standard text individually and their eye movements were recorded which was then followed by an unannounced immediate post-test. The findings indicated differences regarding eye movements among proficiency levels, less skilled learners showed inflated values while more proper values were observed for proficient learners. The results also showed that foreign language learners spent more time on unknown words and less on known vocabulary items. Attention and learning gains also positively correlated; longer fixation values on an unknown word increased its further recognition probability in post-test.

Keywords: Vocabulary development, eye movement behaviors, English as a foreign language, IELTS

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ETİK BEYANNAMESİ

Hacettepe Üniversitesi Eğitim Bilimleri Enstitüsü, tez yazım kurallarına uygun olarak hazırladığım bu tez çalışmasında,

- tez içindeki bütün bilgi ve belgeleri akademik kurallar çerçevesinde elde ettiğimi,
- görsel, işitsel ve yazılı tüm bilgi ve sonuçları bilimsel ahlak kurallarına uygun olarak sunduğumu,
- başkalarının eserlerinden yararlanılması durumunda ilgili eserlere bilimsel normlara uygun olarak atıfta bulunduğumu,
- atıfta bulunduğum eserlerin tümünü kaynak olarak gösterdiğimi,
- kullanılan verilerde herhangi bir tahrifat yapmadığımı,
- ve bu tezin herhangi bir bölümünü bu üniversitede veya başka bir üniversitede başka bir tez çalışması olarak sunmadığımı

beyan ederim.

İmza

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1.1. Introduction

Human eye is the window to mind and cognition. The evolutionary stages of the eye in nature is several (Fernald, 1997). It can be assumed that eye movements are the most frequent human behavior (Bridgemann, 1992), Human beings use their eyes in most portions of their daily life. Human peripheral vision is more than 180° of angle but only the 2° of this vision is crystal clear. In addition, the eyes are quite active organs, they never stand still and even at the most stable position, eyes still make micro movements.

Eye tracking methodology mainly depends on recording eye movements during a visual task. This technique has been used in modern meaning for a few decades especially in psychology and cognitive sciences. Eye movements carry valuable clues about the cognitive aspects of human behavior and for a few decades related research on language and human behavior revealed novelties on cognition and reading (Inhoff & Rayner, 1986; Abrams&Zubel, 1972; Rayner, & Duffy, 1986; Schilling, Rayner, & Chumbley, 1998, Vitu, 1991; Ehrlich, & Rayner, 1981; Balota, Pollatsek, & Rayner, 1985; Rayner, Fischer, & Pollatsek, 1998; Binder, Pollatsek, & Rayner, 1999; Rayner, & Well, 1996; Schustack, Ehrlich, & Rayner, 1987; Zola, 1984; Brysbaert & Vitu, 1998; Rayner, 1998, 2009b; Drieghe, Brysbaert, Desmet, & De Baecke, 2004). It should be noted that most of the research was on first language reading and very slight cases were on foreign language learning. Indeed cognitive dynamics of foreign language reading is quite different than of first language (Grabe, 2010) and related research on foreign language reading would give astounding results.

However, until 2010, nearly no L2 research has been conducted by using eye tracking technique. Attention, consciousness and awareness in L2 have been studied with more subjective methods such as underlining, note taking and verbalizations. Most of the time, such methods suffered from memory decay, reactivity or high levels of subjectivity. On the other hand, although eye tracking can provide much robust and accurate data, eye movements was started to be used as a methodology in many fields quite recently. As a recent trend, eye movements started to become subject to second and foreign language acquisition (Godfroid, Housen&Boers, 2010; Godfroid, Boers&Housen; 2013; Liu, 2014; Winke, Gass&Sydrenko, 2013; Siyanova; Conklin& Schmitt; 2011). Eye movements research in foreign language tend to focus on sentence processing, attention, noticing and morphological processing.

In addition, attention studies with eye tracking in EFL, individual differences are also significant point to consider. Reading comprehension is a proficiency driven notion; better proficiency brings about better comprehension and cognitive abilities during reading. As eye movements can indicate a large portion of human linguistic processing in foreign language reading, cognitive variance among different proficiency levels are promising. In fact, different comprehension levels mean different cognitive abilities and these differences can be observed through eye movements. Different metrics of eye movements refer to different processes and problems and these values may differ regarding foreign language proficiency levels. In detecting foreign language problems and observing foreign language learner development, eye tracking methodology can give robust and accurate results.

1.2. Background of the Study

Eye tracking methodology is quite a recent trend in foreign language research. It is demanding and interdisciplinary; requires technical and computer skills along with higher statistical knowledge and literature on different fields such as cognitive psychology, ophthalmology and psycholinguistics. The research is still not abundant; but accumulating and promising. Related research mostly focused on sentence processing, attention, morphology and noticing.

In terms of current developments, research by Godfroid et al. (2010, 2013) focus on the role of attention and noticing in incidental vocabulary learning through reading. With 27 participants, the researchers produced pseudowords and analyzed how much of these words are recognized in post test. The research resulted with the finding that every 1 second of attention on a pseudoword increased its recognition probability by 8%. This research is invaluable as it represents the robust role of attention and noticing in foreign language reading.

In another research, Winke et al. (2013) scrutinized the caption analysis behaviors of EFL learners by means of eye tracking methodology. The main aim of this research was to define the effect of native language on foreign language behavior.

The results indicated that native language affected the reading times in foreign language. Arabic learners are found to spend more time on captions than other learners from different languages. Chinese learners are observed to have attended less to captions in the unfamiliar condition than the familiar more than other learners did. Such differences indeed showed how L1 and L2 differ regarding cognition.

Liu (2014) examined the effect of morphological instruction in foreign language through eye tracking. In this research, 68 learners received traditional and morphological instruction on vocabulary learning for 7 weeks. This instruction aimed to increase learner morphological awareness and competence to make them develop better word recognition strategies. According to the results, learners received morphological instruction have higher fixation duration on morpheme areas while other learners do not show the same type of behavior. In addition, learners who received morphological instruction showed better success in post test.

Siyanova et al. (2011) scrutinized the idiom processing of L2 learners by using eye-tracking. They used metaphoric expressions as stimulus and 36 learners participated in their research. According to the results, native speakers were advantageous in idiom processing when compared with non-natives. In addition, non-natives were observed to have processed idioms and novel words in identical speed.

Regarding controversies, eye tracking methodology in a foreign language has not yet been developed to make strong claims about awareness in foreign language learning. The main reason behind this is that eye tracking technique is a totally quantitative measure which is not capable of measuring higher qualitative cognitive dynamics. Recent research assumes selectivity between known and unknown words and rather than awareness it has been asserted that "visual awareness" towards linguistic stimuli is the most accurate assumption (Godfroid et al 2010; 2011).

The main contribution on this research is shaping eye tracking in EFL reading as a developmental instrument. Related research needs to accumulate, eye movements in foreign language reading has not been scrutinized enough. Most related research mentioned above dealt mainly with more theoretical dimensions focusing on the role of attention and consciousness in SLA. As a result, the standard measurements of eye movements including late and early measures are still unknown. Although eye movements can give robust and crucial information on foreign language reading, still there is not a certain frame to provide foundations of eye movements in foreign language reading. Indeed learner development can be tracked accurately by eye movement analysis, word recognition skills, sentence processing and fluency can be handled and developed. For instance, SLA research cannot still propose any eye movement difference among different proficiency levels. For such a developmental use of eye tracking methodology, standards do not exist; for instance it is still unknown how much L2 learners pay attention to known and unknown words. In addition, no frame and standards exist for proficiency levels and eye movements; indeed better learners must have different eye movement standards such as gaze duration or rereading times. Moreover, fluency calculations can be done accurately in foreign language reading relying on eye movements and textual features. With this way the reading rate and fluency of L2 learners can be tracked, problems can be detected and problem oriented instructional techniques can be developed. Unfortunately, a certain frame and standards are absent to apply such a developmental structure.

Thus eye tracking methodology in foreign language learning is juvenile which is not ready to be used for developmental purposes. This study aims to fill this gap by framing eye movement standards.

1.3. Statement of the Problem

Attentional standards while reading inhabits invaluable clues about L2 reading behavior. Given that attention is facilitative in SLA and FLA (Schmidt, 1991), these attentional levels have not yet scrutinized enough. Observation of eye movement differences among proficiency levels can provide better solution for foreign language reading. The interpretation of these measures provide objective oriented solutions. However, to establish such a developmental instrument, eye movement standards are required. These standards among CEFR reading levels would led eye tracking methodology to be modified as a developmental instrument in L2 reading.

1.4. Purpose of the study

This dissertation aims to build a frame of attention and standards of eye movement metrics listed below for foreign language reading by explaining relationship with L2 proficiency levels, word recognition skills and sentence processing. Depending on these standards, foreign language reading development can be tracked through eye movement analysis.

- Early Measures
    - Single Fixation Duration
    - First Fixation Duration
    - Gaze Duration
- Late Measures
    - Refixations
    - Regressions out
    - Total Fixation Duration
- Global Measures
    - Reading Rate and Fluency
    - Word Skipping

1.5. Research Questions

1. Is there a significant difference between vocabulary pretest and posttest? If so, what is the facilitative effect of total fixation duration on post test?

2. Is there a linear relationship between word recognition skills in foreign language and early measures (First fixation, gaze duration, single fixation duration)? If so, what are the standard values for early measures in terms of word recognition skills?

3. Is there a linear relationship between word recognition skills in foreign language reading and late measures (Regression out, refixation, total fixation duration)? If so, what are the standard values for early measures in terms of word recognition skills?

4. Is there a relationship between proficiency levels and early measures? If so what are the standard values for each early measure to track learner development?

5. Is there a relationship between proficiency levels and late measures? If so what are the standard values for each late measure to track learner development?

6. Can reading speed and fluency standards be calculated through eye movements in foreign language reading? If so what is the relationship between reading fluency and proficiency levels?

7. What are the standard measures for word skipping in foreign language reading? To what extent do the grammatical function words (articles, auxiliary verbs, and prepositions) are skipped by 3 CEFR levels?

1.6. Significance of the Study

Eye movement research in foreign language acquisition is scarce and even though eye tracking methodology is invaluable as a developmental tool, absence of standards and a robust frame disables its usefulness. With the standards and frames presented in this research, better instructional context and curriculum can be provided for foreign language reading. Accurate and precise developmental tracking of L2 learners will lead better problem solving and faster development in foreign language acquisition.

1.7. Assumptions

It is assumed that this study will contribute to foreign language research and attentional sources in foreign language acquisition. Novel frame and standards are assumed to further developments in foreign language reading and the role of attention and noticing in foreign language acquisition.

1.8. Limitations of the Study

Only 3 core CEFR levels are included in this study; B1, B2 and C1. A1 and A2 learners were hard to find and their eye movements are unpredictable. C2 level learners also could not be found and not included as this is the ultimate level.

1.9. Definition of Key Terms

Eye Tracking: It refers to tracking and defining eye movements through eye tracking hardware and software for various purposes.

Early Measures: It refers to initial stages of word recognition processes in reading including orthography and morphology of the target word. It includes first fixation duration, single fixation duration and gaze duration.

Late Measures: It refers to later stages of linguistic processes in reading featured by discourse and syntactic structure. It includes refixations, regressions out and total fixation duration.

Global Measures: It refers to overall holistic metrics including reading fluency and word skipping which are calculated by depending on the whole text and performance.

CEFR Proficiency Levels: They refer standard foreign language learning proficiency levels defined by Commission of Europe ranging from A1 to C2. This study relies on foreign language reading proficiency.

2. LITERATURE REVIEW

2.1. Introduction

Eye movements are physiological human reactions to certain environmental stimuli. Eye movements are crucial for human life, while reading, searching, watching, driving, shopping and in most parts of life span, eye movements play a significant role to maintain daily life. To understand the nature of this kind of behavior, the anatomy and biological architecture of the eye is important. In this respect a brief history of eye movements research is scrutinized. Then kinds of eye movements are presented including gaze shifting and saccadic eye movements with microsaccadic research. These eye movements are then discussed in terms of reading and information processing including linguistic processing depending on related research.

2.2. The Anatomy of the Human Eye

This part briefly introduces the biological features and capacity of the human eye as a biological organ.

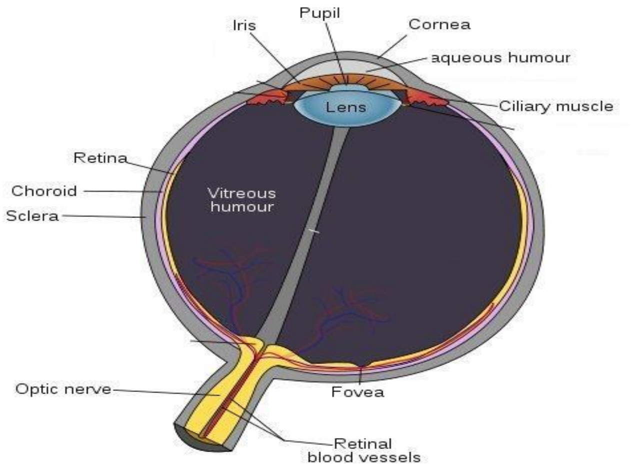

Figure 1. Anatomy of human eye

2.2.1. Retina

Retina allows human to see under various conditions that range from starlight to sunlight. It discriminates wavelength so than human can see colors and object details. It is located at the rear interior surface of the eyeball containing receptors sensitive to light which are called photoreceptors which constitute the first phase of visual perception (Duchowski, 2007). The main function of these Photoreceptors is to convert light energy into neural signals which can be perceived and processed in deeper parts of brain. These neural signals are sent to visual cortex through a bundle of fibers- the optic nerve. Photoreceptors are categorized as rods and cones. cones function as responses for daylight while rods are sensitive to dim and darker vision. In the retina, there are more than 100 million rods and cones. Retina includes a row of cells containing black pigments which is called melanin. Melanin mops up the light that passes through the retina and keeps the light being reflected back due or scattered into the eyeball due to its black chemistry (Hubel, 1995). The back of the retina is known as the macula which enable human to interpret the details of the visual object. This region is yellow with a fairly circular shape with a diameter of 6mm (Hendrickson, 2005). This region is specialized in visual acuity and precision.

2.2.2. Fovea

The center of the macula is named as the fovea which is about 1.5 mm in diameter. This part of retina is the point of sharpest, ultimate visual acuity. Fovea refers to 2° of the visual field in which human vision is at its ultimate acuity (Holmqvist et al., 2011). In other words, human vision has full acuity only in a small area roughly at the size of a thumbnail at arms distance. . So human moves his eyes to see an object sharply. According to De Valois and De Valois (1980), this 2°- 2.5° visual field of acuity is processed by 25% of the visual cortex in brain. Fovea consists of more than 100 thousand cone cells. Some people’s cones are “randomly scattered” which refers less visual sharpness. Whereas, some other people’s cones are more “focused” which enables more visual acuity. Indeed, this explains the variance of sight among people. As there are no rods in the fovea, dim objects in the dark cannot be seen if one looks directly at them.

2.2.3. Cornea

The cornea is the outer layer which covers eye. This dome-shaped layer protects eyes from elements that could cause damage to the inner parts of the eye. Cornea also reflects incoming light and this reflection can be seen by naked eye. Holmqvist et al. (2011) state that modern eye tracking devices use only infrared light to record data which is different from any other common natural light. This is also called corneal reflection, glint or 1st Purkinje reflection.

2.2.4. Iris

Being the color area of the eye, iris is consisted of color pigments. Iris surrounds the pupil and uses the dilator pupillae muscles to widen or close the pupil. With this function, less light is allowed to the eye depending on the brightness. On the other hand, in case of extreme brightness, the iris will shrink the pupil for better visual acuity.

2.2.5. Pupil

Being a black hole in the center of the eye, pupil functions as the manipulator of light (Cassin and Solomon, 1990). Pupil is black due to the light rays entering the pupil being absorbed by the tissues inside the eye directly, or absorbed after diffuse reflections within the eye that mostly miss exiting the narrow pupil. Pupillary response is a physiological response that refers to the variations in the size of the pupil due to light intensity (Ellis, 1981). As pupil controls the intensity of light that enters the eye, it gets wider (dilation or mydriasis) in the dark to absorb more light and narrower (constriction or miosis) in intense light to calibrate intensity. When pupil is narrow, its diameter is 3 to 5 mm. In the dark it will be the same at first, but will approach the maximum distance for a wide pupil 4 to 9 mm.

2.2.6. Sclera

The sclera refers to the "whites" of the eye. Sclera is white however, inside it is brown and contains grooves that help the tendons of the eye attach properly. Sclera mainly functions as a safety organ which secure the eye from external dangers. .

2.2.7. Lens

The lens is located directly behind the pupil. This is a clear layer that focuses the light the pupil takes in. Its main function is to make the necessary adjustments to focus on objects at various distances. To focus an object, lens is manipulated due to its jelly like structure. With ciliary muscles, lens becomes spherical for near objects while it gets flatter for distant objects (Hubel, 1995). As human gets older, lens loses its plasticity and power to focus decreases

2.2.8. Choroid

Between retina and sclera, choroid supplies blood to the eye. In this way, required nutrition is provided for the eye.

2.2.9. The Aqueous Humor

The aqueous humour is a transparent, clear and watery fluid similar to plasma located in the space, between the lens and the cornea. It inflates the eyeball and provides nutrition like amino acids and glucose for ocular tissues. The aqueous humor also serves as an antioxidant and provides defense against pathogens. It also protects cornea against dust, winds and other related external threats.

2.2.10. The Vitreous Humor

Being a jelly-like region, the vitreous humor is placed between the lens and the retina. It is rather expanded by covering nearly 80% of the eye. Light initially entering the eye through the cornea, pupil, and lens, is transmitted through the vitreous to the retina. The vitreous is produced by some of the retinal cells is 98 percent water. The remaining 1 percent is consisted of salts, sugars and collagen fibers, and the remaining one percent is hyaluronic acid, a substance that strongly bonds with water. There are no blood vessels in vitreous humor.

2.2.11. Muscles of Eye Movement

Human eye is an active organ which can move and rotate when necessary with related muscles. Muscles that enable these eye movements are called extraocular muscles which consist of 6 different muscles with unique functions.

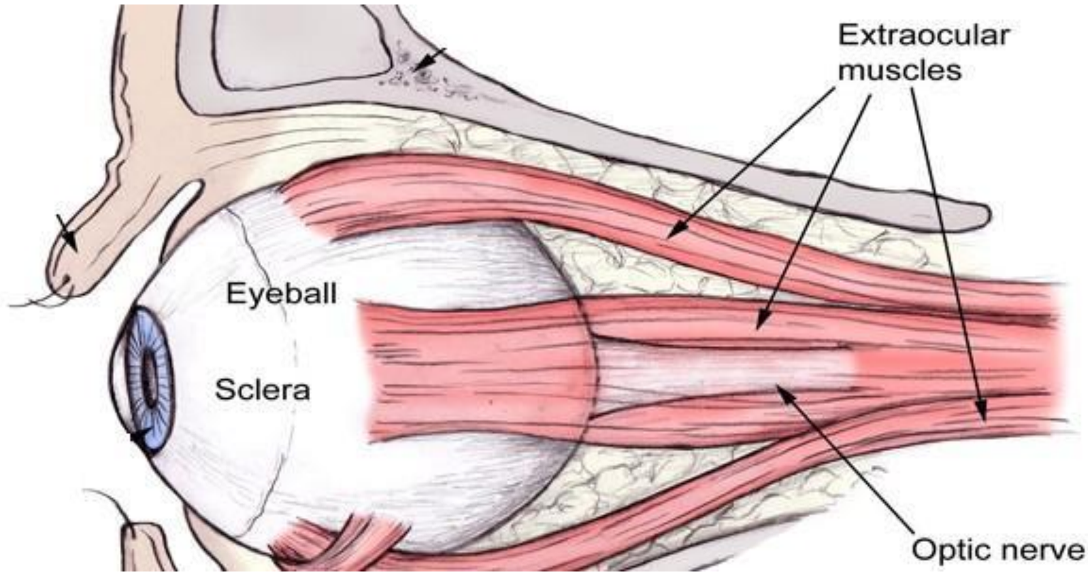

Figure 2. Muscles of human eye

These muscles enable eye movements by pulling the eyeball to the required position. Yanoff and Duker (2008) enlist these 6 extraocular muscles as follows:

Medial rectus (MR): This muscle provides inward eye movements toward the tip of the nose. This function is also called adduction.

Lateral rectus (LR): This extraocular muscle moves the eye outward, further away from the nose. This function is also called “abduction”.

Superior rectus (SR): It provides upward eye movements. This function is also called “elevation”. It also rotates the top of the eye toward the nose (intorsion) and tertiarily moves the eye inward (adduction).

Inferior rectus (IR): Basically, it enables downward movement of the eye. This function is also called “depression”. Furthermore, this muscle rotates the top of the eye away from the nose (extorsion) and makes the eye inward movement (adduction).

Superior oblique (SO): SO basically turns the eyeballs toward the tip of the nose (intorsion). Moreover, it turns the eye downward (depression) and moves the eye outward (abduction)

Inferior oblique (IO): This muscle moves the eye further away from the tip of the nose. This movement also refer “extorsion”. It, besides, moves the eye upward (elevation) and outward (abduction).

2.3. Eye Movement Research and Technical Concerns

This part describes eye trackers as electronic devices, their properties and technical specifications. Also a brief history of eye trackers and research is depicted chronologically.

Eye tracking devices and research on eye movements date back to 18th century in which a number of researchers used many different systems of eye tracking techniques. Eye tracking techniques and methodology has an accumulating nature in which every development led to a better and more precise one.

2.3.1. Eye Tracking Devices in 18th and 19th century

The earliest eye tracking devices date back to 1800s. Due to the infancy of 19th century technology, eye trackers of 1800s were quite difficult to build technically and dramatically uncomfortable for participants. For instance, Huey (1898) used a bite bar to ensure participants' kept their heads still as early devices were quite sensitive to head movements. In addition, Delabarre (1898) anaesthetized eye ball with a solution including 2-3% cocaine and attached a Paris ring to the eye. It was in the early 20th century that Dodge and Cline (1901) introduced the principle of using corneal reflection with an external light source from the fovea. With this technical novelty, eye tracking procedures started to gain a non-invasive feature. This new development became a dominant technique for recording eye movements in latter years.

2.3.2. Brief History of Eye Movement Research in 18th and 19th century

Wade (2007) argues that William Charles Wells; distinguished scholar who was known as one of the first eye movement researchers. His initial studies focused primarily on binocular vision. He also conducted research on visual motion, visual resolution and accommodation. Wells's contemporary Erasmus Darwin was also one of the earliest scientist who included a chapter on eye movements in his book "Zoonomia" published in 1794. Darwin (1794) suggested that human eyes were not actually motionless even on a stable fixation. Regarding this claim, he was the first to have established the foundations of microsaccade research. Another early eye movement researcher was a Scottish physician, William Porterfield. Porterfield created "accommodation" term to describe manipulations in focus of the eye for various distances. He made experiments on "aphakic" subjects and tried to figure out lens function in human. In later years, Porterfield found out that eyeballs moved on the contrary to head movements; the term he called "visual Vertigo" (Porterfield, 1759).

In the early 19th century, Jan Evangelista Purkinje studied visual vertigo by adding a methodological novelty. Purjinke (1820, 1825) applied electrical methods to acquire human eye movements. This technique was employed more densely and efficiently by Eduard Hitzig in 1871 who managed to describe nystagmus by simultaneus application of galvanic stimulation.

Hering (1879) used two rubber tubes similar to a stethoscope electrode placed on eyelids to obtain the sounds of eye muscles during reading. His findings indicated a clapping sound which disappears when they were asked to fixate a target. Indeed, Hering's findings were pointing out saccadic eye movements during reading. Today

Emile Javal is known to be the initiator of saccadic eye movement research in reading.

Early saccadic research in reading was depicted in detail by Tscherning (1898, 1900) in his “Optique physiologie” and in “Pysiologic optics”:

“The eyes are, therefore, in perpetual motion which is made by jerks: they fix a point, make a movement, fix another point and so forth. While reading, the yes move also by jerks, four or five for each line of an ordinary book” (1900)

2.3.3. Eye Tracking Devices in 20th century

With the end of 19th century, early 20th century triggered novelties in eye tracking technologies. Huey (1898, 1900) and Delabarre (1898) developed eye tracking devices which worked with a lever attached to an eye to record movements of the eyes on the surface of a smoke drum (Wade, 2007). The key figure in this period was Dodge (1904; Dodge&Cline, 1901) who first applied photographic eye trackers which needed no intervention to the participants’ eye. Differently, photographic eye trackers did not involve any kind of attachment on the eye. As a result, samples were more comfortable and the method was less invasive like modern eye trackers. By the mid-20th century, new techniques and developments gained pace in recording eye tracking data. Holmqvist, Nyström, Andersson, Dewhurst, Jarodzka and Weijer (2011) enlist these technical developments in eye movement research from around 1950 as follows:

Lense systems with mirrors were used by Ditchburn, Yarbus and others by 1950s and 1970s. This system included contact lenses which made even blinking difficult. Although these contact lenses were quite uncomfortable, they provided very high precision that records every detailed movement of the eye.

Another similar eye tracking system was Electromagnetic Coil System. In this system, a silicon contact lens were placed on the anaesthetized eyeball and electromagnetic induction was measured. According to Collewjin (1998) this procedure has long been accepted as the most precise system. Despite its precision, this system was also quite uncomfortable for the participants.

On the other hand, Electrooculography (EOG) was a system which measured electromagnetic variation of muscular eye ball movements. The working principle of this method was to measure skin temperature with small electrodes on the eye. This methods acquire eye movement data relative to head position as a result it was not generally suitable for point of regard measurements unless head position is also measured (Duchowski, 2007). Moreover, EOG primarily depended upon horizontal movements of eye muscles and suffered so much from muscular noise generated by surrounding muscles. Even today EOG systems are used due to their low-cost feature and high sampling frequency, but still lack accuracy.

Finally, recent technologies depend on Dual Purkinje systems which provide extreme accuracy and precision. However, these systems measures quite a small visual field, expensive and hard to maintain.

Throughout the 20th century, eye movement researchers had to build their own eye tracking devices as ready-made solutions were not possible. This slowed down their research and requires researchers to be competent on electronics even they did not have to. After 1970s, things started to change and manufacturer companies such as ASL (Applied Science Laboratories) emerged. After a decade, number of these companies increased and eye tracking research started to became quite practical with readymade solutions. Today SMI (SensoMotoric Instruments), SR Research with EyeLink System, Tobii Technology and ASL (Applied Systems Laboratory) are pioneering brands of eye tracking industry.

2.3.4. Eye Movement Research in 20th century

In the mid 20th century, the world was shaken by World War II which also brought fundamental changes to science. Large numbers of scientists and engineers focused on applied sciences to protect their countries and attack others. New technologies were sought for this purpose such as radars, submarines, aircrafts and gun control (Westheimer, 2007). However, this trend totally changed in the years after the war. Applied scientists were now seeking the way to solve human biology and nature, to apply electronics and computers in this way. Until then electrodes, stimulators and amplifiers started to take place in applied science including eye movement research.

Even though eye movement research has been made over a century; most of the research were made by holding the head stationary in laboratory environment. Land (2007) points out the fact that there were no solutions for tasks involving participants' mobility and active movements. Early mobile eye trackers were developed by

Norman Mackworth in 1950s (Thomas, 1968). This new device included a head-mounted scene camera which was used to film sample head with corneal reflex. A TV cam was used by Thomas (1962) to obtain data from drivers while driving. However, mobility and recording eye movements were 2 complex issues so first user friendly devices emerged in 1980s when cameras and computers got smaller and mobile.

2.4. Eye Movements

Eye movements are fundamentals of vision and perception which play crucial role in vision. This part scrutinizes eye movements under 3 categories as gaze shifting, gaze stabilizing and fixational eye movements.

2.4.1. Gaze Shifting Eye Movements

This type of eye movements involve saccadic eye movements and smooth pursuits.

2.4.1.1. Saccadic Eye Movements

Humans and many animals do not have a static vision but rather they move their eye to scan and perceive information. It may take place during reading a text, viewing a chart, looking at a picture or driving a car. Eyes are quite active during routine tasks and saccadic eye movements are a part of our lives. Saccadeic eye movements were assumed to have derived from an old French word; “flick of a sail” (Gregory, 1990) which refer to jerky and fast movement of the eyes. To see a visual object, the brain sends signals to the extraocular muscles in the eye which results in a rapid step-like rotation (Findlay&Walker, 2012) which were known as saccades or saccadic eye movements. It is a fast movement of an eye; they are rapid, harmonical movements of both eyes in the same direction (Cassin&Solomon, 1990). Saccades are vital for visual perception as foveal vision is only about 2° and eyes are needed to make fast movements to administer acuity of vision. Fovea is manipulated by saccades and with fovea, the area was of perfect visual acuity. During saccadic movements, cognition processes with the fixation pauses. That is to say, we are totally blind during a saccade. Saccades are coined by Louis Emile Javal; a 19th century French ophthalmologist.

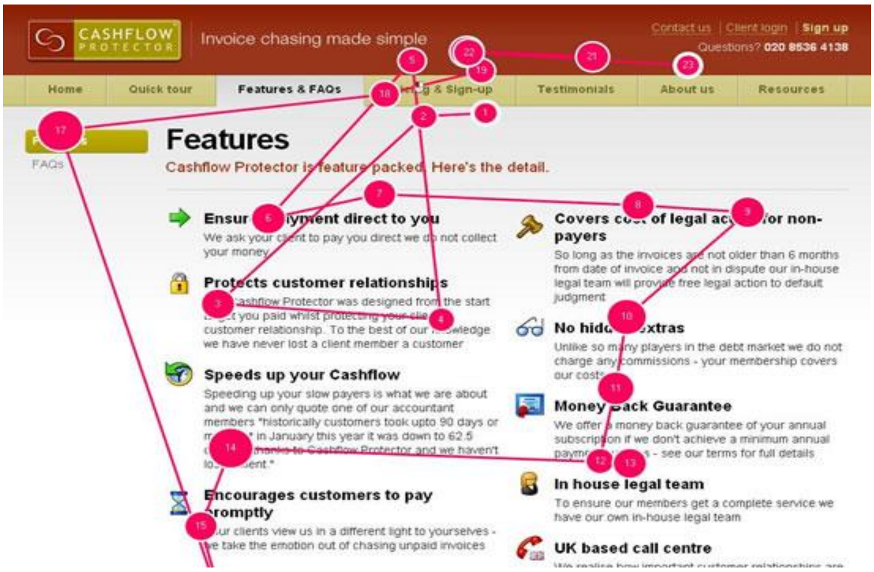

Figure 3. Saccades

Saccadic eye movements are stereotyped and ballistic. According to Shebilske & Fisher (1983), these movements are regarded as one of the most rapid physiological reflexes of human body of which duration ranges from 10 to 100msec. The general assumption is that human is nearly blind during a saccadic movement.

According to Duchowski (2007), saccades are ballistic and stereotyped. Stereotyped refers to the fact that such movements can occurs repeatedly again and again. Ballistic is used to define that such movements are preprogrammed and planned. In other words, once the saccadic movement to the next desired fixation location has been calculated, saccades cannot be altered. According to Carpenter (1977), this situation mainly derives from the assumption that there is limited time for visual feedback to guide eyes to its final location.

Corrective saccades refer to smaller saccades which mainly follows a greater saccade. The short delay between a corrective saccade and saccade is called “inter-saccadic interval”. Such movements basically occur after a very short lag which is also called inter-saccadic interval. These type of saccades takes place even when the stimuli disappear before the eye reaches. They are, however, tend to occur when the target remains visible. These saccades are highly frequent as saccadic accuracy is only moderate – 5%-10% of the saccade amplitude (Kowler & Blaser, 1995).

There are four types of saccadic eye movements as Reflexive and Voluntary saccades, Anti-saccades and Glissades.

2.4.1.2. Reflexive and Voluntary Saccades

It is quite natural to employ a saccadic response to a novel target. Such a saccadic movement made to a target is sometimes called a ”reflexive” or “stimulus-elicited” saccade. For example, a reader may reflexively make a saccade to a word with red font color in a black and white text. On the other hand, in contrast to reflexive saccades, voluntary saccades take place in situations that depend on cognitive control processes like looking for a page number of a topic in a book. Nevertheless, basically it is assumed that all saccades are voluntary and they can be controlled.

2.4.1.3. Anti-Saccade

Saccadic eye movement is thought to be programmed by the frontal cortex. As a diagnostic technique, The anti-saccade task is used to diagnose to reveal the breakdowns related to the frontal lobe, by examining the neurological ability to inhibit the reflexive saccade (Levy, Mendell and Holzman, 2004). In an anti-saccade experiment, the patient is required to fixate on an motionless are like a cross. Then this procedure is followed by a stimulus on either sides. Then the patient is asked to employ a saccade to the opposite of the direction of the stimulus. For instance, when a stimulus is shown to the left of the motionless target, the patient is required to fixate the right side. At this process, if the patient fails to employ a reflexive saccade, an error is considered to occur. This impairment is assumed to have been closely related with a frontal lobe problem. Levy et al. (2004) proposed that such cases include neurological illnesses such as Schizophrenia, Huntington's disease and Parkinson.

2.4.1.4. Glissades

For glissades, Weber and Daroff (1972) were coined. In general, most of the saccades do not stop directly at the intended location but eye wobbles a little bit before stopping. Such a movement is called a glissade (Holmqvist et al., 2011). Glissades were hypothesized to be errors in eye tracking data (Deubel and Bridgeman, 1995) but later Nyström and Holmqvist (2010) described it as an ocular wobbling after main saccades.

2.4.1.5. Smooth Pursuit

Smooth pursuits are gaze shifting eye movements in which eyes follow a moving visual stimulus intentionally to enable the target to fall on the fovea continuously. In other words, pursuit movements occur while pursuing a mobile visual object. Due their physiological flexibility, the eyes are capable of catching the velocity of the mobile target (Duchowski, 2007). Most people are observed to be better at horizontal than vertical smooth pursuit. Most humans are also better at downward than upward pursuit (Grasse&Lisberger, 1992).

Smooth Pursuit eye movements can be divided into 2 stages as open-loop pursuit and closed-loop pursuit (Krauzlis&Lisberger, 1994). Open-loop pursuit has a ballistic nature which is starts with the first response to the visual stimuli and lasts only around 100ms. Following stage is closed-loop pursuit which includes pursuit movement and lasts until the smooth pursuit process ends. Smooth pursuits are complex eye movements which require neurologic coordination. The deficits of smooth pursuits are apparent in diseases like Schizophrenia, autism, and psychotic trauma (Krauzlis&Lisberger, 1994; Takarea et al., 2004). Also drug use and alcohol have negative effects on smooth pursuit movements.

2.4.2. Gaze Stabilizing Eye Movements

These kind of eye movements are about eye-head coordination to provide foveal vision during head movements. It includes Vestibulo Ocular Reflexes and Optokinetic Reflexes.

2.4.2.1. Vestibulo Ocular Reflexes

According to Encyclopedia Britannica (1987) the vestibulo-ocular reflex (VOR), also known as the oculocephalic reflex is an eye movement that enables human to stabilize images on the retina during head movements. VOR produces an eye movement in the direction opposite to head movement to keep the visual stimuli on the center of foveal vision. When the head moves to the right, the eyes move to the left to stabilize the visual field. Human head is quite an active mechanism which produces micro tremors even during motionless state and VOR has a crucial role in stabilizing vision. The VOR is also active in dark or when eyes are closed. In bright and clear conditions, the fixation reflex also supports VOR. Impairment in VOR causes problems in visual perception including reading in which patients could not fixate on the visual field due to micro head tremors. This results with oscillopsia (Straube et. al, 2004).

