LEXICAL DECISION WITH EMOTIONAL WORDS: A PUPIL DILATION STUDY

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LEXICAL DECISION WITH EMOTIONAL WORDS:
A PUPIL DILATION STUDY

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ABSTRACT

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A PUPIL DILATION STUDY

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Written words are not just black remarks but they enable human beings to connect with the environment via the help of their semantic features. Word frequency and emotion are the most studied semantic features which are known to effect word recognition both behaviorally and physically. In the current study, we investigated the effects of interaction between word frequency and emotion on word recognition by using Turkish written words. At the same time, these possible effects were interpreted by the DRC, CDP+ and triangle models of word recognition. We used a subset of words from Affective Norm Database for Turkish Words (TUDADEN) and we generated pseudowords by Turkish plug in for Wuggy Software as stimuli. We collected reaction times and pupil diameters with TOBII T120 eye tracker during the lexical decision task. We collected data from non-depressed male and female participants. The results display that emotional words have shorter reaction times than neutral ones. Meanwhile, high frequency words get faster responses than low frequency words. Thus, these reaction time results replicate the main effect of emotion and word frequency on word recognition. Furthermore, the significant interaction between emotion and word frequency indicate that high frequency, negative words get shorter reaction times than positive and neutral words while low frequency, positive words get the shortest reaction times. However, the pupillary responses do support neither the main effect of word frequency nor emotion. These results suggest that semantic features have a critical role on word recognition process behaviorally; however, these factors do not activate physiological responses during word recognition. Although the physiological differences between the experimental conditions are insignificant, this study presents the first findings of the interaction between emotion and word frequency on Turkish word recognition with the use of pupillary responses.

Keywords: lexical decision task, emotion, word frequency, pupillary response, reaction time

ÖZ

DUYGUSAL KELİMELERLE SÖZCÜKSEL KARAR ÇALIŞMASI:
GÖZ BEBEĞİ ÖLÇÜMLERİ

Ertuğrul, Sahura
Yüksek Lisans, Bilişsel Bilimler Bölümü
Tez Yöneticisi: Yrd. Doç. Dr. Didem Gökçay

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Yazılı kelimeler sadece siyah şekiller değil aynı zamanda taşıdıkları anlamsal özellikleri sayesinde insanların çevreyle iletişim kurmasını sağlayan arabuluculardır. Kelime sıklığı ve duygu, en çok çalışılan ve hem davranışsal hem de fiziksel olarak kelime tanımada önemli etkileri olduğu bilinen anlamsal özelliklerdir. Bu çalışmada, Türkçe yazılı kelimeleri kullanarak kelime sıklığı ve duygu etkileşiminin, kelime tanıma üzerindeki etkilerini araştırdık. Aynı zamanda, kelime sıklığı ve duygunun kelime tanımadaki olası etkileri, bilişsel kelime modelleri aracılığıyla yorumlandı. Çalışmada uyaran olarak kullanılan Türkçe kelimeler, Türkçede Duygusal ve Anlamsal Değerlendirmeli Norm (TUDADEN) veri tabanından seçilmiş olup diğer uyaran grubu kelimemsiler ise Wuggy yazılımının Türkçe eklentisi ile oluşturulmuştur. Sözcüksel karar çalışması sırasında katılımcıların tepki sürelerinde ve göz bebeğinde oluşan değişimleri TOBII T120 göz izleme cihazı ile kaydettik. Çalışma için hem erkek hem kadın depresyonsuz katılımcılardan veri topladık. Sonuçlar, duygusal kelimelerin yüksüz (nötr) kelimelerden daha hızlı tanındığını göstermektedir. Aynı zamanda, sonuçlar, kelime sıklığı yüksek olan uyaranlara, kelime sıklığı düşük olan uyaranlara oranla daha kısa sürede tepki verildiğini göstermiştir. Bu bulgular ışığında, çalışmamızın tepki süresi ölçümü sonuçları, kelime sıklığı ve duygunun kelime tanımadaki ana etkisini desteklemiştir. Bu ana etkiye ek olarak, kelime sıklığı ve duygu arasındaki etkileşim, kelime sıklığı yüksek olumsuz uyaranların, olumlu ve yüksüz uyaranlardan daha hızlı tanındığını; fakat öte yandan, kelime sıklığı düşük olumlu uyaranların, diğer uyaran gruplarına oranla daha hızlı tanındığını göstermiştir. Fakat göz bebeği ölçümü sonuçları, ne kelime sıklığının ne de duygunun kelime tanımadaki ana etkisini desteklemiştir. Genel olarak, bu sonuçlar, kelime sıklığı ve duygunun kelime tanımada davranışsal olarak önemli bir role sahip olduğunu fakat fizyolojik olarak herhangi bir tepkiyi tetiklemediğini ortaya çıkarmıştır. Ayrıca, fizyolojik sonuçlar, uyaran grupları arasında herhangi bir farklılık göstermemesine rağmen, bu çalışma, Türkçe kelimeleri tanıma görevi sırasında, kelime sıklığı ve duygu etkileşiminin göz bebeği üzerindeki etkisini araştıran ilk çalışmadır.

Anahtar kelimeler: sözcüksel karar çalışması, duygu, kelime sıklığı, tepki süresi, göz bebeği tepkisi

THE
DEDICATION
OF THIS THESIS
IS SPLIT
SEVEN WAYS:
TO MY PARENTS ALWAYS CARING:
SULTAN and İLYAS;
TO MY BELOVED SIBLINGS:
ZEYNEP and BAYRAM
TO MY LOVELY CATS WITH FUR and PUR:
VEGA and SAHUŞ
and TO MY PRECIOUS FRIEND
WHO STUCK WITH ME
UNTIL THIS
VERY END:
ANIL

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Cognitive science has historically risen from the question: how does the mind work? Depending on this question, the classical cognitive science follows computational representational approach for the inquiry of mental processes as human problem solving, learning, language, attention and decision making. On the other hand, cognitive science is challenged with issues such as environment (integration of environment into cognition), consciousness, embodiment, and emotion. These challenges are being tested by experimental methods and philosophical aspects alongside with computational representational methods in an attempt to solve the mind-brain puzzle.

The environment helps the human beings experience limitless knowledge related to the shapes, colors, sounds, smells, and movements. This knowledge reflects on the language, or, in other words, language represents much of this knowledge (Binder et. al. 2009). This close relation between words and the experienced knowledge is called 'semantics' (Bréal, 1987). From the start of the cognitive science, access from written remarks (orthography) to semantics has been a topic of interest. Thus, many computational models have been developed to understand and explain the process of word recognition as it pertains to semantic processing (Forster, 1976, 1989; Paap et al., 1987; McClelland and Rumelhart, 1981; Seidenberg and McClelland, 1989; Frost, 1998; Coltheart et. al., 2001; Harm and Seidenberg, 2004; Rastle and Brysbaert, 2006; Deutsch et. al., 2003; Perry et. al., 2007; Dunabeitia et. al., 2009). These models have also been supported by the results of experimental studies (Taylor, Rastle, and Davis, 2012; Carreiras et. al., 2014). At the same time, the models have presented predictions and interpretations for experimental studies which are based on direct human recognition. Thus, this two-way interaction between the models and experimental results becomes important for human-computer interaction. Since the written domain is the main communication way between humans and computers, better interaction will develop by understanding how semantic processing occurs. In addition, the improvements on the models bring them closer to human cognition. For instance, the models can be revised for their semantic component in order to represent the entire human word recognition process, especially in term of emotion (Kuperman et. al., 2014).

Emotion has become one of the interesting topics in cognitive science after the case of Phineas Cage whose frontal lobe was damaged by an iron rod which caused partial loss of cognitive and emotional abilities. Beforehand, cognition - problem solving, planning, memory, attention - seemed to be separated from emotion. This view was supported by some neurobiological findings which assign separate brain areas for cognition (Fuster and Alexander, 1971; Kubota and Niki, 1971) and emotion (Papez, 1937; MacLean, 1949). More recently, it is suggested that the brain regions assigned to solely cognition or emotion are actually interacting with each other (Damasio, 1994; Phelps, 2006; Davis and Whalen, 2001; Dolan, 2003; Davidson et al., 2003; Moll et al., 2005, Drevets and Raichle, 1998; Pessoa, 2008). Damasio and Carvalho (2013) have presented evolutionary proofs for the integration of emotion and cognition. These results are obtained by either behavioral methods including reaction times and questionnaires or physiological methods including neuroimaging, skin conductance, and pupillary responses.