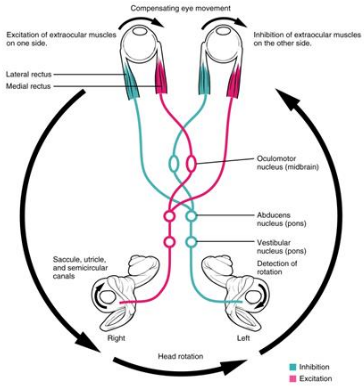

Figure 4. Vestibu Ocular Reflex

2.4.2.2. Optokinetic Reflexes

The optokinetic reflex can be considiered as a combination of a smooth pursuit and a saccade movement. The optokinetic reflex is crucially important for stabilizing the image of visual input on the retina and interacts with Vestibulo Ocular reflexes. To follow a moving visual stimulus, optokinetic reflexes provide head and eye coordination to enable visual perception and resets back to the starting point when visual process ends. In other words, Optokinetic reflexes allow human to fixate back on the starting point at the end of a smooth pursuit movement when visual stimuli moves out of the visual field. Optokinetic reflexes develop roughly about 6 months of age in a healthy infant and remains throughout life. (Atkinson, 1984). This reflex plays an important role in everyday experience for most people in the context of driving, as objects tend to move rapidly past the driver in the periphery, which requires a rapid ocular response, while maintaining primary fixation on the road.

2.4.3. Fixational Eye Movements

These kind eye of movements occur when retina is stabilized over a stationary object of interest (Duchowski, 2007). This type of eye movements movements refer to the maintaining of the visual gaze on a single location. Humans and other animals with a fovea typically may fixate on a single stimulus. They are categorized in three groups: microsaccades, ocular drifts, and ocular microtremor. Although their existence has been known since the 1950s, the role and importance of fixational eye movement is still debated.

2.4.3.1. Microsaccades

Microsaccades are short, rapid, involuntary eye movements, similar to miniature versions of voluntary saccades. While fixating, eyes are never static, but rather making micro movements. Rolfs (2009) arfued that microsaccades typically occur during prolonged visual fixation for several seconds, not only in humans, but also in animals with foveal vision.

Figure 5. Microsaccade

The picture above is totally motionless but we perceive it moving. Microsaccades in eye movement research has been controversial issue for over 50 years (Martinez, Macknik and Hubel, 2004). It was originally proposed that microsaccades serve to re-foveate the target after intersaccadic drifts. This idea, however, was opened to debate in 1970s. Microsaccade research in 2000s showed that microsaccades may function as correcting eye blink fixational errors.

2.4.3.2. Ocular Drifts

Drifts are low-velocity components of which nature is not clear yet. Drifts occur in inter saccadic intervals as random walk (Engbert&Kliegl, 2004).

2.4.3.3. Ocular Tremor (Nystagmus)

Ocular tremors, also called as microtremor or physiological nystagmus, are small eye movements in 60hz similar to drifts during fixation. Their measurement requires highly specialized devices and mostly studied to solve human neurology (Michalik, 1987). Holmqvist et. al (2011) propose that they can be imprecise muscle control related to extraocular muscle system.

2.5. Eye Movements in Reading and Information Processing

Although eye movement research has quite a long history, research on using eye movements to investigate cognitive processes is relatively new. Studies of the relationship between eye movements and cognitive processes have appeared over the past 20 years in which human cognition is scrutinized through eye movements.

Rayner (1998) divides eye movement research into three periods as first, second and third era. The first era of eye movement research derives from Emile Javal's observations and studies of eye movements in reading in about 1879. In this period, many basic and fundamental principles of eye movements were discovered such as saccadic suppression, saccade latency and the size of perceptual span.

This first era lasted until 1920s .The second era was relatively more behaviorist and experimental in which research took an applied focus (Rayner, 1998). However, little research was conducted on eye movements in reading. Tinker (1958) explained this pessimistic situation by stating that everything possible had already been discovered about reading on eye movements. Surely technological capabilities of this age affected experimental research on eye movements and reading played an important role in this infertility.

Having begun in 1970s, the third era of eye movement research has been marked by technological developments in eye movement recording systems which provided more accurate and more easily obtained measurements (Rayner,1998). In addition, large amounts of eye tracking data could be obtained in large laboratory environments in which eye tracking devices and computers were blended. The development of general theories of language processing has made it possible to use eye movement records for a critical examination of the cognitive processes underlying reading.

2.5.1. Basic Characteristics of Eye Movements in Reading and Information Processing

To obtain information in a cognitive task such as reading, searching for an object of looking at an object, human beings make eye movements called saccades. They are fast, stereotyped and ballistic movements of the eye through which a visual is perceived.

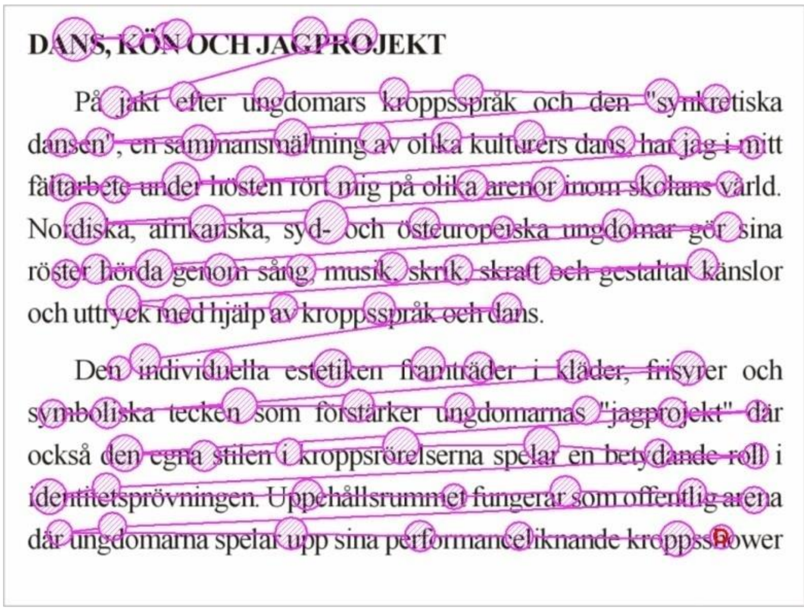

Figure 6. Saccades during reading

Saccades are significant eye movements when compared with aforementioned terms. *Pursuit eye movements* take place when the eyes follow a moving target; the speed of pursuit eye movements is remarkably slower than saccades and, if the target is moving rapidly across the visual field, successive saccades occur to catch up with the object. (White, 1976). *Vergence eye movements* happen when we move our eyes inward, toward each other, in order to fixate on a nearby object. (Rayner,1998). And *vestibular eye movements* are compensatory eye-head coordination when the eyes rotate to compensate for head and body movements in order to maintain foveal vision and fixation. Pursuit, vergence, and vestibular eye movements are important and densely studies in eye movement research, but saccadic eye movements are more relevant and crucial in reading and related information processing tasks. For saccades, brain blocks visual cognition and vision is blurred. This process is called saccadic suppression or saccadic masking (Matin,1974; Uttal&Smith,1968). Usually, human are not aware of these mental pauses during eye movements as saccade durations are so short and any disruptions might not be particularly remarkable. Throughout reading, saccades move in parallel with comprehension and saccadic programming is clear. However, there is a lag associated during saccadic movement, because all saccades are motor movements which demand time to plan and execute. This phenomena is called saccadic latency. The related research shows that average duration of saccade latency varies between 150-175ms (Abrams& Jonides,1988; Rayner, Slowiaczek, Clifton, & Bertera, 1983).

Between these saccades, eyes remains still at a certain point at about 200-300ms depending on the stimuli which is called fixation. However, eyes are never totally motionless and during fixations, three types of micro eye movements occur: microsaccades, nystagmus (tremor) and drifts. Tremors of the eyes are quite small and their exact nature is unclear yet but according to Rayner (1998), the assumption is that movements of the eye are related to perceptual activity and help the nerve cells in the retina to keep firing. Drifts and microsaccades are relatively larger micro movements than the nystagmus movements. Still nature of these fixational micro eye movements could not be solved completely but it is assumed that these movements are closely related to extraocular muscle system of the eye.

2.5.2. Saccadic Suppression, Saccadic Latency and the Size of Perceptual Span

Saccadic suppression (also known as Saccadic Masking) refers to the fact that human beings do not perceive information during an eye movement. During eye movements, brain selectively blocks visual processing and neither the motion of the eye nor the gap in visual perception is noticeable to the viewer.

Bucci,Gignac and Kapoula (2008) describes saccadic latency as the latency period of saccades between the appearance of a new stimulus and the starting of the eye movement. During this process, several other processes occur such as the shift of visual attention to the new stimulus, the disengagement of oculomotor fixation and the computation of the new parameters. These processes involve divergent cortical and sub-cortical areas. Saccadic latency is quite relative and varies from individual to individual, trial to trial. However Carpenter (1988) describes typical average latency as 200ms.

The size of perceptual span refers the angular span of human perception in which vision is in highest acuity. The visual field of the human eye is roughly 180° of arc. However, most of this arc refers to peripheral vision or side vision. Peripheral vision can be described as the area of vision out of the direct line of vision. In this arc, most visual objects are blurred and unclear for perfect perception. This blurriness is closely related with rods, nerve cells located largely outside the macula of the retina. In other words, human beings cannot see this 180° of arc clearly but quite blurred. At about 60°, human vision is better but still in low resolution. This part of perceptual span is called near peripheral vision. 10° of arc in human perceptual span is termed as parafoveal vision in which over average resolution is enabled. In this part, both rods and cones exist and human vision is nearly clear. The sharpest and the peak of human vision acuity takes place in the fovea in which cones are densely placed. Foveal vision equals to 2°-2.5° of arc and the vision is at its highest resolution. The visual field that is observed with proper resolution to read text generally refers approximately 6° of arc. This arc is wide enough to allow a clear view of nearly five words in a row when printed text at ordinary size is held about 50 centimeters from the eyes.

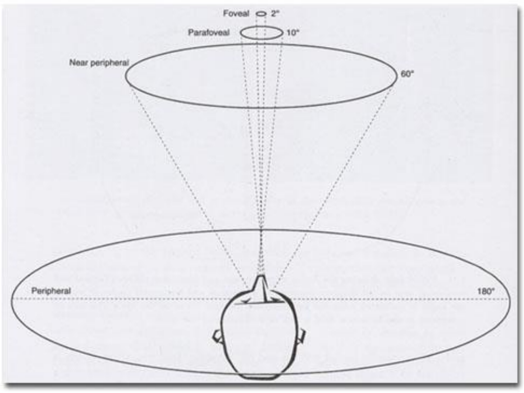

Figure 7. The size of human perceptual span

2.5.3. Eye Movements in Reading

Reading and other visual processes shows quantitative differences in terms of fixations and saccade lengths. According to Table…, silent reading greatly differs from simultaneous typing and reading while it also differs from music reading and scene perception. Specifically, Table 1 asserts that reading aloud has higher fixation durations and less saccade length which refers to the fact that as cognitive load is positively correlated with fixations and negatively correlated with saccade length.

Table 1. Fixation Duration and Saccade Length in different visual processes (Rayner,1998)

Task	*Mean fixation duration (ms)*	*Mean saccade size (degrees)*
Silent Reading	225	2 (about 8 letters)
Oral Reading	275	1.5 (about 6 letters)
Visual Search	275	3
Scene Perception	330	4
Music Reading	375	1
Typing	400	1 (about 4 letters)

2.5.3.1. Saccades and Fixations

In reading, eye fixations last about 200-250ms and the mean saccade length is 7-9 letter spaces in English language (Rayner,1998). Although most words in a text are fixated during reading, some others are skipped, thus foveal processing of all words is not vital for cognition. Carpenter and Just (1983) points out that content words are fixated about 85% of the time, whereas function words are fixated about 35% of the time. There is a clear relationship with fixation duration and word length; as the length of a word increases, fixation duration on that word tends to be higher (Rayner & McConkie, 1976). Function words are shorter than content words, so most of the time they are skipped by the reader and content words are more fixated. Short words with 2-3 letters are only fixated around 25% of the time, whereas 8 letters and longer words are almost always fixated and often revisited. Moreover, readers do not fixate in the blank spaces between sentences in a text (Abrams & Zuber, 1972).

2.5.3.2. Regressions

Natural saccadic movement in reading English is from left to right. However, this does not mean that reader always follow this natural path. Usually, 10- 15% of the saccades are regressive movements (regressions) which refer to right-to-left movements along the sentence structure. Such movements are only a few letters long. Additionally, short within-word regressive saccades may occur which are due to problems that the reader has processing the currently fixated word. A long regression may be due to the reader’s desire to understand the text better or reader may have made quite a long saccade already and missed information. Most of the time, especially longer regressions (longer that 10 letter) are indicative of discursive and syntactic impairments during reading. In such cases, skilled readers are very experienced and immediately send their eyes to that part of text that caused them difficulty (Frazier & Rayner, 1982; Kennedy, 1983; Kennedy & Murray, 1987). On the other hand, poor readers engage in more backtracking through the text (Murray & Kennedy, 1988). Text and comprehension difficulties strongly influence the number of regressions that readers make. According to Duffy (1992), readers tend to regress to a word on the current line rather than to words on previous lines. Frazier and Rayner (1982) also emphasize that when readers encounter a disambiguating statement, they often make regressions. Several research show that many regressions are due to comprehension failures (Blanchard & Iran-Nejad, 1987; Ehrlich, 1983; Frazier & Rayner, 1982; Just & Carpenter, 1978; Shebilske & Fisher, 1983; Vauras, Hyöna, & Niemi, 1992).

2.5.3.3. Return Sweeps

Return sweeps are long regressive saccadic eye movements from the end of a line to the beginning of the next one. Regressions should not be confused with return sweeps in which readers make a saccade from the end of one line to the beginning of the next. Through return sweeps, readers often make small corrective movements to the left. In a normal text, 20% of fixations are done during return sweeps. As corrective saccades are often made following return sweeps, it should not be assumed that readers make extreme fixations on the beginning of a line. The first fixation on a line tends to be longer than other fixations (Heller,1982), and the last is shorter (Rayner, 1978). According to Heller (1982), experienced readers are much better in saccade programming and they execute economical return sweeps in which corrective saccades and fixation durations are less when compared with less proficient readers.

2.5.3.4. Refixations

In a text, roughly 15% of the words are refixated. In other words, these words receive additional fixations before the reader skips another word (Rayner, 1998). O'Regan and Levy-Schoen (1987) argued that main reason for refixations on a word is landing the saccade in a “bad” place. As a result, processing of the word is distributed over two or more fixations. This means that refixation processes aim to calibrate the optimal viewing location. First fixations tend to be longer than the second fixations most of the time (Rayner et al., 1996). In addition to bad saccade landings, frequency of the words affects the first fixation of words that are fixated twice (Sereno, 1992). There is also evidence that contextual variables influence whether a reader will make an additional fixation on a word. Balota, Pollatsek and Rayner (1985) showed that readers were less likely to have their next fixation remain in the currently fixated word if it was predictable in the sentence context.

Despite all quantitative information concerning fixations, saccades and regressions mentioned above, these measures considerably changes due to reader and text variables. Within a single passage, reader’s fixations vary from 100ms to 500ms and saccade length varies from 1 to 15 letters. Even if it is rare, fixations as short as

50ms and saccade sizes of 15 letters can be observed. Movements of the eye are also affected by typographical and textual variables. As the text becomes challenging, fixation duration increases, saccade length decreases, and the frequency of regressions increases (Jacobson & Dodwell, 1979; Rayner & Pollatsek, 1989). Additionally, effective factors like the quality of the print, font style and size, line length, and letter spacing (Kolers, Duchnicky,& Ferguson, 1981; Morrison & Inhoff, 1981) influence eye movements.

2.5.4. Word Recognition and Eye Movements

To extract textual information, readers move their eyes through the text. Where they move their eyes and how long they looked at a word give significant clues about cognitive processing during reading. Related eye movements and reading research clearly proposes that fixation time on a word is shorter if the reader has a valid preview of the word and if the word is easy to identify and understand.

Three eye tracking measurements are commonly used to investigate word recognition during reading: First fixation duration, single fixation duration and gaze duration. Being the first contact with the textual input, first fixation duration is the duration of the first fixation made in an interest area during forward reading. Provided that there is only a single fixation on the area, this measurement refers to single fixation duration. And gaze duration represents the sum of all fixations made in an interest area before the eyes leave that area (Godfroid, 2012). First fixation duration and gaze duration are the two most frequently reported dependent variables in psycholinguistic eye-movement research (Rayner, 1998). Several factors affect eye movements during word recognition in reading. These factors range from frequency to contextual issues.

2.5.4.1. Word Frequency

The frequency of a word in a language is a strong determiner of fixation duration in reading. According to Rayner (1977) and Just and Carpenter (1980), readers look longer at infrequent words when compared with more frequent words. Even word lenght has been found to be non-effective on the fixation durations of frequent words (Rayner and Duffy, 1986; Inhoff and Rayner, 1986). On the other hand, gradual decreases in these measures have been observed when readers meet same words several times in a short passage. Rayner, Raney and Pollatsek (1995) argue that after a few same lexical encounters of high or low frequency words, the gap between them is equalized. Remarkably, durations of fixations on low frequency words decreases with rehearsal in memory; the durations of fixations on high frequency words also decreases, but not as dramatically as for low frequency words.

2.5.4.2. Word familiarity

Despite identical frequency values, words may differ in terms of familiarity. Frequency is a corpus based variables, on the other hand, word familiarity is determined from vocabulary scales. Effects of word familiarity on eye movements, especially fixation durations are depicted in a number of studies. According to Williams and Morris (2004), readers attend more on less familiar vocabulary items they do for more familiar ones. They tend to spend most of the time by rereading the informative context that followed unfamiliar words. More regressions are made and gaze durations are longer for unfamiliar words when compared with familiar words. Similarly, Chafin, Morris, and Seely (2001), reported that less familiar words received more first fixation duration, gaze duration and spillover effect in the first encounter.

2.5.4.3. Age of Acquisition

Frequency and familiarity are not only determinants of eye movements in reading. The age of acquisition or the period in which language has been acquired is a strong determinant of word processing in reading. Juhazs and Rayner (2006) found out that words acquired in early age were fixated for less time than lately acquired words.

2.5.4.4. Number of Meanings

Words including more than one meaning are a strong predictor of eye movements in reading. Basically, an ambiguous word which has two equally similar but unrelated meanings receive more fixation when compared with an unambiguous word despite length and frequency effects. If disambiguating information is given after the ambiguous word, fixations and regressions increases. On the other hand, when the disambiguating information precedes the ambiguous word, readers don’t look any longer at the ambiguous word. Apparently, the context has a crucial role which can give sufficient information for the reader to choose the contextually appropriate meaning. Whereas, in the case of biased ambiguous words when the subordinate meaning is instantiated by the context, readers look longer at the ambiguous word than the control word.

2.5.4.5. Morphological Effects

Most eye movement research mainly focused on monomorphemic words which were relatively simple. This has also been largely true of research on eye movements and word recognition. However, a vast number of studies have also focused on morphemically complex words. One of these studies was the research by Pollatsek, Hyönä, & Bertram, 2000, who studied the processing of Finnish words which by their very nature tend to be long and morphologically complicated. Hyönä and Pollatsek (1998) proposed that the frequency of the first morpheme in two-morpheme words influenced how long readers fixated on the word.

2.5.4.6. Contextual Constraints

A fair number of eye movement research has revealed that words that can be predicted from the earlier context are attended for less time than words that are not predictable (Ehrlich and Rayner, 1981; Balota, Pollatsek, and Rayner, 1985; Ashby, Rayner, and Clifton, 2005). Such studies showed that not only are fixation time measures are attended less on high predictable words than low predictable words, but also readers tend topay zero fixation (skip) over high predictable words.

2.5.5. E-Z Reader Model

This study was built upon E-Z Reader model (Reichle, Pollatsek, Fisher, & Rayner, 1998; Pollatsek, Reichle, & Rayner, 2003; Rayner, Reichle, & Pollatsek, 2005) in eye movement data interpretation. Having been inspired by Morrison's Oculomotor Theory (1984), the E-Z Reader model is a quantitative model of skilled reading which helps to explain the relationship between cognitive processes and eye movement control during reading. According to this model, recognition of a word begins with the attention on that words. This recognition process is completed in 2 stages: Early and late stages. In the first stage, orthographic form of the word is processed in which the familiarity of the word is checked. Once this process is efficiently done, next saccade is planned. This stage is the very initial phase of lexical Access. The second stage of word recognition involves the identification of a word's morphological and semantic forms. In this stage, lexical Access may or may not occur.

3. EYE TRACKING METHODOLOGY

3.1. Introduction

Eye tracking is one of the robust and accurate interdisciplinary methodologies of cognitive and linguistic research. As related research emphasizes the relationship between human mind and eye movements, eye tracking is a strong apparatus to reveal depths of mind. While eye tracking methodology is a robust technique, it is also sensitive and demanding. In this section how to maintain data quality and correct data acquisition procedures are scrutinized. In terms of technical concerns, types of eye trackers and their role in different cognitive paradigms are presented. Regarding data analysis, common statistical techniques and approaches are discussed through related research. In the final part, main auxiliary methodologies for eye tracking are mentioned briefly.

3.2. Data Quality

Data quality in eye tracking systems refers to the property of raw data samples produced by the eye tracking device. It is the total result of combinations shaped by sampling frequency, latency, precision, accuracy and participant specific features such as glasses, lenses, mascara and any calibration problems (Holmqvist et al., 2011). Data quality in eye tracking related research is crucial as it leads discussion and outcomes; more efficient and healthy data results in better outcomes and results while reverse results in a misleading research.

3.2.1. Types of Eye Trackers

Although all modern eye trackers use video based pupil corneal reflection technology, there are many types of eye trackers depending on research objectives. For instance, you need different types of eye trackers for reading research and sports research. Most of modern eye trackers are video based devices which records corneal infrared reflection. Typically, a video-based eye tracker works with infrared illumination, an eye video camera and an extra scene camera for mobile head mounted systems. The systems may be static; head mounted or rely on head tracking. These types are not only different in terms of illumination and camera but also show variety in the data recorded.

3.2.1.1. Static Eye Trackers

Static eye trackers are the most common eye tracking systems in which both illumination and eye camera works in front of the participant in a certain distance. There are two sub-types of static eye trackers: Tower-mounted and remote eye trackers.

3.2.1.2. Tower mounted eye trackers

Tower mounted eye trackers are in close contact with participants restraining head movements. The main aim of limiting head movements in tower mounted devices is to provide more accurate and precise data. Previously, bite bars were used to restrict head movements but today head and chin rests are used which provides more comfort for participants (Holqvist et al. 2011). But despite all, these devices create quite an experimental setting and not much comfortable for the participants. These systems are commonly used in microsaccade and neurology research.

3.2.1.3. Remote eye trackers

On the other hand, remote eye trackers has nothing to do with participants and mostly placed on the table or attached under the monitor on a laptop on which stimuli is presented. These systems are capable of viewing and recording eye movements from a certain distance. Remote eye trackers are small user friendly devices which provide practice in different settings as they can be attached to any monitor or laptop via USB. In addition, remote eye trackers enable a natural setting as they do not disturb participants. However, remote eye trackers are quite vulnerable to head movements and any environmental distraction and provide poorer quality of data. Despite their ease to operate, participants tend to forget the existence of the eye tracker. When a participant moves his head and eyes out of the reach of the device then returns his head to the initial position again, the remote eye tracker takes some time to resume tracking. This is termed as “recovery time” and may damage data quality. But recently these systems are elevated to higher standards by the manufacturers and commonly used by researchers as they provide easy and robust solutions. They are commonly used in reading research.

Remote Eye Tracker Tower Mounted Eye Tracker

Figure 8. Static Eye Tracking Systems

3.2.1.4. Mobile Systems

Mobile eye tracking systems refer to recording of eye tracking data in any mobile task such as driving, shopping and sports. They are also called head-mounted eye trackers in which both illumination and camera is placed on an helmet, a cap or a pair of glasses. The scene camera records the stimuli or the scene of view and the data is saved on a laptop which is commonly placed in a backpack. Recently many manufacturers tend to produce glasses rather than helmets as they provide much more natural experimental environment. And instead of backpack, a small recording device is attached at the back of the participant.

Head Mounted Eye Tracker Eye Tracking Glasses

Figure 9. Mobile Eye Tracking Systems

3.2.2. Metrics of Data Quality in Eye Tracking Systems

Eye tracking systems are electronic and software based devices which have different features and provide a wide array of data quality. Picking up the right device for a certain research is important in terms of data quality. For instance while using a 500Hz device for UX studies is unnecessary, it is vital for microsaccade or neurology research. Data quality related metrics for eye tracking systems are as follows.

3.2.2.1. Eye Tracker Sampling Frequency and Error Estimation

Sampling frequency is one of the most vital features of an eye tracking device. Sampling frequency is measured in “hertz (Hz)” which refers to how many times a sample is taken in a second. A sample in eye tracking data is the instant photo of the eye movement measured in miliseconds. While a 60Hz eye tracker records the eye movements of a subject 60 times per second, a 500Hz system does the same process for 500 samples per second.

Sampling rates of modern eye trackers range from 30Hz to 2000Hz which means that their sampling speed is quite variable. 25-30Hz eye trackers are considered to the slowest systems which records data in PAL and NTSC quality. 60-120Hz systems are common and used mostly in general reading and UX research. 250Hz eye trackers are threshold devices which represents the low-end of high speed devices. 500-1000Hz and 2000Hz eye tracking systems are not devices that a researcher can see everywhere and not many manufacturers produce these devices due to their cost and expenses.

The main argument is not the speed but which sampling rate to use. The answer depends on what will be done with the eye tracker. Latency and estimated error rate in eye trackers are crucial points to consider in terms of sampling rate. These metrics depend on the sampling rate and measured in terms of miliseconds. For instance, expected error and latency for an 50Hz system can be found by $\frac{1000}{50} = 20$ms. In other words, in an 50Hz system, there are 20ms between samples of eye movements such as fixations or saccades. The latency and the error refer to the possibility of the eye movement to emerge in these milisecond intervals. Any eye movement emerging in these intervals cannot be represented in the data. On the other hand, in a 500Hz system latency and error rate is 2ms which means that milisecond intervals between each sample is 2ms. So latency and error rate is considerably less in a 500Hz system when compared with 50Hz system. However, this does not mean that any eye tracking related research should be conducted with at least 500Hz systems. Eye tracking is an interdisciplinary too of measurement and depends heavily on the research objectives. To obtain data in UX studies, 30Hz and 50Hz devices are used commonly bu UX researchers. In reading research, estimated error rate and latency more than 20ms is nor recommended. In reading, saccades are around 30-40ms and larger than 10° (Holmqvist et al, 2011) and this means that an 60Hz system can record 1-2 samples per second. However for smaller saccades like tremors, microsaccades and drifts, higher sampling frequencies are required. According to the review of Martinez-Conde and Macknik and Troncoso with Hubel (2009), microsaccadic research requires at least 200Hz sampling rates.

Table 2. Sampling Frequencies for Microsaccadic Research (Martinez-Conde et al. (2009)

Sampling Frequency	*Number of Studies*
<200Hz	1
200-300Hz	9
500Hz	25
1000Hz	2

3.2.2.2. Accuracy and Precision

Accuracy of an eye tracker can be defined as the average difference between the true gaze position and the recorded gaze position. On the other hand, precision is the ability of the eye tracker to reliably reproduce a measurement. A good eye tracker is both accurate and precise.

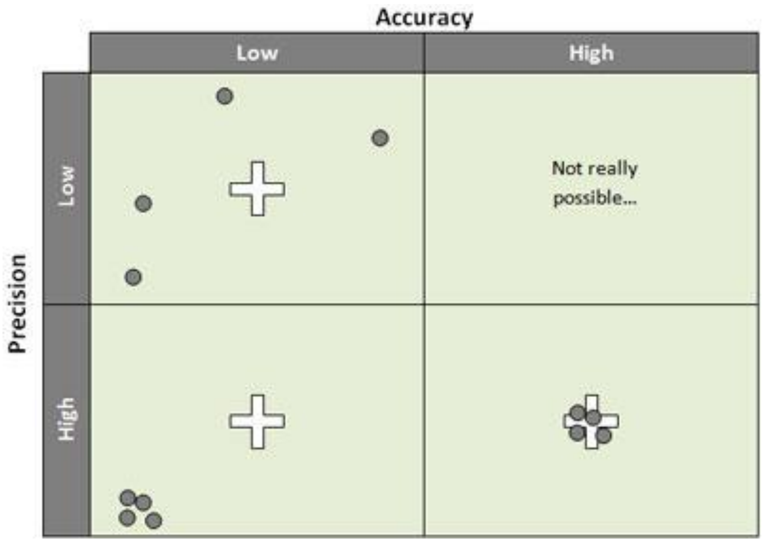

Figure 10. Accuracy and Precision

Common terminology related with accuracy and precision are as follows:

Offset: Angular distance between calculated fixation location and the location of the intended target. It is also the operational definition of accuracy.

Drift: A gradually increasing offset which is quite common in older eye trackers.

System-inherent noise: It is also known as “spatial resolution” which refers to the best possible precision of an eye tracker. This metric is ususally measured with artificial eyes by the manufacturers.

Oculomotor Noise: In general it refers to microsaccadic movements of the eye such as tremor, microsaccade and drifts although these micro movements are accepted to be parallel with cognitive processing.

Typical Precision: The average precision of an eye tracker measured from a high sample size of participants with a wide spectrum of eye physiology. It is the typical precision rate of an eye tracker.

Optic Artefacts: These include physiologically impossible eye movements with larger amplitudes often created by glasses, lenses, additional reflections and varying ambient light conditions.

Environmental Noise: It includes any electromagnetic or mechanical disturbance in the recording setting.

Noise (General): The sum of system-inherent, optic artefacts and oculomotor and environmental noise.

3.2.2.3. Robustness (Versatility)

Robustness is a quality of an eye tracker that refers to how well it works well with different participant groups. As human eye physiology incudes large amount of variables such as eye color, glasses, contact lenses or cosmetic applications on the eye, a good eye tracker is expected to work well with all of these. Poor robustness causes data loss and poor data quality while strong robustness is time saving and provide high quality reliable data. Today, high cost systems have high levels of robustness due to various hd camera angles and resolution.

3.2.2.4. Tracking Range and Headboxes

Tracking range (visual field of recording) refers to the efficient distance between the participant and the stimuli. It is about how far the participant can look at the stimuli while data is recorded. Similarly, headbox is the area in which participant can move without any damage to the recording process and data. Most high end eye trackers operate in tracking range of 45cm to 80cm. And for most of it, headbox volume is averagely about 30x21 at 60cm distance.

3.2.2.5. Monocular and Binocular Eye Tracking

Monocular eye tracking refers to the process of recording data from one eye only while binocular data acquisition enables data recording from both eyes. It is commonly believed that movements of left and right eye are identical so a vast majority of research is done monocularly (Holmqvist et al. 2011). In addition, monocular eye trackers are more affordable and researchers tend to prefer monocular data acquisition in eye tracking. Binocular eye tracking in mostly preferred in infant studies, clinical and neurological diagnostics and detailed microsaccadic research. It should be noted that with the recent developments in eye tracking technology; most of the devices are binocular today. Some companies also present monocular and binocular options for the researchers like Viewpoint Eye Tracker by Arrington research.

3.2.2.6. The Parallax Error

Parallax error is a distance related error types observed in mobile eye tracking systems. It simple refers to the misaligning of gaze cursor with the actual gaze location due to various distances. The underlying reason for parallax error is the fact that the scene camera and the eye look at the scene from slightly different angles

(Holmqvist, et al., 2011). Parallax error would be zero if the distance is identical with the calibration plane. However, when mobile participant starts to change location and look at different objects in different distances, parallax error is inevitable. Recent eye tracking technologies offer various hardware solutions to parallax error such as depth calibration and linear depth correction.

3.3. Experimental Design and Data Acquisition

Like other physiology and experimental research such as in neurology and psychology, eye tracking based research is sensitive and needs a carefully planned research design. First, researcher is required to make operationalization; that is to say, he needs to make the research idea precise and robust enough to record as behavioral and physiological data. There is no magic want to make this process immediate and it requires planning and piloting. As the scrutinizing of the research questions and results will depend on the physiological and behavioral data acquired from defined participants, eye tracking research demands step by step planning to reach accurate and objective oriented results.

3.3.1. The Explorative Pilot

Best research is the one which flows slowly through a tunnel of research plan. The explorative pilot is a small scale pilot study which will give a general sense about the research. Explorative pilot has a significant value as its results may give the researcher new insights show him any potential problem and draw a general research map. It includes an explorative study with a few participants to checkout if the planned research can be done. Through this small scale pilot, researcher must control if the eye tracking experiments can be maintained, observe any potential dysfunctions (electronic and behavioral) that may occur due to large scale of participants and modify research questions. For instance, in a research which aims to analyze the effect of classroom noise on reading behavior through eye tracking metrics, an explorative pilot can be employed with 3-4 participants. In this small scale pilot, researcher checks out if the stimulus (sound and text) works well with participants and observes experimental sessions regarding any potential problems such as electronic dysfunction, duration and participant behavior towards stimulus. In the end, researcher takes precautions, modify experiment and experimental setting or consider new variables such as memory or perception. The researcher may also notice that he may need new auxiliary instruments such as scales or interviews.

3.3.2. The Fishing Trip

The fishing trip refers to a larger pilot after and explorative pilot in which researcher tries to figure out which eye tracking metrics answers research questions of the planned study. There are many eye tracking metrics such as fixations, saccadic movements, refixations or dwell times and the researcher aims to categorize which ones work well with the related research. Holmqvist et. al (2011) resemble this phase to throwing a wide net in the water hoping that there will be fish. However, this phase may not give reliable results if the research is a “significance” oriented statistical study due to the low participant number. It may also exhaust researcher as recruiting participants, stimulus preparation, experimental design and analytic procedures take time. Moreover, researcher may be disappointed by finding no effective result. Despite all, fishing trip is required to avoid any severe research problems and it may also be an alternative for explorative pilot.

3.3.3. Theory Driven Operationalization

Every serious research needs a theory or a paradigm to be built on. Most research derives from previous ones as a rule of scientific development but the idea of a research may not depend on a theory of a paradigm or at least researcher may have hard times to root his idea on an acceptable scientific construction. When researcher is lucky enough, he may find a theory, a model or a research tradition to depend on. For instance, one of the pillars of this PhD thesis depends on an aspect of “The eye mind hypothesis” in first language reading which proposes that readers fixate more on the linguistic items that they find challenging. So this PhD thesis seek answers if the situation is the same in foreign language reading. Once the theory is based, the conceptual structure of the research is reasonable in general and requires a suitable experimental design.

3.3.4. Research Tradition Oriented Operationalizations

Due to the accumulative nature of scientific research development, certain topics become influential in time and become “Research Traditions” which depend on the accumulation of experimental results. These research traditions accommodate well defined paradigms in accordance with effective techniques, measurements and metrics. Depending on these research traditions saves life, researcher designs his idea depending on a well formed scientific construction and can get effective and accurate results. These traditions have a transitory nature; a tradition may be blended with another if enough theoretical and practical bases are provided. For instance, a qualitative paradigm in foreign language research can be blended with visual search tradition to analyze foreign language learner perception during a learning task.

The major research traditions in eye tracking research are as follows:

3.3.4.1. Visual Research

Visual search tradition includes a perceptual task involving active visual scan of the visual environment for a target such as a particular object or a feature among distractors which involve other objects or features. The principles of visual search are founded by Treisman and Gelade (1980). Visual search mainly focuses on attention and eye movements through a cognitive and visual perspective (Ranade, 2015). Searching for a face in a crowd or looking for a book on a messy desk are some tasks employed in visual search tradition.

3.3.4.2. Reading Research and Related Methodological Paradigms

This research tradition scrutinizes language processes involved in text comprehension. Reading research depends on syntactic and morphological aspects of language and tries to describe reading behavior depending on these factors. Commonly, a text is presented as a stimuli and the participant is asked to read it in a given duration. Major metrics for reading research are first fixation durations, first pass, refixations, saccade length, between and within word regressions (Holmqvist et al., 2011).

Gaze contingency refers to the display changes of stimuli depending on where or at what a participant is looking. There are two types of Gaze Contingency: Active (interactive) and passive gaze contingency.

Active gaze contingency is the process in which participant actively uses his gaze to control the change. For instance, a command can be fulfilled after fixating a region more than 400 miliseconds. According to Holmqvist et. al. (2011), a 50 Hz eye tracker with high accuracy and precision is enough for this process.

Passive gaze contingency is different and used commonly in reading and psycholinguistics research. Unlike active gaze contingency, passive gaze contingency does not require the participant to actively control the modification. Instead, researcher designs the experiment so that participant even cannot notice that the stimulus is changing. In reading research, passive gaze contingency enables researcher to obtain data about how much information is picked up from the word to the right of the fixated word. Passive gaze contingency experiments require a high end eye tracker and a fast system with suitable software. There are three common passive gaze contingency paradigms:

In "moving window paradigm", only currently fixated word which is also called "window" is visible in a sentence. The eye movements during this "window" are compared to eye movements in normal reading without any invisible areas. This is closely related with the contribution of peripheral vision to the cognitive processes during reading. It is found that peripheral vision is vital to solve the fixated word. On the other hand, "moving mask paradigm" is the inverse of the window. In this method, fixated word is blocked to reveal contribution of foveal information to the peripheral information. It is found that reading with a mask slows down the process dramatically while regressive saccades highly increased. The third one is "the boundary paradigm". In this method, a selected target word in the sentence is changed to a preview (anything meaningful or meaningless) before the fixation reaches the word. Once the participant fixates the preview, it is changed to its correct form. The main objective in this process is to figure out the effect of preview on fixation time.

Passive contingency paradigms demand high levels of cognitive and syntactic knowledge, besides such experiments can be done by high end devices. Related research shows that this paradigm helps the researchers to figure out the perceptual span and reveal the contribution of peripheral information such as orthographic or phonological features or role of foveal vision acuity to reading processes (Reder, 1973; McConkie & Rayner, 1975, Rayner, 1975; Balota, Pollatsek & Rayner, 1985; Miellet & Sparrow, 2004).

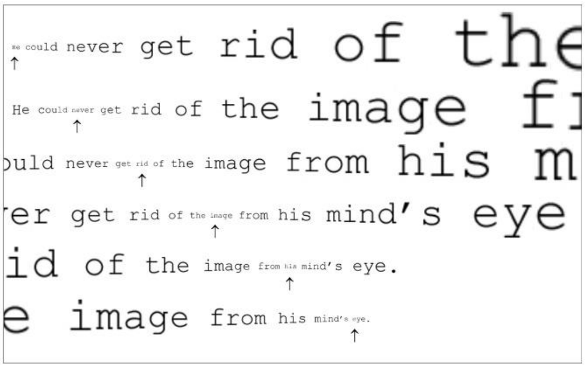

Figure 11. Moving Mask Paradigm

3.3.4.3. Scene Perception

Scene perception focuses on how we perceive visual scenes. Scenes include still images and videos which may be accompanied with audio stimuli. A stimulus is commonly presented on a computer monitor and researchers look for how it is perceived by the participants through fixations, AoIs and other eye movements.

3.3.4.4. Usability Research

Usability or UX research is a relatively recent tradition which focuses on actual real world use of different artefacts and relates it to cognition. Unlike other elder research traditions, the stimuli cannot be manipulated and real world interactions are scrutinized. Due to their real world focus, usability designs are quite sensitive to experimental setting and require participants to show behaviors highly identical to their real world performances. Where drivers looks more, how pilots administer a control panel in planes or where experienced engineers look most in a machine are all about usability.

3.4. Designing the Task

Similar to other psychological research instruments, eye tracking has limitations even with high quality data. Human behavior consists of several complex variables in which psychological, neurological and biological components work in a blending fashion. Hyrskykari et al. (2008) points out the fact that a person's gaze on a certain region or point may not mean that he is having a cognitive process or having difficulty in perception. The person may fixate on a location not because he does not understand but because he already knows it and it attracts his attention. Likewise, Triesch et al. (2003) show that participants fixate on a region but no working memory trace can be observed. Moreover, Underwood (2003) found out that drivers talk about objects in detail that they haven't fixated during driving. Similar results are also reported by Griffin and Spieler (2006). Eye tracking as a meter of complex human behavior needs a proper and a well-designed task to avoid those limitations to a high extent. Holmqvist et al. (2011) enlists 3 major criteria for a good eye tracking task:

> *“The task should be neutral with regard to the experimental and control conditions. The task should not favor any particular condition” (pp: 77).*

The eye tracking task should be natural in terms of experimental and control conditions. To reach a healthy comparison between these two provides results for the research so researcher has to pay attention to keep the balance between them. For instance, stimuli that is presented in experimental and control phases should be identical. Indeed, a less challenging reading text in experimental condition may give the researcher statistical significance but this results won’t be accurate enough.

> *“The task should be engaging. An engaging task distracts the participant from the fact that they are sitting in, or wearing, an eye tracker and that you are measuring their behavior” (pp:77).*

The task designed should be attractive enough to motivate the participant to fulfill. When the participant does not find the task interesting and attractive enough, his awareness of experimental setting rises in which he notices eye tracker or any experiment related environment. Then he may not present natural behavior.

> *“The task should have a plausible cover story or be non-transparent to the participant. This stops the participant from second-guessing the nature of the experiment and trying to give the experimenter the answers that she wants. When the experiment itself causes the effects expected it is said to have demand characteristics” (pp:77).*

The plausible cover story here is about how researcher will hide the experiment and theory from the participants. In other words, participants should not know that their eyes are tracked in detail. Of course, in terms of research ethics, participants should be informed about the experiment in consent forms but this does not mean that they will be informed about saccades or fixations. That is to say, when participants know that backwards saccades refer to regressions in reading which mean that they have reading comprehension difficulties, they may tend to make less regression to show that they have less comprehension problems. In addition, giving detailed information about the device and experimental setting will distract the participant throughout the task.

Experimental procedures include how participants behave throughout the experiment and its health positively correlates with planning. Just asking participants to look at a picture or to read a passage is not enough for an efficient experimental procedure and researcher is required to be brief, clear and explanatory. Recent eye tracker software is suitable for these purposes which guides the participant throughout the experiment. But these parameters are set by the researcher, not by the software.

To avoid task related problems in eye tracking research, researcher and participant interaction is vital. Holmqvist et. al (2011) state that the task start when the researcher first contacts with the potential participants. Starting from the beginning, researcher should inform the participants about what they will and will not do throughout the experiment. He should also give brief explanation of the study and aims without explaining any scientific detail. In addition, researcher should pick up participants with previously defined criteria related to the research questions such as age, gender, graduate degree, employment, glasses, lens and so on.

3.4.1. Sample Size

Sampling and sample size can be defined after designing the experiment. Researcher has to choose participants with previously defined criteria as eye tracking trials are quite experimental and sensitive. Sample size is another crucial point to consider. Eye tracking trials are sensitive experimental procedures which takes time. For each participant, researcher has to spend time depending on the duration of the experiment and the calibration procedures. For instance, single experiment may have 10 minutes in total including calibration. So 40 participants take nearly 7 hours to finish. On the other hand, low participant number would probably not give significant results. Sample size actually depends on the researcher and current trends in research. What researcher should keep in mind is that extreme numbers of participants (low or high) will not give accurate results. For instance, while a researcher cannot find significance in .05 level with %95 confidence interval with 35 participants, same task may give significant results in same parameters with 500 participants. In the same situation, results with 6 participants cannot be generalized. In addition, researcher should consider participant exclusions due to bad data quality. So, for a healthy experiment and reliable results, 30-80 participants are ideal.

3.5. Statistical Procedures in Eye Tracking Data

Once data is collected, researcher analyzes the data to seek answers for the research questions. Through a number of quantitative steps, the data can be prepared for interpretation.

3.5.1. Data Exploration

Data exploration is an initial statistical step which is highly significant. In this process, data is explored to optimize it for further statistical processes. Throughout this exploration, some participants are excluded and data is scrutinized in terms of its quality.

First step is to check whether the data quality is sufficient. Recent eye tracker software are able to inspect recorded data through gazeplots, heatmaps and scanpath plots. By scrutinizing these, researcher can have a general sense of the quality of the data.

Second step includes distribution of variables. That is, researcher checks out if the data is normally distributed. However, most of the time eye tracking data is not normally distributed (Holmqvist et al. 2011). Eye movement metrics such as fixations and saccadic measures tend to have skewed distribution which indicates that data is not normally distributed. Then data can be transformed into normal distribution by using proper statistical software.

Third step of data exploration is to identify outliers which aim to define values falling outside normal range of measurement. Outliers are excluded to promote data quality.

3.5.2. Data analysis

In this part, researcher identifies levels of measurement including nominal, ordinal and interval variables. Commonly, demographic values such as gender or age are categorical variables while fixations and saccadic measurements can be treated as interval variables. Depending on these statistical identifications and results of data exploration, researcher employs statistical tests in accordance with the research questions. Some of the common statistical tests defined by Holmqvist et al. (2011) are ANOVA, Regression, Logistic Regression, Multilevel Modeling and Loglinear analysis.

3.6. Methodological Triangulation of Eye Movement Data

Eye tracking is quite a useful interdisciplinary tool which can be employed in many different fields. Despite its fascinating benefits for behavioral research, eye tracking has also limitations and short comings. For instance, eye tracking provides regions and degrees of a cognitive process but may not alone explain it in detail. As a result, research may need to support eye tracking data with some other research tools for further scrutiny and scientific exploration. By blending these tools, weaknesses of one tool can be complemented by the strength of another which enhances scientific persuasiveness, credibility and confidence which is termed as methodological triangulation or cross validation (Denzin, 1970; Bryman, 1984; Webb et al. 1966). These auxiliary data includes measurements such as questionnaires, EEG (Electroencephalography), GSR, fMRI (function Magnetic resonance imaging), Motion Tracking and verbal data.

3.6.1. Verbal Data

When eye tracking data is stuck, the easiest way to reveal insights in a cognitive process is to ask people through verbalization. Interviews helps the researcher to explain eye tracking data however there may be a difference between what participants report and what they do in a behavioral task. Watson (1920) and Duncker (1945) developed a method called "think-aloud which is quite a reliable verbalization method. There are two primary ways to conduct a think aloud interview. Participants may be required to verbalize their thoughts on the target area during the eye tracking experiment and this simultaneous method is called Concurrent Think-aloud protocol. On the other hand, participants may describe their experiences after the task is completed which is called Retrospective think aloud protocol. Both of these methods provide useful verbalization data about the cognitive processes.

3.6.2. Questionnaires and Likert Scales

Questionnaires and likert scales are low tech but crucial tools of investigation which may give insights to an eye tracking study. Through these instruments, researcher can build correlations and statistical relationships between eye movements and questionnaire items or components. However it should be noted that response bias may occur which refers to the difference between what participants respond and how they behave. This greatly affects the efficiency and accuracy of the triangulation. Researcher should consider and take precautions to avoid response bias.

3.6.3. Galvanic Skin Response

Being a part of the autonomic nervous system, sympathetic nervous system functions to regulate various body functions including sweating, heart rate, breathing, and digestion. The sympathetic nervous system controls sweat (Martini, 2001), thus this measure is used as an indicative of emotional or physiological arousal to examine the emotional state. Galvanic Skin Response (electro dermal response) refers to the physiological process of the skin which momentarily becomes an efficient conductor of electricity during a physiological arousal. GSR method measures this electrical conductance of the skin depends on the amount of moisture on the skin. Triangulation of eye tacking and GSR provides further exploration of the relationship between cognitive load, emotional reactions and anxiety through pupil dilation.

3.6.4. Electroencephalography (EEG)

Human brain processes through electric signals between neurons. EEG is a neurological measurement which detects and acquires electrical activity in brain with small metal discs called electrodes attached to the scalp. EEG is a demanding process which requires experience in neurology and experimental abilities. Most of the time, signals acquired through the scalp are not strong enough for further analysis and these signals are amplified for data analysis by the EEG hardware. The raw EEG data is mostly used for clinical and diagnostic purposes.

As sampling frequencies of eye tracking and EEG are identical, triangulation of these two provides advanced scientific exploration. In cognitive psychology and triangulation of eye tracking and EEG, raw EEG data is taken and time locked to average certain repeated signals. This technique is called ERP (Event related potentials (Luck, 2005). Such an averaging process enables all brain activity filtration that is not related to the appearance of the stimulus. The Event Related Potential (ERP) technique can provide raw EEG data, which refers to the neuro-electrical activity acquired from the brain which can be then used to investigate desired cognitive processing. In reading research with eye tracking, these parameters are used to explain cognitive processes (Dambacher and Kliegl, 2007; Takeda et al., 2001; Simola et al. 2009).

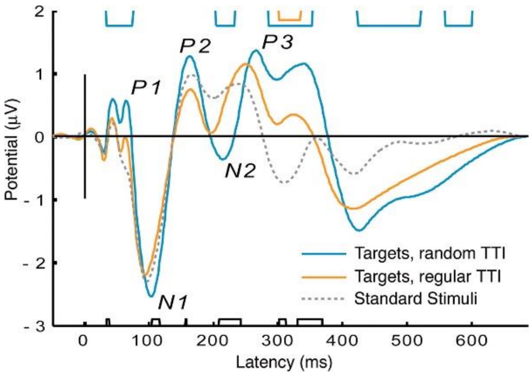

Figure 12. ERP data

3.6.5. Functional Magnetic Resonance Imaging (fMRI)

Functional Magnetic Resonance Imaging is a neuroimaging procedure using MRI technology which measures brain activity by enabling the observation of blood flow in neurotic system (Huettel et al. 2009). FMRI basically relies on the fact that the activation of a certain cerebral region depends on the blood flow in that region. It is challenging to triangulate fMRI and ET as temporal resolutions of them are different (Holmqvist et al. 2011). While ET measures eye movements in 0.5- 1ms time, fMRI functions in temporal resolution of 1000ms. Despite the challenges, some studies blended these methods. Simola, Stenbacka and Vanni (2009) measured the activity in visual cortex during eye movements. Ford, Goltz, Brown and Everling (2005) used an anti-saccade task which is compatible with slow fMRI data.

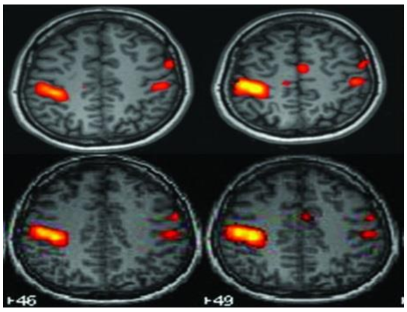
Figure 13. fMRI process

4. EYE MOVEMENTS AND FOREIGN LANGUAGE READING

4.1. Introduction

Eye movements throughout reading accommodate invaluable clues about human reading behavior. In recent years, eye movements have been started to be scrutinized in detail in foreign language reading. How readers respond to different syntactic structures, lexical items, distinguished contextual features, saccadic programming and many more issues of foreign language reading in terms of eye movements are quite trendy. In this part reading and foreign language reading is defined. Lower and higher level cognitive processes during foreign language reading are presented including word recognition and sentence processing. In addition related linguistic concerns such as ambiguity, deep structure, traditional grammar, sentence structure are discussed. The role of working memory through foreign language reading and word recognition is also handled in terms of related research and paradigms. And finally attention and consciousness in foreign language are examined in detail. These details include noticing and noticing hypothesis in foreign language, debates on consciousness in foreign language and criticisms to noticing hypothesis relying on related foreign language research.

4.2. Definition of Reading

Human beings did not born with an innate reading ability but instead reading was invented by people only about 5000 years ago (Wolf, 2007). We read with little effort and little planning and approximately over 80 percent the world population can read (UNESCO, 2007). We read books, newspapers, advertisements and any written code and understand them in accordance with our cognitive skills. We read various printed materials including books, magazines, posters, emails, billboards and many others to relax, to learn, to obtain information, to send information and we always read whenever we write. We read at school, at the office, in the shopping market, at home and anywhere a person can imagine throughout the daily life. In addition to read, reading is a must in modern society, without it, an individual cannot carry on a modern life.

Today people not only read in their native language but also read in a second or more languages. People are developing their L2 skills either in formal or in informal settings. Development of reading skills is vital for a foreign language learner to perceive and string along with the foreign language world. It is important to communicate with speakers of other languages, to integrate a foreign language community, to travel abroad, to get a good job, to obtain information, to recognize new cultures and be entertained. In addition, modern societies today puts great emphasis on learning more languages. Societies of the modern world are getting more and more complex and Grabe (2010) emphasizes that foreign language reading is one of the keys for being a successful citizen in rapidly developing world.

For more than a century, English is rising as the lingua franca of the modern world and its impact of educational systems all over the world is remarkable. Today, a majority of education systems require students to learn English for various purposes to a certain extent. Crystal (1995) defines it as a reality of 21th century. This reality is fulfilled with great speed today and reading is an inseparable part of it. In most economies and educational systems of the world, reading in English is seen as a primary prequisite for career development, professional and academic success.

Reading is a basic life skill which has been defined various times by many researchers. Urquart and Weir (1998) define reading as the process of extracting information encoded in language form via the medium of print. Similarly, Koda (2005) handles reading as a process in which comprehension occurs while the reader obtain and integrates various information from the text and combines it with what is already known. Surely, reading is certainly a process; it is a combination of complex processes. Reading is perceived as a general process of these process combinations and it can be defined with these processes. Grabe (2010) explains reading with 10 processes:

- A Comprehending Process
- A Rapid Process
- A Strategic Process
- An Efficient Process
- An Interactive Process
- A Purposeful Process
- A Learning Process

- A Flexible Process
- An Evaluative Process
- A Linguistic Process

Fluent reading is a rapid process, an average reader reads most printed materials at about 250–300 wpm. This rate may vary due to the characteristics of the material but normally readers read at high speeds. Similarly, reading is an efficient process in which readers combine and coordinate different cognitive skills such as word recognition, syntactic parsing, meaning formation, inferencing and critical evaluation. Reading is a comprehending process, that is, people read to understand and comprehend a text normally. All cognitive processes involved in reading serve this primary objective. Reading is an interactive process. Firstly, reading process involves parallel interaction of several cognitive skills such as sentence parsing or word recognition. Secondly, reading is an interaction of writer and reader; writer conveys intended message and reader interprets it. Reading is a strategic process which requires reader multiple efforts such as anticipation information, mental summarize or repairing comprehension breakdowns. These multiple efforts make reading a flexible process in which reader adapts himself to reading goals. Reading is an evaluative process; readers continuously evalute and monitor their processing throught reading. Readers also evaluate writer and ask questions such as “Do I like author’s message?”, “Is the information interesting?”, “Do I agree with the author?”. All these evaluations and interactive processes make reading a learning process. People make decisions and evaluate depending on what they read; memory related functions are active during reading which enables learning new experiences. And finally, reading is a linguistic process. Without grammatical, syntactical or phonological competences, people cannot decode written graphic forms and comprehension do not take place.

4.3. Types of Reading in terms of Academic Purposes

People read various printed materials for a number of purposes. They read a novel to entertain, an exam paper to evaluate or a scientific article to obtain information. Human cognition is flexible and adapts to the objectives of reading. Grabe (2010) enlists 6 different types of reading.

4.3.1. Scanning and Skimming

Scanning and skimming refers reading quickly to search for a specific information (Guthrie, 1988). These processes include high rates of word per minute (wpm) and relatively quite fast. Scanning is mainly employed to identify a specific graphic form (e.g. a word, a sentence or a picture) while skimming mainly refers to quickly reading to have a general understanding of the text. When a student looks for the term “eye tracking” in a book, he employs scanning. Similarly, when a student tries to understand if a certain text is about “eye tracking”, he employs skimming.

4.3.2. Reading to Learn

Reading to learn is generally employed in educational and professional settings. Basically, reading a certain text to obtain specific information for further use is reading to learn. Reading to learn is quite a demanding cognitive process as the reader is required to remember the obtained information and recall it when needed (Carver, 1992; Enright et al., 2000). As a result, reading to learn processes are rather slow and people read about 200 wpm (Carver, 1992). For instance, a student reads a biology book to learn about cellular structure of human beings.

4.3.3. Reading to Integrate

One of the most challenging types of reading is reading to integrate. It requires advanced cognitive skills as it requires the reader to read multiple texts and synthesize them (Chall, 1983). This type of reading is commonly employed in academic settings which requires reader to combine different segments of information to a single unified piece of information. Reading to integrate requires experience as reader is needed to organize an efficient frame of information synthesizing.

4.3.4. Reading to Evaluate

Reading to evaluate is a critical process and includes complex cognitive features similar to reading to integrate. Previous knowledge and employing it to the reading process is crucial to reach a critique of the text. Grabe (2010) points out that the primary requirement of reading to evaluate, “except the ability to construct a careful understanding of the text, is that it involves the application, and especially rhetorical control, of a reader's attitudes, emotional responses, interests, and preferences to the interpretation of the text”. Evaluating an exam paper or criticizing a research paper are some examples of reading to evaluate.

4.3.5. Reading for General Comprehension

Being the most common reading purpose, reading for general comprehension is the default assumption for the term reading comprehension (Carver, 1992). It is employed while reading a novel, a newspaper or a magazine. In fact, comprehension purposes also provide a foundation for other reading purposes mentioned but more automatized than other types of reading. The level of comprehension can be developed rapidly with periodical extensive reading.

4.4. Construction of Fluency and Comprehension During L2 Reading

According to Ashby and Rayner (2006), once reading is learned, it becomes an automatic process which is effortless and unconscious. Surely, readers are rarely aware of the complex cognitive procedures involved during reading. However, this unawareness does not make reading an easy process. Grabe (2010) categorizes these processes in to two components as lower level processes and higher level processes.

4.4.1. Lower Level Processes and Word Recognition

Lower level processes in reading refer to a group of skills which have the potential to become strongly automatized. These processes include word recognition, syntactic parsing and semantic proposition encoding. These three major components of lower level reading processes work in coordination with working memory and comprehension cannot take place without the efficient operation of them.

Word recognition is one of the most crucial processes of reading comprehension and a strong predictor of reading ability (Adams, 1999; Juel, 1988; Perfetti, 2007). Reading research shows that comprehension and fluency in reading is only possible with rapid and automatic word recognition. During reading, readers focus visually on almost 80% of the content words while functions words are not fixated in high rates. During reading, a word is recognized in less than 100ms (Ashby & Rayner, 2006; Breznitz, 2006) and readers fixate on a word about 200-250ms averagely. As a result, a fluent reader can automatically and effortlessly reads a text a 250-300 wpm. On the other hand, inefficient word recognition leads to comprehension breakdowns and slow rates of reading.

To employ word recognition, a reader must recognize words rapidly by activating links between graphic form and phonological information, building appropriate semantic and syntactic constructions and recognition morphological structures such as affixation or derivation. These sub skills are described as “constituents of word recognition” by Perfetti and Hart (2001). These processes show that word recognition involves the interaction of activated orthographic, semantic, syntactic and phonological processes.

4.4.1.1. Orthographic Processing

Orthographic processing refers to the recognition of visual forms in a text. Grabe (2010) categorizes these forms as letters, letter groups, visual word shapes, and key shapes that are letter parts such as the long vertical line in “l” or “b,” or the right-hand curve in “b” or “o” or “p”. According to connectionist theories of word recognition, all of this orthographic information is processed in groups rather than in letter-by-letter fashion. There is a close relation with the amount of orthographic information and reading rate. Longer words take more time to process while shorter ones take less time (Rayner & Pollatsek, 1989).

4.4.1.2. Phonological Processing

In word recognition processes, phonological activation is the first step before orthographic, morphological and semantic processes (Grabe, 2010). The main model of phonological processing in word recognition is the Dual Route Model.

The Dual Route Model (Coltheart, 2005; Coltheart et al., 1993, 2001) proposes that that two separate mental routes are involved in reading aloud and word recognition with output of both mechanisms contributing to the pronunciation of a written stimulus. First mechanism is the lexical route which proposes that every word a reader has learned is represented in a mental database of words and their pronunciations like a dictionary (Zorzi et al. 1998). When a skilled reader sees and visually recognizes a written word, he accesses the mental dabase and retrieve the information about its pronunciation (Coltheart et al. 1993). This mental database encompasses every learned word but this route doesn't enable reading of nonwords such as “kucsxy”. Another component of Dual Rote Hypothesis is the nonlexical or sublexical route which suggests that readers sound out a written word. This process is accomplished by identifying the word parts (letters, phonemes, graphemes) and applying phonological rules such as connected speech (Pritchart et al. 2012). This mechanism can be thought of as a letter-sound rule system that allows the reader to actively build a phonological representation and read the word aloud.

4.4.1.3. Semantic and Syntactic Processing

Semantic and syntactic information in a word becomes available after word recognition and is used for word-integration and comprehension processes. However, this does not mean that no semantic and syntactic information contribute to lexical access. Coltheart et al. (2001) proposes that through automatic spreading activation mechanisms, before a word after another is accessed lexically, semantic and syntactic information retrieved previously is employed on the neighboring word before its lexical access. Collocates and lexical relations such as synonymy, hyponymy or antonymy are accessed in a similar way. Semantic and syntactic processes are less apparent as they are slower relatively but they can be observed easily with non-fluent readers.

4.4.1.4. Lexical access

When readers start to process words while reading, they start retrieving ortographic information from letters or letter groups. Then they access phonological features of these orthographic units such as consonants and vowels. These processes activate reader's mental lexicon and scans for potential word forms for semantic and syntactic access. Within the accumulation of these word recognition processes, word candidates contribute orthographic, phonological, and semantic information to the process until the form that is the best match is then accessed. All these activation procedures builds the matching lexical item and lexical access occurs in working memory.

In L2 reading contexts, beginners cannot build a matching lexical entry in their mental lexicon for unknown words. They may be able to pronounce and recognize them; both orthographic and phonological access takes place but no semantic, syntactic process is accomplished. As a result, lexical access does not occur. In such situations, word recognition can be said to be in minimal level.

4.4.1.5. Morphological Processing

Morphological concerns of word recognition have a significant place in reading research (Carlisle, 2003; Carlisle & Stone, 2005; Rayner & Pollatsek, 1989; Kuo & Anderson, 2008; Mahony, Singson, & Mann, 2000; Nagy, Berninger, & Abbott, 2006; Nagy et al., 2003). Derivational processes through affixation are highly common in many languages including English and morphological knowledge is observed to contribute a lot to word recognition processes (Carlisle, 2000; Deacon & Kirby, 2004; Nagy, Berninger, & Abbott, 2006; Shu et al., 2006; Liu, 2014). The information retrieved from morphological clues helps readers to access syntactic aspect of the words. Grabe (2010) states that a current issue is whether or not morphological processing plays a role in lexical access itself or if it primarily provides key information for integrating words into syntactic structures and meaning groups after these words have been accessed.

4.4.2. Automaticity in Word Recognition

All of the processes above embody automaticity. Word recognition should be a rapid and automatic for fluent reading and comprehension. However, speed may not always refer to comprehension but automaticity is critical. When a reader gains automaticity, he cannot stop himself from recognizing a word. For instance, when we see the word “free”, we automatically access all processes including orthographic, phonological, semantic, syntactic, morphological and lexical if the word is already in our mental lexicon. It is a parallel processing in which brain activates all required mechanism simultaneously. This procedure cannot be controlled and all happens just in 100 or 200ms. Fluent readers have large mental lexicons which they rapidly recognize words accurately and effortlessly throughout reading.

4.4.3. Contextual Effects in Word Recognition

Normally, fluent readers who can apply all processes mentioned above rapidly and accurately do not need the context to access a word. The main reason is that retrieving information from the context takes time to process and interpret (Rayner & Pollatsek, 1989; Stanovich, 1980). A fluent reader accomplishes all parallel processes in about 200–250 milliseconds and do not need time consuming contextual procedures. However, context information may be crucial for slow readers and foreign language learners. It is a useful support for word recognition when a reader slows down because of processing difficulties, or a word that is confusing or not well known or well learned (Grabe, 2010). In such cases, contextual clues are used for accurate word recognition despite slow rate of reading.

4.5. Syntactic Processes

In linguistics, syntax refers to the appropriate rules which are applied to build sentential constructs to convey a message. Grammatical rules that combine sentences to meaningful wholes are vital for cognition and interpretation.

4.5.1. Traditional Grammar

Traditional grammar is a Latin originated grammatical system which is considered to be the most common and widespread grammar. It is also known as pedagogical grammar as it is the type of grammar that is used for educational purposes (Matthew, 2006). Traditional grammar includes the following lexical classes which are commonly known:

Nouns: computer, mountain, George, river, love

Articles: a, an, the

Adjectives: happy, desperate, large, extraordinary

Verbs: play, talk, dream, study, read

Adverbs: slowly, bravely, quickly, yesterday, today, frequently, weekly

Prepositions: at, in, near, with, under, between

Pronouns: he, she, it, we, they, you, myself, herself, mine, yours

Conjunctions: and, but, because, while, when, moreover

4.5.1.1. Sentence

“Sentence” is one of the words that we are quite familiar. Even though the term “sentence” seems quite simple, it is not so. As a linguistic term, sentence has been defined with more than 100 different definitions but none of these descriptions are perfectly adequate. Basically, a sentence is a grammatical organism consisting of one or more words that are grammatically linked. A sentence expresses a complete thought which is built with combinations of related words. In addition, a sentence can also be defined in orthographic terms alone, such as defining it as anything which is contained between a capital letter and a full stop (Halliday& Matthiessen, 2004). Both of the statements below are sentences:

Workers finished their work in the afternoon. (a typical sentence with a subject, adverb, object and a verb)

London. Michaelmas term lately over, and the Lord Chancellor sitting in Lincoln's Inn Hall. Implacable November weather (Dickens, 1853). (Orthographically defined sentence; combination of related linguistic units between a capital letter and full stop).

4.5.1.2. Clause

A clause is a statement that generally consists of a subject and a verb and expresses a complete thought like “Emre is playing outside.” Sentences typically include a single or more clauses. Technical details are as follows:

An independent clause contains a subject, a verb, and a complete thought like in “Peter published his article 2 months ago.”

A dependent clause contains a subject and a verb, but no complete thought. For example:

“…., before she sleeps.” or “….than my laptop.”

In English, a dependent clause usually begins with a dependent word. Dependent clauses are also knows as subordinate clauses and mostly a subordinating conjunction is used to link the subordinate clause to an independent clause. Some common subordination conjunctions are “but, before, that, than, why, if, while, when, after, if, as” and so on. With these subordinating conjunctions we build subordinating clauses which cannot express a complete thought without an independent clause. For example:

……because George left the city. (Subordinate clause stands alone and makes partial sense)

She was so unhappy because George left the city. (Subordinate clause is linked to an independent clause and together they express a complete thought).

4.5.2. Types of sentences by Structure

A Simple Sentence has one independent clause:

Thomas drives car.

A compound sentence has two independent clauses joined by a subordinate conjunction, transition or by semicolon.

Thomas drives car and Michael rides motorbike.

A complex sentence has one dependent clause (mostly starting with a subordinating conjunction or a relative pronoun) joined to an independent clause.

Thomas drives car better than Mary does.

A Compound-Complex sentence has two independent clauses joined to one or more dependent clauses.

When Thomas drives car, Jack rides bike and Mary rides bicycle.

4.5.3. Concord (agreement)

Concord (aka agreement) is a grammatical process in which a word changes form depending on related words (Pyles, 2009). For example, consider the sentence "Mehmet studies hard to pass". This sentence is a present tense expression and the verb "study" is modified by an inflectional morpheme (-s) depending to the subject (Mehmet). In other words, the verb is inflected to provide the agreement between the subject and the verb. Concord depends on a number of factors as listed below:

4.5.3.1. Number

Concord takes place depending on number; singular or plural forms. Some examples are "dogs are – a dog is", "pilots fly- a pilot flies" or "their cars are- a car races" and so on.

4.5.3.2. Person

Simple, agreement is also based on the subject. For example, we use "is" for he, she, it, or lexical morphemes like cat, laptop or mouse. For we, you and they, we use are. We never produce a sentence like "She are quite hardworking" or "They is going to race".

4.5.3.3. Tense

Tenses are cool topics of language education in which most of our teachers always warned us about "-s" in present tense or "did" and "V2" issues. Indeed such warnings do not seem to have worked much, even everybody knows tenses somehow, they still cannot speak. Anyway, agreement between tense requirements and verb is important; we use different suffixes and auxiliary verbs for different tenses. Not only tenses but also direct- indirect speech and active- passive voice tense agreement is important for concord. “Ahmet is go to shopping” and likes damages concord.

4.5.3.4. Gender

We cannot use “his” for a female or “her” for a male in English. When gender is unknown, “it” or “its” is used.

4.5.4. Deep vs. Surface Structure

According to Chomsky (1965) a sentence in a language has two layers of representation which are called “deep structure” and “surface structure”. **Surface structure** refers to what is seen on the sentence surface. For example:

You activate the air conditioner.

The air conditioner is activated by you.

Activate the air conditioner.

These three sentences seem identical but they are different sentences. In each of those sentences, similar words are used in different syntactic and grammatical rules to express an identical thought but these sentences are not the same, in other words, they have different surface structures.

Our linguistic knowledge asserts us that although those 3 sentences seem different, they are closely related in meaning and they express an identical thought. So we can say that they have the same underlying cognitive construct; they have the same **deep structure.** Pinker (2007) defines deep structure as the abstract grammatical relationships in a sentence. Here is an example you can consider on more:

Şu çocuk bilgisayarı kırdı hocam.

Bilgisayarı kıran şu çocuktu hocam.

Hocam bilgisayar şu çocuk tarafından kırıldı.

Şu çocuk kırdı bilgisayarı hocam.

4.5.5. Syntactic Ambiguity

In syntax, ambiguity refers to the property of having more than a single interpretation of a sound, word, phrase or sentence (Smith&Kosslyn, 2014). Syntactic ambiguity (amphiboly or structural ambiguity) is a type of ambiguity in sentence level which can be described as a sentence may have more than one underlying meaning. For instance:

Agent 47 killed the murderer with a knife.

Penceremden uçan kuşları seyrediyorum.

The first sentence can be interpreted in two ways: Agent 47 may have killed the murderer by using a knife or Agent 47 may have killed the murderer who had a knife. In the second sentence, the subject may be watching the birds that flew from the window or the subject may watch the flying birds by the window. Such sentences are syntactically ambiguous sentences from which are open to more than a single interpretation.