Lexical decision task provides a relevant framework to observe the integration of emotion and cognition in verbal modularity. The task requires classifying whether the letter string is a word or pseudoword. During the task, it is found that the brain regions related to the semantic processing are activated (Binder et. al., 2003). At the same time, the semantic features of the word interact with the task by facilitating or delaying the responses. These semantic features basically include word frequency concreteness, and orthographic neighborhood alongside with semantic meaning. The semantic meaning is explained by two dominant descriptors: evaluation and activity corresponding to emotional valence and arousal respectively (Osgood, Suci and Tannenbaum, 1957). In the literature, lexical decision with emotional words demonstrated the interaction between cognition and emotion through several studies with reaction time (Kousta, Vinson, and Vigliocco, 2009; Larsen et. al., 2008; Estes and Adelman, 2008), event related potentials (Hofmann et.al., 2009; Kanske and Kontz, 2007; Carretie et.al., 2008; Scott et.al., 2009; Schacht and Sommer, 2009a; Schacht and Sommer, 2009b; Palazova et.al., 2011, Recio et.al., 2014), with functional neuroimaging (Kuchinke et. al., 2005, Nakic et. al,. 2006) and with pupillary responses (Kuchinke et. al, 2007, Bayer, Sommer, and Schacht, 2011). The word recognition process is also shown to be influenced by the interaction of emotion and word frequency (Kuchinke et. al., 2007; Nakic et. al., 2006; Scott, O'Donnell, and Sereno, 2014).

In the current study, effects of emotion and frequency on word recognition process are examined through reaction times and pupil diameters. The difference between high and low frequency groups is expected to be found in reaction times and pupillary responses. It is also hypothesized that the emotional conditions such as positive or negative may have differential effects on reaction times and pupilllary responses.

Remainder of the current script consists of five chapters. In chapter 2, literature review, introductions about the studies of word recognition, affective system, and pupil dynamics are presented. The motivation of this study is also mentioned in Chapter 2. The following section, chapter 3, covers the materials, participants, stimulus selection process and methodology. Results of the experiment are presented in chapter 4. In the chapter 5,   results are interpreted and discussed in a comprehensive manner. Finally, chapter 6 presents a concise conclusion.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the process of word recognition, affective system and lexical decision task are reviewed based on the previous studies. In addition, the contributions of frequency and emotion on word recognition and pupil size and dynamics are also dicussed. In the first section, word recognition and its relationship with frequency were discussed. Then, in the second section, evolutionary and cognitive aspects, and neural correlates of the affective system are explained. In the last section, pupil size and its mechanisms related to the autonomous nervous system and cognitive load are given including pupillary responses. This chapter is completed with motivation for the initiation of this thesis, research questions and hypotheses in the last part.

2.1 Word recognition

Visual word recognition could simply be defined as the access from the printed remarks to word meaning. This access is ordinarily activated for literate people when they encounter a written word; however, despite this ordinary access, it has been a revelation which reaches over arbitrary remarks to semantic meaning. The classical view states that each word had its own lexical entity in the lexicon which is a mental dictionary of words. Then, the classical view describes the word recognition as 'lexical access' or 'lexical selection', and lexical access is realized when the word and its lexical entity are matched. On the other hand, this one to one match was opposed by connectionist model of reading (Seidenberg and McCleland, 1989). The connectionist view suggests that the lexical entities were represented by sets of simple sublexical units rather than a whole. Thus, lexical access was realized when the sublexical units were combined satisfactorily. Based on these assumptions, several early computational models were developed in order to explain visual word recognition: bin model (Forster, 1976; 1989), the activation-verification model (Paap et al., 1987), the interactive activation model (McClelland and Rumelhart, 1981), and parallel distributed processing models (Seidenberg and McClelland, 1989).

2.1.1 The models of word recognition

The early models of word recognition are generally based on two main assumptions (e.g. Gough, 1972; Masaro, 1975; Morton, 1969). The first assumption suggests that serial processing steps are followed one by one, and the direction of the information is one way, forward that is (i.e.after the completion of the previous stage, the next stage initiates) (Figure 2.1). The second assumption suggests that this information

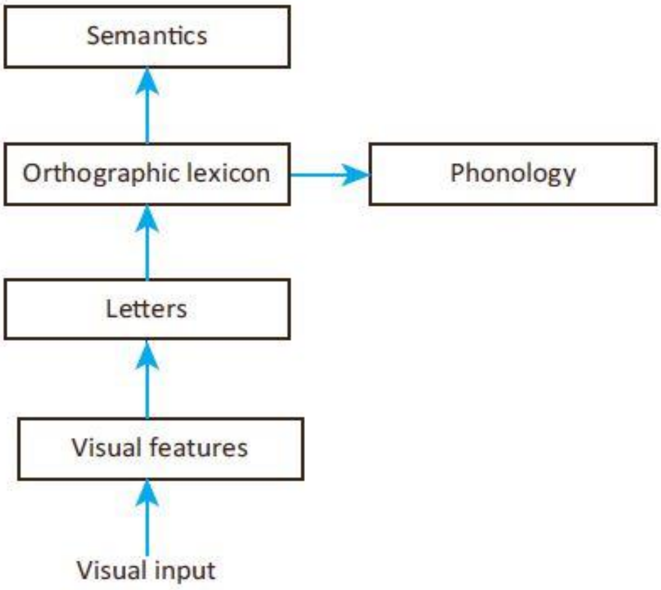

Figure 2.1 The one-way forward model of word recognition
(early model of word recognition depicted in Carreiras et.al., 2014, p.2)

processing system works autonomously with the entrance of lexical information (Forster, 1981). According to these models, the system is activated with the entrance of the visual input, then the visual input is matched its relevant semantic representation by the feed-forward system. Although these models clearly defined prelexical and lexical levels of word recognition, they depicted that the word recognition was achieved hierarchically from lower levels to higher levels. Nevertheless, recent studies revealed that there was a reverse movement from higher levels to lower levels (Frost, 1998; Rastle and Brysbaert, 2006; Deutsch et. al., 2003; Dunabeitia et. al., 2009). These studies claimed that phonological, morphological and semantic information influences lower level of word recognition such as orthographic processing. Thus, in order to observe this interaction between semantics and orthography, dual-route cascaded (DRC) model (Coltheart et. al, 2001), the triangle model (Harm and Seidenberg, 2004; Plaut et. al., 1996) and the connectionist dual-process (CDP+) model (Perry et. al., 2007) was included. Although these models were developed for reading aloud, they were effective models to explain other word recognition tasks such as lexical decision task (Binder et. al., 2003; Carreiras et. al., 2007; Kuchike et. al., 2005) , word naming (Binder et. al., 2005), and semantic priming (Sachs et. al., 2008). (For detailed review on cognitive models and word recognition process, please see Taylor, Rastle and Davis, 2013)

2.1.1.1 The dual-route cascaded model of reading aloud

The DRC model (Coltheart et. al., 2001) consists of two routes extending from visual feature units to semantic system (Figure 2.2). These routes follow different

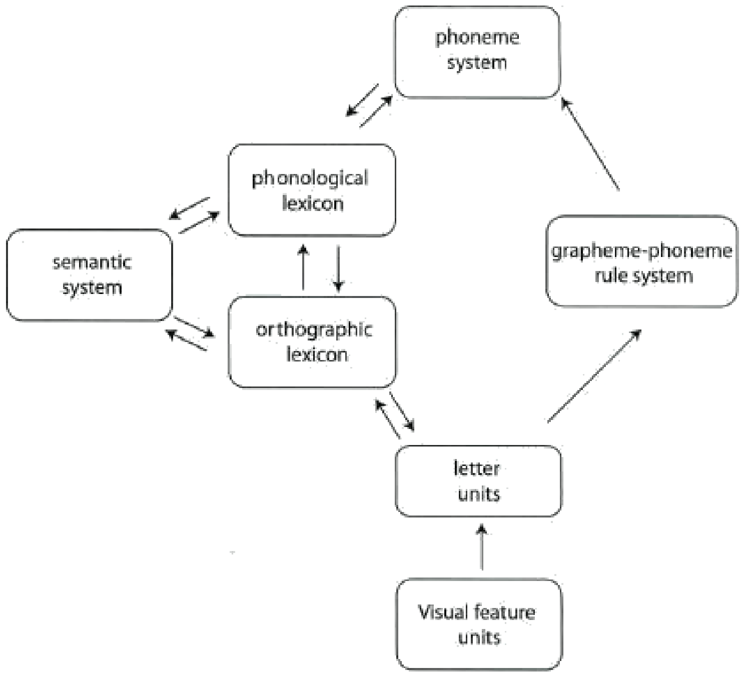

Figure 2.2 The dual-route cascaded model of reading aloud (Coltheart et. al., 2001)

steps in order to translate orthography to phonology. In the nonlexical route, the letters or combination of letters are converted into corresponding single sounds (phonemes) depending on the phonological rules in the language. Then, by based on this translation from orthography to phonology, the visual word form is matched with its phonological form. This route is effective for reading pseudowords. On the other hand, in the lexical route, the orthographic form of whole word is matched with its phonological form without decomposing it into sounds. This route is effective for reading irregular words whose phonological forms do not match with their sound compositions (e.g. pint, knife). As expected, the use of nonlexical route by irregular words ends with regular pronunciation for them (e.g. pint rhymed with mint). In addition, the use of lexical route by pseudowords ends with either no response or pronouncing corresponding real word rather than pseudoword (starn – start). In contrast to pseudowords and irregular words, both routes are appropriate for the pronunciation of regular words.