When a sentence is totally ambiguous and ambiguity cannot be solved by the end of the sentence; this sentence is globally ambiguous. Two examples above are both globally ambiguous sentences. On the other hand, a sentence is locally ambiguous when only a part of it is ambiguous. In locally ambiguous sentence, ambiguity is resolved by the end of the sentence. For example:

The old train,… (2 meanings = "the old people train others" or "the old train")

The old train, the young fight. (Single meaning, no ambiguity)

4.5.6. Lexical Ambiguity

Different from syntactic ambiguity, lexical ambiguity refers to ambiguity in word level; a word's having more than one interpretation or meaning. Lexical ambiguity is closely related with lexical relation polysemy. For example:

I can't find my bat, where is it?

In the sentence above, word "bat" is ambiguous as it may mean a baseball bat or the flying mammal. Solving lexically ambiguous sentences depends heavily on linguistic context.

4.5.7. Garden Path Sentences

Gleason and Ratner (1998) describes garden path sentences as ambiguous syntactic structures which mislead the reader or disable interpretation. Actually, a garden path sentence is a grammatically correct construction. They mislead the reader to an unexpected semantic ending and most of the time initial interpretation of the reader is wrong. In psycholinguistics, garden path sentences point out the fact that readers read one word at a time due to eye physiology and foveal limitations. Some examples are as follows:

The old man the boat.
The girl told the story cried.

The man who hunts ducks out on weekends

4.6. The Psychology of Reading

Reading is the process in which reader extracts and comprehends information from a text. The psychology of reading focuses on how this information is extracted and how comprehension occurs through cognitive, sensory and neural mechanisms.

4.6.1. Cognitive Aspect: Memory And Reading

All human behavior is manipulated by memory. Memory mechanisms covers a large portion of reading behavior ranging from recognizing words to comprehending sentences and building a meaningful textual network (Taylor&Taylor, 2013). Basically, memory can be scrutinized in two main categories: Working Memory and Long term memory.

Long-term memory involves the permanent records of our experiences and our efforts to interact and understand our environment. It is the storage of more permanent knowledge and skills. Alphabet, thousands of words, phrases, linguistic structures, grammar and a vast number of linguistic knowledge are restored in long term memory. When needed, required items in this storage is recalled during reading. When a necessary item is absent in long term memory, short term memory overpowers its capacity throughout the reading process.

On the other hand, the term “working memory” is less comprehensive and refers to a limited capacity cognitive system which is capable of briefly storing and manipulating information involved in the cognitive performances such as reasoning, comprehension and learning. According to Grabe (2010), while long-term memory is a major resource of reading, the key memory concept for reading comprehension is working memory. Working memory is a real time phenomenon which enables the cognitive processes in the mind during active processing of information while long-term memory is a vast unlimited type of human cognitive system.

Alan Baddeley and Graham Hitch proposed a model of working memory in 1974, in an attempt to describe a more accurate model of short-term memory. Theoretically, working memory consists of a limited-capacity attentional control system which is called “the executive control”. This system has 2 sub components as “phonological loop” and visuo-spatial sketchpad.

4.6.1.1. Central Executive

According to this working memory model, the central executive is the most crucial part as it controls and monitors the actions of other components; slave systems by relating them to long term memory. With its limited capacity, central executive acts as an executive core during cognitive processes. Baddeley (1986) explains central executive with a metaphor: The manager makes responsible decisions on which issues deserve attention and which can be ignored. In addition, central executive choose strategies for problem solution. In fact even manager can do limited number of jobs at the same time.

4.6.1.2. Slave System 1: Phonological Loop

This part of working memory mainly deals with sounds of written and spoken stimuli. It has two parts: Phonological Store and Articulatory Control Process.

Phonological Store is closely related with speech perception and stores written or spoken information in sound form like an “inner ear”. It directly stores spoken input while written forms must be transformed into an articulatory code before storing.

The articulatory control process is the “inner voice” which rehearses information in the phonological store. It continuously loops information like a tape. An example is remembering our school number when we hear it. As long as this number is active in this area, we can retain it at any time from the working memory. In addition to these, the articulatory control process also transforms written forms into an articulatory code which is required for phonological store.

The phonological loop performs critical functions for word learning and word-recognition skills. When a new word is learned, it is stored, rehearsed and reinforced by phonological loop for long term usage. (Baddeley, 2006; De Jong, 2006).

4.6.1.3. Slave System 2: The Visuospatial sketchpad

The Visuospatial Sketchpad is the component of working memory responsible for handling visual and spatial information. It acts like an "inner eye" which displays and manipulates visual and spatial information held in long-term memory. Remembering written words is closely related with the processes of visuospatial sketchpad.

4.6.1.4. Slave System 3: The Episodic Buffer

The episodic buffer is a component which is added to the model later. (Baddeley, 2000). This new slave system is a multimodal temporary store which can store multiple types of information unlike other two slave systems. While phonological loop or the visuospatial sketchpad are specialized and deal with particular types of information, episodic buffer deals multiple types of information and binds different types of information from different sources in the working memory. For instance, a spatial information like a scene may include phonological information simultaneously and it is hypothesized that episodic buffer binds all the visual, phonological and active information from this scene.

In lower level processes, the role of working memory is critical. This role is direct and supports phonological, orthographic and morphological processes in word recognition. Working memory stores learned words and enables its recognition. In addition, it establishes the link between sentence processing and reading comprehension by processing syntactic and semantic features. Moreover, executive control in Bradleys and Hitch's model suppresses unnecessary information quickly and unconsciously (Baddeley, 2006; Friedman & Miyake, 2004).

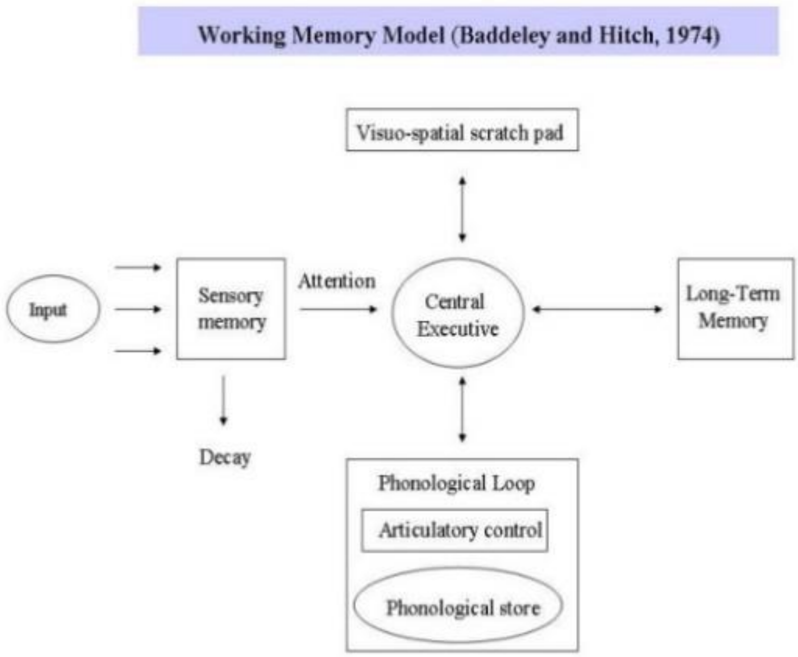

Figure 14. Working Memory Model by Baddeley and Hitch, 1974

4.6.2. Neural Aspect: Brain and Reading

The human brain consists of **left hemisphere** and a **right hemisphere** that have different but complementary functions. In almost all right-handed people, as well as in most left-handed people, verbal material is processed by the left hemisphere, and nonverbal, visual-auditory material, by the right hemisphere (Taylor&Taylor, 2013; Levy & Trevarthen, 1976; Milner, 1975; Moscovitch, 1979). Left Hemisphere function has analytic and sequential capabilities while right hemisphere function is imagic and wholistic. As language requires sequential and analytic processing, it is usually processed by the left hemisphere. Right hemisphere supplements linguistic processing when needed. In reading, following neural areas are involved:

Angular gyrus: This part integrates visual and phonetic information during reading.

Broca's area: This part produces speech while reading aloud.

Wernicke's area: This part analyzes and comprehends written material.

Motor area: Motor area executes motor activities during reading such as controlling extra ocular muscles.

Occipital lobe: This part processes visual information including letters, sentences and whole text.

Corpus callosum: This part connects two hemispheres

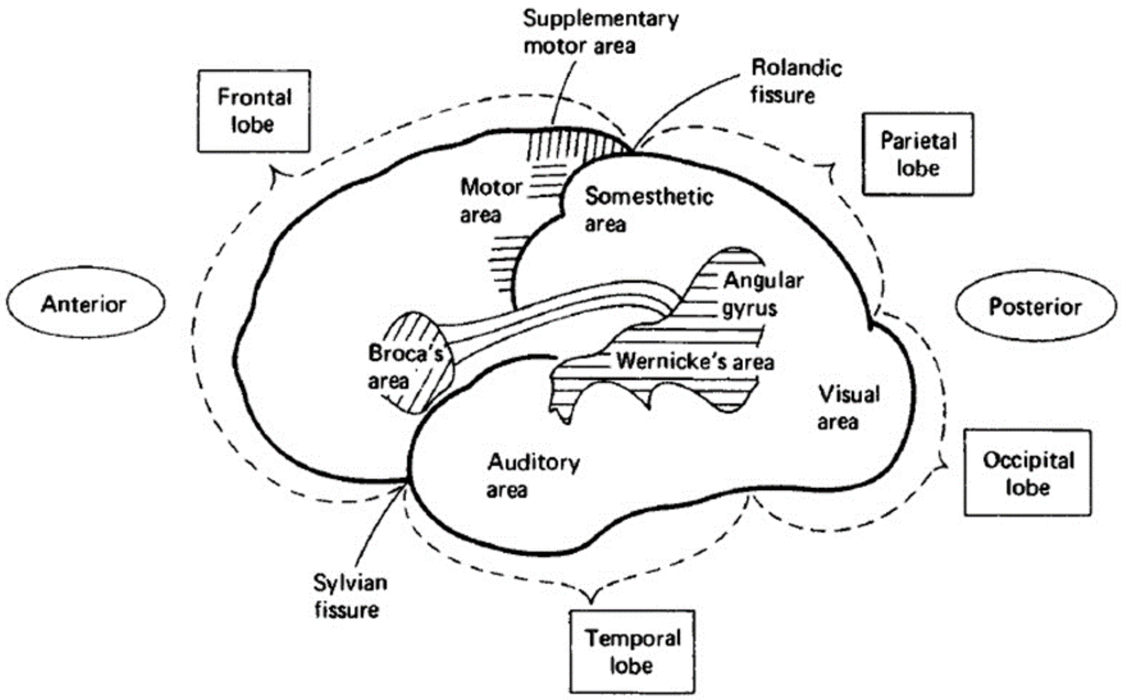

Figure 15. Cerebral parts in Reading (Taylor, 1976)

4.6.3. Sensory Aspect: Eyes and Reading

4.6.3.1. Early and Late Measures

Related eye tracking research emphasizes that eye tracking methodology is a strong diagnostic tool for detecting visuo-cognitive problems caused by deficiencies such as Alzheimer, schizophrenia, dementia and dyslexia (Brown et al., 1983; Hutton et al., 1984; Abel and Ziegler, 1988; Blackwood et al., 1991; Sweeney et al., 1994; De Luca et al., 1999; Jones et al., 2008; Crutcher et al., 2009). In such diagnostic research, eye movements are used to detect problems caused by such handicaps and optimal solutions are sought for better treatment.

In reading behavior, certain eye movements metric indicate different measures. Mainly there are 2 measurements: early and late measures (Clifton, Staub, & Rayner, 2007; Rayner, 1998, 2009b; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989). The main assumption is that early measures (first pass reading time) are indicatives of initial information integration. On the other hand, late measures are more syntactic and discursive; more linked with the integration and re-analysis of information in the syntactic structure (Rayner et al., 1989; Paterson et al., 1999). Early measures refer to single fixation duration, first fixation duration and gaze duration which mainly indicate initial stages of sentence processing. This initial process mainly refer to word recognition and lexical access (Clifton et al., 2007. The inflation of early measures indicate word recognition problems including lack of orthographic, morphological and phonological access. As a result, reading and comprehension is interrupted. On the other hand, regressions, refixations and total fixation duration refer to late measures. Unlike early measure, late measures for word recognition indicates a syntactic or discursive challenge. When learners cannot figure out the lexical aspect of a word, they may regress from the word (regression out) or reread (refixation) it. Total fixation duration refers to mostly all indexes (early and late) except regression out and indicates a summary of fixational movement. Late measures are believed to be sensitive to later processes associated with comprehension of a text, such as information re-analysis and discourse integration (Rayner et al., 1989; Paterson et al., 1999). However it should be noted that, as eye movements are highly flexible and sensitive, a late measure may turn into an early measure, especially regressions. Hence, ”early" and "late" definition may be misleading, if they are considered as first-stage vs second-stage processes that are assumed in models of sentence comprehension (Rayner, Carlson, & Frazier, 1983; Frazier, 1987).

4.6.3.2. Reading Fluency

Obviously, the ability to read rapidly and accurately is so fundamental to reading success (Kame'enui & Simmons, 2001: 204) Reading fluency and speed with comprehension is the sum of linguistic abilities; word recognition skills and sentence processing skills which all define how fluent and fast L2 learners read and understand. Better Word recognition skills; morphological, orthographical, syntactic, semantic and phonological subskills lead faster understanding of a vocabulary item. This automatization process enables the recognition of a word quickly and this item is already restored in long term memory. When these skills are accomplished with good syntactic knowledge, sentence processing skills, grammatical competence and discourse competence, high reading fluency develops.

Related research asserts that 260-300 word per minute is an optimal value for reading rate for proficient readers in L1 (Carver, 1982, 1983, 1990, 1992; Taylor, 1965; Grabe, 2010).

Grade	wpm	Wpm
1	80	68
2	115	99
3	138	121
4	158	141
5	173	156
6	185	169
7	195	181
8	204	192
9	214	204
10	224	216
11	237	234
12	250	248
13		263
14		278
15		294
16		309
17		324
18		340

Figure 16. Taylor rates in wpm for different grades at school

According to the Taylor rates above, skilled readers can read 250-340 wpm. When the concern is reading for learning, optimal value is about 300wpm. On the other hand, according to Segalowitz (1991), L2 reading rate is at least 30% slower. This rate can be revealed by eye movements which can give precise and accurate reading rate in foreign language.

4.6.3.3. Word Skipping

Throughout reading, not all words are fixated by the readers. Frequency and length of a word and its predictability in the context determine how much it is fixated. More frequent, shorter words and highly predictable words are fixated less most of the time (Inhoff & Rayner, 1986; Rayner, & Duffy, 1986; Rayner, Sereno, & Raney, 1996; Schilling, Rayner, & Chumbley, 1998, Vitu, 1991; Balota, Pollatsek, & Rayner, 1985; Binder, Pollatsek, & Rayner, 1999; Ehrlich, & Rayner, 1981, Rayner, & Well, 1996; Schustack, Ehrlich, & Rayner, 1987; Zola, 1984; Rayner, Fischer, & Pollatsek, 1998). And sometimes some words take zero fixation and they are skipped by the reader. According to Rayner (1998), about 30% of the words in a text are skipped and gain zero fixation. This skipping rate is closely related with length of the word; short words are skipped more. (Brysbaert & Vitu, 1998; Drieghe, Brysbaert, Desmet, & De Baecke, 2004; Rayner, 1979; Rayner & McConkie, 1976; Vitu, O'Regan, Inhoff, & Topolski, 1995). In addition to length, predictability has an effect on Word skipping. Words which can easily be predicted from the context tend to be skipped by the readers (Altaribba, Kroll, Sholl, & Rayner, 1996; Balota, et al., 1985; Drieghe et al., 2004; Ehrlich & Rayner, 1981; Rayner, Binder, Ashby, & Pollatsek, 2001; Rayner & Well, 1996; Schustack, Ehrlich, & Rayner, 1987). Additionally, high frequency words are skipped more than low frequency words (Henderson & Ferreira, 1993; Radach & Kempe, 1993; Rayner & Fischer, 1996). It is obvious that lexical, morphological and visual features of a word predicts word skipping.

Depending on the related research, it is hypothesized that short and frequent grammatical function words including articles, auxiliary verbs and prepositions may tend to be skipped by foreign language learners. Indeed skipping rate may indicate syntactic and sentence processing skills. Better learners with better syntactic skills have automatization in sentence processing which may then lead them to skip function words such as the, is, at etc. In addition to this, there must be a linear relationship with foreign language reading rate and word skipping as word skipping can contribute to fluency.

4.7. Higher Level Processes

As mentioned recently, low level processes include word formation component, grammatical issues and sentence parsing. However, these processes are not enough for comprehension and provide a superficial understanding of a text. At this point, higher level processes integrate with comprehension which roughly refers to going beyond the words and sentences. The main component abilities of higher-order comprehension processing include the following:

- A set of reading skills and resources under the command of the executive control mechanism in working memory (strategies, goals, inferences, background knowledge, comprehension monitoring)
- A text model of reader comprehension
- A situation model of reader interpretation

4.7.1. A Text Model of Reader Comprehension

A text is a cognitive network of ideas and cognitive processes begin with the first word of the text. Each upcoming linguistic unit is a new part of this network and the linkages constructed by the reader through these units enables comprehension. As readers read a sentence, a cognitive activation occurs and new sentences form new related cognitive activations within the existing network. The new elements may strengthen the previous information or may overlap with them which then cause a cognitive pruning in which unnecessary information is dumped. For example:

The girl took the gun on the table.

She looked at the man.

“Freeze” she said “or I will shoot!”.

He raised his hands and startled.

“Put the gun down” said the man.

When a reader reads first sentence, “a girl with a gun” is activated. With the second sentence, new information is activated and “a man” is added to the context. In the third sentence, “the girl” is strengthened with pronoun “she” and reader links “shoot” with “the gun” and “the gun” gains more activation. In the fourth sentence, “the man” is activated again and reader perceives an antagonist-protagonist like interaction within a narrative. As the text progresses previously mentioned unit “the table” starts to fade away and gets pruned. In the final sentence, “the gun” and “the man” are reinforced”.

Grabe (2010) states that the key to forming the text model of comprehension is establishing a network from the ongoing processing of words, sentences, and propositions. In the 5 sentences above, the reader generates a network through textual units.

Throughout this process, readers do not only rely on textual items to generate an overall cognitive network. The general background knowledge of the reader also integrates with the text and the reader also creates an abstract identification of the text. Reader’s background knowledge should activate a “girl” figure that is young, beautiful, smart and restless or a “man” figure who is coward, dangerous or insidious for example. The reader also activates the genre knowledge and should notice that this is a narrative. In addition to this, reader’s semantic and pragmatic knowledge should assert that the word “freeze” refers to its associative meaning which is “to stand still”. This background knowledge enables the reader to make inferences and solve any kind of ambiguities. To sum up, text model comprehension depends on links in a textual network, pruning of unnecessary elements, overlaps and inferences through background knowledge.

4.7.2. A situation Model of Reader Interpretation

Aside from textual networks in a text, readers always integrate their attitudes, goals, expectations and past reading experiences to the text. This reader oriented information is the core of situation model of interpretation which is established by mental circumstances generated by the reader himself regardless of textual networks. In doing so, readers can have a critical view on the text both in terms of what the writer wants him to understand and how readers feel about the text and the writer (Kintsch & Rawson, 2005; Noordman & Vonk, 1999; Perfetti, van Dyke, & Hart, 2001). This model of reading comprehension is closely related with cognitive psychology that views comprehension as the creation of an appropriate mental model of the situation presented by the text. Grabe (2010) enlists the factors influencing construction of situation model as follows:

- Similar story instances
- Reader purpose
- General background knowledge
- Task expectation
- Genre activation
- Attitudes towards the writer, story, genre, episode
- Evaluation of the importance of information
- Inferences needed for interpretation (of genre, episode, hierarchical organization, purpose)

Lets take a look at the 5 sentences mentioned above. Even before reading, reader activates the background knowledge in long term memory including previous experiences in such stories. Reader decides his purpose and activates attitudes towards the writer and establishes expectation from the text. Reader also activates genre and decides it is a detective story or an adventure story. But all these activation and constructs will be accomplished by the textual information and reading begins. Reader engages in low level processes and integrates a textual model.

By reading the first sentence, reader may think that this is an exciting or a cliché opening. The girl may be embodied in reader’s mind as a victim or a tough detective depending on the previous similar reading experiences. Sentence 2 introduces a man; maybe another detective, a murderer, a thief or an innocent figure. The third sentence may clear the vague girl figure and reader may be sure that she is a detective depending on his previous experience with the word “freeze”. Through the progress, reader starts to gain a critical view and make inferences about the narrative. He may evaluate the excitement value, the power of antagonist-protagonist interaction, his enthusiasm in the story and measures if the story meets his goals of reading. Depending on such criticisms, reader may even stop reading. All these mental progressions changes from text to text.

4.7.3. Two Model Account of Comprehension

Both text model and situation model represents different processes and requirements in terms of comprehension. While text model emphasizes the textual features, situation model points out background knowledge, attitudes and purpose of reading. A two-level text-processing model incorporates both a view of text as representing an author's meaning and as incorporating a reader's construction of text meaning (Grabe, 2010). Different proficiency levels of reading, various purposes for reading, and different types of texts or genres will put emphasis more on either on a text model of comprehension or a situation model of interpretation (Kintsch, 1998). For instance, a technical manual which describes an electronic device do not need a situation model:

“Attach the cable to the red socket to proceed. Put the socket into the device. Push the power button.”

The sentence above requires a text model interpretation rather than a situation based model. It directly asserts the steps to activate a device and reader do not need any background information or attitude towards the writer. On the other hand, more abstract text such as poems need high levels of situation models. For example:

“And this was the reason that, long ago,

In this kingdom by the sea,

A wind blew out of a cloud, chilling

My beautiful Annabel Lee;

So that her highborn kinsman came

And bore her away from me,

To shut her up in a sepulchre

In this kingdom by the sea."

In the poem "Annabell Lee" by E. A. Poe, reader is required to depend on situation model. To Such a genre invites personal interpretation which cannot be simply achieved by relying on text model. Most poems intentionally underspecify a text model of comprehension and readers cannot reach comprehension through textual networks. Most poems privilege the situation model of reader interpretation.

Grabe (2010) points out that readers with weak background knowledge during reading are likely to produce recalls that reflect the information presented in the text. On the other hand, learners with strong background knowledge produce recalls with higher levels of background knowledge and evaluative commentary (Kintsch, 1998; Long, Johns, & Morris, 2006; McNamara & Kintsch, 1996; McNamara et al., 1996). Second, readers who have minimal background knowledge can still carry out tasks that rely heavily on text-model representations (Adams, Bell, & Perfetti, 1995; Voss & Silfes, 1996); such tasks include summaries, simple recall tasks, and multiple-choice recognition questions. Thus, task demands interact with the construction of a text model and a situation model.

In terms of foreign language learners, lack of adequate L2 proficiency does not let them to create a text model due to limited vocabulary knowledge or sentence parsing skills. In such situations, learners overrely on a situation model. However, situation model enables too limited and general comprehension which then lead L2 reading comprehension problems.

4.8. Noticing, Consciousness and Attention in Foreign language Reading

Consciousness and attention is a controversial topic of debate in applied linguistics which revolves around the role of conscious cognitive mechanisms like various types of attention on foreign language acquisition. In this respect, a groupd of researchers believe that conscious understanding of the target language is needed if learners are to produce correct forms and use them appropriately. This wiev proposes that the result of not knowing the rules of the target language, forgetting them, or not paying attention (Schmidt, 1990). Early research (Bialystok, 1978; Rutherford and Sharwood Smith,1985) and recent eye movement research (Godfroid et al. 2013; Winke et al. 2013, Liu, 2014) asserted that consciousness and attention have a facilitative effect on foreign language acquisition and learning; especially in foreign language reading.

On the other hand, another group of researchers strictly believe that language learning is essentially unconscious. Krashen (1981, 1983, 1985) established a certain distinction between two independent processes called “learning” and “acquisition”. In this proposition, while learning is fundamentally a conscious process which is full of challenges, acquisition is a subconscious genuine process in which acquisition takes place unconsciously in a relatively easier fashion. In addition, in this frame, learning can never replace acquisition.

4.8.1. Consciousness in Foreign language

Consciousness is a comprehensive psychology term which can be described as individual awareness, feelings, memories, sensations and environment. For a better understanding, the term “consciousness” can be divided into several senses as: consciousness as intention, consciousness as awareness and consciousness as knowledge.

4.8.1.1. Consciousness as Awareness

As assumed commonly, consciousness is a quality mostly defined with awareness (Rotner 1987; Battista 1978). A number of researchers have recognized that there are degrees of awareness (Baruss 1987; O'Keefe 1985; Tulving 1985). There are several levels of which three are crucial according to Schmidt (1990).

Level 1: Perception

As a general belief, perception refers to the mental organization and the ability to generate internal representations of external stimuli. (Oakley 1985b; Baars 1986). This term can be defined as the recognition and interpretation of sensory information. It is the interpretation of organization, identification, and interpretation of sensory information (either aural or visual) in order to examine the environment. Any kind of perception includes signals in the nervous system, which then result from physical or chemical stimulation of the sense organs. People perceive sounds, visuals, smells and taste. This process includes how we respond to the information. Thus, perception is a process in which sensory input extracted from the environment and used as a medium of interaction with that environment. Perception enables this meaningful interpretation. In the case of word perception, each letter of the alphabet is in itself a single letter. When the words are perceived, we think of them as one singular unit that is made up of smaller parts called letters. Throughout this organization of letters into words that people can extract a meaning. In other words, reader perceive an entire word, and this word has a specific meaning that can be found in the dictionary.

Level 2: Noticing (focal awareness)

There is a crucial distinction between noticing and perception. Bowers (1984) points out the critical difference between information that is perceived and information that is noticed. For instance, throughout the reading process, the content of the text is noticed such as words, letters, syntactic and textual features but we perceive a background noise outside or a song playing on the radio if we choose to pay attention to them. Noticing thus refers to a concentrated experience.

Level 3: Understanding

According to Schmidt (1990), noticing is the basic sense in which we commonly say that we are aware of something Upon noticing, the noticed unit can be analyzed and compared to similar noticing experience which may than build a certain level of understanding and comprehension.

4.8.1.2. Consciousness as intention

Consciousness is an ambiguous term which is closely related with intention. Most of the time, things done consciously are also done intentionally. The primary controversy in use of the term consciousness is the issue of passive awareness and active intent. When something is done with conscious, people usually think it is done with intention. People also speak of conscious efforts, attempts, and strategies, referring to the volitional, deliberate nature of the action. Hence, it is vital to distinguish between consciousness as awareness and consciousness as intentional behavior as these are often dissociated. In this respect, intentions may be either conscious or unconscious (Baars 1985), and people are most of the time become aware of things we do not intend to notice.

4.8.1.3. Consciousness as knowledge

According to White (1982) that knowing something is also being conscious of it. It is argued that experiential consciousness and knowledge cannot be the same thing. White also warns that the difference between conscious and unconscious knowledge is theoretically vague when different authors are compared, since the controversies of consciousness are combined with those of knowledge—equally difficult in psychological terms.

4.8.2. Attention in Foreign language

Attention refers to the ability of an individual to concentrate on specific stimuli while ignoring others. There are 4 main subsystems of attention. Firstly, alertness refers to an overall readiness to deal with incoming stimuli. Secondly, orientation is the direction of attentional resources to certain types of stimuli. Thirdly, detection can be defined as the cognitive registration of a particular stimulus. And finally, inhibition is deliberately ignoring some stimuli. In SLA theory, it has been proposed that attention to language forms can facilitate language acquisition. There is a consensus on facilitative function of attention through which certain cognitive abilities are directed and focused on linguistic units. However, the main controversy is whether this attentional sources are conscious or not. Basically, attention is limited, selective and partially subject to voluntary control.

4.8.2.1. Attention as a limited quality

It is a general assumption that attention has a limited capacity (Kahneman, 1973) and this assumtion has been accepted by a vast number of researchers in FLA and SLA. For this limitation, Wickens (1989) proposed that attention as a limited capacity involves unique resource pools for unique purposes and sensory registers (visual, auditory, vocal and manual). Here it refers to the assumption that attention-oriented tasks can be conducted at the same time more efficiently if several different modalities were included. Each of these sensory registers are thought to have a limited capacity also, which was proved by Miyamoto (1998) empirically. As commonly believed, there are 2 primary ways via which humans process language. First is top-down processing and the second is bottom-up processing. Both these processes are assumed to benefit same modality as they are both associated with language understanding. Miyamoto (1998) revealed that there was an exchange between top-down processing and bottom-up processing. In the case of one's efficient process, the other tends to be less efficient.

4.8.2.2. Attention as a selective quality

Due to the limited nature of attentional sources, attention is required to be strategically allocated between tasks. In many L2 learning context, the semantic aspect of linguistic messages is the most important (VanPatten, 1990). That is why limited attention sources are initially directed to lexical units. In L2 reading, it can be hypothesized that attention is paid on vocabulary items rather than auxiliary verbs. In addition to this, longer words are paid more attention when compared with shorter ones as they include more interactive cognitive load. A number of related research showed that selectivity is the primary aspect of attention and emphasizes the significance of selection.

4.8.2.3. Attention as a subject to voluntary control

In foreign language instruction, one of the crucial point in classroom is to attract learner attention to linguistic input. Instructors can ask learners to attent different aspects, such as pronunciation, lexical items, syntax, discourse structuring and so on (Hulstijn & Hulstijn, 1984). It is because attention can be controlled to a certain extent which can be used to facilitate learning. On another aspect, learner may be willing of unwilling to pay attention which makes attention as a self-controllable mechanism. On the contrary, there is an involuntary aspect of attention which may come up in case of unexpected stimulus. This stimulus may be a loud noise, a sudden visual or any kind of sensory modality. Attention control is significant in foreign language instruction, that's why most of the time language laboratories are isolated as sound or external stimulus proof.

There is a certain consensus in psychology and cognitive science that learning cannot occur without attention (Wolford and Morrison, 1980; Carlson and Dulany, 1985; Fisk and Schneider, 1984; Posner, 1992; Velmans, 1991). However, this consensus does not take place in foreign language acquisition even though attention is a crucial factor of learning experience. According to Lightbown and Spada (1994), a focus on form is necessary and desirable especially when provided in a communicative context. Similarly Schmidt (1995) states that the role of attention is obvious in vocabulary learning as vocabulary items are learned through attention in the reading process. Recently, Godfroid et al. (2013) found out that attention to vocabulary items facilitates the recognition of unknown vocabulary. In foreign language, the strongest view of consciousness and attention is Noticing Hypothesis by Schmidt.

4.9. Noticing and Noticing Hypothesis

Consciousness has always been a hot topic in foreign language which has been a subject to many SLA research. The popularity of consciousness, attention and awareness promoted with the Noticing Hypothesis by Schmidt in the early 1990s. According to Schmidt's hypothesis, foreign language acquisition is not solely an unconscious process, on the contrary, it is a process in which consciousness has a significant role. This view is constructed through a number of influential research by Schmidt (Schmidt, 1990; 1993; 1994; 1995a; 1995b; Schmidt and Frota, 1986) and has been studied by many researchers (Ellis, 1993; 1994; Fotos, 1993; 1994; Fotos and Ellis, 1991; Harley, 1993; Larsen-Freeman and Long, 1991; Long, 1991; Robinson, 1995; 1996; Zalewski, 1993).

4.9.1. Noticing

Noticing is the crucial term for the debate of consciousness in SLA which is considered to be a level of awareness. It can be described as the experience which is brought about by drawing learners' selective attention to a certain linguistic form. With noticing, input is transformed into intake which enables learning. Schmidt (1990) proposed that noticing is vital for input to become intake, that is, vital for L2 learning. In addition, Schmidt (2001) asserted that least requirement of noticing is closely related to attending to key grammatical elements. Noticing is also called "focal awareness" (Atkinson & Shiffrin, 1968), "episodic awareness" (Allport, 1979) and "apperceived input" (Gass, 1988). All these terminology refers to a certain level of attention to form to facilitate learning.

The Noticing hypothesis is a claim about how input turns into intake which is the input that is used for acquisition. According to noticing hypothesis, consciousness and attention to form has an undeniable effect on foreign language learning. In the strong form of the hypothesis, favored by Schmidt, noticing is a vital ingredient for learning. Weak form assumes that noticing may be helpful not necessary.

Schmidt and Frota (1986) emphasized the significance noticing in L2 learning. According to their claims, when a learner is to learn and use a particular type of verbal form, its practice in classroom is not enough. (Iwanaka, 2007). Furthermore, conscious awareness or focal awareness is required for that input to be able to be used later. Their results from a diary study showed many instances of L2 use matching the learners' reports of what was noticed while interacting with native speakers. Indeed such findings support the hypothesis that L2 learning cannot take place without attention. In his research, Schmidt (1990) argues by relying on his personal experience of Portuguese to confirm the hypothesis that the input is transformed into intake via attention. As a result of meaning-processing predomination, form becomes optional which often loses out to meaning. Schmidt (1990, 1995, 2001) has argued the significance of focal attention and asserted that learners of a second language are required to direct attention to some aspects of input.

4.9.2. Criticism and Objection to Noticing Hypothesis

Despite the attractive nature of noticing hypothesis, it also has generated a number of controversies and criticisms.

First of all, as Fundamentals of noticing hypothesis mainly depend on diary studies, it is criticized to be too coarse (Tomlin & Villa, 1994). It is mainly criticized because attention is a quality which can be measured in milliseconds and cannot depend on weeks of longitudinal diary studies. Indeed, this objection was quite right as attention is a micro-momental observation. However, Schmidt (2010) asserts that with the developing technologies, detailed online measurement of attention is possible through eye tracking (see Godfroid, 2010, 2013; Godfroid, Housen, & Boers, 2010).

Secondly, attention may be required for some types of learning but not some others. Gass (1997) has rejected the proposal emphasizing the vitality of attention as all learning may not have input. Related research showed that language learners who has taken instruction on a single type of relative clause also have done well on other types of relatives that are higher in the relative clause accessibility hierarchy, Gass stated that input on those constructions did not exist at all and asserted that "how could attention to input be a necessary condition for all aspects of learning" (p. 16). However, such an absence of input does not make noticing hypothesis wrong but irrelevant. In such cases where there is no input, noticing may not take place which makes the hypothesis irrelevant rather than incorrect or misleading. Schmidt (2010) asserts that although some implicit learning studies have claimed that some forms of learning do not require attention, a vast of the evidence supports the opposite interpretation that no learning occurs in these studies without attention (Perruchet & Pacton, 2006). In deed it should be noted that some kinds of learning require more attention than some others such as acquisition of foreign language reading.

Finally, attention to environmental stimuli does not play a direct role in acquisition because most of what "constitutes linguistic knowledge is not in the input to begin with". This criticism has been expressed by Carroll (2006a, 2006b), who pointed out that "problems associated with the idea that "input" for language learning is something objective and observable in the environment, whereas in reality the stuff of acquisition (phonemes, syllables, morphemes, nouns, verbs, cases, etc.) consists of mental constructs that exist in the mind and not in the environment at all". In case of absence, there is no possibility of noticing them. This controversy was established within a more general stance; acquisition is "not mediated by conscious awareness, explicit instruction, feedback, or correction" (Carroll, 2006a, p. 17). Identical objections were made by Truscott (1998) and by Schwartz (1993), who suggested that noticing is related to metalinguistic knowledge but not to linguistic knowledge (competence), to "learning" but not to "acquisition" in Krashen's (1981) sense. In a more general sense, attention is more related with usage based theories by Bley-Vroman (2009); Bybee & Eddington (2006) or Goldberg (1995) rather than generative theories. Bybee (2010), arguing for exemplar-based representations of language, comments that what learners experience is specific instances or tokens of constructions.

Indeed, controversies and debates on noticing hypothesis still exist but for more than a decade, the hypothesis by Schmidt keeps its significant place in foreign language research.

4.10. Attention and Incidental Vocabulary Acquisition in L2 by Reading

Given that noticing and attention are facilitative in SLA, L2 reading is a beneficial way to acquire vocabulary. As attention to linguistic forms during reading is optimal, learners can acquire vocabulary items throughout reading via attentional mechanisms. In SLA literature, reading is regarded as a efficient tool for acquiring vocabulary (Brown, 1994; Grabe, 1991). Related SLA research shows that reading is a reliable tool for vocabulary acquisition in a foreign language, without any explicit vocabulary learning, reading process alone can result in incidental vocabulary development (Day, Omura, &Hiramatsu, 1991; Krashen, 2004; Lehmann, 2007; Lee & Hsu, 2009; Ponniah, 2009). According to Ponniah (2011), every time readers attempt to recognize unfamiliar print during reading, they at least acquire partial semantic access. In time, accumulative exposure brings about incidental vocabulary acquisition. This process is subconscious; readers do not know that they acquire vocabulary while they read, however, they subconsciously absorb meaning. This well-established notion relies on the comprehensible input hypothesis (Krashen, 2004) which asserts that reading results in the subconscious acquisition of vocabulary, syntax, and spelling. The main argument of this hypothesis is that focus on meaning leads subconscious acquisition rather than focus on form. Related experimental classroom studies showed consistent results indicating that vocabulary was acquired incidentally by learners through reading (Elley, 1989; Kweon and Kim, 2008; Day et al., 1991; Vagovich& Newhoff, 2004).

However, this subconscious process requires explicit vocabulary instruction; reading alone is error-prone in L2 vocabulary acquisition (Laufer, 2005). Sole reading to acquire vocabulary is risky and long term process. Therefore, if the aim is to expand learners' vocabulary through reading, it seems desirable to enhance or complement reading activities by some form-focused component aimed at drawing the learners' attention more explicitly toward the targeted lexical forms (Godfroif et al, 2013). In this respect, subconscious attention is not enough to facilitate learning. Increasing learner awareness to forms and enhancing attention is required for optimal success.

4.11. Reading Proficiency Level Descriptors in CEFR

According to Common European Framework of Reference for Languages (CEFR) by CoE, reading proficiency levels are described as follows:

Table 3. CEFR Reading Proficiency Descriptors

Proficiency Level	***Descriptors***
C2	Can understand and interpret critically virtually all forms of the written language including abstract, structurally complex, or highly colloquial literary and non-literary writings. Can understand a wide range of long and complex texts, appreciating subtle distinctions of style and implicit as well as explicit meaning.
C1	Can understand in detail lengthy, complex texts, whether or not they relate to his/her own area of specialty, provided he/she can reread difficult sections.
B2	Can read with a large degree of independence, adapting style and speed of reading to different texts and purposes, and using appropriate reference sources selectively. Has a broad active reading vocabulary, but may experience some difficulty with low-frequency idioms.
B1	Can read straightforward factual texts on subjects related to his/her field and interest with a satisfactory level of comprehension.
A2	Can understand short, simple texts on familiar matters of a concrete type which consist of high frequency everyday or job-related language Can understand short, simple texts containing the highest frequency vocabulary, including a proportion of shared international vocabulary items.
A1	Can understand very short, simple texts a single phrase at a time, picking up familiar names, words and basic phrases and rereading as required.

The proficiency levels described above also refer to developments in cognitive abilities. As the learners' proficiency develops, their word recognition and sentence processing skills increase. This development brings about better establishment of a textual network while reading; as a result, comprehension is more proper and better. The levels and comprehension ability are closely associated which may refer to changes in eye movement behavior. Relying on these descriptors, eye movement metrics of different proficiency levels are expected to be different. With better word recognition skills and automatization, first fixation duration, gaze duration and single fixation duration values are expected to be less. On the other hand, total fixation duration, regressions and rereading times decrease with the increasing syntactic and discursive ability. In sum, CEFR proficiency levels described above are assumed to be linked with eye movements.

5. METHODOLOGY

5.1. Introduction

In this part, the methodology of this PhD thesis is presented in detail. Sample size and information with the apparatus including hardware and software used to acquire data are given in detail. The instruments used in this research such as exams and texts are presented in detail. Moreover, the research design and data acquisition procedure are explained step by step. Eye movement metrics used are also explained like gaze duration, total fixation duration and rereading times. Data analysis procedures including statistical techniques such as regressions and between subject tests are given in detail. And finally research questions which are aimed to be answered are presented.

5.2. Participants

100 subjects (17 males and 83 females) who are EFL learners participated in this research. The participants were freshman and sophomore students in ELT department in Hacettepe University. The age range of the participants was 18 to 22. Freshman and sophomore students were chosen to provide homogeneity in IELTS exam and proficiency level. Call for participation was announced first for all freshman and sophomore students. After announcement, students who were willing to participate in this research are enlisted and willingness was of primary importance. All learners started learning English as a foreign language in Turkey at a late age about 11. None of the learners were native and their L1 was Turkish. Participants' level of proficiency in English was at least B1 (intermediate) and maximum C1 (lower advanced) levels of the Council of Europe's (2001) Common European Framework of Reference.

Due to eye sight problems, too wet contact lenses, cosmetic intervention (mascara, eyeliner etc.), noisy data and offset problems, 15 participants are excluded from the study. This exclusion was made depending on the eye movement sampling rate provided by the Tobii studio software and this 15% proportion was below 90% sampling threshold. 10 participants who did not take IELTS exam also excluded. 75% of the participants provided efficient, accurate and healthy data for further analysis (15 males, 60 females, 27 B1 level, 38 B2 level and 10 C1 level). All of 75 participants had either normal or corrected-to-normal eyesight. The detailed table for 75 participants is given below:

Table 4. Participants

		Count	Table N %
Grade	*Freshman*	37	49,33%
	Sophomore	38	50,66%
Age	*18-19*	37	49,33%
	20-22	38	50,66%
Gender	*Male*	15	20,0%
	Female	60	80,0%
	B1	27	36,0%
CEFR Level	*B2*	38	50,7%
	C1	10	13,3%
TOTAL N		75	100%

5.3. Apparatus

Eye movements were recorded with the TOBII TX300, a remote advanced eye-tracker manufactured by TOBII. The Tobii TX300 Eye Tracker sets a new standard for remote eye trackers. Its unique combination of 300 Hz sampling rate, very high precision and accuracy, robust eye tracking and compensation for large head movements extends the possibilities for unobtrusive research of oculomotor functions and human behavior. This device can record an eye movement sample at every 3.3 milliseconds which equals to 300 samples at every second with high accuracy and precision. Tobii TX300 allows large head movements and provides a natural experimental setting without chinrest. The system is designed for studies that require a higher sampling rate including Neuroscience research, ophthalmology research, psycholinguistic and reading research in which detailed analysis of saccades, correction saccades, fixations, pupil size changes and blinks are required. TOBII TX300 is used for many related research on reading and psycholinguistics recently (Ridder et al, 2014; Oakley&Ma, 2014; Brelstaff et al, 2012; Vurro et al, 2014; Penttinen& Ylitalo, 2012; Inceoglu&Spino, 2013; Martinez Gomez&Aizawa, 2012; Schmidtke, 2014).

5.3.1. Eye Movement Software

For data design, acquisition, visualization and interactive eye movement analysis, Tobii Studio Enterprise Software 3.2.3 is used. It provides a comprehensive platform for stimuli presentation, recording, observation, visualization and analysis of eye tracking and other data streams. Large amounts of data are easily processed for meaningful interpretation. In this research, this software enabled data recording with Tobii TX300 and recorded data to be quantified and visualized for further statistical analysis.

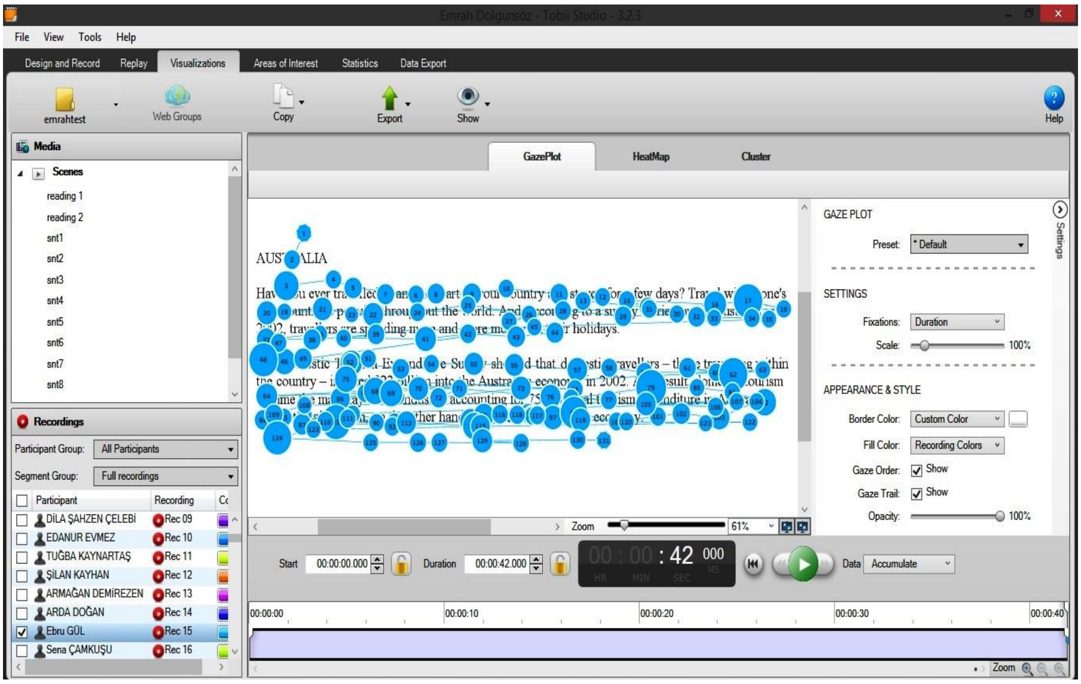

Figure 17. Tobii Studio 3.2.3 Visualized Data Sample

5.4. Instruments

In this section, instruments used are presented.

5.4.1. IELTS General Reading Test

To define learner reading proficiency levels, a General Reading IELTS Exam was used which can be found and downloaded at British Council Website (http://takeielts.britishcouncil.org/prepare-test/practice-tests/reading-practice-test-1-general-training). It was ensured that any of the participants had not taken an IELTS Exam before. This general reading exam included 40 reading comprehension questions including a wide range of different types of test items such as fill in the blanks, true-false, multiple choice and matching questions. It requires learners to complete the test in 60 minutes.

5.4.2. Vocabulary Knowledge Scale

Reading is surely a highly cognitive process and familiarity also plays a significant role. Solely asking learners to write down the meanings of words may not be enough to assess their knowledge. To provide better understanding of participant knowledge of vocabulary in this research, a vocabulary knowledge scale is used depending on the areas of interests in the reading paragraph. 15 different vocabulary items were selected from the reading paragraph and participants' knowledge of vocabulary was assessed through a vocabulary knowledge scale which could provide efficient vocabulary assessment (Joe, 1994; McNeill, 1996; Scarcella and Zimmerman, 1997; Dale (1965); Paribakht and Wesche, 1993; Wesche and Paribakht, 1996). 15 different vocabulary items were chosen by the researcher and a Vocabulary Knowledge Scale is prepared. In this scale learners were required to choose the best of the 3 options –"I know the word", "I am familiar but not sure" and "I have no idea". If the first 2 options were chosen, participants should write the Turkish meaning(s) or their predictions about the word as shown in the example below:

Table 5. Vocabulary Knowledge Scale Sample

WORD	OPTIONS	TURKISH MEANING
AGRICULTURE	☐ I KNOW THIS WORD!	
	☐ I AM FAMILIAR BUT NOT SURE.	
	☐ I HAVE NO IDEA!	

At the end of the procedure, knowing the word by writing its meaning equaled to 2 points, familiarity and prediction equaled to 1 point and not knowing the word came up with no points. This scale is used in pretest and post test procedures.

5.4.3. Materials

Materials are the reading stimulus used in this research. As eye movement behavior is quite sensitive to linguistic features through reading, a standardized reading text was used (suitable for at least B1 level) rather than making up a new one to promote validity and reliability. Primarily, a standard IELTS General Reading passage which was different from the exam was obtained from http://www.ielts-exam.net/docs/reading/IELTS_Reading_General_13_Passage_1.htm. As this passage was too long for an eye tracking study, the first half of the passage was taken as the stimuli. The extracted passage was divided into 2 homogenous parts and presented for the participants on a 23'' TFT monitor. The reading passage included 203 words, 1297 characters and 11 sentences with Times New Roman, 18-pt font. To promote natural reading, the passage was presented as a whole rather than sentence by sentence fashion. An example is provided in figure… below.

AUSTRALIA

Have you ever travelled to another part of your country and stayed for a few days? Travel within one's own country is popular throughout the world. And, according to a survey carried out in Australia in 2002, travellers are tending to spend more and more money on their holidays.

The Domestic Tourism Expenditure Survey showed that domestic travellers – those travelling within the country – injected $23 billion into the Australian economy in 2002. As a result, domestic tourism became the mainstay of the industry, accounting for 75 per cent of total tourism expenditure in Australia. International tourism, on the other hand, added $7 billion to the economy. Overall, in present dollar terms, Australians spent $7 billion more on domestic tourism in 2002 than they did when the first survey of tourist spending was completed in 1991.

Figure 18. First part of reading stimulus

To avoid any bias and check whether participants really read the text in parallel with the purpose of the experiment, a multiple choice comprehension test with 3 items was prepared by the researcher. The questions were simple and were about the main idea of the passage. This test was given to the participants right after the eye tracking session. It aimed to assess if participants were efficiently reading. All participants are observed to respond correct for all of the 3 questions.

5.5. Procedure

Step 1: The call for participants was announced for freshman and sophomore students. Students who are willing to participate were enlisted. Students were not given any detailed information about the details of the research but told that the current research was about measuring reading skills in foreign language through eye movements.

Step 2: Each participant sat for the eye tracking session one by one within the control of the researcher. Before starting the session, the participant took the vocabulary knowledge scale as the pretest. After pretest, calibration procedure was done with 9 point grid calibration setting. Then the texts were presented in Times New Roman, 18-pt font, on a 23'' monitor with 1920x1080 screen resolution set up at 67 cm from the participants' eyes. At this distance, 4.0 character spaces equaled 1° of visual angle.

Figure 19. Participant Position and Visual Angle

Step 3: After eye tracking session, each participant took the vocabulary knowledge scale again as posttest right after the experiment. At this step, they also took the brief comprehension check test.

Step 4: After a week, to define participants' proficiency levels, the General Reading IELTS exam was conducted collectively.

5.6. Data Analysis

In this section, how the data is analyzed presented.

5.6.1. Defining Areas of Interests

15 areas of interests for vocabulary knowledge were defined by the researcher. These AOIs included content words which were chosen depending on length, frequency and recognition level. These vocabulary items were also tested in pretest and posttest. These words are as follows:

Table 6. AOIs for Vocabulary Knowledge

AOI	*LENGTH (characters)*	*FREQUENCY*	*RECOGNITION LEVEL (%)*
To travel	6	36197	98,7%
Survey	6	32827	88,0%
Traveler	8	2907	96,0%
Billion	7	66979	44,0%
Mainstay	8	772	6,7%
Domestic	8	27446	80,0%
To combine	7	12277	70,7%
Agriculture	11	11750	89,3%
Souvenirs	9	1033	38,7%

Accommodation	13	2133	80,0%
To spring up	9	328	16,0%
Catering	8	1670	21,3%
To pour into	9	874	46,7%
Retail	6	10624	2,7%
Manufacturing	13	12034	66,7%
MEAN	**8,53**	**14656**	**56,3%**

Length, frequency and familiarity were 3 main criteria for defining these AOIs. These 15 AOIs included both long and short words (accommodation vs retail), both frequent and infrequent words (travel vs spring up) and both familiar and unfamiliar words (survey vs mainstay). Average length of the AOIs is 8,53, average frequency is 14656 and average recognition level is 56,3%. Frequencies of the words were extracted from COCA (Corpus of Contemporary American English).

To scrutinize word skipping issues, 22 AOIs were defined by the researcher. These AOIs include 5 auxiliary verbs (has, have, are, is), 10 articles (a, an, the) and 7 prepositions (in, into, on, throughout, within).

Table 7. AOI for Word Skipping

AOI	***MORPHOLOGICAL CATEGORY***
Have	Inflectional, bound, auxiliary verb
İs (x2)	Inflectional, bound, auxiliary verb
Are	Inflectional, bound, auxiliary verb
has	Inflectional, bound, auxiliary verb
The (x7)	Functional, free, article
An	Functional, free, article
A (x2)	Functional, free, article
In (x3)	Functional, free, preposition
On	Functional, free, preposition
İnto	Functional, free, preposition
Within	Functional, free, preposition
Through	Functional, free, preposition

5.6.2. Calculating Eye movement Metrics for Reading

5.6.2.1. First Fixation Duration Index

First fixation duration is defined as the duration of the first contact with the AOI when more than one fixation is made on the related AOI.

Figure 20. First Fixation Duration

As seen in the figure above, first fixation on the word “Domestic” is the 45th fixation, just followed by the 46th fixation on the same word.

5.6.2.2. Single Fixation Duration Index

Single Fixation duration refers to the fixational index which occurs when only one fixation is made on the related AOI.

Figure 21. Single Fixation Duration

The AOI (survey) above has taken just one fixation in total (29th fixation) which is called single fixation duration index. So duration of 29th fixation point equals to single fixation duration of the AOI.

5.6.2.3. Gaze Duration Index

Gaze duration refers to the sum of all successive fixations in the AOI until a following saccade regresses or exits out of the region.

Figure 22. Gaze Duration

Figure 22 above illustrates a gaze duration in which sum of 50th and 51th succesive fixations equal to the gaze duration on the AOI (domestic). It can be observed that the following saccade (52th fixation point) exits the region. So the sum of the duration in 50th and 51th fixation point equal to gaze duration of the AOI.

5.6.2.4. Regression Path Duration Index

Regressions are eye movements with special characteristics. Basically, a regression refers to making an eye movement reverse to the reading direction. Regression path duration is calculated by any fixation made throughout this reverse movement. In this research, regression made in the word is not counted as they most of the time derive from landing problems. But rather, regressions from AOI to another word are taken into account which refer to parsing and comprehension issues in reading.

Figure 23. Regression Path Duration

In the figure above, after 31th fixation point on the AOI (travellers), the participant regresses back to the word "2002" and makes two successive fixations on that word. In such a situation a regression occurs and it is calculated by summing up 31th, 32th and 33th fixation points.

5.6.2.5. Second Pass Duration Index (Refixation or Rereading time)

Second pass duration is calculated when a participant exits the AOI by making a forward saccade or a regressive saccade out of the region but then turns back to the same AOI and refixates on it. It is computed by summing up the fixation(s) during rereading time.

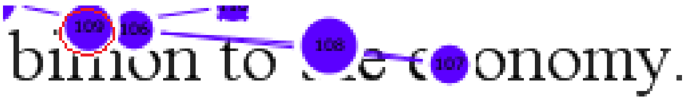

Figure 24. Second Pass Duration

As seen in figure 24, the participant fixates on the AOI (billion) with 106th fixation point and exits the AOI with 107th fixation point. But then, he regresses and refixates the related AOI with 109th fixation. So the duration in 109th fixation point equals to the second pass duration of the AOI above.

5.6.2.6. Total Fixation Duration Index

As a common eye movement index, total fixation duration refers to the sum of all fixation duration on the related AOI regardless of their type of fixation. Total fixation duration is calculated by summing up any fixation duration on the related AOI by dismissing their characteristic features such as being a regression or second pass.

Figure 25. Total Fixation Duration

The figure above illustrates a total fixation duration which can be computed by summing up all related fixation point duration in the AOI (accommodation). These points are 67th, 68th, 69th and 70th fixations regardless of their detailed features.

5.6.3. Computing Reading Fluency and Speed

Rather than depending on subjective coarse estimation of word per minute (wpm) as a reading fluency and speed index, this research used a novel technique to compute reading fluency and speed which totally depends on eye movements. Unlike other techniques which primarily rely on how many words are read in given time, this technique offers robust, objective and accurate solution for reading speed and fluency. This technique mainly depends on Bullimore and Bailey's (1995) formula with which they aimed to calculate reading speed and fluency of maculopathy patients. The formula comes out with how many characters are read in a second. To benefit from this formula in foreign language reading, in this research, the researcher assimilated and developed it one step further to achieve how many words are read in the given time by adding task features to the formula.

$$\frac{Letters}{Second} = \frac{Total\ Saccades}{Dwell\ Time\ on\ Task\ (second)} \times \frac{Total\ Forward\ Saccades}{Total\ Saccades} \times \frac{Total\ Task\ Character\ Count}{Total\ Forward\ Saccades}$$

All saccadic data (total saccades, regressive saccades, dwell time) can be extracted from eye tracking software (Tobii Studio). To find Reading Speed (RS) this formula proposes that Total Saccades divided by Dwell Time equals to the Fixation Rate (FR). Total Forward Saccades are computed by subtracting regressive saccades from Total Saccades. Then Total Forward Saccade divided by Total Saccades equals to Forward Saccade Ratio (FSR). Total Task Character Count divided by Total Forward Saccade equals to Letters per Forward Saccade (L/FS).

And it follows that:

$$RS = FR \times FSR \times L/FS$$

At then end of the calculation, RS gives how many characters are read in a second. To find out how many words are read in a minute in foreign language, the researcher developed a new formula:

$$\frac{Task\ Character\ Count}{Task\ Word\ Count} = Mean\ Character\ Count\ per\ Word$$

Then;

$$RS \times 60 = Characters\ Read\ per\ Minute$$

Then;

$$\frac{Characters\ Read\ per\ Minute}{Mean\ Character\ Count\ per\ Word} = Words\ Read\ per\ Minute$$

In other words;

$$WPM = \frac{RS \times 60}{MCC/W}$$

5.6.4. Word Skipping

Word skipping refers to AOI's having zero fixation. Literally, it means that related AOI is skipped and did not attract the attention of the reader. But it does not mean that readers do not see the words they skip but rather the attention rate is so low that it is surpassed by the eye tracking software filter (e.g. 15 milliseconds). In another aspect, the reader may have gained an extreme automaticity on those AOIs and prefer not to spend too much cognitive load on related AOI.

During reading, most of the time skipped words are short function words which are morphologically functional/free and inflectional/bound. This category includes short prepositions, auxiliary verbs and articles. Skipping these words are also closely related with parsing skills.

As is mentioned in the previous section, 22 different AOIs including prepositions, auxiliary

verbs and articles were defined by the researcher. In the visualization analysis, each of these AOIs was checked one by one whether they are skipped or not. Then count for skipping rate is calculated (e.g. 14 out of 22).

5.6.5. Statistical Procedures

In this part, statistical procedures used are presented.

5.6.5.1. Micro and Macro Analytic Computations

The quantified data was entered and analyzed by SPSS 21. An inductive methodology was used for all data sets.

All 6 eye movement metrics (single fixation, first fixation, gaze duration, second pass, regressions and total fixation duration) were first analyzed for each 15 AOIs. Then for each index, means were calculated. Then these mean indices were computed depending on the vocabulary knowledge scale to figure out a detailed output bout how much attention was paid to known, unknown and familiar words.

Word Skipping and Reading Speed were calculated as count. How many words out of 22 AOI was counted for each participant. Reading speed was calculated as wpm depending on the mean word length as 6.38 in the reading passage.

In terms of proficiency, IELTS scores of the learners are converted into IELTS Bands first and then these band scores transformed to CEFR Levels (http://www.ielts.org/researchers/common_european_framework.aspx).

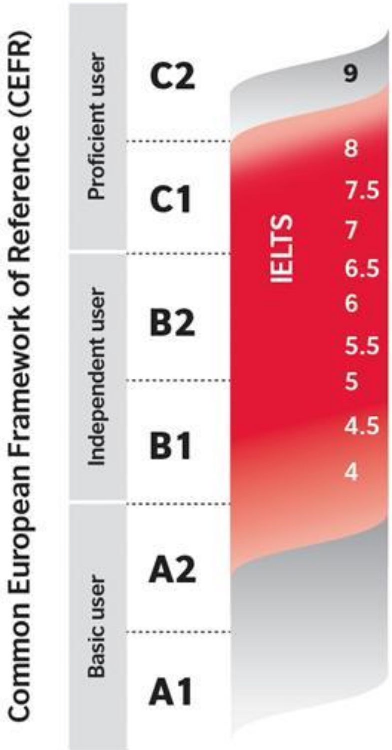

Figure 26. CEFR Equivalents for IELTS General Reading Exam

Vocabulary Knowledge Scale was analyzed by applying 3 types of scores. Each participant gained 2 points for each word known, 1 point for each prediction (familiarity) and 0 points for wrong or blank choice. Each word was entered as data within this scale and all computations were made depending on this scale. In addition, a developmental score was computed for each participant by subtracting pretest from posttest.

To sum up, the data set established for this research includes 464 different variables and 34800 points of data obtained from 75 different participants.

5.6.6. Statistical Techniques

To reveal any potential answers for research questions, a number of statistical techniques were used to analyze the data. The selection of techniques primarily depended on accuracy and statistical precision.

5.6.6.1. One Way ANOVA

The one-way analysis of variance (ANOVA) is used to determine whether there are any significant differences between the means of three or more independent groups (Neuwirth&Heiberger, 2009). In ANOVA, 2 main assumptions should be met to conduct it. First is normality which shows that the data is normally distributed. Second is Levene's test which is used to test if independent samples have equal variances. Equal variances across samples is called homogeneity of variance. To apply ANOVA, Levene’s homogeneity of variance should be above .05 level of significance. If Levene’s test results indicate statistical significance ($p <.05$), ANOVA results will not be correct.

When assumptions are provided, ANOVA can be conducted. In significance conditions, post hoc tests such as Tukey and Scheffe also can be applied to see detailed significance levels.

5.6.6.2. Pearson Correlation

Assuming that the data is normally distributed, the Pearson product-moment correlation coefficient is a measure of the strength of a linear association between two variables and is shown by *r*. Basically, a Pearson correlation attempts to draw a line of best fit through the data of two variables, and the Pearson correlation coefficient, *r*, indicates how far away all these data points are to this line of best fit (how well the data points fit this new model/line of best fit).

Pearson correlation coefficient may be in positive and negative direction which indicates 2 different types of linearity between variables. Statistical significance is not everything but the strength of the correlation and direction is vital. Dancey and Reidy (2004) categorizes *r* strength as follows:

Table 7. Dancey and Reidy’s (2004) categorization for *r*

Value of the Correlation Coefficient	***Strength of Correlation***
1	***Perfect***
0.7 - 0.9	***Strong***
0.4 - 0.6	***Moderate***
0.1 - 0.3	***Weak***
0	***Zero***

5.6.6.3. Simple Linear Regression

Simple Linear Regression is the extended version of Pearson correlation. This statistical technique mainly aims to reveal the predictive effect of an independent variable on a dependent variable (Weisberg, 1985). This dependent variable as an output should be continuous variable. The predictive quality is explained in R^2 which refer to the explanatory and predictive power of the independent variable on dependent variable. However, simple linear regression requires a number of assumptions to be met. These assumptions are as follows:

Sample Size: Although there is not a clear cut definition for required sample size for simple linear regression, 50 is considered to be minimum.

Linearity and Additivity: There should be a constant linear relationship between predictor variable and the dependent variable. This linearity can be checked by Pearson correlation coefficient and scatter plots.

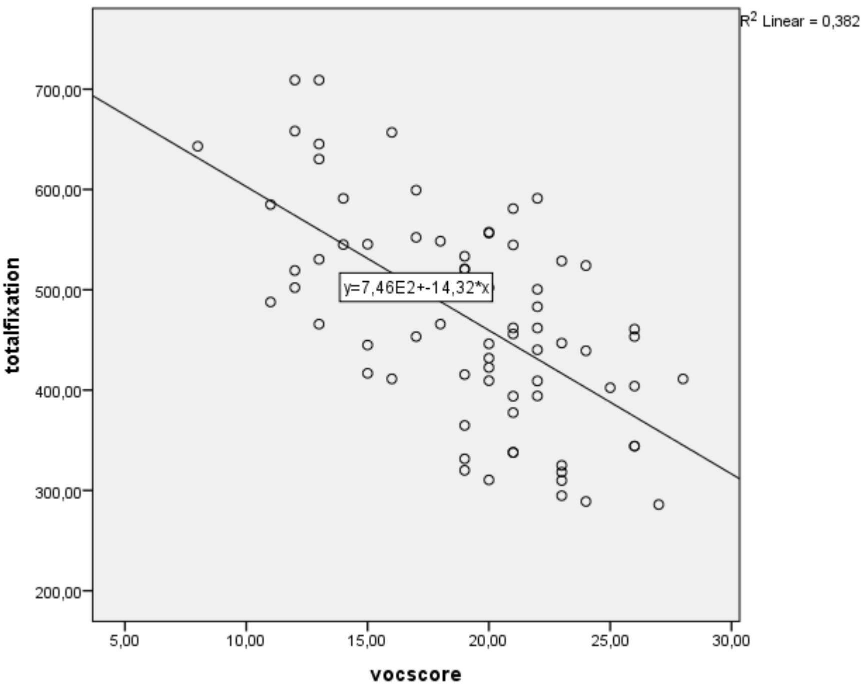

Figure 26. Example of Linearity between variables

Normality: For simple linear regression, the data should be normally distributed.

Homoscedasticity: The assumption of homoscedasticity (literally, same variance) is central to linear regression models. Homoscedasticity describes a situation in which the error term (that is, the “noise” or random disturbance in the relationship between the independent variables and the dependent variable) is the same across all values of the independent variables. Heteroscedasticity (the violation of homoscedasticity) is present when the size of the error term differs across values of an independent variable.

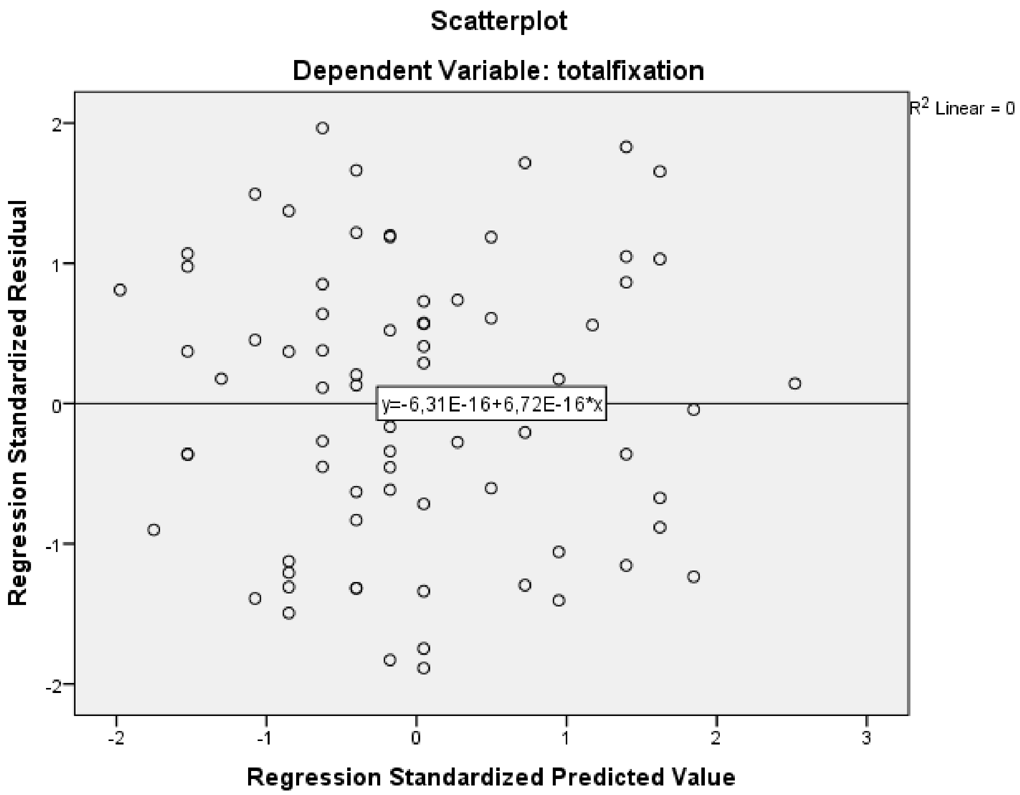

Figure 27. Example of Homoscedasticity for Linear Regression

5.6.6.4. Multiple Regression

Multiple regression is the extended model of simple linear regression. Different from simple linear regression, multiple regression aims to reveal the predictive power of multiple independent variables on a single dependent variable (Tabachnick& Fidell, 2001). Multiple regression requires simple linear regression assumptions and also multicolinearity. Multicolinearity is a critical assumption for multiple regression which primarily depends on the correlation between predictor variables. When there is a strong linear relationship between predictor variables, multicolinearity occurs and multiple regression results will not be accurate. It is assumed that Pearson correlation between independent variable should be smaller than .08 (*r<.08)*. Then Multicolinearity assumption can be checked by interpreting Condition index (>10 violates), VIF (variance inflation factor >10 violates) and Tolerance values (T < 0.2 violates).

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	730,478	33,688		21,683	,000	663,337	797,619		
	wpmspeed	-1,293	,162	-,683	-7,980	,000	-1,616	-,970	1,000	1,000
2	(Constant)	851,191	37,424		22,745	,000	776,588	925,794		
	wpmspeed	-,982	,152	-,518	-6,446	,000	-1,286	-,678	,841	1,189
	vocscore	-9,531	1,863	-,412	-5,116	,000	-13,245	-5,818	,841	1,189

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	wpmspeed	vocscore
1	1	1,966	1,000	,02	,02	
	2	,034	7,564	,98	,98	
2	1	2,936	1,000	,00	,01	,00
	2	,038	8,760	,14	,99	,22
	3	,025	10,752	,85	,01	,77

a. Dependent Variable: totalfixation

Figure 28. Collinearity Diagnostics for Multiple Regression

5.6.6.5. Generalized Estimation Equations (GEE)

GEE is an advanced statistical procedure which is mostly done when the outcome is a binary variable. In statistics, a generalized estimating equation (GEE) is used to estimate the parameters of a generalized linear model with a possible unknown correlation between outcomes (Ziegler& Vens, 2010). In GEE, long data format is used for a robust estimation of the power of the predictor variable on the outcome variable. Then, with ID variable, repeated outcomes are nested within participants.