2.1.1.2 The triangle model of reading aloud

The triangle model (Harm and Seidenberg, 2004; Plaut et. al., 1996) has three main components as orthography, phonology and semantics with hidden units among them (Figure 2.3). In contrast to the DRC model, there are no separate routes for letter-sound translation and whole word phonology match. The regularities in pronunciation are ruled by direct orthography to phonology interaction while irregularities are ruled by orthography to semantics interaction. In addition, the model learns how to pronounce the visual inputs with the help of correct pronunciation as feedback after its attempt to pronounce. Thus, it discover the rules for letter- sound transfers and also it cares for letter combination of words in order to capture correct pronunciation of letter sets which will appear in another word.

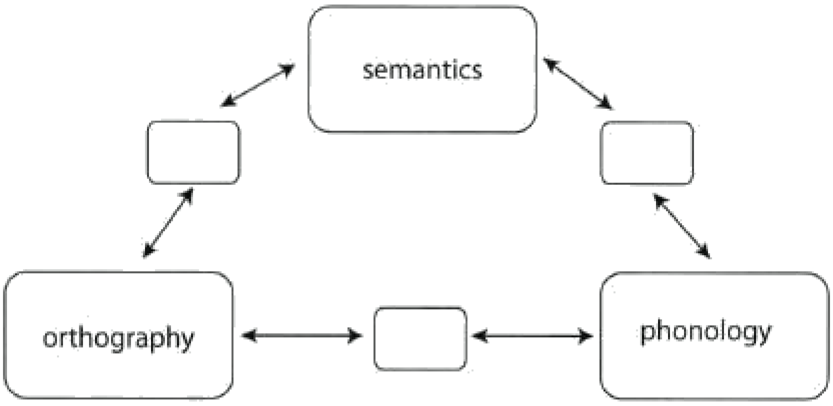

Figure 2.3 The triangle model of reading aloud
(Harm and Seidenberg, 2004; Plaut et. al., 1996)

2.1.1.3 The connectionist dual-process model of reading aloud

The connectionist dual-process (CDP+) model (Perry et. al., 2007) has two routes for letter-sound translation and whole word phonology match as like DRC model (Figure 2.4). Although the lexical route is similar to DRC model, the nonlexical route shows differences from the DRC model. In the DRC model, the regular rules for letter-sound translation are independent from the context, that is, neighbor letters do not affect the pronunciation of the target letter. On the other hand, in CDP+ model, the nonlexical route includes two layers, and so, it has the ability to capture the effect of context into the pronunciation. Just like the triangle model, CDP+ model could learn to the change in the pronunciation depending on neighbor letters. Nevertheless, since the CDP+ model has only two layers, it could have difficulties to detect the correct pronunciation for the letter appearing both in regular and irregular contexts. Thus, it is less effective than the triangle model in terms of detecting context dependent pronunciations. In CDP+ model, the visual input activates both of the routes in parallel. Afterwards, the outputs of two routes are checked on the phonological output buffer in order to select correct phonological form.

2.1.1.4 The factors for analysis of cognitive models and experimental results

The cognitive models are useful to predict or interpret the results of the experimental studies on visual word recognition. The consistence between model and experimental result provides an opportunity to reveal mechanisms related to word recognition. Taylor, Rastle and Davis (2013) conducted a meta-analysis study

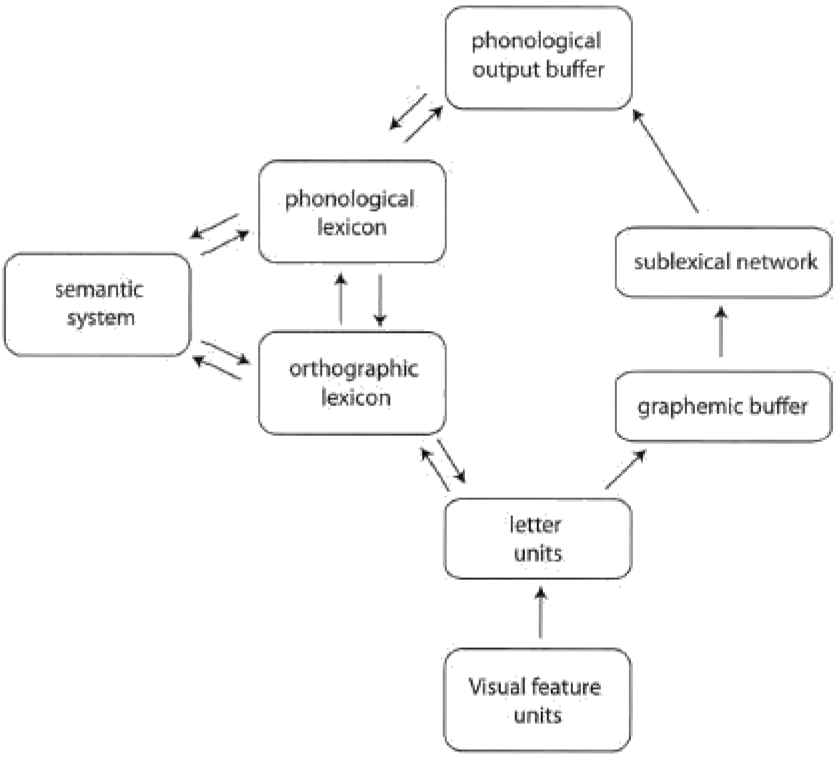

Figure 2.4 The connectionist dual- process model of reading aloud (Perry et. al., 2007)

in order to highlight the relationship between cognitive models and neural activities of brain. They evaluated blood-oxygenation-level-dependent (BOLD) signal in terms of two factors: engagement and effort. They evaluated which model components or brain regions are engaged by stimulus and how much effort the stimulus need to process. For engagement, they assumed that the region or component engaged by stimulus would be activated greater than the other regions or components. For effort, after the engagement, they expected that some stimulus would be more appropriate for the representations and so it would require less effort than the others. Their study showed that these factors are useful to explain relationship between cognitive models and experimental results. Thus, in this study, the same factors are applied to reaction times and pupil dilation results in order to predict and interpret the effect of semantic features on the word recognition process.

2.1.2 Word recognition and word superiority effect

The cognitive models show that written word recognition starts with process of orthographic features, that is, letters. Actually, the letters do not usually appear outside of words. Thus, Cattell (1886) suggested that letters in real words were easily recognized compared to the ones in pseudowords (e.g. “n” letter when in word “born” and in pseudoword “gorn”). Reicher (1969) and Wheeler (1970) developed an experimental design in order to test this word effect on letter recognition. The word or pseudoword was presented to the participants and it was masked. After masking, the participants were asked to choose the correct letter from one of the options for signed position. For example, 'card' was shown, after then the final position of stimulus is signed with an arrow, and the participants was asked to choose either 'd' or 't'. This paradigm resulted with word superiority effect on letters. It was revealed that letters were chosen correctly when they appeared in words. Thus, word superiority effect supported the interaction between orthographic level and semantic level of word recognition. The lower level word processing is influenced by absence of higher level word processing.

The aforementioned cognitive models interpret this effect in different ways. The DRC and CDP+ models have two routes for the words or pseudowords for access from orthography to phonology then to semantics. For engagement factor, since pseudowords do not have any meaning, the lexical route is not available for them; therefore, the nonlexical route is activated. The nonlexical route includes context- and form-independent rules related to the familiar words. Thus, this route works slowly and results with wrong matches for pseudowords compared to real familiar words. For effort factor, it could be assumed that the pseudowords require more effort than the real words. This workflow of the DRC and CDP+ model is correlated with the word superiority effect. As seen, in these models, the orthography of words is processed faster than the pseudowords. Thus, it could be assumed that the letters in words gets same advantage of faster processing thanks to their host. On the other hand, the triangle model has a context dependent orthography processing system. It composes the rules by based on the environment when the letters appear. Thus, in this model, the orthographic typicality is important than lexicality (Sibley, Kello, Plaut and Elman, 2008). It assumes that if pseudowords have same orthographic features with the words, they will be processed as same as the words. Based on this assumption, the word superiority effect could be reinterpreted with the help of the triangle model. If letter compositions (n-gram) are available in the target language, the letters in this composition will be recognized faster than the other ones in the nonexistent compositions. For engagement and effort factors, the pseudowords activate the same pathway with real words; however, it takes more effort for processing unusual letter compositions rather than the usual ones. (Actually, the CDP+ model is sensitive to context to the small extent; however, it has a very limited system compared to the triangle model.)