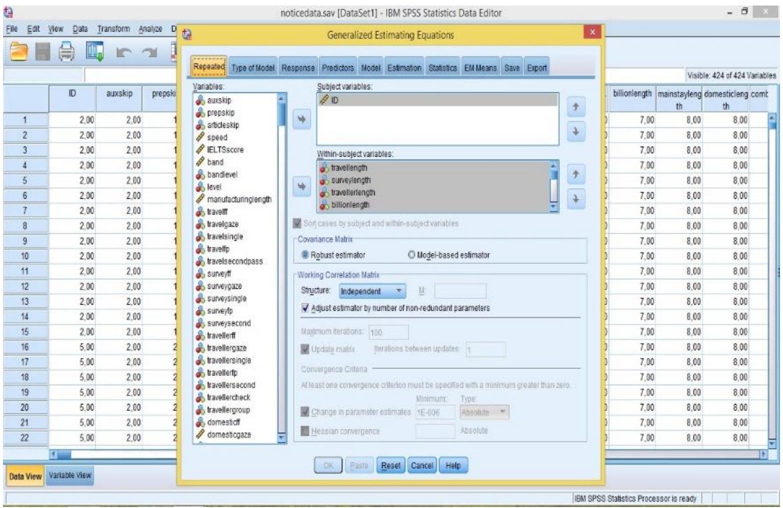

Figure 29. GEE

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	-2,627	,1997	-3,018	-2,235	172,912	1	,000	,072	,049	,107
fix100	,174	,0309	,113	,235	31,701	1	,000	1,190	1,120	1,264
(Scale)	1									

Dependent Variable: trans2
Model: (Intercept), fix100

Figure 30. GEE output (Parameter Estimates)

Although linear and continuous models can also be possible, binary outcomes give better results. In this research, GEE logistic regression is conducted in which the outcome is a dichotomous variable and predictor is a continuous one. With constant and beta values obtained from parameter estimates results, the predictive power can be estimated through formula below:

Odds=exp(logit) =>

e^{b_0} = ? (obtained from parameter estimates)

The odds of correct recognition for 100-ms fixation : $e^{b_0+b_1}$ = ? (obtained from parameter estimates)

odd=prob/(1-prob) => prob=odd/(1+odd)

The probability of correct recognition: $\frac{e^{b_0}}{1+e^{b_0}} = \text{x}$

The odds of correct recognition: $\frac{e^{b_0+b_1}}{1+e^{b_0+b_1}}$ = y

$$y - x \ = estimation\ coefficient\ in\ percentage$$

5.6.6.6. Welch Test

Welch test is a between subjects statistical procedures similar to One Way ANOVA and t-test (Welch, 1947). It is applied when One Way ANOVA assumption of Levene Test is violated. As ANOVA cannot be applied when test of homogeneity is significant between groups, Welch test is applied to have an accurate result.

6. FINDINGS AND RESULTS

6.1. Introduction

In this section, answers to the research questions will be discussed and elaborated regarding findings.

6.2. Is there a significant difference between vocabulary pretest and posttest? If so, what is the facilitative effect of total fixation duration on post test?

Eye movement literature on reading behavior suggests that learners fixate on unknown words more than they do on known words. This case also indicates an aspect of selective attention; attentional sources vary depending on word recognition. In addition, unknown words accommodate more cognitive load than known words and recognition process is longer. In this research, known and unknown word difference is based on lexical access. A reader may read the word, pronounce it correctly and even may recognize its morphological features and function in a sentence. However, despite these, the meaning of the word may still be unclear. According to Grabe (2010) in such conditions, no lexical access occur and word recognition can be assumed to be at minimal level. Total fixation duration is the main index for this issue and total fixation mostly a constitution of 3 metrics: First fixation duration, gaze duration and rereading times.

6.2.1. Knowns vs. Unknown Words

The descriptives regarding known and unknown words for first fixation, gaze duration, second pass times and total fixation duration are as follows:

Table 8. Mean for 4 metrics and lexical access

	Known Mean (ms/SD)	*Unknown Mean(ms/SD)*	*N*
Total Fixation Duration	369 (95,40)	515 (123,68)	75
First Fixation Duration	258 (47,99)	276 (64,86)	75
Gaze Duration	356 (68,47)	504 (190,71)	75
Rereading Time	299 (124,33)	409 (134,94)	25

Total fixation duration is observed to have differed significantly regarding known and unknown words; t(74) = 8,327, p = ,000. A similar effect is also observed for gaze duration; t(74) = 6,411, p = ,000 and for rereading times; t(24) = 3,092, p = ,005. No significant difference is found for first fixation duration; (74) = 1,799, p = ,077. The main reason for this findings can be assumed to be associated with learner's isomorphic competence of initial word recognition skills; especially orthography. When L2 learners meet a vocabulary item, as they are still familiar with orthography, their first fixation duration is identical regardless of lexical access. If the word is unknown and there is minimal or no lexical access, gaze duration is inflated and difference occurs which also inflates total fixation duration.

In addition to mean differences, a clear correlation between word recognition and total fixation duration is observed. The scatter plot below indicates the linearity between total fixation duration and word recognition level.

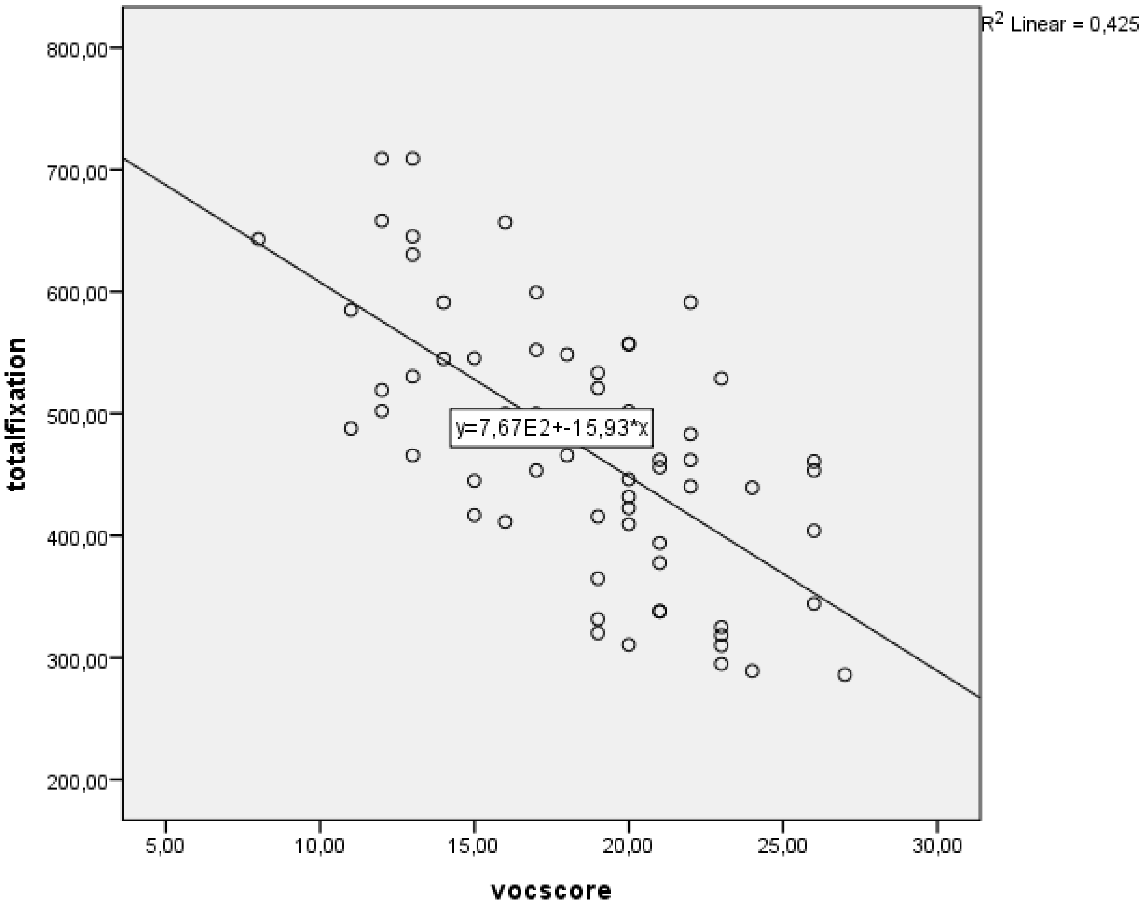

Figure 31. Scatter Plot for linearity between Total fixation and Vocabulary Score

The scatter plot indicates that there is a negative correlation between vocabulary scores and total fixation duration. In other words, participants with better vocabulary score fixated less on vocabulary items. In accordance with scatterplot, Pearson correlation results asserts that there is a strong negative correlation between the two variables [r = -652, n = 75, p = ,000].

Mean differences, Scatter plot for linearity and Pearson correlation results clearly show that participants fixate longer on unknown words and higher vocabulary scores negatively correlate with total fixation. These findings obviously points out more attentional sources are paid to unknown vocabulary items in reading and word recognition skills manipulates the attentional span.

As relationship between attention and word recognition levels are clear, a new assumption arises. Related research on attention, consciousness and noticing asserts that attentional sources may have a facilitative effect on learning. In accordance with this assumption, there may be a facilitative effect of total fixation duration on word recognition in post test. That is to say, the unknown words which are fixated more through reading may be predicted or known in post test results.

6.2.2. The Facilitative Effect of Noticing in Foreign language Reading

First of all, a paired samples T Test is conducted to find out if there is any significant difference between pre test and post test. The results are shown below:

Table 9. Paired Samples T Test for Pre and Post tests

	Paired Differences					*t*	*df*	*Sig. (2-tailed)*
	Mean	*SD*	*Std. Error Mean*	*95% CI of the Difference*				
				Lower	*Upper*			
Pair 1 Post-Pre	3,21154	3,52769	,48920	4,19365	2,22942	6,565	74	,000

Table 9 indicates that there is a significant difference in the scores for pre test (M= 18,82, SD= 4,52) and post test (M= 22,03, SD= 4,26) conditions; t(74) = 6,565, p = ,000. Linguistic exposure through reading caused the post test results to increase slightly about 4 points. The hypothesis is that total fixation duration on unknown words is a predictor of post test scores. To estimate the potential effect of total fixation duration on post test results, a *Generalized Estimation Equation (GEE)* procedure with long data format has been conducted. In this procedure, vocabulary items are nested within participants, post test results as binary output (0-1) are taken as the dependent variable and total fixation is the only covariate. To obtain better interpretation, total fixation/100 is taken as the predictor. The general overview of GEE output are as follows:

Table 10. Model Information

Dependent Variable		Post Test[a]
Probability Distribution		Binomial
Link Function		Logit
Subject Effect	1	ID
Within-Subject Effect	1	Vocabulary Items
Working Correlation Matrix Structure		Independent

a. The procedure models ,00 as the response, treating 1,00 as the reference category.

Table 10 above can be explained as a GEE procedure post test with the dependent variable and total fixation duration as the only covariate. ID variable is the subject variables and vocabulary items are nested within ID variable to observe detailed estimation of total fixation duration on post test scores. Participant information for GEE is also given below:

Table 11. Correlated Data Summary

Number of Levels	***Subject Effect***	***ID***	75
	Within-Subject Effect	***Index1***	15
Number of Subjects			75
Number of Measurements per Subject	***Minimum***		15
	Maximum		15
Correlation Matrix Dimension			15

GEE output indicated that total fixation time is a significant predictor of the probability of posttest recognition (Wald χ 2 (1) = 39.440, p = .000). As the covariate is a significant predictor, further main output is open to interpretation. The table below explains the main output of GEE.

Table 12. GEE Parameter Estimates

Parameter	***B***	***SE***	***95% Wald CI***		***Hypothesis Test***			***Exp(B)***	***95% Wald CI for Exp(B)***	
			Lower	***Upper***	***Wald Chi-Square***	***df***	***Sig.***		***Lower***	***Upper***
(Intercept)	-1,736	,1789	-2,087	-1,386	94,158	1	,000	,176	,124	,250
fix100	,253	,0403	,174	,332	39,440	1	,000	1,288	1,190	1,394
(Scale)	1									

Depending on this table, the extracted parameters are enlisted below:

$b_0 = -1,736$

$b_1 = 0,253$

$e = 1{,}288$

In this respect;

The odds of correct recognition for no fixation: $e^{b_0} = 0.64444530164$

The odds of correct recognition for 100-ms fixation: $e^{b_0+b_1} = 0.68706017415$

In Logistic Regression as odd=prob/(1-prob) => prob=odd/(1+odd)

The probability of correct recognition for no fixation:$\frac{e^{b_0}}{1+e^{b_0}} = 0{,}391$

The odds of correct recognition for 100-ms fixation:$\frac{e^{b_0+b_1}}{1+e^{b_0+b_1}} = 0{,}407$

The difference = 0,391 – 0,407 = 0,016

The final coefficient is for 1 millisecond increase in fixation duration. To manipulate it for a second for better interpretation, it is multiplied by 1000. The results of GEE points out that for every second (1000ms) longer that a participant looked at an unknown word, the probability that it would be recognized on the posttest increased by 16%.

In conclusion, attention has a facilitative effect on unknown linguistic items. When foreign language learners meet an unknown word through reading, most of the time they pay considerable attention which may facilitate learning. This attention is somewhat selective and conscious as learners can allocate different amounts of attentional sources to words in different recognition level. In terms of foreign language instruction 2 main points arises:

First of all, exposure to linguistic items facilitates vocabulary learning. Then it comes to the point that form focused instruction and grammar instruction is essential for foreign language reading skill. As learners pay attention to grammatical items and vocabulary, their potential to predict or recognize those increases in a certain extent.

Secondly, foreign language reading has an obvious conscious aspect in which learners can distinguish between known and unknown words. Learner reaction throughout reading varies regarding recognition levels and they have a cognitive subsystem which manipulates attention. This attention points out consciousness which can also facilitate learning.

Finally, to enable incidental vocabulary acquisition, including unknown linguistic items in instruction is essential. Krashen's i+1 hypothesis is worth to mention at this point which assumes that foreign language learners should be provided input a slightly above their current proficiency. In foreign language reading, when learners are exposed to linguistic items slightly below their proficiency level, they actually develop a further potential to recognize those items in progressing learning experience.

6.3. Is there a linear relationship between word recognition skills in foreign language and early measures (First fixation, gaze duration, single fixation duration)? If so, what are the standard values for early measures in terms of word recognition skills?

In this research, terms "early" and "late" are used to categorize and present well-coordinated results rather that categorizing eye movements as early and late.

In addition to early measure problem detection, for a few decades, eye movements and reading research obviously established the developmental aspect of eye movements and reading behavior. In such research, skilled readers and unskilled readers have different standards of eye movement measures. Table below includes some standard measures:

Table 13. Approximate Mean Fixation Duration and Saccade Length in Reading, Visual Search, Scene Perception, Music Reading, and Typing (Rayner,1998)

Task	*Mean fixation duration (ms)*	*Mean saccade size (degrees)*
Silent Reading	225	2 (about 8 letters)
Oral Reading	275	1.5 (about 6 letters)
Visual Search	275	3
Scene Perception	330	4
Music Reading	375	1
Typing	400	1 (about 4 letters)

In this respect, it should be noted that eye movement research in foreign language is quite a recent trend. Unlike first language reading research, foreign language reading does not have eye movement standards to detect language developmental problems. Moreover, proficiency based differences of eye movements in foreign language reading have not yet been defined clearly with a robust frame. In this part, an eye movement frame to detect proficiency level differences in foreign language reading will be established. Then this frame can be used to detect foreign language reading problems.

6.3.1. Relationship between Word Recognition Skills and Early Measures

It is hypothesized that vocabulary knowledge is a strong predictor of early measures. *The Multiple Spline Curve Plot* below shows how early change when controlled with vocabulary score measures:

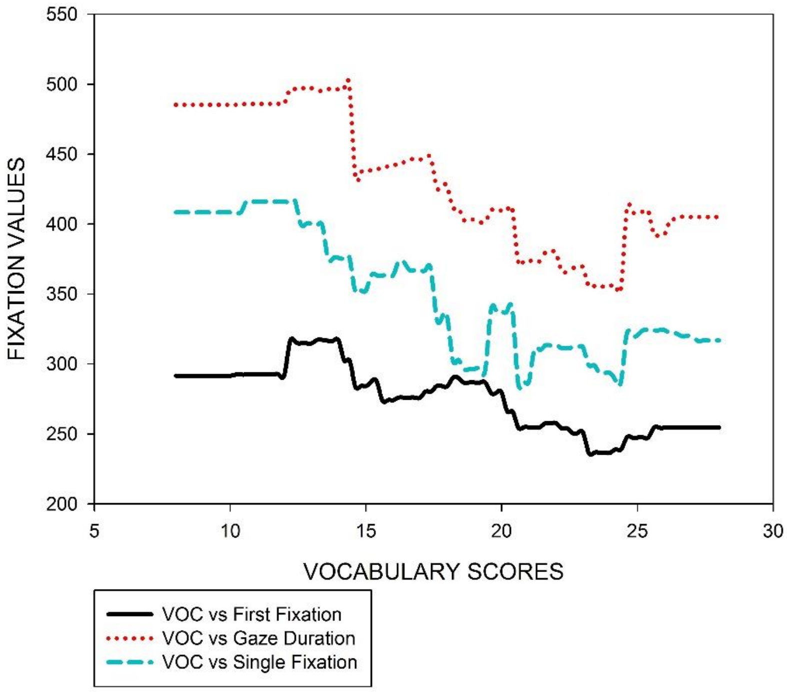

Figure 32. Multiple Spline Curve Plot for Early Measures and Vocabulary Scores

In general, gaze duration is observed to have higher values when compared with first fixation duration (black color) and single fixation duration (blue color). For a deeper look, correlation table below illustrates the main relationship between vocabulary score and early measures:

Table 14. Pearson Correlation for Vocabulary Scores and Early Measures

		firstfixation	*gazedurat*	*singlefixation*
	Pearson Correlation	-,578**	-,476**	,244*
vocscore	***Sig. (2-tailed)***	,000	,000	,035
	N	75	75	75

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The findings point out that there is a negative correlation between vocabulary scores and first fixation duration [r = -578, n = 75, p = ,000] and gaze duration [r = -476, n = 75, p = ,000]. Both coefficients have moderate to strong correlation which means that as the vocabulary knowledge increases, first fixation duration and gaze duration decreases. As a result, higher vocabulary knowledge facilitates rapid word recognition. In addition to this, there is a positive correlation between single fixation duration and vocabulary knowledge [r = ,244 n = 75, p = ,035] with a weak r coefficient. Different from other early measures; as vocabulary knowledge increases single fixation duration increases also. It can be assumed that higher word recognition skills lead to very fast word recognition which can be accomplished by a single fixation point.

Pearson correlation is just the tip of the iceberg. To scrutinize the relationship between word recognition and early measures, linear regression analysis was conducted. The findings are as follows:

Table 15. Model Summary for Vocabulary Score and Early Measures

Model	*R*	*R Square*	*Adj. R Square*	*SE Estimate*	*Change Statistics*				
					R Square Change	*F Change*	*df1*	*df2*	*Sig.*
Voc-FF	,578[a]	,334	,325	46,236	,334	36,581	1	73	,000
Voc- GD	,476[a]	,227	,216	77,608	,227	21,438	1	73	,000
Voc- SF	,244[a]	,060	,047	60,346	,060	4,624	1	73	,035

Table 16. ANOVA for Vocabulary Scores and Early Measures

Model		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Voc-FF	***Regression***	78201,777	1	78201,777	36,581	,000[b]
	Residual	156058,111	73	2137,782		
	Total	234259,887	74			
Voc-GD	***Regression***	129118,749	1	129118,749	21,438	,000[b]
	Residual	439679,190	73	6023,003		
	Total	568797,939	74			
Voc-SF	***Regression***	16838,033	1	16838,033	4,624	,035[b]
	Residual	265843,611	73	3641,693		
	Total	282681,644	74			

Table 17. Regression Coefficients for Vocabulary Scores and Early Measures

	Model	*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
FF	***(Constant)***	290,484	23,819		12,196	,000
	vocscore	-7,307	1,208	-,578	-6,048	,000
GD	***(Constant)***	593,595	39,980		14,847	,000
	vocscore	-9,389	2,028	-,476	-4,630	,000
SF	***(Constant)***	80,827	31,088		2,600	,011
	vocscore	3,391	1,577	,244	2,150	,035

Linear Regression results implied that vocabulary scores significantly predicted first fixation duration (β = - 7, 307, t(73) = 6,048, p = .000.) Vocabulary Scores also explained a significant proportion of variance in first fixation duration (R2 = ,334, F (1, 73) = 36,581, p =.000). The results indicate that 1 point increase in vocabulary score decreases first fixation duration by approximately 8 milliseconds.

In addition to first fixation duration, it is observed that vocabulary scores significantly predicted gaze duration. (β = - 9, 389, t(73) = 4, 630, p = .000.) Vocabulary Scores also explained a significant proportion of variance in gaze duration (R2 = ,227, F (1, 73) = 21,438, p =.000). The results indicate that 1 point increase in vocabulary score decreases gaze duration by approximately 10 milliseconds.

And finally linear regression results showed that vocabulary scores significantly predicted single fixation duration. (β = 3,391, t(73) = 2,150, p = .035). But vocabulary Scores explained a low proportion of variance with significance in gaze duration (R2 = ,060, F (1, 73) = 4,624, p =.035). The results indicate that 1 point increase in vocabulary score also increases single fixation by approximately 4 milliseconds.

It is obvious that vocabulary score manipulates attention in the initial recognition of vocabulary during foreign language reading. Thus, eye movements can be used as a developmental tool to track orthographic, morphological, semantic and phonetic aspects of initial word recognition. However, to track such a developmental progress regarding early measures, a frame including standard values for early measures for foreign language reading is needed.

6.3.2. Standards of Early Measures and Word Recognition Skills

Table below shows the standard measurements for early measures:

Table 18. Mean Early Measures in Foreign language Reading

	N	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
First fixation	614	63,00	1537,00	275,0000	129,87632
Gaze duration	1113	103,00	4730,00	417,4510	246,37627
Single fixation	501	112,00	1530,00	327,7844	163,89895

According to the Table 18, mean first fixation duration is 275 ms (SD = 129,87) and mean single fixation duration is 328 ms (SD = 163,89). Gaze duration has a mean of 418 ms (SD = 246,37). It can be assumed that low first fixation duration is most of the time followed by a successive saccade which inflated the gaze duration. According to Rayner (1998), the average fixation mean is 225 ms in first language. In this respect, foreign language gaze duration is observed to be quite high which means that although first fixation duration is observed to be normal, gaze duration is high in foreign language. It can be assumed that word recognition in foreign language includes more cognitive load when compared with first language.

On the other hand, single fixation duration is different in some aspects. Single fixation duration is an advanced early measure which refers to a single fixation point on the AOI. In other words, this metric indicates a very fast word recognition which is accomplished by a single fixation point. According to the table above, single fixation duration is observed to be high (over 225 ms threshold). This means that even though learners of a foreign language can recognize a word with a single glimpse, it is still above the average in first language. In addition, single fixation duration is observed to be occurred half less than gaze duration which can lead to the assumption that foreign language learners recognize words with more than a single saccade. That is to say, word recognition in foreign language requires more than 1 fixation point which refers to the finding that most of the time language learners spend more cognitive energy than they do in their native language.

For more detailed standardization, the Table… below shows how much attention is paid to unknown, known and familiar words regarding early measures by foreign language learners:

Table 19. Mean Early Measures for Known, Familiar and Unknown Vocabulary Items

	WRL	*N*	*Mean*	*SD*	*Std. Error Mean*
First Fixation	***Unknown***	303	286,7558	156,31665	8,98016
	Known	311	263,5466	96,35266	5,46366
Gaze Duration	***Unknown***	486	454,1317	292,62017	13,27352
	Known	627	389,0191	199,08005	7,95049
Single Fixation	***Unknown***	183	362,3279	176,71415	13,06309
	Known	318	307,9057	152,82750	8,57014

An independent-samples t-test was conducted to compare early measures in terms of 2 word recognition levels (unknown and known). The significance table is given below:

Table 20. T Test Significance Table for Early Measures and Word Recognition Levels

		Levene's Test for EV		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*MD*	*SED*	*95% CI Lower*	*95% CI Upper*
First Fixation	***EVA***	8,641	,003	2,221	612	,027	23,209	10,450	2,686	43,731
	EVnA			2,208	500,193	,028	23,209	10,511	2,556	43,861
Gaze Duration	***EVA***	4,949	,026	4,409	1111	,000	65,112	14,768	36,136	94,088
	EVnA			4,208	814,235	,000	65,112	15,472	34,746	95,483
Single Fixation	***EVA***	7,812	,005	3,622	499	,000	54,422	15,026	24,899	83,945
	EVnA			3,483	336,587	,001	54,422	15,623	23,690	85,154

According to the Table 20, a significant difference between unknown and known words are observed regarding all three early measures. In terms of first fixation, unknown words attracted more attention (M= 287, SD= 156,31) than known words did (M= 264, SD= 96,35). This difference is observed to be significant, t(612)= 2,221, p = ,027. Similarly, regarding gaze duration, unknown words attracted more attention (M= 455, SD= 292) than known words did (M= 390, SD= 199). This difference is observed to be significant, t(1111)= 4,409, p = ,000. And finally in terms of single fixation duration, unknown words attracted more attention (M= 363, SD= 176) than known words did (M= 308, SD= 152). This difference is observed to be significant, t(499)= 3,622, p = ,000.

The findings indicate that lexical access to a vocabulary item has a critical role in the initial word recognition. On an unknown word, short first fixation duration is most of the time followed by a longer saccade inflating gaze duration. Having a lexical access to a word greatly shortens the initial recognition and lessens the cognitive load. As orthography is the main initial unit for word recognition, first fixation duration for words are low and identical. However, when learners have no lexical access to a word, they are challenged by the morphology and phonology of that alien word. As a result gaze duration is inflated. And finally, when foreign language learners make a single fixation on a word, it is most of the time above the threshold for first language (225ms). Single fixation duration refer to a rapid recognition and made mostly on the words with lexical access. It is obvious that foreign language learners fixate more than once on most words, especially on unknown vocabulary items.

6.4. Is there a linear relationship between word recognition skills in foreign language reading and late measures (Regression out, refixation, total fixation duration)? If so, what are the standard values for early measures in terms of word recognition skills?

In this part, late measures and its relationship in L2 reading was discussed.

6.4.1. Relationship between Word Recognition Skills and Late Measures

The Multiple Spline Curve Plot below shows how late change when controlled with vocabulary score measures:

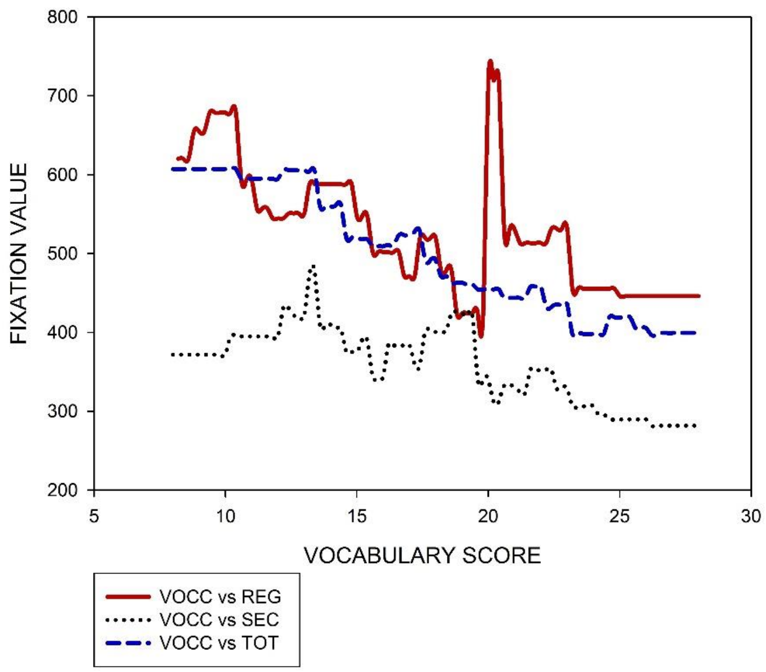

Figure 33. Multiple Spline Curve Plot for Late Measures and Vocabulary Scores

The general overview on late measures and vocabulary knowledge indicates that there is a relationship between late measures and word recognition skills.

Refixations has a lower value when compared with regressions out and total fixation duration which have identical values. For a more detailed relationship, Generalized Estimation Equations Linear Regression is conducted:

Table 21. Standards for Late Measures

	N	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
reg	71	113,00	1613,00	536,4225	242,30038
sec	156	115	1233,00	346,4359	212,15260
totalfx	1115	112,00	2210,00	479,5659	254,32771

According to the Table 21, mean regression out duration is 537 ms (SD = 242,30) and mean refixation duration is 347 ms (SD = 212,15). Total fixation Duration has a mean of 480 ms (SD = 254,32). Regression out and refixations are not available all the time as learners do not tend to reread of go back frequently.

6.4.2. Relationship between Vocabulary Scores and Regression out

To reveal any potential relationship between 2 variables, a GEE Linear Regression procedure has been conducted.

Table 22. Data Summary for GEE Linear Regression for Vocabulary Scores and Regressions out

Number of Levels	Subject Effect	ID	39
	Within-Subject Effect	Index1	14
Number of Subjects			39
Number of Measurements per Subject	Minimum		1
	Maximum		6
Correlation Matrix Dimension			14

Data summary asserts that 39 participants made regressions out of the 14 AOI. Parameter Estimation table is given below:

Table 23. Parameter Estimates for Regression out and Vocabulary Scores

Parameter	*B*	*Std. Error*	*95% Wald Confidence Interval*		*Hypothesis Test*			*95% Wald Confidence Interval for Exp(B)*	
			Lower	*Upper*	*Wald Chi-Square*	*df*	*Sig.*	*Lower*	*Upper*
(Intercept)	736,740	109,5992	521,930	951,551	45,187	1	,000	4,691E+226	.[a]
vocscore	-10,694	6,3484	-23,136	1,749	2,837	1	,092	8,964E-011	5,749
(Scale)	57541,876								

GEE output revealed that vocabulary knowledge is not a significant predictor of the probability of regression out duration (Wald $\chi 2$ (1) = 45.187, p = .092). That is to say, regressions out of a word is not predicted by vocabulary knowledge. Foreign language learners may regress out of a word as they cannot figure out the syntactic structure of the sentence. In addition, even though they know the word, they may still regress out of that word as they cannot comprehend the previous syntactic structure. As a result, it can be assumed that higher word recognition skills is not a strong predictor of comprehension, grammar and syntactic knowledge is required for full success.

However, T test results showed up a difference between known and unknown words although word recognition is not a strong predictor of regression out:

Table 24. Mean Regression out for Known and Unknown Words

	voc	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
Reg out	Unknown	36	611,8333	277,47262	46,24544
	Known	35	458,8571	171,47100	28,98389

And the T Test results are as follows:

Table 25. T Test for Regression out and Word Recognition Levels

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% CI*	
									Lower	*Upper*
Regression out	EVA	3,426	,068	2,785	69	,007	152,97619	54,92743	43,39897	262,55341
	EVnA			2,803	58,590	,007	152,97619	54,57753	43,75084	262,20154

Regarding regressions out, unknown words are fixated more (M= 612, SD= 277) than known words (M= 459, SD= 172). This difference is observed to be significant, t(69)= 2,785, p = ,007. Descriptively, a difference is observed in terms of regression out and lexical access. Learners of a foreign language tend to regress out of the words they have no lexical access more than the words they have lexical access. However, when the number of words regressed out in total are considered (71 out of 1115), it can be assumed that foreign language learners do not prefer to regress out of vocabulary items while reading. There may be 2 main reasons for this issue. Foreign language learners may not be using reading strategies (including guessing meaning from the context) much due to lack of strategy instruction. Or this may be due to the experimental setting of the research in which learners have time limitations. In case of any reason, regression out should be handled carefully to examine word recognition skills of foreign language learners.

6.4.3. Relationship between Vocabulary Scores and Refixations

To reveal any potential relationship between 2 variables, a GEE Linear Regression procedure has been conducted.

Table 26. Data Summary for GEE Linear Regression for Vocabulary Scores and Refixations

Number of Levels	Subject Effect	ID	59
	Within-Subject Effect	Index1	15
Number of Subjects			59
Number of Measurements per Subject	Minimum		1
	Maximum		7
Correlation Matrix Dimension			15

Data summary asserts that 59 participants made regressions out of the 15 AOI. Parameter Estimation table is given below:

Table 27. Parameter Estimates for Refixations and Vocabulary Scores

Parameter	*B*	*Std. Error*	*95% Wald CI*		*Hypothesis Test*			*95% Wald CI*	
			Lower	*Upper*	*Wald Chi-Square*	*df*	*Sig.*	*Lower*	*Upper*
(Intercept)	489,885	91,4213	310,703	669,068	28,714	1	,000	8,641E+134	3,737E+290
vocscore	-7,540	4,3405	-16,047	,967	3,017	1	,082	1,074E-007	2,631
(Scale)	44248,220								

According to the Table 27, similar to regression out parameters, vocabulary score is not a strong predictor of refixating a word (Wald χ2 (1) = 28,714, p = .082). Indeed, related findings indicate that higher word recognition skills will not mean that no refixation would occur. Refixations most of the time inhibits fluency and solely knowing the words in a text do not mean efficient comprehension. Rather than word recognition, syntactic knowledge and higher sentence processing skills with good grammatical competence is required.

In addition, foreign language learners' refixation on unknown words more than known words do not show any significance. A t test is conducted to reveal any difference:

Table 28. Mean for refixations regarding word recognition levels

	voc	N	Mean	Std. Deviation	Std. Error Mean
Refixation	Unknown	86	364,5581	227,13135	24,49220
	Known	70	324,1714	191,42388	22,87953

And T test results are as follows:

Table 29. T Test for Refixations and Word Recognition Levels

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	MD	SED	95% CI of the Difference	
									Lower	Upper
Refixations	EVA	,875	,351	1,184	154	,238	40,38671	34,10749	-26,99224	107,76566
	EVnA			1,205	153,800	,230	40,38671	33,51628	-25,82498	106,59840

Regarding refixations, there is no significant difference between unknown words and known words, t(154)= 1,184, p = ,238. Descriptively, no difference is observed in terms of refixations and lexical access. Depending on these findings, it can be assumed that learners may refixate on the words they know or do not know, regardless of lexical access. It can be assumed that refixations on a word is not lexical access driven but rather syntactic and sentential. These findings show that vocabulary knowledge is not a solution for better comprehension and fluency in foreign language. Form focused instruction and grammatical competence is vital.

6.4.4. Relationship between Vocabulary Scores and Total Fixation Duration

Total fixation duration can be described as the sum of all metrics (excluding regression path duration) made on an AOI. To reveal any relationship, a correlation has been conducted between vocabulary scores and total fixation duration:

Table 30. Pearson Correlation between Vocabulary Scores and Total Fixation Duration

		vocscore	totalfixation
vocscore	Pearson Correlation	1	-,618**
	Sig. (2-tailed)		,000
	N	75	75

**. Correlation is significant at the 0.01 level (2-tailed).

A strong negative correlation between vocabulary scores and total fixation duration is observed [r = -618, n = 75, p = ,000]. It can be assumed that as vocabulary knowledge increases, total fixation duration tends to decrease. For a detailed estimation, linear regression has been performed vocabulary score as the predictor and total fixation duration as the dependent variable:

Table 31. Model Summary for Vocabulary Score and Total Fixation Duration

Model	*R*	*R Square*	*Adj. R Square*	*SED*	*Change Statistics*				
					R Square Change	*F Change*	*df1*	*df2*	*Sig. F Change*
VOC-TFD	,618[a]	,382	,374	81,540	,382	45,173	1	73	,000

a. Predictors: (Constant), vocscore

Table 32. ANOVA for Vocabulary Scores and Total Fixation Duration

Model		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
VOC-TFD	*Regression*	300353,164	1	300353,164	45,173	,000[b]
	Residual	485372,050	73	6648,932		
	Total	785725,214	74			

a. Dependent Variable: totalfixation

b. Predictors: (Constant), vocscore

Table 33. Regression Coefficients for Vocabulary Scores and Total Fixation Duration

Model		*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*	*95,0% CI for B*	
		B	*SE*	*Beta*			*Lower Bound*	*Upper Bound*
1	*(Constant)*	746,030	42,006		17,760	,000	662,312	829,749
	vocscore	-14,321	2,131	-,618	-6,721	,000	-18,567	-10,074

a. Dependent Variable: totalfixation

According to the Linear Regression results, vocabulary scores significantly predicted total fixation duration (β = - 14, 321, t(73) = 17,760, p = .000.) Vocabulary Scores also explained a significant proportion of variance in total fixation duration (R2 = ,382, F (1, 73) = 45,173, p =.000). The results indicate that 1 point increase in vocabulary score decreases total fixation duration by approximately 15 milliseconds.

The findings above obviously reveal a strong relationship between total fixation duration and word recognition skills. As foreign language learners develop their word recognition skills, they automatically decrease their total fixation time on vocabulary items which contribute to fluent reading and comprehension.

As there is a strong relationship between word recognition skills and total fixation duration, it is hypothesized that learner fixation on unknown and known words may have a significant difference. First standard measures are as follows:

To reveal any potential difference, a t test is conducted word recognition level as the factor and total fixation duration as the dependent variable:

Table 34. Mean Total fixation duration regarding word recognition levels

	WRL	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
Total Fixation	***Unknown***	488	525,9713	267,41013	12,10509
	Known	627	443,4482	237,67748	9,49192

And the significance table is as follows:

Table 35. T Test for Total fixation duration in terms of Word Recognition Levels

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*MD*	*SED*	*95% CI of the Difference*	
									Lower	*Upper*
totalfx	***EVA***	2,583	,108	5,444	1113	,000	82,52315	15,15920	52,77931	112,26698
	EVnA			5,365	981,357	,000	82,52315	15,38278	52,33623	112,71006

According to the table above, unknown words are fixated more (M= 526, SD= 267) than known words (M= 444, SD= 237). This difference is observed to be significant, t(1113)= 5,444, p = ,000. So it can be assumed that foreign language learners fixate on unknown words more than they do for known words. As unknown vocabulary items require more cognitive load to resolve ortographic, syntactic, morphological and semantic aspects, total fixation duration is longer. It comes to the point that vocabulary knowledge is a significant factor in fluency and comprehension.

Another point is about noticing. High fixation values on unknown items actually refer to the fact that attentional sources are paid more on them. According to the noticing hypothesis, these sources can facilitate learning and as fixation index on unknown vocabulary items are higher, all second learners have the tendency to learn if this attention can be effectively in instruction.

And finally, it is observed that mean total fixation duration on vocabulary items in foreign language reading is about 485 milliseconds which is quite above the first language fixation threshold; 225 milliseconds. It can be assumed that foreign language reading is unlike first language reading in terms of total fixation parameters. Foreign language reading accommodates more cognitive load in which both word recognition and sentence processing issues play significant role. It should be noted that most foreign language learners are native L1 reader who are at least proficient in ortography. Despite this competence, the fixation index is still quite high which points out the fact that a detailed vocabulary instruction including all constituents (morphology, ortography, semantics, syntax) is required.

6.5. Is there a relationship between proficiency levels and early measures? If so what are the standard values for each early measure to track learner development?

Eye movements in reading can give strong clues about learning reading development. Both late and early measures can indicate developmental aspects of the learner without any subjectivity. With the efficient use of eye tracking methodology, problem detection in foreign language reading can be made with robust accuracy; the analysis can indicate word recognition problems or syntactic challenges and even reading fluency issues. Previous research shows that this methodology can be used to track learner development:

Table 36. Mean for eye movement standards for different proficiency levels (Taylor, 1965; Buswell, 1922; Rayner, 1985b; McConkie et al.,1991)

	GRADE						
	1	***2***	***3***	***4***	***5***	***6***	***Adult***
Fixation duration (ms)	355	306	286	266	255	249	233
Fixations per 100 words	191	151	131	121	117	106	94
Frequency of regressions (%)	28	26	25	26	26	22	14

According to the Table 36, the mean values of fixation duration in first language decreases as the level increase which refer to the fact that better learners have less inflated fixation duration. Depending on related research, such a frame with more details and measures can be established for foreign language reading.

As mentioned in previous chapter, early measures indicate initial word recognition processes and it is hypothesized that this measures (first fixation, gaze duration and single fixation) can vary depending on proficiency level.

Here are 3 scanpath samples from a B1, B2 and C1 learner:

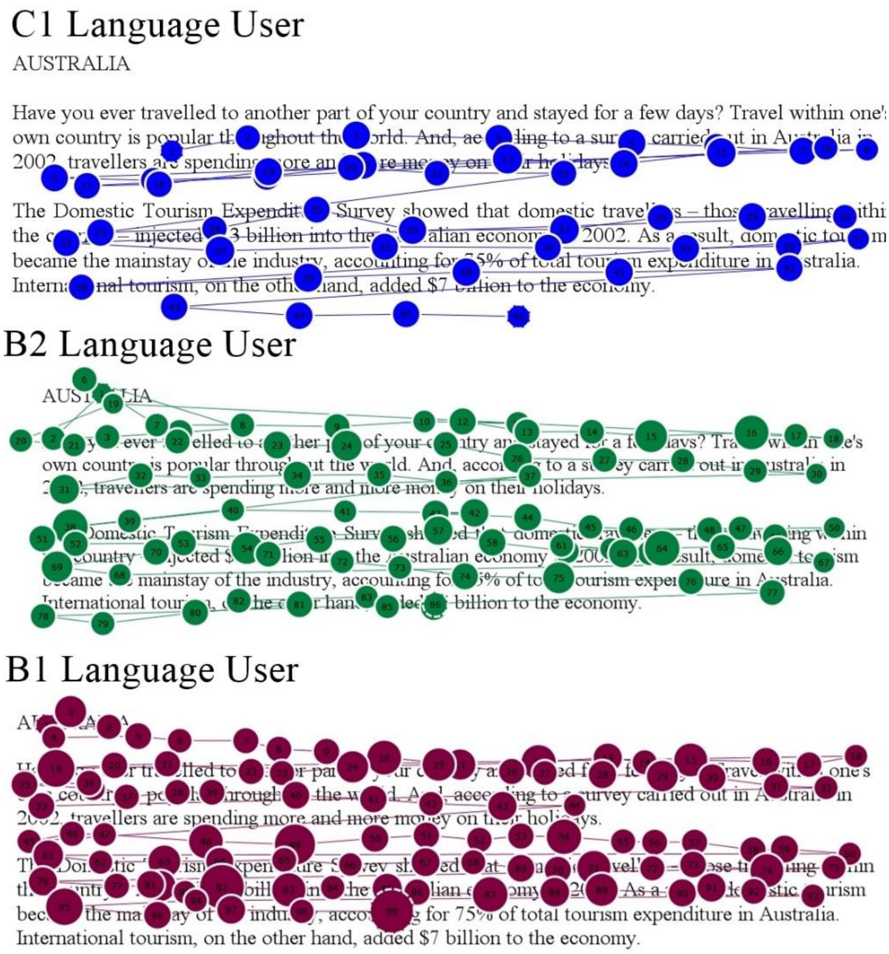

Figure 34. Scanpaths for 3 CEFR Levels

The general panorama in Figure 34 shows that different proficiency levels have different scanpaths. As can be seen above, fixation count and reading behavior is different in 3 different levels. In B1 level sample, the fixation points are closer and numerous, while these values seem less in B2 and C1 levels. B1 sample also is observed to have more inflated values (larger bubbles) when compared with higher proficiency levels.

Skilled learners are expected to have less inflated values while unskilled ones may have higher values. Better proficiency level means better vocabulary, better syntactic and word recognition skills and better linguistic handling including analyzing the context and discourse easily for comprehension. On the other hand, low proficiency levels refer to lack of efficient word recognition skills, problems in sentence processing and challenges in contextual and discursive aspects.

6.5.1. Relationship between Early Measures and IELTS Scores

It is hypothesized that there is a linear relationship between early measures and proficiency level.

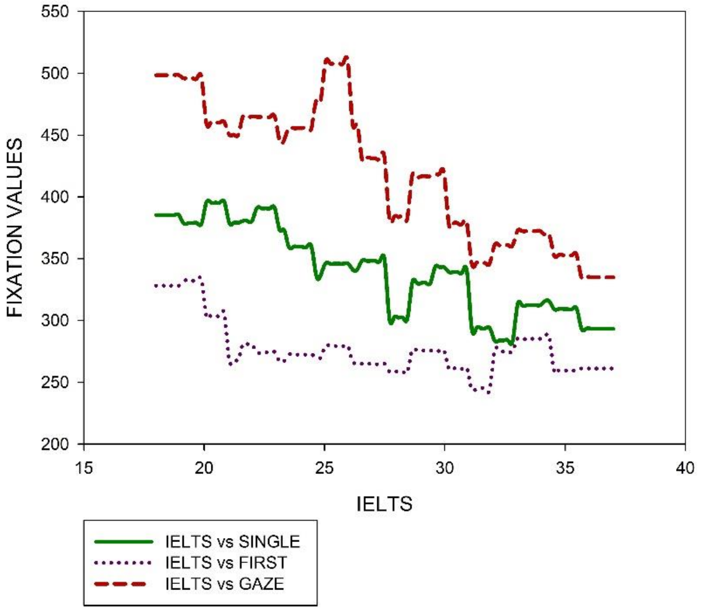

Figure 35. Multiple Spline Curve Plot for Early measures and IELTS Scores

Depending on the Figure 35 above, gaze duration has the utmost value and probably have the highest linear relationship with proficiency level. It is followed by single fixation duration with a potential linearity. And finally first fixation duration is with lowest values with a slight potential linearity. To have a better understanding, Pearson correlation is conducted:

Table 37. Pearson Correlation for Early Measures and IELTS Scores

		IELTSscore	*singlefix*	*firstfix*	*Gaze dur*
IELTSscore	*Pearson Correlation*	1	-,365**	-,241*	-,543**
	Sig. (2-tailed)		,001	,038	,000
	N	75	75	75	75

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

A moderate negative correlation is observed between IELTS scores and gaze duration [r = -,543, n = 75, p = ,000]. A similar correlation is also observed for IELTS scores and single fixation duration [r = -,365, n = 75, p = ,001]. Correlation between first fixation duration and IELTS score is still significant but weak [r = -241, n = 75, p = ,038].

The general correlational panorama shows that gaze duration and single fixation duration may be proficiency driven and first fixation duration has a potential. To see the predictive power of IELTS scores on early measures, linear regression has been conducted on each of three measures.

6.5.2. Linearity between Gaze Duration and IELTS Scores

To reveal any potential linear relationship between IELTS Scores and Gaze Duration, linear regression procedure is conducted. The results are as follows.

Table 38. Model Summary for IELTS Scores and Gaze Duration

Model	*R*	*R Square*	*Adj. R Square*	*St. Error of the Estimate*	*Change Statistics*				
					R Square Change	*F Chg.*	*df1*	*df2*	*Sig. F Change*
IELTS-GAZE	,543[a]	,295	,286	73,15327	,295	30,573	1	73	,000

a. Predictors: (Constant), IELTSscore

Table 39. ANOVA for IELTS Scores and Gaze Duration

Model		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
IELTS-GAZE	***Regression***	163608,707	1	163608,707	30,573	,000[b]
	Residual	390652,243	73	5351,401		
	Total	554260,949	74			

a. Dependent Variable: gazeFIXED

b. Predictors: (Constant), IELTSscore

Table 40. Regression Coefficients for IELTS Score and Gaze Duration

Model		*Unst. Coefficients*		*St. Coefficients*	*t*	*Sig.*	*95,0% Confidence Interval for B*	
		B	*Std. Error*	*Beta*			*Lower Bound*	*Upper Bound*
1	***(Constant)***	676,921	47,675		14,199	,000	581,904	771,938
	IELTSscore	-9,423	1,704	-,543	5,529	,000	-12,819	-6,026

a. Dependent Variable: gazefix

Linear Regression results point out that IELTS scores significantly predicted gaze duration (β = - 9, 423, t(73) = 5,529, p = .000.) IELTS Scores also explained a significant proportion of variance in gaze duration (R2 = ,295, F (1, 73) = 30,573, p =.000). The results indicate that 1 point increase in IELTS score decreases gaze duration by approximately 10 milliseconds.

6.5.3. Linearity between First Fixation Duration and IELTS Scores

To reveal any potential linear relationship between IELTS Scores and first fixation duration, linear regression procedure is conducted. The results are as follows.

Table 41. Model Summary for IELTS Scores and First Fixation Duration

Model	R	R Square	Adj. R Square	Std. Error of the Estimate	Change Statistics				
					R Square Chg.	F Change	df1	df2	Sig. F Change
IELTS-FF	,241[a]	,058	,045	52,40330	,058	4,485	1	73	,038

a. Predictors: (Constant), IELTSscore

Table 42. ANOVA for IELTS Scores and First Fixation Duration

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12316,513	1	12316,513	4,485	,038[b]
	Residual	200465,697	73	2746,105		
	Total	212782,209	74			

a. Dependent Variable: firstfixFIXED

b. Predictors: (Constant), IELTSscore

Table 43. Regression Coefficients for IELTS Scores and First Fixation Duration

Model		Unstd. Coefficients		Std. Coefficients	t	Sig.	95,0% CI for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	344,284	34,152		10,081	,000	276,218	412,349
	IELTSscore	-2,585	1,221	-,241	2,118	,038	-5,018	-,152

a. Dependent Variable: firstfixFIXED

Linear Regression results point out that IELTS scores significantly predicted first fixation duration (β = -2,585, t(73) = 2,118, p = .038). However, IELTS Scores cannot explain a significant proportion of variance in first fixation duration (R2 = ,058, F (1, 73) = 4,485, p =.038). Regression results showed that first fixation is not much driven by proficiency.

6.5.4. Linearity between Single Fixation Duration and IELTS Scores

To reveal any potential linear relationship between IELTS Scores and single fixation duration, linear regression procedure is conducted. The results are as follows.

Table 44. Model Summary for IELTS Score and Single Fixation Duration

Model	R	R Square	Adj. R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Chg.
IELTS-SFD	,365[a]	,133	,121	75,98161	,133	11,233	1	73	,001

a. Predictors: (Constant), IELTSscore

Table 45. ANOVA for IELTS Score and Single Fixation Duration

	Model	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
IELTS-SFD	***Regression***	64848,546	1	64848,546	11,233	,001[b]
	Residual	421443,917	73	5773,204		
	Total	486292,464	74			

a. Dependent Variable: singlefixed

b. Predictors: (Constant), IELTSscore

Table 46. Regression Coefficients for IELTS Score and Single Fixation Duration

Model		*Unstd. Coefficients*		*Std. Coefficients*	*t*	*Sig.*	*95,0% CI for B*	
		B	***Std. Error***	***Beta***			***Lower Bound***	***Upper Bound***
1	***(Constant)***	499,451	49,519		10,086	,000	400,760	598,142
	IELTSscore	-5,932	1,770	-,365	-3,352	,001	-9,460	-2,405

a. Dependent Variable: singlefixed

Linear Regression results indicate that IELTS scores significantly predicted single fixation duration (β = -5,932, t(73) = 10,086, p = .001). In addition, IELTS Scores explain a significant proportion of variance in single fixation duration (R2 = ,133, F (1, 73) = 11,233, p =.001). These results show that single fixation duration is proficiency driven.

Depending on these results, it can be assumed that first fixation duration does not vary regarding proficiency levels. This may be due to the fact that all learners are familiar with the L2 orthography in terms of word recognition. But as word recognition process progresses, proficiency makes difference and proficient learners of L2 are much better in morphological, semantic and syntactic aspect of L2. Moreover, when it comes to recognizing a word at first glance with a single fixation point, proficiency plays an important role. Higher proficiency predicts the time spent in this process by decreasing it. Low level proficiency levels still spend more time even though they can recognize the word with a single fixation point.

As the relationship between proficiency levels and early measures or word recognition is established, standards for each proficiency level is required for each of 3 measures. With these standards, L2 learners' progress can be tracked in terms of initial word recognition skills. In addition, problems of initial word recognition can be observed and target-specific solutions can be provided.

6.5.5. Standard values for early measures in terms of CEFR Levels

As mentioned before, eye tracking methodology can be used to track learner development in foreign language reading. To provide this robust tracking, standards are required for all measures for different proficiency levels. These standards for early measures in terms of 3 CEFR levels (B1, B2, C1) are described below:

Table 47. Early Measure Standards for 3 different proficiency levels

		N	Mean	SD	SE	95% CI for Mean		Min	Max
						LB	UB		
Single Fixation	B1	27	371,82	83,461	16,062	338,81	404,84	240,25	583,29
	B2	38	319,20	76,691	12,441	293,99	344,40	173,50	512,25
	C1	10	303,95	59,541	18,828	261,35	346,54	214,00	400,00
	Total	75	336,11	81,064	9,360	317,46	354,76	173,50	583,29
First Fixation	B1	27	282,53	52,885	10,177	261,60	303,45	218,75	472,88
	B2	38	270,93	55,922	9,0718	252,55	289,32	194,25	496,00
	C1	10	255,85	45,702	14,452	223,15	288,54	191,86	338,63
	Total	75	273,10	53,623	6,1918	260,76	285,43	191,86	496,00
Gaze Duration	B1	27	475,45	85,444	16,443	441,64	509,25	351,27	706,87
	B2	38	394,65	70,295	11,403	371,55	417,76	247,67	511,13
	C1	10	347,68	49,842	15,761	312,02	383,33	269,93	421,87
	Total	75	417,48	86,544	9,993	397,56	437,39	247,67	706,87

As it can be observed through the Table… above, as the proficiency level increases, all 3 early measures tend to decrease. Indeed this linearity points out that proficiency is a drive for early measures and word recognition skills in foreign language reading.

In terms of single fixation duration, B1 learners has a mean of 372ms (SD = 83,461) and B2 learners have a mean of 320ms (76,691). C1 learners have lowest mean (M= 304, SD= 59,541). Average duration for single fixation duration is observed to be 337ms (SD = 81,064). Similarly, regarding gaze duration, B1 learners have a mean of 476ms (SD = 85,444) and B2 learners have a mean of 395ms (SD = 70,295). C1 learners have the lowest gaze duration (M = 348, SD = 49,842). Average gaze duration has a mean of 418ms (SD = 86,544). In terms of first fixation duration, B1 learners have a mean of 283ms (SD = 52,885) and B2 learners have a mean of 271ms (SD = 55,922). C1 learners again has the lowest value (M = 256, SD = 45, 702). Average first fixation duration is 274ms (SD = 53,623). Through the descriptive it can observed that B1 learners are above the average measures while C1 learners are always have values below the threshold.

To reveal if these descriptive differences are significant, One Way ANOVA is conducted CEFR level as the factor and early measures as dependent variable. The results are as follows:

Table 48. One Way ANOVA for CEFR Levels and Early Measures

		Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
singlefixed	***Between Groups***	55651,086	2	27825,543	4,652	,013
	Within Groups	430641,378	72	5981,130		
	Total	486292,464	74			
firstfixFIXED	***Between Groups***	5553,749	2	2776,874	,965	,386
	Within Groups	207228,461	72	2878,173		
	Total	212782,209	74			
gazeFIXED	***Between Groups***	159245,972	2	79622,986	14,513	,000
	Within Groups	395014,977	72	5486,319		
	Total	554260,949	74			

A significant effect of proficiency level is observed on single fixation duration at the $p<.05$ level, F(2,72) = 4,652, p = ,013]. Similarly, a stronger significance is valid for gaze duration, F(2,72) = 14,513, p = ,000]. Unlike these 2 measures, no significance is observed for first fixation duration regarding 3 CEFR Levels, F(2,72) = ,965, p = ,386].

First fixation duration and gaze duration; most importantly, are successive measures of initial word recognition. Most of the time, a first fixation duration is followed by another saccade(s) which all constitute gaze duration. First fixation is therefore the most initial measure which is primarily about orthography. As all L2 learners in this context (ELT) are highly familiar with orthography due to their L1, no significance is expected. However, when learners start to analyze morphological and syntactic role of the vocabulary items, a new fixation point is added. If learner has problems with the morphology, syntax and lexical aspect of the word, this new fixation point is longer which inflates the gaze duration. That is why while all proficiency levels are identical in terms of first fixation duration, they differ to a great extent regarding gaze duration.

Another point to consider is single fixation duration. The difference between proficiency groups refers to the fact that even though low level learners recognize a word at first glance and analyze all constituents with a single fixation point, they still have higher values when compared to higher level learners. It can be assumed that cognitive processes related to word recognition skills (analyzing orthographic, morphological, syntactic and semantic aspects of a word) are slower for low level learners. This rate of speed can be due to the lack of exposure to linguistic items.

6.6. Is there a relationship between proficiency levels and late measures? If so what are the standard values for each late measure to track learner development?

Similar to early measures, late measures with standards can be used to track learner development in foreign language reading. Refixations, regressions out and total fixation duration each can give clues about the discursive and syntactic aspects of word recognition. In all three metrics, inflated values indicate word recognition problems; inability to determine the role of the related vocabulary item in the context and discourse.

6.6.1. Relationship between Late Measures and IELTS Scores

It is hypothesized that there is a linear relationship between late measures and proficiency level.

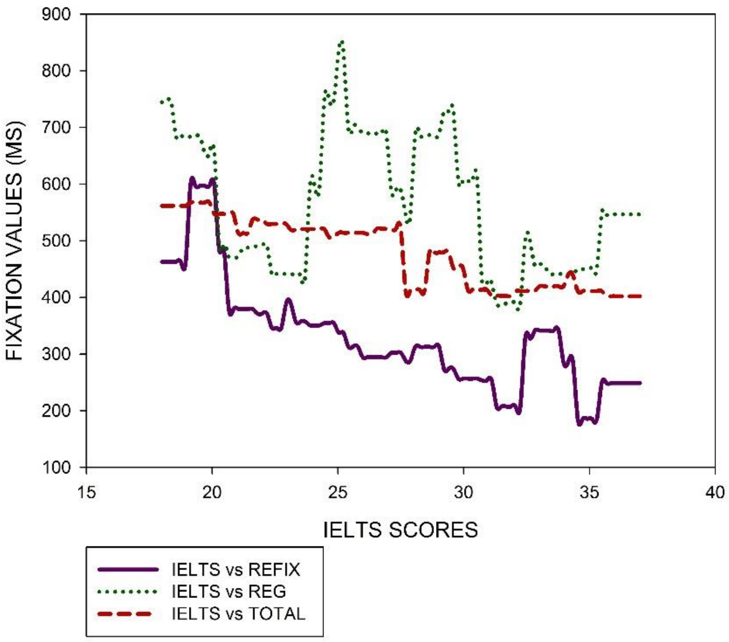

Figure 36. Multiple Spline Curve Plot for Late measures and IELTS Scores

According to the Figure 36 above, regression out duration has the utmost value with a high standard deviation. Secondly, total fixation duration is between 400-550ms and seems to have linear relationship with IELTS scores. Finally refixations has the lowest value and have a potential linearity with IELTS Scores. For a more detailed overview, Pearson correlation is conducted:

Table 49. Pearson Correlation for Late Measures and IELTS Scores

		IELTS	Total Fixation	Refixation	Regression
IELTS	Pearson Correlation	1	-,496**	-,324*	-,216
	Sig. (2-tailed)		,000	,017	,186
	N	75	75	54	39

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

A moderate negative correlation is observed between IELTS scores and total fixation duration [r = -,496, n = 75, p = ,000]. A similar correlation is also observed for IELTS scores and refixations [r = -,324, n = 39, p = ,017]. There is no correlation between regression out and IELTS scores [r = -216, n = 54, p = ,186].

In general, it can be assumed that total fixation duration and rereading times are proficiency driven. Same effect is not observed for regression out. To see the relationship in detail and to reveal the predictive power of IELTS scores on late measures, linear regression has been conducted on each of three measures.

6.6.2. Linearity between Total Fixation Duration and IELTS Scores

To reveal any potential linear relationship between IELTS Scores and Gaze Duration, linear regression procedure is conducted. The results are as follows.

Table 50. Model Summary for IELTS Scores and Total Fixation Duration

Model	R	R Square	Adj. R Square	SE of the Estimate	Change Statistics				
					R Square Chg.	F Chg.	df1	df2	Sig.F Chg.
IELTS-TFD	,496[a]	,246	,236	90,092	,246	23,805	1	73	,000

a. Predictors: (Constant), IELTSscore

Table 51. ANOVA for IELTS Scores and Total Fixation Duration

	Model	Sum of Squares	df	Mean Square	F	Sig.
IELTS-TFD	Regression	193214,327	1	193214,327	23,805	,000[b]
	Residual	592510,886	73	8116,587		
	Total	785725,214	74			

a. Dependent Variable: totalfixation

b. Predictors: (Constant), IELTSscore

Table 52. Regression Coefficients for IELTS Score and Total Fixation Duration

Model		Unstd. Coefficients		Std.Coefficients	t	Sig.	95,0% CI for B	
		B	Std. Error	Beta			LB	UB
1	(Constant)	752,824	58,715		12,822	,000	635,806	869,843
	IELTSscore	-10,240	2,099	-,496	4,879	,000	-14,423	-6,057

a. Dependent Variable: totalfixation

Linear Regression results point out that IELTS scores significantly predicted total fixation duration (β = -10,240, t(73) = 4,879, p = .000.) IELTS Scores also explained a significant proportion of variance in total fixation duration (R2 = ,246, F (1, 73) = 23,805, p =.000). The results indicate that 1 point increase in IELTS score decreases total fixation duration by approximately 11 milliseconds.

6.6.3. Linearity between Refixations and IELTS Scores

To reveal any potential linear relationship between IELTS Scores and refixations, linear regression procedure is conducted. The results are as follows.

Table 53. Model Summary for IELTS Scores and Refixations

Model	*R*	*R Square*	*Adj. R Square*	*SE of the Estimate*	*Change Statistics*				
					R Square Chg.	*F Chg.*	*df1*	*df2*	*Sig. F Chg*
IELTS-REFIX	,324[a]	,105	,088	175,13268	,105	6,107	1	52	,017

a. Predictors: (Constant), IELTSscore

Table 54. ANOVA for IELTS Scores and Refixations

Model		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
IELTS-REFIX	***Regression***	187315,188	1	187315,188	6,107	,017[b]
	Residual	1594915,686	52	30671,455		
	Total	1782230,874	53			

a. Dependent Variable: refix

b. Predictors: (Constant), IELTSscore

Table 55. Regression Coefficients for IELTS Scores and Refixations

Model		*Unstd. Coefficients*		*Std. Coefficients*	*t*	*Sig.*	*95,0% CI for B*	
		B	*SE*	*Beta*			*LB*	*UB*
1	***(Constant)***	673,834	140,416		4,799	,000	392,069	955,599
	IELTSscore	-12,503	5,059	-,324	-2,471	,017	-22,655	-2,351

a. Dependent Variable: refix

Linear Regression results point out that IELTS scores significantly predicted refixations (β = -12,503, t(73) = 4,799, p = .000). IELTS Scores also explain a significant proportion of variance in refixations (R2 = ,105, F (1, 73) = 6,107, p =.017). These results indicate that rereading times for a vocabulary item may change depending on the proficiency level.

6.6.4. Linearity between Regression out and IELTS Scores

To reveal any potential linear relationship between IELTS Scores and regressions out, linear regression procedure is conducted. The results are as follows.

Table 56. Model Summary for IELTS Score and Regression out

Model	*R*	*R Square*	*Adj. R Square*	*SE of the Estimate*	*Chg Statistics*				
					R Square Change	*F Change*	*df1*	*df2*	*Sig. F Change*
IELTS - REGS	,216[a]	,047	,021	219,52588	,047	1,812	1	37	,186

a. Predictors: (Constant), IELTSscore

Table 57. ANOVA for IELTS Score and Regression out

Model		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
IELTS-REGS	*Regression*	87335,077	1	87335,077	1,812	,186[b]
	Residual	1783089,687	37	48191,613		
	Total	1870424,764	38			

a. Dependent Variable: REG

b. Predictors: (Constant), IELTSscore

Table 58. Regression Coefficients for IELTS Score and Single Fixation Duration

Model		*Unstd Coefficients*		*Std. Coefficients*	*t*	*Sig.*	*95,0% CI for B*	
		B	*SE*	*Beta*			*LB*	*UB*
1	*(Constant)*	825,757	191,688		4,308	,000	437,360	1214,154
	IELTSscore	-9,246	6,868	-,216	-1,346	,186	-23,162	4,670

a. Dependent Variable: REG

Linear Regression results indicate that IELTS Score is not a strong predictor og regression out (β = -9,246, t(73) = 4,308, p = .186). Likewise, IELTS Scores cannot explain a significant proportion of variance in single fixation duration (R2 = ,047, F (1, 73) = 1,812, p =.186). As a result, regression out is not proficiency driven. All proficiency levels tend to regress from a word or not to regress. Regression out of a vocabulary item cannot be explained by proficiency level.

In depth correlational analysis of three late measures points out that both total fixation duration and rereading times are predicted by proficiency level. Higher proficiency means less total fixation duration and rereading times. In other words, when L2 learners develop their syntactic and sentence processing skills along with vocabulary knowledge, their time to analyze vocabulary items and defining their role in the syntactic structures decrease. On the other hand, same relation is not possible with regressions out. The results showed that all learners may regress out of a vocabulary item regardless of their levels. So regressions out should be handled out carefully.

6.6.5. Standard values for Late Measures in terms of CEFR Levels

As mentioned before, eye tracking methodology can be used to track learner development in foreign language reading. To provide this robust tracking, standards are required for all measures for different proficiency levels. These standards for late measures in terms of 3 CEFR levels (B1, B2, C1) are described below:

Table 59. Late Measure Standards for 3 different proficiency levels

		N	*Mean*	*SD*	*SE*	*95% CI for Mean*		*Min*	*Max*
						Lower	*Upper*		
Total Fixation	***B1***	27	530,31	76,153	14,655	500,18	560,43	411,27	709,07
	B2	38	447,02	103,449	16,781	413,02	481,02	289,00	709,07
	C1	10	401,10	90,237	28,535	336,54	465,65	285,93	580,93
	Total	75	470,88	103,043	11,898	447,17	494,59	285,93	709,07
Refixation	***B1***	22	406,26	211,530	45,098	312,48	500,05	198,50	1200,00
	B2	26	295,17	145,537	28,542	236,38	353,95	120,00	634,33
	C1	6	218,05	125,329	51,165	86,530	349,58	63,00	381,50
	Total	54	331,86	183,376	24,954	281,81	381,91	63,00	1200,00
Regression	***B1***	17	609,60	214,708	52,074	499,21	720,00	352,00	1067,00
	B2	16	561,43	259,919	64,979	422,93	699,93	151,50	1134,00
	C1	6	494,16	107,032	43,695	381,84	606,48	337,00	654,50
	Total	39	572,08	221,859	35,525	500,16	644,00	151,50	1134,00

According to the descriptives in Table 59 above, as the proficiency level increases, all 3 late measures tend to decrease. Indeed this linearity points out that proficiency level manipulates late measures in foreign language reading.

Regarding total fixation duration, B1 learners have a mean of 531ms (SD = 76,153) and B2 learners have a mean of 448ms (SD = 103,449). C1 learners have lowest mean (M= 402, SD= 90,237). Average duration for total fixation duration among proficiency levels is observed to be 471ms (SD = 103,043). Likewise, in terms of refixations, B1 learners have a mean of 407ms (SD = 211,530) and B2 learners have a mean of 296ms (SD = 145,537). C1 learners have the lowest gaze duration (M = 219, SD = 125,329). Average rereading time has a mean of 332ms (SD = 183,376). In terms of regression out, B1 learners have a mean of 610ms (SD = 214,708) and B2 learners have a mean of 562ms (SD = 259,919). C1 learners again has the lowest value (M = 495, SD = 107,032). Average regression out is 573ms (SD = 221,859). Through the descriptive it can observed that B1 learners are above the average measures while C1 learners are always have values below the threshold.

To reveal if these descriptive differences are significant, One Way ANOVA is conducted by using CEFR level as the factor and late measures as dependent variables. The results are as follows:

Table 60. One Way ANOVA for CEFR Levels and Late Measures

		Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Totalfixation	***Between Groups***	165691,058	2	82845,529	9,620	,000
	Within Groups	620034,155	72	8611,585		
	Total	785725,214	74			
Refixation	***Between Groups***	234515,149	2	117257,575	3,864	,027
	Within Groups	1547715,725	51	30347,367		
	Total	1782230,874	53			
Regs	***Between Groups***	62178,667	2	31089,333	,619	,544
	Within Groups	1808246,097	36	50229,058		
	Total	1870424,764	38			

A significant effect of proficiency level is observed on total fixation duration at the p<.05 level, F(2,72) = 9,620, p = ,000]. A similar effect is also valid for refixation with lower power, F(2,72) = 3,864, p = ,027]. Unlike these 2 measures, no significance is observed for regression out regarding 3 CEFR Levels, F(2,72) = ,619, p = ,544].

According to these findings, proficiency levels are sensitive to late measures to a certain extent. Total fixation duration which refers to the sum of most fixational indices on a word tend to decrease with increasing proficiency which indicate that better learners allocate less time on vocabulary items in a syntactic structure. Better learners are faster in identifying the function of a vocabulary item in a sentence, and even when they reread it due to discourse and co-text problems, they still allocate less time on these vocabulary items when compared less skilled learners. On the other hand, low level proficiency causes inflation in total fixation duration. When learners cannot enable lexical access to a vocabulary item, they automatically cannot designate its function in a syntactic structure which also inflates rereading times. As a result, all inflated measures increase total fixation duration. This inflation causes comprehension problems, inhibits fluency and analyzing context.

Refixations occur when learners cannot figure out the role of vocabulary item in a sentence. In addition, they may refixate when they cannot fully analyze and process the sentence. Better learners refixate less due to their higher syntactic competence and word recognition skills. They are faster and most of the time they do not need to reread a vocabulary item. On the contrary, less skilled learners refixate more and spend more time in rereading a vocabulary item. This is mainly due to lack of grammatical competence and word recognition skills which should be taught hand in hand.

Regarding regression out, although descriptive analysis represent an overall difference, the relationship between proficiency levels and regression out is weak. As can be seen in the descriptive part, most learners do not tend to regress and they are motivated to go on reading. This results with lack of enough data points for better predictive analysis. Indeed, regression out should be a subject to research with ambiguous or garden path sentences which may reveal better coefficients. However it should be note that better learners still have less inflated values of regression out of a word when compared with less skilled learners.

6.7. Can reading speed and fluency standards calculated through eye movements in foreign language reading? If so what is the relationship between reading fluency and proficiency levels?