In our study, the orthographically similar pseudowords were chosen for lexical decision task. Thus, since they are orthographically similar, it is expected that their performance would be affected by only semantic differences. In addition, this expectation is also correlated with the triangle model while the DRC and CDP+ models do not present clear difference for orthographic and semantic effects.

2.1.3 Word recognition and word frequency effect

Word frequency refers to number of times when the word encountered on written or auditory domains. Such encounters strengthen access from orthographic representation to semantic meaning, which makes frequent words more familiar. Correlated with their familiarity, the words are recognized faster and accurately since they have quicker access to their meaning.

Historically, frequency attracted the interests of language researches; therefore, frequency was used as one of the main descriptors in word recognition models. The early models searched the candidate words for presented orthography by starting from high frequency words to low frequency words during lexical selection (Becker, 1980; Forster, 1976; Paap et. al., 1987). At the end, they found linear correlation between frequency and word recognition performance. On the other hand, more developed models used frequency in order to feed and adjust thresholds of units. In these models, when the word frequency got higher, threshold of the word, which is required for corresponding meaning access, got lower (Coltheart et.al., 2001; McClelland and Rumelhart, 1981; Perry et.al., 2007). Thus, high frequency words were recognized faster than low frequency words. In addition, the experimental studies supported applications of the models. At lexical decision task, participants had difficulty to discriminate low frequency words from pseudowords because it was easy to mix the low frequency words with pseudowords due to the participants' unfamiliarity with the low frequency words (Balota and Chumbley, 1984).

In our study, the word frequency is manipulated as a factor of word recognition. Thus, in order to interpret its possible effects on reaction times and pupil dilation, three cognitive models, DRC, CDP+ and triangle, was examined in terms of engagement and effort factors. First of all, it should be stated that pseudowords are assumed as zero frequency. It is because they are encountered for the first time by the model or participant. Based on this assumption, in the DRC and CDP+ model, pseudowords is expected to activate the nonlexical route rather than the lexical route because of the lack of their semantic meaning. Since the nonlexical route is based on the rules related to the familiar words, the pseudowords will need more effort to be recognized and so this process will take longer compared to words. On the other hand, the words will cause differential recognition performance according to their frequency. High frequency words will be faster and less effortful than low frequency words since the rules in the system are dependent on familiarity. Thus, it could be assumed that pseudowords do not engage with the semantic component of the model, and so, they would follow the nonlexical route which takes longer and effortful. The low frequency words have access to the semantic component; however, they would also follow the nonlexical route since the system is less familiar to them. On the other hand, high frequency words would take the lexical route which is a shortcut from orthography to phonology. Or, the nonlexical route would take shorter for high frequency words than the low frequency words because of the word familiarity. In short, according to the DRC and CDP+ model, we expect that the pseudowords would have more effortful processing than words. Among words, low frequency words would have more effortful processing than high frequency words.

The triangle model also supports this assumption; however, it explains this difference in terms of semantic component engagement. The rules in the triangle models are composed of word entrance, and, the system cares for the context around the letter or letter strings. Thus, in terms of orthographic typicality, the triangle model suggests that orthographically similar letter strings, both words and pseudowords, are processed with same effort. Nevertheless, the system requires more time and effort to define a letter string as a pseudoword since pseudowords have no corresponding representation in the semantic component. This semantic matching process is also effortful for low frequency words since they have no strong representations in the system. On the other hand, high frequency words access their semantic representation effortlessly. Shortly, according to the triangle model, we expect that pseudowords would need more effort than the words at the semantic processing, and, low frequency words would be more effortful to process than high frequency words.

Although the frequency effect on word recognition is undeniable, it is not the only factor influencing word recognition process. Thus, in the current study, alongside with frequency, the effect of semantic richness, especially emotion, is investigated.

2.2 Affective system

The biological body needs to maintain its constant physical state in order to survive. This process requires detecting crucial changes in the system and responding to them as quickly as possible. The body activates both autonomic physiological reactions and mental experiences to be back to its optimal state. The mental experiences refer to fundamental feelings corresponding to the physiological states such as hunger, thirst, anger, surprise or joy. The activation of these feelings has an evolutionary role on the organism's survival (Damasio and Carvalho, 2013). When imbalance is detected in the physical state, the experienced emotional circuit increases attention and facilitates perceptual processing by activating sensory systems, and mobilizes muscles and triggers motor action by initiating reflex responses (Lang and Bradley, 2010).

The core emotional neural circuit consists of brain regions, subcortically, the amygdala, the nucleus accumbens (NA), and the hypothalamus, and cortically, the orbitofrontal cortex (OFC), the anterior cingulate cortex (ACC), and the ventromedial prefrontal cortex (VMPFC) (Pessoa, 2008). Researches with animals revealed that the emotional circuit is controlled mainly by the bilateral amygdalae (e.g., Davis, 1992; Fanselow and Poulos, 2005; Kapp et al., 1994; LeDoux, 2003). The amygdala is an almond shaped brain structure consisting of approximately 10 nuclei in the temporal lobe (LeDoux, 2007). It collects the information from cortex and thalamus (sensory), and hippocampus (memory), and then, it connects with central nucleus and extended amygdale and range of other brain centers. Thus, it increases related information processing and initiates avoid or approach behaviors (Lang and Bradley, 2010).

To sum up, the affective system has primitive role on the survival of the organism. When the organism encounters external stimuli, it activates the sensory system with increased attention and triggers the action. The center of this emotional neural circuit is the bilateral amygdalae.

2.2.1 Motivational mechanisms

Emotional neural circuits embody two motivational systems: defensive and appetitive. The defensive system is engaged to unpleasant affect while the appetitive system is related with pleasant affect. This motivational classification was brought up firstly by Konorski (1967). He proposed that survival reflexes of human beings were either preservative or protective. The preservative reflexes were activated in order to maintain the body's constant condition and carry its own kind to next generations. These reflexes are comprised of ingestion, copulation, and nurture. On the other hand, the protective reflexes deal with threats towards the presence of the organism by withdrawing from unpleasant conditions or rejecting them. Konorski was not only interested only with physical reflexes but also suggested a relationship between the affective states and the motivational system. He stated that the preservative system consists of pleasant affects such as sexual passion, joy, and nurture. On the other hand, the protective system consists of fear, anger and disgust. Konorski's classification was reinterpreted by Dickinson and Dearing (1979). The preservative system was defined as attractive, and the protective system was defined as aversive, which were controlled by unconditioned stimuli. In addition, the perceptual-motor patterns and the course of learning were explained.

In general, affective valence originates from two primitive motivational mechanisms: approach/appetitive mechanism triggers the positive affect; and the defense mechanism triggers the negative affect (Lang and Bradley, 2010). This two-polar (positive-negative) mechanism is called valence. On the other hand, the intensity of the experienced emotion corresponds to affective arousal. Arousal is correlated with the degree of survival need. This need is correlated with predator attacks, hunger, and copulation. The relationship between valence and arousal is controversial although the experienced emotions seem to be easily classified as appetitive or defensive. The appetitive mechanism triggers the body's approach behavior to the pleasant stimuli while the defense mechanism triggers three different behaviors: "fight or flight", and "freeze" behavior.

2.2.1.1 Approach mechanism and positivity bias

Positive stimulus activates the approach mechanism without delay. On the contrary, activation of the defense mechanism by negative stimulus is not possible all the time. Thus, this asymmetry between approach mechanism and defense mechanism results with faster response for positive stimulus compared to negative stimulus. When looked over in general view, emotions are experienced in accordance with the change on physical state of the body. Generally, it is assumed that the body state is normally in positive condition. Clark and Clark (1977) explained this assumption with an example: the normality of milk is “good milk”, and the absence of its normality is described as “gone bad”. Thus, in ordinary routines, positivity is an expected norm while negativity is an unexpected state. Since positivity is matched to normal, the possibility of encounter with positive stimuli is higher than negative stimuli during daytime. This is supported by the study of Zajonc (1968) which states that positive words have high frequency in English correlated with “mere exposure” effect. This frequency effect is also explained as “Pollyanna hypothesis” by Boucher and Osgood (1969). They suggested that people shows tendency to see the world from the bright side and so their language use is also in the positive direction.

Based on early studies, Unkelbach et. al. (2008) suggested that positive information does not require detailed explanation because it is already widespread and easy to understand; therefore, positive stimulus has tendency to show similarity with each other. It could be said that when somebody is happy, calm and nice, at the same time, it could be assumed that s/he is warm, friendly, and somewhat beautiful (Berman and Kenny, 1976). Nevertheless, when somebody is sad and nervous, it does not mean that s/he is also angry and boring or somewhat ugly. Thus, Unkelbach et. al. (2008) stated that positive information distributes in clustered groups, that is, they can be found in close groups, which is named as “density hypothesis”. This similarity between positive stimulus is observed not only within words but also facial expressions, that is, while normal-attractive faces share similar features, abnormal-unattractive faces have great variety of features as too small eyes, too big eyes, thin lips, big noses and so on (Potter et. al., 2007). This overgeneralization of positive information was also tested with word frequency during lexical decision task by Unkelbach et. al. (2010). They found out that positive words are recognized faster than negative words even when both emotional groups had the same frequency values.

2.2.1.2 Defense mechanism and negativity bias

In contrast to the approach mechanism, the defense mechanism is not activated all the time by negative stimulus. The complexity for negative affect was observed by previous researches. Taylor (1991) suggested the dominance of the defense mechanism over the approach mechanism. This dominance, so called negativity bias, is assessed as the evolutionary role of the defense mechanism for survival: withdraw from the threat is more critical than the approach for a reward (Cacioppo and Gardner, 1999). By supporting this bias, Pratto and John (1991) suggested the automatic vigilance model of emotion which states early detection of negative stimuli by attention mechanism. On the other hand, the research by Fox et. al. (2011) proposed that negative stimuli get similar attention as positive or neutral stimuli; however, attention stays longer on the negative stimuli. They stated that negative stimulus directs attention over its own content by distracting the attention on the task. Rothermund, Wentura and Bak (2001) also observed same trend in their results and they showed that negative information processing conflicts with task requirements during color naming. This process of defense mechanism is related with primitive freezing behavior of animals, which is observed when the animals encounter a predator in the natural environment (Algom et al., 2004).

2.2.1.3 Motivational mechanisms and congruent-incongruent emotions

Alongside with the pleasantness of stimulus, approach and defense mechanisms are also affected by intensity of the stimulus, that is, these mechanisms are triggered mostly by how much the stimulus is affective regardless of their positivity or negativity. The interaction between pleasantness (valence) and intensity (arousal) indicate that it is easy to approach to positive and low arousal stimuli while it is easy to withdraw from negative and high arousal stimuli (Robinson et. al., 2004) because high arousal is felt as threat while low arousal is felt as safety. The behavioral and neural responses for emotional pictures and faces supported this possible positive-low arousal, negative-high arousal interaction (Norris et.al, 2010). In addition, this is not specific to just human beings but these conditions are observable for all organisms in the nature. Schneirla (1959) showed that paramecium (lower animal) approached to the moderate light whereas it avoided intense light. Thus, based on the approach/avoid behavior, positive low arousal and negative high arousal are named as congruent groups, and positive high arousal and negative low arousal are named as incongruent groups (Robinson, 1998). The faster responses are expected for the congruent ones and late responses are expected for the incongruent ones.

Overall, experienced emotions are the parts of physiological behaviors. Human emotions can be expressed as action: anger - attack; sexual desire – approach; fear – escape (Frijda, 1986). Although processes of the motivational system are adapted to the new environmental changes by inhibition of overt physiological reflexes, they still influence human behavior. Thus, in our study, the activation of motivational systems through affective words is the main topic of interest.

2.2.2 Dimensional space of emotion

Feelings are experienced with the activation of physical actions during the body state changes. Alongside the behavior, emotional information is also observed in verbal expressions through the development of language. The primitive drives of emotion (attractive and aversive) with accompanying arousal are defined as main semantic descriptors at end of serial language studies.

Osgood and his colleagues (1957) revealed that the meaning gathers around 2-5 directional descriptors although the human brain has capacity to produce limitless expressions. Thus, they developed the semantic differential method by using polar adjectives at the opposite end of a scale such as good-bad, soft-hard, slow-fast. Then, the wordlist were assessed with these polar adjective criteria. Finally, the principal component analysis indicated that these extensive criteria could be represented by four major components, and three of these semantic descriptors were evaluation, potency, and activity. The succeeding studies found out that evaluation and activity are valid components through different age groups (Osgood, 1957, p.58) and cultures (Osgood, 1957, chap 4). The researches on visual (pictures, Osgood, 1957; Fontaine et al., 2007) and auditory (music, Osgood, 1957) modalities also proved that these two components are not specific for only verbal expressions but they were valid semantic emotional descriptors in all domains. It was not surprising that these two components correspond to valence (evaluation) and arousal (activity). To represent emotional dimensions, evaluation and activity were replaced with the terms: valence and arousal. The recent computer based study by Samsonovic and Ascoli (2010) ended up with valence and arousal as two dominant factors after the analysis of multi-dimensional emotions. In addition, Vinson, Ponari and Vigliocco (2014) conducted a regression analysis over affective words to investigate the relationship between valence and arousal, and they found out that valence and arousal did not have an interaction. Based on these studies, it was accepted that valence and arousal are two independent emotional categories.

The distribution of emotional data on two dimensional space (valence and arousal axes) is described by two models: Circumplex Model (Russell, 1980) and PANA Model (Watson et al., 1999) (Figure 2.5). Circumplex Model includes a horizontal axis ranged from misery to pleasure (valence) and a vertical axis ranged from sleepiness to arousal (arousal). It projects the emotional distribution with a doughnut like shape, that is, emotional expressions spread all over the axes. This model has been supported by the studies conducted with multi-dimensional semantic evaluation criteria (Barett, 2004; Terraciano et al., 2003; Fontaine et al., 2007; Faith and Tayer, 2001; Sauter, 2006). On the other hand, PANA Model comprises of two 45 degree rotated axes named as negative affect ranging from high negative affect to low negative affect (starts at left upper corner and ends at right lower corner), and positive affect ranging from high positive affect to low positive affect (starts at right upper corner and ends at left lower corner). It projects the emotional distribution with a boomerang like shape, that is, emotional expression gathers around a u - shape line. This model has been supported by the studies conducted with limited semantic evaluation criteria, mostly by valence and arousal (ANEW, IADS, Bradley and Lang, 2008; Mikels, 2005; Libkuman, 2007; TUDADEN, Gokcay and Smith, 2008).

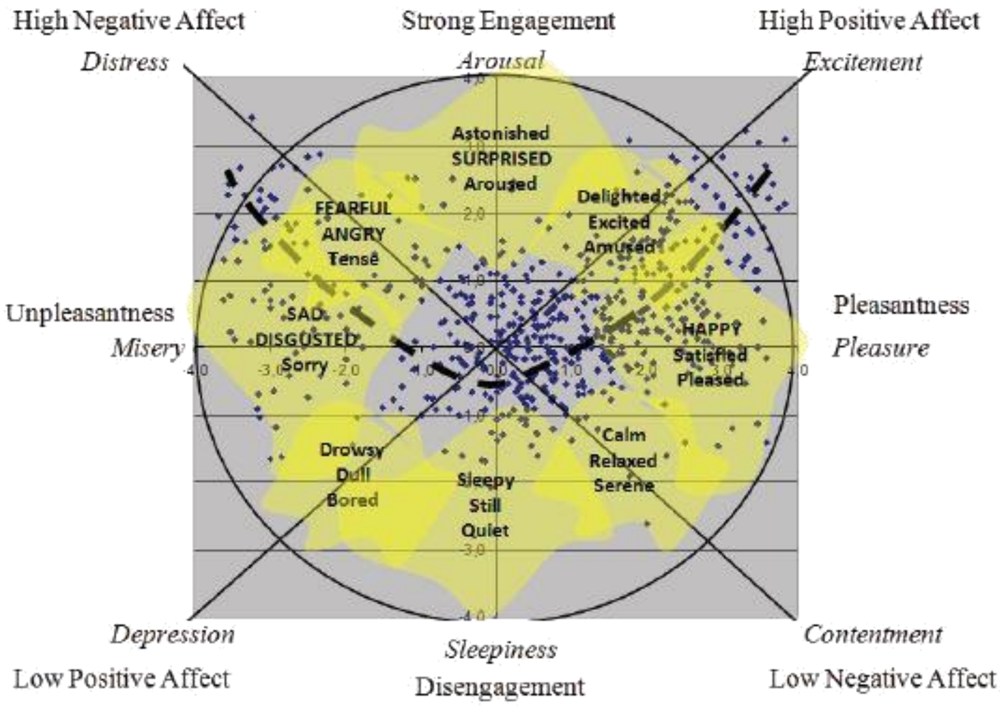

Figure 2.5 Emotions distributed on two space axes: yellow fan represents Circumplex Model distribution, black dots represents PANA Model distribution (Gokcay, 2011, ch.3, p.62)

Shortly, it seems that multidimensional affective language can be reduced to two main semantic descriptors as valence and arousal which are related to two dominant motivational systems: approach and avoid. Valence and arousal are the main focus of our study, and so experimental stimuli were controlled by these emotional factors.

2.2.3 Lexical decision task

Lexical decision task is an experimental paradigm which asks the participants to evaluate strings of letters to decide whether they are words or pseudowords. This paradigm first appeared and was named as lexical decision in the study of Meyer and Schvaneveldt (1971). Lexical decision is a well designed paradigm to test the effect of semantic features on the word recognition process. Since the task does not require direct semantic information, effects of semantic features are observed without the influence of content. In addition, the previous lexical decision studies revealed that the word recognition process is significantly different for semantically variable words even when they have same orthographic and phonological features. Thus, in order to evaluate the effects of lexical features on word recognition, lexical decision task was chosen in our study.