It is hypothesized that both word recognition skills and proficiency level predict reading rate. To reveal a detailed relationship, Multiple Linear Regression is conducted vocabulary scores and IELTS scores as the predictors and reading rate (wpm) as the dependent variable. The results are as follows:

Table 61. Model Summary for VS-IELTS and WPM

Model	*R*	*R Square*	*Adj. R Square*	*SE of the Estimate*	*Change Statistics*				
					R Square Change	*F Change*	*df1*	*df2*	*Sig. F Change*
V-IELTS-WPM	,456[a]	,208	,186	49,069	,208	9,457	2	72	,000

a. Predictors: (Constant), vocscore, IELTSscore

Table 62. ANOVA for VS-IELTS and WPM

Model		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
V-IELTS-WPM	***Regression***	45543,789	2	22771,894	9,457	,000[b]
	Residual	173362,773	72	2407,816		
	Total	218906,562	74			

a. Dependent Variable: wpmspeed

b. Predictors: (Constant), vocscore, IELTSscore

Table 63. Regression Coefficients for VS-IELTS and WPM

Model		*Unstd. Coefficients*		*Std. Coefficients*	*t*	*Sig.*	*95,0% CI for B*		*Correlations*			*Collinearity*	
		B	*SE*	*Beta*			*LB*	*UB*	*Zero-order*	*Partial*	*Part*	*Tol*	*VIF*
1	***(Constant)***	59,182	33,965		1,742	,086	-8,526	126,8					
	IELTS	2,717	1,287	,249	2,111	,038	,151	5,283	,380	,241	,221	,789	1,268

vocscore	3,474	1,444	,284	2,406	,019	,596	6,353	,399	,273	,252	,789	1,268

a. Dependent Variable: wpm

According to the results of the multiple regression, both proficiency and word recognition skills predict reading rate, F(2,72) = 9,457, p = ,000. It means that better vocabulary knowledge with better comprehension skills including sentence processing skills increase reading rate and fluency. In addition, word recognition is observed to contribute more to reading rate than proficiency does (β = 3,474, t(72) = 2,426, p = .019). One point increase in vocabulary score also increases reading rate by about 4 words per minute. In other words, automatization in word recognition skills in foreign language reading has a significant role in reading rate rather than grammatical and syntactic competence. It can be assumed that even low level proficiency learners can develop their reading rate by learning new vocabulary rather than focusing on grammatical structures. And surely, by developing their lexical competence, an increase is expected in their reading rate. However, the role of sentence processing skills should not be ignored as recognizing a word is also related with analyzing the syntactic structure and discourse in a sentence.

6.7.1. Foreign language Silent Reading Rate among CEFR Levels

To reveal reading rate and fluency in L2, one way ANOVA is conducted. The results are as follows:

Table 64. Standard Reading Rates for 3 CEFR Levels

	N	***Mean***	***SD***	***SE***	***95% CI for Mean***		***Min***	***Max***
					LB	***UB***		
B1	27	177,1486	28,84493	5,55121	165,7379	188,5593	120,14	228,06
B2	38	207,3450	57,21236	9,28107	188,5398	226,1503	116,20	398,28
C1	10	239,3577	70,36837	22,25243	189,0192	289,6962	167,92	408,63
Total	75	200,7427	54,38931	6,28034	188,2288	213,2565	116,20	408,63

In terms of reading rate and fluency, B1 learners have a mean of 178wpm (SD = 28,84) and B2 learners have a mean of 208wpm (SD = 103,449). C1 learners have highest wpm (M= 240, SD = 70,36). Average wpm for L2 learners is about 200wpm (54,38). Depending on these findings, it can be assumed skilled L2 readers read more words per minute while less skilled ones fall behind the average mean fluency.

As the homogeneity between variances assumption is violated, Welch test is applied to find out the significance between groups:

Table 65. Welch Test for Reading Rate and Proficiency Levels

	Statistic[a]	*df1*	*df2*	*Sig.*
Welch	6,544	2	22,209	,006

a. Asymptotically F distributed.

According to the Welch test, B1, B2 and C1 levels are significantly different from each other (F_{asymp}= 6,544, df1 = 2, df2 = 22,209, p = ,006). It can be assumed that as learner competence in L2 reading develops, reading rate also increases. And with these standards, L2 learners reading rate can be tracked and calculated accurately.

These findings assert that L2 reading is quite different from L1 reading. As L2 reading bears more cognitive load, it is much slower when compared with L1 reading. L2 reading is observed to be about 20% slower than L1 reading in optimal degree. In addition to this, word recognition skills greatly contribute reading rate and fluency. Automatization in word recognition leads to faster and more fluent reading and it can be assumed that low proficiency foreign language learners pay considerable attention to unknown words. This long attentional span lengthens reading time resulting with slow rates of reading. On the other hand, the role of grammatical and syntactic knowledge should not be ignored. Even though learners have lexical access to a vocabulary item, sometimes they may reread or regress from it as they could not process the sentence efficiently. These rereading times and regressions inflates total fixation duration which causes slower reading rates.

6.8. What are the standard measures for word skipping in foreign language reading? To what extent do the grammatical function words (articles, auxiliary verbs, and prepositions) are skipped by 3 CEFR levels?

In this part, word skipping during L2 reading was scrutinized.

6.8.1. Relationship between Reading Rate and Word Skipping

As skipped words are zero fixation words, this zero attention contributes to reading fluency in foreign language.

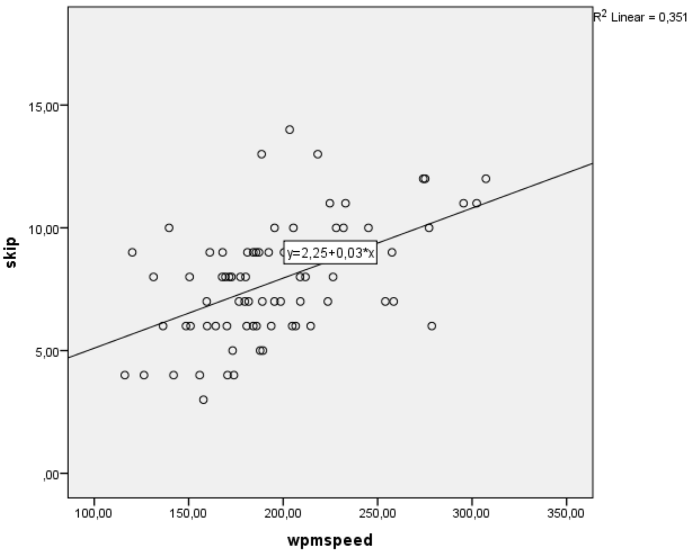

Figure 37. Scatter Plot for Reading Rate and Word Skipping

According to the Figure 37, there is an obvious linearity between word skipping and reading rate. To dig this relationship more, Pearson correlation is conducted:

Table 66. Pearson Correlation between Reading Rate and Word Skipping

		Reading Rate (wpm)	*Word Skipping Rate*
Reading Rate (wpm)	*Pearson Correlation*	1	,592**
	Sig. (2-tailed)		,000
	N	75	75

**. Correlation is significant at the 0.01 level (2-tailed).

According to Table 66, there is a strong positive correlation between the two variables [r = ,592, n = 75, p = ,000]. These findings indicate that word skipping contributes to reading fluency. As the number of skipped items increase in a text, reading rate also increases.

6.8.2. Word Skipping Standards for Foreign language Reading

As there is a relationship between word skipping and reading rate, word skipping rates are beneficial to track L2 fluency development. To enable such a robust tracking, standard measures for L2 word skipping rates are required.

Table 67. General Word Skipping for Foreign language Reading

	N	*Min*	*Max*	*Mean*	*SD*	*%*
Aux skip	75	,00	4,00	1,9733	1,19654	40%
Prep skip	75	,00	5,00	1,7333	1,09462	25%
Article skip	75	,00	8,00	4,2667	1,54512	43%
Total skip	75	3,00	17,00	7,9733	2,61995	37%
Valid N (listwise)	75					

Depending on Table 67, it can be assumed that L2 learners skip about 37% of the functional grammatical words while reading (N=75). It means that 1 of the 3 function words are skipped. Technically, auxiliary words such as am, is, was etc. are skipped by 40% (N=75) and nearly half of these function words are skipped in general by L2 learners. Similarly, prepositions are skipped by a rate of 25% (N=75) and 1 of each 4 prepositions take zero fixation. And most skipped function words are articles (the, an, a) with a skipping rate of 43% (N=75) in foreign language reading. Nearly half of the articles in foreign language reading are skipped by L2 learners.

6.8.3. Standard Word Skipping Rates and CEFR Levels

As better learners have better syntactic skills, they can process sentences faster than less skilled L2 learners. So it is hypothesized that proficiency is a factor in word skipping rates.

Table 68. Word Skipping Standards for 3 CEFR Levels

		N	*Mean*	*%*	*SD*	*SE*	*95% CI for Mean*		*Min*	*Max*
							LB	*UP*		
Aux skip	***B1***	27	1,7037	34%	1,137	,218	1,25	2,15	,00	4,00
	B2	38	1,8421	37%	1,151	,186	1,46	2,22	,00	4,00
	C1	10	3,2000	64%	,788	,249	2,63	3,76	2,00	4,00
	Total	75	1,9733	40%	1,196	,138	1,69	2,24	,00	4,00
Prep skip	***B1***	27	1,2222	18%	,891	,171	,86	1,57	,00	3,00
	B2	38	1,8947	27%	,952	,154	1,58	2,20	,00	4,00
	C1	10	2,5000	36%	1,509	,477	1,42	3,57	,00	5,00
	Total	75	1,7333	25%	1,094	,126	1,48	1,98	,00	5,00
Article skip	***B1***	27	3,8148	38%	1,210	,232	3,33	4,29	1,00	6,00
	B2	38	4,3421	44%	1,712	,277	3,77	4,90	,00	7,00
	C1	10	5,2000	52%	1,316	,416	4,25	6,14	3,00	8,00
	Total	75	4,2667	43%	1,545	,178	3,91	4,62	,00	8,00
Total skip	***B1***	27	6,7407	31%	2,030	,390	5,93	7,54	3,00	11,00
	B2	38	8,0789	37%	2,306	,374	7,32	8,83	4,00	13,00
	C1	10	10,9000	46%	2,923	,924	8,80	12,99	7,00	17,00
	Total	75	7,9733	37%	2,619	,302	7,37	8,57	3,00	17,00

According to Table 68, auxiliary verbs are skipped by B1 learners at a rate of 34% (N=27) and by B2 learners at a rate of 37% (N=37). C1 learners auxiliary verb skipping rate is quite high (64%, N=10). In terms of preposition skipping, B1 learners skip them by 18% (N=27) and B2 learners by 27% (N= 38). C1 learners skip preposition at a rate of 36% (N=10). Articles are most skipped function words, B1 learners skip them with a rate of 38% (27) and B2 learners by 44% (N=38). C1 learners skip more than half of the articles (52%, N=10).

General word skipping rate distribution among 3 proficiency levels are also in an ascending fashion. B1 learners skip about each 1 of 3 function words (31%, N=27). B2 learners have higher rates in word skipping (37%, N=38). And C1 learners has the highest rates, they nearly skip half of the function words while reading (46%, N=10).

These standards were also found to be significant.

Table 69. One Way ANOVA for Word Skipping and 3 CEFR Levels

		Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Aux skip	***Between Groups***	17,664	2	8,832	7,203	,001
	Within Groups	88,282	72	1,226		
	Total	105,947	74			
Prep skip	***Between Groups***	13,921	2	6,961	6,705	,002
	Within Groups	74,746	72	1,038		
	Total	88,667	74			
Article skip	***Between Groups***	14,440	2	7,220	3,204	,046
	Within Groups	162,227	72	2,253		
	Total	176,667	74			
Total skip	***Between Groups***	127,098	2	63,549	12,014	,000
	Within Groups	380,848	72	5,290		
	Total	507,947	74			

There is a significant effect of proficiency level on word skipping rates at the p<.05 level [F(2,72) = 12,014, p = ,000]. In detail, 3 proficiency levels significantly differ from each other regarding auxiliary skipping rates at the p<.05 level, [F(2,72) = 7,203, p = ,001]. A similar significance is also observed for preposition skipping, [F(2,72) = 6,705, p = ,002]. In terms of article skipping, the significance is not much strong but still valid at the p<.05 level, [F(2,72) = 3,204, p = ,046].

The findings indicate that second learners nearly skip half of the function words. This skipping rate is proficiency driven; better learners skip more while less skilled ones tend to fixate. Most skipped function words are articles and it is observed that “the, a, an” are not much fixated most of the time especially by proficient learners. Likewise, better learners tend to skip most auxiliary verbs such as “am, is, are, was etc.” and this rate falls as the proficiency level decreases. Least skipped function words are prepositions. Articles and auxiliary words are short linguistic items with only a few letters long and their function is automatized in proficient learners. Even for less skilled learners, a certain extent of grammatical competence is enough to skip most of them. However prepositions are distinguished, some prepositions are longer such as through, between, under, beside etc. while some of them are quite short like at, in, on etc. In addition, prepositions are less predictable and may carry a critical meaning which may affect comprehension. In addition, less proficient learners may be unfamiliar with low frequency prepositions such as beneath, within, among, underneath etc. which may then take considerable amount of fixation. Thus due to length, frequency and predictability effects, attentional levels for prepositions are higher and skipping rate is low for prepositions in foreign language. As word skipping contributes reading fluency in L2, prepositions should be instructed carefully in foreign language classrooms.

7. DISCUSSION AND CONCLUSIONS

7.1. Introduction

In this section, conclusions are aimed to be presented and discussed relying on the findings of the study. The results will be handled and evaluated in terms of practical and pedagogical implications in foreign language reading. In accordance, suggestions will be made.

7.2. Conclusion

This study aimed to reveal attention and foreign language reading relationship by proposing eye movement standards for developmental foundations in foreign language reading. The findings are evaluated step by step. Firstly, this research unfolded the facilitative aspect of attention, noticing and consciousness in foreign language reading. Secondly, eye movements are related to word recognition levels and standards are established. Thirdly, eye movements are evaluated in terms of proficiency levels and a certain developmental frame is manifested. And finally word skipping and reading fluency in foreign language reading are analyzed one by one regarding different proficiency levels.

First of all, attentional sources and consciousness are hot issues of debate in foreign language acquisition. For a few decades, foreign language acquisition is mostly proposed as a totally unconscious motivation; manifesting itself without conscious and effort. In 1990s, the reveal of noticing hypothesis by Schmidt put fuel to the fire claiming that foreign language acquisition has a strong conscious aspect; noticing. The findings in this research showed that attention and noticing are undeniable in foreign language acquisition. Especially in reading, form and structure gain importance and attentional sources are cognitively allocated. Foreign language learners showed selective attention behavior; they pay different attention to word in different levels of lexical access. The findings assert that words without lexical access attract more attention than words with lexical access; this is surely closely related with cognitive load in unknown vocabulary items. Most importantly, this attentional levels can be facilitative and noticing is directly proportional with later recognition of unknown vocabulary items. Most of the time, exposure to unknown vocabulary in a textual context facilitates its further recognition. This exposure is highly global; it accommodates different levels of noticing, attention and consciousness. This study embodied this exposure in foreign language reading.

Depending on the “attention fact” the results of this study indicate that foreign language acquisition has a formal and a conscious aspect. This finding emphasizes the role of focus on form and grammar instruction in foreign language. Even though “communicative camp” has been discrediting the role of grammar for a long time; three things cannot long be hidden behind the sun, the moon, and the truth (Confucius). Total unconsciousness is not the way human mind works but formal aspects as an attractant play significant role in foreign language learning. Depending on the findings in this study, grammar instruction in foreign language reading is inevitable.

In terms of word recognition, many aspects are ignored in vocabulary instruction. Solely depending on lexical access (memorizing meanings) is not much efficient in foreign language reading. *Orthography* is denied but vital; letters and syllabi and their recognition has a crucial role in suppressing excessive cognitive load and relaxing working memory. As a result, vocabulary can easily be transferred long term memory. Even though sounds traditional; making L2 learners to write down words for several times may work well to emphasize orthographical competence in foreign language reading. Beside orthography, morphological instruction should be included as saccades are relatively short in foreign language reading. When L2 learners have morphological awareness and competence, they may program their saccades to land on affixes which decreases the time spent on recognizing the word. Lexical access on a word may be easier with morphological competence and this easiness decreases total fixation duration on that vocabulary item. This decrease will surely relax working memory and let it to allocate more capacity for harder items. It also helps syntactic parsing and sentence processing; enabling shorter entrenchment of the word in the textual context and discourse.

According to the findings in this study, foreign language instructors should include unknown vocabulary items and grammatical structures all the time which validates Krashen’s i+1 hypothesis. As attention on unknown forms may facilitate further recognition, teachers should always include some unknown words and structures beyond learner level to a certain extent.

Secondly, the findings indicate a certain relationship between word recognition skills and eye movement metrics. Most of the time, lack of word recognition skills inflate most of these indices decreasing fluency and comprehension. Word recognition is a vital element and learner development in word recognition skills can be tracked with the frame and standards proposed in this study. The overall table is shown below:

Table 70. Early and Late Measure Standards

Category	*Eye Movement Metric*	*Mean (ms)*
Early Measures (Initial Word Recognition)	***First fixation***	275,0000
	Gaze duration	417,4510
	Single fixation	327,7844
Late Measures (Syntactic and Discursive)	***Regression Out***	536,4225
	Rereading Time	346,4359
	Total Fixation Duration	479,5659

These standards also vary depending on word recognition levels as shown below:

Table 71. Early and Late Measure Standards regarding Word Recognition Levels

Category	*Eye Movement Metric*	*Word Recognition Level*	*Mean (ms)*
Early Measures (Initial Word Recognition)	***First Fixation***	***Unknown***	286,7558
		Known	263,5466
	Gaze Duration	***Unknown***	454,1317
		Known	389,0191
	Single Fixation	***Unknown***	362,3279
		Known	307,9057
Late Measures (Syntactic and Discursive)	***Regression Out***	***Unknown***	611,8333
		Known	458,8571
	Rereading Time	***Unknown***	364,5581
		Known	324,1714
	Total Fixation Duration	***Unknown***	525,9713
		Known	443,4482

Precisely, higher first fixation duration and gaze duration indicate initial word recognition problems associated with orthography, morphology and phonology. Single fixation duration is task related phenomena but average single fixation duration indicate higher word recognition skills. This inflation is a result of inadequate orthographical, morphological and phonological knowledge. Later processes including total fixation duration, rereading times and regression out refer to recognizing word in a syntactic context. Inflated late measures indicate syntactic problems and inability to recognize word in a syntactic structure. These measures indicate requirement for sentence processing and grammar instruction. Through these metrics, word recognition and syntactic challenges in foreign language reading can be detected and objective oriented methodologies can be developed to solve these problems.

Thirdly, eye movements are proficiency driven most of the time and there are distinguishing differences between skilled and unskilled readers. The situation is the same for foreign language reading; most measures are proficiency dependent. The results of this study revealed that different proficiency levels have different scanpaths. Low level learners have shorter saccades, big bubbles indicating inflated fixation times and slower rates of speed. For skilled learners, longer saccades, smaller bubbles and higher rate of reading speed are observed. A detailed table is given below:

Table 72. Early and Late Measures regarding Proficiency Level

Category	*Eye Movement Metric*	*Proficiency Level*	*Mean (ms)*
Early Measures (Initial Word Recognition)	***Single Fixation***	***B1***	371,82
		B2	319,20
		C1	303,95
		Total	336,11
	First Fixation	***B1***	282,53
		B2	270,93
		C1	255,85
		Total	273,10
	Gaze Duration	***B1***	475,45
		B2	394,65
		C1	347,68
		Total	417,48
Late Measures (Syntactic and Discursive)	***Total Fixation Duration***	***B1***	530,31
		B2	447,02
		C1	401,10
		Total	470,88
	Rereading Time	***B1***	406,26
		B2	295,17

	C1	218,05
	Total	331,86
Regression Out	***B1***	609,60
	B2	561,43
	C1	494,16
	Total	572,08

In detail, better learners have less inflated early measures which indicate that they have better vocabulary knowledge and initial word recognition skills. Advanced learners have higher phonological, morphological and orthographic skills which enables them to process a word rapidly. Better learners also have less inflated late measures; they reread less, regress less and spend less time on a word. These advantages indicate higher syntactic and sentence processing skills. On the other hand, less skilled learners have inflated values for both measures; lack of orthography, morphology, phonology and besides inadequate sentence and discourse processing skills. Less skilled learners tend to fixate more, reread more and regress more.

Clearly different proficiency levels showed different scanpaths and metrics. The world is being obsessed with technology more and more and why should not advanced technologies used in foreign language instruction? The revealed differences in this study prove that eye tracking methodology can be used as a developmental tool to track learner development. Even the minimal reading errors can be detected in word recognition and syntactic level. Solutions would hit the bull’s-eye. By the way it should be noted that this study is a head of a curve, a part of the great campaign leading a novelty. In a few years’ time, at least 2 eye tracking classrooms are established in Sweden and Canada including eye trackers for each learner. In upcoming years, these advanced technology eye tracking classes will multiply surely. And this study is not just chasing these advancements but also becoming a part of it. In less than 20 years’ time, all known shall turn to dust in foreign language instruction; educational neuroscience shall rise and there shall be no place for lies.

Finally, this study reveals that not all words are fixated in foreign language reading. These standards are given below:

Table 73. Word Skipping Rates in Foreign language Reading

Skipped Items	***Skipping Rate***
Auxiliary Verbs	40%
Prepositions	25%
Articles	43%
Total skip	37%

In foreign language reading, most skipped words are observed to be auxiliary words and articles followed by prepositions. These rates varies among different proficiency levels:

Table 74. Word Skipping Rates regarding Proficiency Levels

Skipped Item	***Proficiency Level***	***Skipping Rate***
Auxiliary skip	***B1***	34%
	B2	37%
	C1	64%
	Total	40%
Preposition skip	***B1***	18%
	B2	27%
	C1	36%
	Total	25%
Article skip	***B1***	38%
	B2	44%
	C1	52%
	Total	43%
Total skip	***B1***	31%
	B2	37%
	C1	46%
	Total	37%

This skipping rate is closely related with good sentence processing skills which comes out with efficient grammar instruction. This skipping rate is low for unskilled learners and higher for better ones. Good learners skip most short words and grammatical units but still comprehend them. Lower levels of proficiency ends up with less skipping rates and even paying attention to articles. Word skipping is also a measure of grammatical competence which can be used to evaluate learner grammatical skills.

Word skipping greatly contributes to reading fluency in foreign language. The findings in this study showed that even best foreign language readers read 20% slower than a native speaker. The table below indicates different reading rates for different proficiency levels:

Table 75. Reading Fluency and Rate regarding Proficiency Levels

Proficiency Levels	*Reading Rate (wpm)*
B1	177,1486
B2	207,3450
C1	239,3577
Total	200,7427

Previous word per minute calculations are weak; they do not include regression and forward saccade ratio in calculation of foreign language reading fluency. That is why results are too coarse and rough. Current study assimilated a novel calculation methodology by depending on a certain formula in ophthalmology. In this calculation, eye movement indices such as fixation count, regressions, total dwell time and forward saccade ratio are blended for more accurate results. Firstly, this proves that eye tracking methodology can be used to calculate reading rate and fluency in foreign language. Secondly, the calculation results are in a linear fashion; while better learners are fast readers, low level ones have slower rates. Thirdly, word recognition is a stronger predictor when compared with grammatical competence. And finally, learner reading fluency development can be tracked with these standards and frame.

7.2. Pedagogical Implications

Eye tracking methodology enables in-depth analysis of L2 reading behavior. Thus, problem detection and developmental observation are possible which greatly contribute efficient reading acquisition. First of all, attention and consciousness are a part of foreign language acquisition which are especially obvious in L2 reading. Secondly, eye tracking methodology is the future developmental tool in foreign language acquisition with frames and standards. And finally, eye movements emphasize the role of form in foreign language and guide L2 classrooms.

In foreign language instruction, this study shows that attention can facilitate learning regarding noticing hypothesis. Especially in L2 reading instruction, learning process gains pace by making students pay attention to intake. With attention, this intake is transformed into input which can be transferred to long term memory. As unknown linguistic items are paid more attention and cognitive load by L2 learners, they are the centers of attraction. When these items are supported by visuals and attraction tools, the facilitative aspect of attention can be activated. As a result, visuals or attraction tools do not directly enable learning but they evolve attention to a facilitative aspect.

With this respect, i+1 gains importance. Unknown linguistic items are centers of attraction and L2 instructors should always include some items beyond learner level. This can hold up attention to a certain degree which enables the use of working memory sources with attentional sources to facilitate learning.

Secondly, eye tracking methodology is a robust developmental tool to track L2 reading behavior. With standards and frames, each metric indicates a certain phenomenon. Periodical eye tracking sessions throughout the academic year will surely reveal different developmental patterns which can help to detect errors and provide solutions. The table below summarizes the issue:

Table 76. Eye Movements and problem-solution in L2 Reading

Eye Movement	*Degree*	*Interpretation (depending on the standards)*	*Potential Solution*
First Fixation	***High***	Initial word recognitions problems (orthography especially)	Writing the words several times
	Low	Proper	-
Gaze Duration	***High***	Initial word recognition problems (orthography, morphology, phonology, semantic access)	Writing the word several times, phonological activities, reading aloud practice, morphological instruction
	Low	Proper	-
Single Fixation	***High***	Slower word recognition process (even with lexical access)	Extensive reading, silent reading in class
	Low	Faster word recognition process	-
Second Pass Time	***High***	Inability to process item in the syntactic and discursive context	Grammar instruction, sentence processing activities, extensive reading, strategy instruction
	Low	Proper	-
Regression Out	***High***	Inability to process item in the syntactic and discursive context	Grammar instruction, sentence processing activities, extensive reading, strategy instruction
	Low	Proper	-

Total Fixation Duration	***High***	Sum of problems Initial word recognition and syntactic processing	Requires extensive instruction with vocabulary and grammar practice along with extensive reading
	Low	Proper	-
Word Skipping	***High***	Proper syntactic and sentence processing skills	-
	Low	problematic syntactic and sentence processing skills	Grammar instruction, extensive reading
Reading Rate	***High***	Fluent	-
	Low	Non-fluent	Expanded instruction focusing on grammar instruction and extensive reading

Finally, this study emphasizes the importance of grammar instruction in foreign language learning. Most of the time, grammar is a blurred spectra among L2 instructors. However, this study shows that grammar has a reputable role in foreign language learning; especially in L2 reading. Focus on form and explicit grammar instruction is necessary; L2 learners are required to see the syntactic structure clearly to facilitate them while reading.

Reading occurs in milliseconds and many reading difficulties are hidden in those milliseconds. In this study, it has been observed that less proficient learners with poor word recognition and syntactic skills are also less fluent, skipped less words and spend more time on linguistic items ending up with less comprehension. Proper grammatical competence along with better word recognition skills would enable efficient development of L2 reading behavior. Besides, isolated practices of semantic aspects of words will not work well; morphological and phonological instruction is necessary even in silent reading. L2 reading problems are associated with the lack of sentence processing and word recognition skills rather than higher cognitive processes. Most of the time, L2 learners deal with proper texts such as stories, essays or simplified literary texts rather than textual materials requiring specific intellect like articles on literature or physics. So problems lie within low level cognitive processes rather than higher level processes. Thus, the concerns are working memory, word recognition skills and syntactic parsing. Lacking the low level constituents causes learning and processing inhibitions during reading; it obstructs the building of a textual network. When learners cannot build a textual network in the text depending on words and sentences, comprehension does not occur. As a result, developing lexical and grammatical competence by blending grammar-morphological-phonological instruction would bring success in L2 reading.

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APPENDICES

APPENDIX 1. ETHICS COMMITTEE APPROVAL

T.C.
HACETTEPE ÜNİVERSİTESİ
Rektörlük

Sayı : 35853172/ 433 — 3708

28 Kasım 2014

EĞİTİM BİLİMLERİ ENSTİTÜSÜ MÜDÜRLÜĞÜNE

İlgi: 23.10.2014 tarih ve 1987 sayılı yazınız.

Enstitünüz Yabancı Diller Eğitimi Anabilim Dalı İngiliz Dilli Eğitimi Bilim Dalı Bütünleşik Doktora Programı öğrencisi **Emrah DOLGUNSÖZ**, **Doç. Dr. Arif SARIÇOBAN**'ın danışmanlığında yürüttüğü **"Yabancı Dil Olarak İngilizce Öğrenenlerin IELTS Genel Okuma Seviyeleri Açısından Göz Hareketi Davranışlarının ve Farklılıklarının Tanımlanması"** başlıklı tez çalışması Üniversitemiz Senatosu Etik Komisyonunun **25.11.2014** tarihinde yapmış olduğu toplantıda incelenmiş olup, etik açıdan uygun bulunmuştur.

Bilgilerinizi rica ederim.

Prof. Dr. Ü. Şebnem HARPUT
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APPENDIX 2: AOIs

AOI
1. To travel
2. Survey
3. Traveler
4. Billion
5. Mainstay
6. Domestic
7. To combine
8. Agriculture
9. Souvenirs
10. Accommodation
11. To spring up
12. Catering
13. To pour into
14. Retail
15. Manufacturing

APPENDIX 3: COMPREHENSION CHECK

Please answer the questions below. (2 mins)

1. **The paragraph is about………………….**

a. Australia and Kangaroos

b. Usa and Australia

c. Tourism in Australia

2. **Tourism is the…………..**

a. Smallest industry in Australia when compared to agriculture

b. Largest industry in Australia when compared to agriculture

c. Harmful for Australian economy

3. **Domestic Tourism accounts for the……………**

a. 25 percent of total tourism economy in Australia

b. 75 percent of total tourism in Australia

c. Little part of Australian tourism

APPENDIX 4: VOCABULARY KNOWLEDGE SCALE (SAMPLE)

PLEASE WRITE THE MEANINGS OF THE WORDS BELOW IF POSSIBLE DEPENDING ON OPTIONS.

WORD	OPTIONS	TURKISH MEANING
1. TO TRAVEL	☐ I KNOW THIS WORD!	
	☐ I AM FAMILIAR BUT NOT SURE.	
	☐ I HAVE NO IDEA!	
2. SURVEY	☐ I KNOW THIS WORD!	
	☐ I AM FAMILIAR BUT NOT SURE.	
	☐ I HAVE NO IDEA!	
3. TRAVELLER	☐ I KNOW THIS WORD!	
	☐ I AM FAMILIAR BUT NOT SURE.	
	☐ I HAVE NO IDEA!	
4. BILLION	☐ I KNOW THIS WORD!	
	☐ I AM FAMILIAR BUT NOT SURE.	
	☐ I HAVE NO IDEA!	
5. MAINSTAY	☐ I KNOW THIS WORD!	
	☐ I AM FAMILIAR BUT NOT SURE.	
	☐ I HAVE NO IDEA!	
6. DOMESTIC	☐ I KNOW THIS WORD!	
	☐ I AM FAMILIAR BUT NOT SURE.	
	☐ I HAVE NO IDEA!	

APPENDIX 5: TEXT STIMULUS SUITABLE FOR B1, B2 AND C1 LEVELS

AUSTRALIA

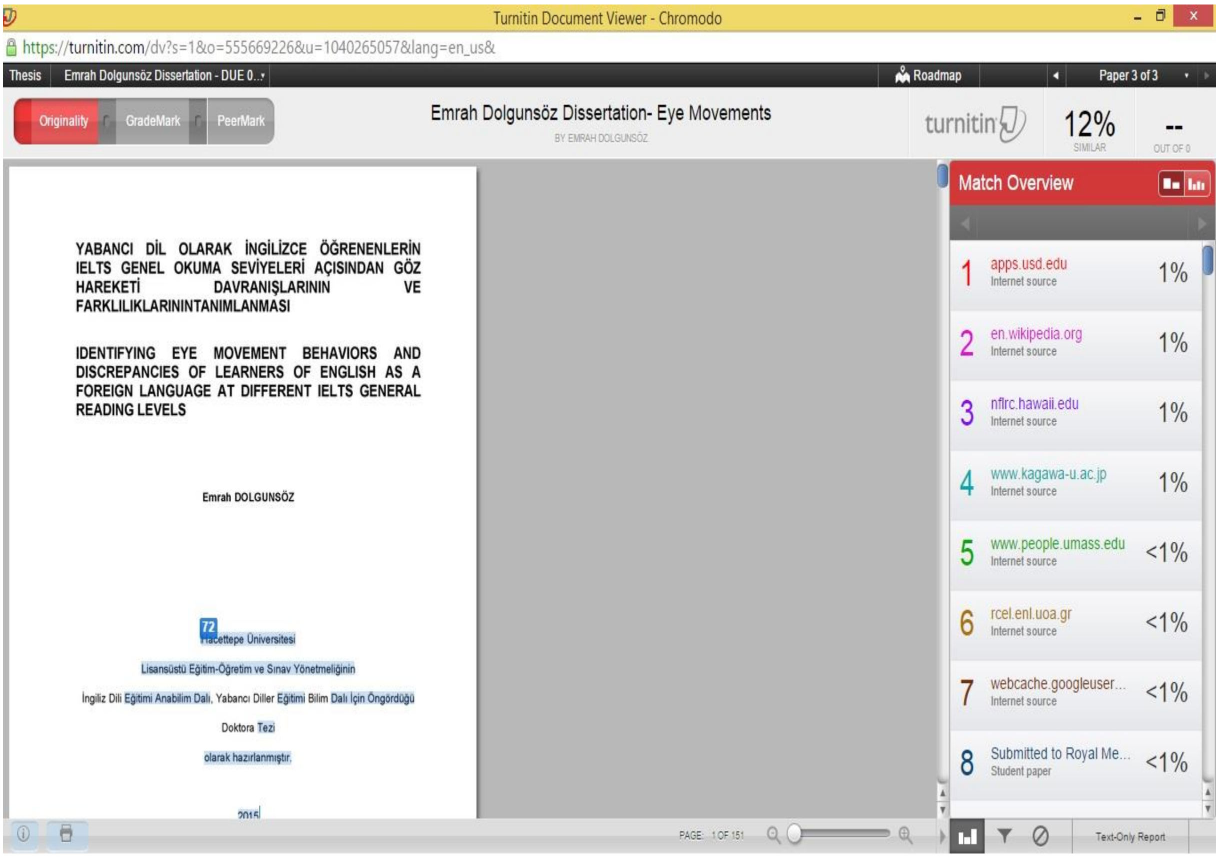
Have you ever travelled to another part of your country and stayed for a few days? Travel within one's own country is popular throughout the world. And, according to a survey carried out in Australia in 2002, travellers are spending more and more money on their holidays.

The Domestic Tourism Expenditure Survey showed that domestic travellers – those travelling within the country – injected $23 billion into the Australian economy in 2002. As a result, domestic tourism became the mainstay of the industry, accounting for 75% of total tourism expenditure in Australia. International tourism, on the other hand, added $7 billion to the economy.

So, tourism has become one of Australia's largest industries. The combined tourist industry now accounts for about 5% of the Australian economy, compared with agriculture at 4.3% and manufacturing at 8%. Tourism is therefore an important earner for both companies and individuals in a wide range of industries.

For example, the transport industry benefits from the extra money poured into it. Hotels spring up in resort areas to provide accommodation, and the catering industry gains as tourists spend money in restaurants. The retail sector benefits as well, as many tourists use their holidays to shop for clothes, accessories and souvenirs.

APPENDIX 6. ORIGINALITY REPORT



P.S. Quotes and Bibliography included

ÖZGEÇMİŞ

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Yabancı Dil	İngilizce: Okuma (Çok iyi), Yazma (Çok iyi), Konuşma (Çok iyi)	

İş Deneyimi

Stajlar	-	-
Projeler	-	-
Çalıştığı Kurumlar	Bayburt Üniversitesi, Eğitim Fakültesi, Bayburt	

Akademik Çalışmalar

Yayınlar (Ulusal, uluslararası makale, bildiri, poster vb gibi.)

SARIÇOBAN, A., & DOLGUNSÖZ, E. (2013). OPINIONS OF ELT INSTRUCTORS ON DISTRUPTIVE BEHAVIORS IN TURKEY: A COMPREHENSIVE STUDY ON CONCEPTS AND REACTIONS. Atatürk Üniversitesi Kazım Karabekir Eğitim Fakültesi Dergisi, (27), 63-76.

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Seminer ve Çalıştaylar

Sertifikalar

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