2.2.4 Emotion and lexical decision task

Three models (the DRC, CDP+ and triangle models) of word recognition assumed that word recognition process is affected by orthographic and semantic features. The previous language studies showed that, as one of the main semantic features, emotion has also shown prominent effects on word recognition. Nevertheless, they also revealed that it is nearly impossible to observe separate effect of emotion on written word recognition without the interference of the other factors. It is because word recognition is a continuous process reaching from orthography to semantics. Thus, alongside with emotion, contributions of other factors like word length, frequency, orthographic neighborhood, concreteness are inevitably observed (Larcen, Mercer, and Balota, 2006). Considering this fact, the cognitive models of word recognition and previous studies with emotional words are evaluated below. In addition, since lexical decision with written words is chosen as the experimental design for the current study, existing studies with lexical decision task are included.

The cognitive models of word recognition are well designed to interpret factors such as lexicality, orthographic typicality, frequency, and irregularity. Nevertheless, it could be said that the current models of word recognition are inadequate to cover the semantic richness of words. For instance, interference of new factors specific to this level as concreteness, emotion and imageability. However, these are not handled by the cognitive models which translate the words from orthography to phonology, and simply match their semantic representations.

In order to protect the relation between the models and the experimental results, some suggestion for semantic processing could be made. Based on the motivational mechanisms, it could be said that emotion increases the attention and triggers quick response. Thus, it could be assumed that emotional words also increase the attention and provide quick recognition. Then, if it is so, in basic sense, the models should be supported by an attention unit interacting with semantic processing. In addition, emotional words show different recognition performance related to their valence (positive – negativity) and arousal (high – low), so, another unit (a general one: memory or a specific one: emotion) could be included in order to evaluate this difference. Shortly, as far as we are concerned, a semantic processing component with two new units as attention and emotion might prove useful.

Estes and Adelman (2008a, 2008b) controlled the affective words in terms of word frequency, word length, orthographic neighborhood, contextual diversity and arousal, and under these conditions, they found slower reaction times for negative words compared to positive words. The same trend for negative words was also observed by Larsen et. al. (2008). Their results supported automatic vigilance of emotion, which supposed that attention was held strongly on negative stimulus. On the other hand, in the study of Kousta et. al. (2009), negative words were recognized with similar reaction time for positive words, but emotional words were faster than neutral words. Kousta et. al. (2009) stated that emotional valence facilitates word recognition (Lang, Bradley and Cuthbert, 1997) when the lexical factors like arousal, concreteness, age of acquisition, and familiarity were well controlled.

Arousal is the most debatable factor for word recognition. Larsen et. al. (2008) stated that for medium and low arousal, slower reaction times were observed for negative words but this differentiation disappeared with high arousal. Recio et. al. (2014) found similar results for arousal change by controlling the factors: imageability, word frequency, word length and orthographic neighborhood. The negative words were recognized slower than neutral and positive words when they had low and medium arousal but not high arousal. They also found out that faster responses for positive words were obtained for low and medium arousal condition while they had similar reaction times with negative words within the high arousal condition. On the other hand, Hofmann et. al. (2009) focused on the conflict of negative words by controlling mainly word frequency, word length, imageability, and orthographic neighborhood. They compared arousal change (high-low) of negative words by comparing negative words to low arousal positive and neutral words. They showed that high arousal negative words had similar faster responses with low arousal positive words while low arousal negative words had slower responses than low arousal positive words and neutral ones.

Nevertheless, arousal is not usually a precise predictor, and the interaction between arousal and other lexical factors could change the reaction time dynamics of word recognition. Scott et. al. (2009; 2014) showed the interaction of word frequency with high arousal while word length was standardized. For high frequency, only positive words were recognized quickly, and their reaction times were faster than negative and neutral words. On the other hand, for low frequency, both negative and positive words had faster reaction times than neutral words. The same reaction time trend was observed in the study of Kuchinke et. al. (2007) which was standardized mainly by word length, imageability, and orthographic neighborhood. However, they did not control the arousal values of words precisely. Additionally, Mendez-Bertola et. al. (2011) compared high arousal negative words with neutral words while concreteness and word length was standardized. They found out that for high frequency, negative words did not differ from neutral words; however, for low frequency, negative words were responded faster than neutral words. On the other hand, Nakic et. al. (2009) found out that high arousal negative words were responded faster than neutral words. It was also found out that high frequency – high arousal negative words had the fastest reaction times compared to the other condition (high frequency-low arousal, low frequency-high arousal negative). At the same time, for low frequency, the high arousal negative advantage over neutral words was maintained in this study.

In short, emotion (valence: negative, positive, neutral, and arousal: high, low, medium) is confounded by combination of several factors such as orthographic features (word length, word frequency, orthographic neighborhood) and semantic features (concreteness, imageability). Nevertheless, it is still controversial how these interactions are related with word recognition. The findings across the reported results are not consistent.

Language domain is another factor in these studies. The studies of Larsen et. al. (2008), Estes and Adelman (2008a, 2008b), Scott et. al. (2009; 2014), Kousta et. al (2009) and Nakic et. al. (2009) were conducted in English while the studies of Kuchinke et. al. (2007), Hoofman et. al. (2009) and Recio et. al. (2014) were conducted in German. In addition, Mendez-Bertola et. al. (2011) conducted their study in Spanish.

Thus, in our study, it is aimed to investigate the interaction between high arousal valence groups (positive, negative), neutral words and word frequency (high and low) with Turkish affective words to seek how well the link between cognitive models and experimental results is established.

2.3 Pupil size and dynamics

The pupil is the hole at the center of the iris, and it allows the light to pass through the eye. When the structure of the iris is studied, the pupil is found to be surrounded by smooth muscles: *circular sphincter muscle* (innermost) and *radial dilator muscle* (outermost) (Andreassi, 2000, ch. 10). These smooth muscles regulate the response and size of the pupil. These muscles are moderated by autonomous nervous system which is divided into two pathways as parasympathetic and sympathetic. The pupil constriction is realized with stimulation of circular sphincter, that is, parasympathetic pathway constricts the pupil. The pupil dilation is realized with stimulation of radial dilator muscles, that is, sympathetic pathway dilates the pupil (Loewenfeld & Lowenstein, 1993). For pupil dilation, two pathways work together. The sphincter muscle is inhibited and it relaxes. Meanwhile, sympathetic pathway is activated, then, radial dilator muscle contracts, and the pupil opens (Joos and Melson, 2012, ch.49, p.241). In short, as seen in Figure 2.6, the pupil has a complex physiology.

2.3.1 Primary functions of pupil

The primary function of the pupil is to provide optimal visual processing for organisms. Since it is sensitive to light, its main task is to control the intensity of the light getting through the eye. The entrance of light changes the pupil size depending on its intensity. The light based response of the pupil is called as pupillary light reflex. The pupil constricts in order to reduce the intensity of light when bright light enters the eye, for example looking at sun. On the other hand, the pupil dilates in order to gather enough amount of light when entering a dark room. In addition, alongside with light reflex, another main function of pupil is to constrict when it tries to focus on a near object, and this response is called as near reflex. The near reflex happens in order to decrease the large attention area of near object.

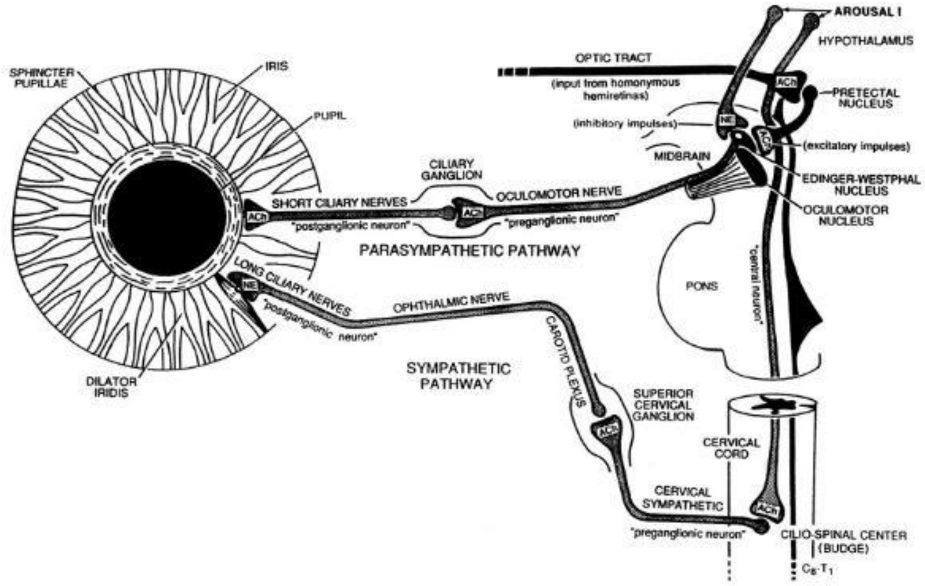

Figure 2.6 The pupil and autonomous nervous system (Joos and Melson, 2012, ch.49, p.241)

2.3.2 Pupil dilation and cognitive load

It is stated that pupil is mainly responsible for the regulation of light entering the eye. Dependent on this aim, the pupil size changes in accordance with the amount of light. Nevertheless, the pupil size changes with other factors as well. It is affected from physiological and psychological factors such as fatigue, non-visual stimulus, sexual preference, level of cognitive load, and affective load (Goldwater, 1972; Tyron, 1975). These light independent factors could be gathered under one term as "attention" (Hoeks and Levelt, 1993).

The attention based pupillary responses were first suggested by Lowenstein (1920). Then Hess and Polt (1964) conducted the first systematic study of attention. They observed pupil changes by presenting a multiplication problem and asking to solve it mentally. They revealed that pupil started to dilate at the presentation of problem and gradually continued its dilation during solution process. Then, the pupil size reached its maximum dilation before verbally reporting solution. By following verbal report, it gradually turned back to its initial state. In addition, they showed that the more difficult the multiplication problem was, the greater pupil size dilated. It was because that the amount of attention required for task increased with the difficulty of problem, and it ended up with higher pupil size. Thus, it was found out that attention was linearly correlated with pupil dilation. On the other hand, Kahneman and Beatty (1966) found out same effect of attention on pupil size by applying a short term memory task. In the task, they presented three - seven series of number string and asked the participants keep in mind and then report the string in order. They observed same pupil dilation pattern during the task. It started to increase with the presentation of first number, and then started to decrease with reporting of each number in the string. Additionally, as the number of strings increased, pupil dilated greater. Also, the pupil started to redilate when the participants were asked to repeat the string again. Alongside with the problem solving and short term memory tasks, the pupil size change during sentence processing was also investigated. It was found out that as the complexity of the sentences increased; the pupil dilated more (Ahern, 1978; Ahern and Beatty, 1981).

Shortly, the previous studies showed that as the difficulty of cognitive processing increases, pupil size gets bigger. Thus, in our study, it is expected to observe the effect of word frequency on pupil size because the cognitive models of word recognition assumed that low frequency words are processed slower and more effortfully than high frequency words. In other words, according to cognitive models, processing of low frequency words would increase cognitive load. On the other hand, for pseudoword and word comparison, the DRC and CDP+ model predict greater pupil dilation for pseudowords. It is because pseudowords are processed slower and more effortful than the words since they have no meaning and theoretically they have zero-frequency. In contrast, the triangle model predicts that for orthographic processing, pseudowords would have similar pupil dilation with words. It is because according to the triangle model similar orthographic features are processed in a similar way. On the other hand, for semantic processing, pseudowords would have greater pupil dilation than words since pseudowords have no meaning; therefore, semantic processing would be slower and more effortful for them.

2.3.3 Pupil dilation and affective load

The physiological change in the body accompanies emotional experience. The evolutionary interaction between physiology and emotion is also observed on the pupil size. In his book *The Expression of the Emotions in Man and Animals,* Charles Darwin (1872) reported the pupil dilation for fear and other emotions. On the other hand, Hess (1965) found out that pupil dilated at the presentation of positive pictures while it constricted at the presentation of negative pictures (Steinhauer et. al., 1983). Nevertheless, this early finding of pupil size change in accordance with emotion was criticized by Janisse (1977). It was claimed that these studies were not methodologically well controlled. After they developed a better controlled methodological design, Janisse (1974) and Mudd et. al. (1990) revealed that not only positive pictures but also negative pictures increased the pupil size. The same increased pupil size pattern for emotional stimulus over neutral ones was also found in auditory domain with emotional sounds by Partala and Surakka (2003).

The recent finding of Bradley et. al. (2008) presented a well-controlled methodology and explanation for the relationship between the pupil size and emotion. They investigated the effect of emotion on pupil size with emotional pictures by standardizing luminance and picture background (simple figure-ground, complex scene). They found out that regardless of background complexity, the pupil dilated greater for emotional pictures over neutral pictures. Based on these results, they suggested that the appearance of emotional stimuli triggers the activation of the basolateral and then central nucleus of the amygdala. The amygdala activation extends to the lateral hypothalamus from which sympathetic pathway starts. Thus, the activation of sympathetic pathway ends with pupil dilation. They stated that although this evolutionary connection between emotional arousal (processed in amygdala) and sympathetic pathway is not anymore apparent, this finding supports their connection (Lang and Bradley et. al., 2010).

The cognitive models of word recognition are not adequate to interpret the effect of emotion on word recognition and pupil dilation. By suggesting an additional unit for emotion, accounting for the effects of emotion on word recognition becomes possible. If emotional words activated the sympathetic pathway, at the same time, in the model, emotion unit activation would be initiated. This activation would be for the engagement of semantic component for words rather than pseudowords. The neural activation for words is assumed through the engagement of the semantic component in the model. Therefore, in the same way, sympathetic pathway activation would represent the engagement of emotion unit. For physiological response, the emotional words activate amygdala as the words activate brain regions related to semantic processing (Davis and Gaskell, 2009; Binder et. al., 2009; Price, 2010). On the other hand, like pseudowords, neutral words would not have corresponding representations in additional emotion unit in the model. This would make their process slower and more effortful than the emotional words. Along with this assumption, pupil would get larger for neutral words rather than emotional ones.

2.3.4 Pupil dilation and lexical decision task

There are only two lexical decision task studies with affective words and pupil dilation (Kuchinke et. al., 2007; Bayer, Sommer, and Schacht, 2011). Kuchinke et. al. (2007) investigated the interaction of emotion and word frequency on pupil dilation. They found out only main effect of frequency on pupil dilation. It revealed greater pupil dilations for low frequency words when compared to high frequency words. They did not come up with any pupil size difference among emotion groups (positive, negative, and neutral); however, reaction times showed a significant effect for valence. On the other hand, Bayer, Sommer and Schact (2011) found out that low arousal words increased pupil size when compared to high arousal words. Thus, both of these studies ended up with the conclusion that for lexical decision task, autonomous nervous system was not activated by emotional value of words; in contrast, cognitive load affected the pupil size. These findings are correlated with three cognitive models of word recognition. They assume that low frequency words require more effort for processing rather than high frequency. For low arousal, these findings are correlated with the assumption which states that less emotional words would not engage with emotion unit and so they would require more effort to process.

2.4 Motivation, Research Questions and Hypotheses

Experimental studies consistently highlight that emotional words get faster reaction times compared to neutral words. However, the effect of valence sub-groups (eg. positive, negative) is controversial. Some of the studies obtained slower reaction times while the other ones obtained faster reaction times for negative valence. Such variance in the results may be related to other features that relate to orthography and semantics including arousal, concreteness, word frequency, word length, and orthographic neighborhood. On the other hand, studies with emotional words have shown that there is no significant effect of emotion on pupil dilation.

On another front, word frequency is clearly a significant factor in word recognition. High frequency words have shorter reaction times than low frequency words. In addition, low frequency words initiate higher pupil dilation than high frequency words. Cognitive models of word recognition (the DRC, CDP+ and triangle models) successfully predict the main effect of frequency; however, they are not adequate to predict and interpret the effect of emotion on word recognition. Depending on the findings of the current study, the cognitive models can be revised in order to include the effects of emotion.

The research questions and hypotheses of our study are as follows:

Research Question 1: How does word processing differ with respect to words and pseudowords in terms of reaction times and pupil response?

> **Hypothesis 1:** Since the cognitive models of word recognition suggest that the pseudoword processing requires longer time and more effort than words, it is predicted that pseudowords will get longer reaction times and higher pupil dilation.

Research Question 2: Does emotion make any significant difference among words for reaction times and pupil responses?

> **Hypothesis 2:** Since the theory of motivated attention and affective states suggests that motivationally significant stimulus capture quick attention, it is predicted that reaction times for emotional words will be shorter than neutral ones.

> **Hypothesis 3:** Since the emotional words are matched for their semantic features, it is predicted that both positive and negative words will have similar reaction times.

Hypothesis 4: Since the arousal triggers the autonomous nervous system activation which is responsible for pupil dilation, it is expected that emotional words will have higher pupil dilation than neutral ones.

Research Question 3: Does word frequency make any significant difference among words for reaction times and pupil responses?

Hypothesis 5: Since all three cognitive models of word recognition suggest that processing of low frequency words is slower and effortful, it is expected that high frequency words will get faster reaction times than low frequency words.

Hypothesis 6: Since the pupil dilation is affected from the cognitive load, it is expected that low frequency words will have higher pupil dilation than high frequency words.

CHAPTER 3

METHOD

In this chapter, scale-based materials, experimental stimuli, participants and experimental design are covered. The experiment is conducted as mixed display of the set of words and pseudowords. In order to subdue the boredom effect, the experiment is split into two runs.

3.1 Materials

3.1.1 Scale-based materials

In the present study, Beck Depression Inventory (BDI) and Positive and Negative Affect Schedule (PANAS) are used as scale-based materials.

Beck Depression Inventory

The Beck Depression Inventory (BDI) was applied to clarify that the participants are not depressed. The BDI was first created by Dr. Aaron T. Beck in 1961 (Beck, 1961). It is extensively used to measure the intensity of depression. It is a self-report inventory which includes 21 multiple chose questions with four items. The items on questions cover symptoms of depression as hopelessness, irritability, cognition and physical symptoms. The assessment is performed by summing the degree of each item, which extend to non-severe (0) or to severe (3); therefore, 0 and 63 are respectively minimum and maximum scores which can be obtained. The scores are interpreted as follows: 1-10 normal, 11-16 mild mood, 17-20 borderline clinic depression, 21-30 moderate, 31-40 severe and over 40 extreme depression.

The BDI was adapted to Turkish population with internal consistency (Cronbach's *a*) .74 by Hisli (1988) and Sahin and Sahin (1992). Considering Turkish population results, the scores under 20 are assessed as non-depressed. We admitted participants with BDI scores 0-20 to our study. The inventory sheet applied in the study can be reached in Appendix A.

Positive and Negative Affect Scale (PANAS)

The Positive and Negative Affect Scale (PANAS) was applied to assess the participants' current mood at the beginning of the experiment. The PANAS is a widespread standardized test for mood or affect assessment. The 20 item-scale including two sets of positive and negative affect was created by Watson, Clark, & Tellegen (1988). Positive affect (PA) displays the intensity of alertness and activeness of a person while negative affect (NA) displays how much fear, anger and guilt a person feels. The PANAS was adapted and validated with internal consistencies (Cronbach's *a*) .83 for positive set and .86 for negative set by Gençöz (2000).

In order to evaluate their current mood, the participants are asked to rate each item (e.g. guilty, interested) on a 5 point Likert type scale which extends from 1= very slightly/not at all to 5 = extremely. The assessment is performed by summing scores of items 1, 3, 5, 9, 10, 12, 14, 16, 17 and 19 for positive affect score, and items 2, 4, 6, 7, 8, 11, 13, 15, 18, 20 for negative affect score. The minimum and maximum scores are 10 and 50 respectively for each affect type. The increase of the scores means that the levels of positive/negative affect gets higher. When the participant has greater positive score than her/his negative score, s/he is assessed to be in positive mood; on the contrary, if her/his negative score is greater than her/his positive score, s/he is assessed to be in negative mood. We admitted participants with scores of PA greater than scores of NA to our study. The scale sheet applied in the study can be reached in Appendix B.

3.1.2 Experimental materials

Experimental stimuli are acquired from the Affective Norm Database for Turkish Words (TÜDADEN) list (Gökçay & Smith, 2012). The database consists of emotional ratings for 1500 Turkish nouns. The emotional ratings are based on Osgood's (Osgood, Suci, & Tanenbaum, 1957) semantic study which reveals main emotional dimensions with factor analyses of large amount of verbal judgments. Turkish words are evaluated on two affective dimensions as valence (ranging from unpleasant to pleasant) and arousal (ranging from calm to excited). Furthermore, the third dimension is added as the degree of concreteness (ranging from abstract to concrete). The ratings are done on a 9-point scale supported by the graphical illustration: the Manikin of Emotional Rating (MERT) created by Anıl Ilgaz. In addition to these three dimensions, we included word frequency values obtained later from KelimetriK software (Erten, Bozşahin, & Zeyrek, 2013) generated from a 490 million written word database BOUN Corpus (Sak, Güngör, & Saraçlar).

High frequent 20 words and low frequent 20 words for each valence group (positive, negative and neutral) were used for the lexical decision task. The list of stimuli can be reached at Appendix F.

3.2 Stimuli selection process

In the experiment, the stimulus sets consist of words and pseudowords.

Word Selection Process

The experimental stimuli were controlled in two main factors: word frequency and emotional valence. In order to control word frequency, the wordlist was divided into two non-overlapping groups: high frequency words and low frequency words, each containing 60 words. Frequency values over 50 per million were accepted as highly frequent, and the frequency values below 20 per million were accepted as lowly frequent.

The valence dimension was divided into three non-overlapping groups of words: negative, neutral and positive. Each group contained 40 words equally distributed to two frequency groups. TUDADEN database contains emotional ratings that range from 1 (totally negative) to 9 (totally positive) for valence, and 1 (totally low arousing) to 9 (totally high arousing) for arousal dimension. The valence conditions were assigned as negative for ratings below 3.5, neutral for ratings between 4.5 and 6, and positive for ratings over 7. The other main affective dimension, arousal, was kept high for emotional words (negative and positive) having ratings over 6. In order to have a totally neutral group with no emotional value, arousal cutoffs 4 and 5.5 was used for the neutral words. The dimensional distribution of emotional values is presented in Figure 3.1. In order to standardize the perception of stimuli, the word length was controlled to be between 4 and 10 letters. The summary statistics for the experimental stimulus are presented in Table 3.1.

Pseudoword Selection Process

For the experimental task, 120 pseudowords corresponding to each Turkish word used in the study were generated by Turkish plugin of Wuggy software. Wuggy software was first created by Keuleers and Brysbaert (2010), and Turkish plugin was added by Erten, Bozşahin and Zeyrek (2013). The software takes the syllabified version of the words as the input, and a pseudoword is produced based on the word’s onset, nucleus, and coda patterns. The software also produces average Orthographic Levenshtein Distance between the pseudoword and its twenty counterparts (OLD20), neighbors at edit distance 1, number of overlapping segments, and deviation statistics. OLD20 values indicate the number of words which can be produced by editing a single letter of the pseudoword. In order to match the neighbor size, close OLD20 values with $M = 2.32$ and $SD = 0.65$ were taken for pseudoword set.

3.3 Experimental design

This experiment aims to find effects of valence and frequency on reaction times and pupillary responses in a subset of words from TUDADEN database.

3.3.1 Participants

20 native Turkish participants (10 female, 10 male) between ages of 21-32 ($M = 26.75$, $SD = 4.20$) took part in the study. Participants were right handed and had

normal or corrected to normal vision. All participants were healthy, not under the effect of psychoactive medication, and reported no history of neurologic and affective disorders. Since the participants had 20 or lower BDI scores, none of the participants were considered as outliers in terms of depression. Although most of the participants were tended to be in positive mood with higher PANAS positive affect scores than negative affect scores, one of the participants had higher negative affect scores than positive affect scores, and s/he was excluded from the analysis.

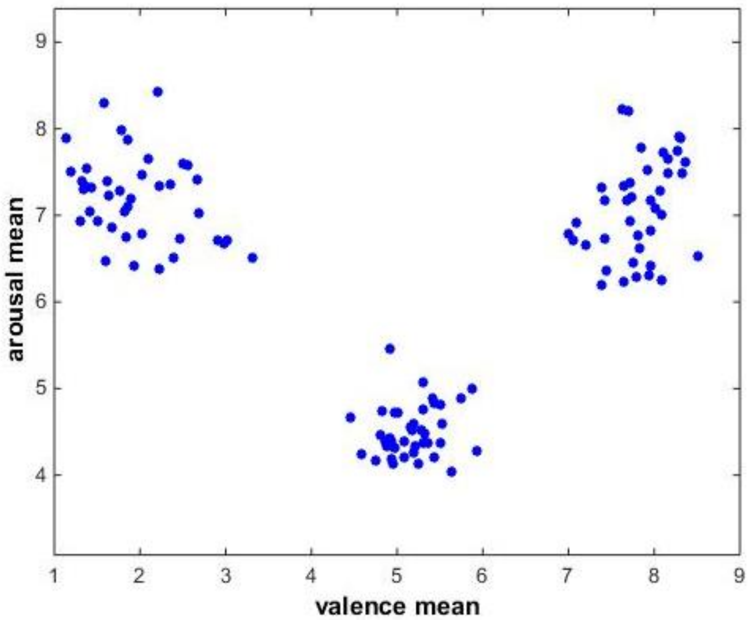

Figure 3.1 2-dimensional emotional space (valence- arousal) of Turkish wordlist used in the experiment, each point corresponds to a single word's valence and arousal ratings

Table 3.1 The mean values and standard deviations of the experimental factors for six stimulus groups

Groups		Emotional valence		Emotional arousal		Frequency (per million)		Letters	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
High frequency	Positive	7,88	0,31	7,26	0,58	121,42	55,26	5,95	1,50
	Negative	1,86	0,41	7,29	0,59	121,20	68,23	5,75	1,07
	Neutral	5,31	0,33	4,51	0,29	205,36	64,74	5,20	1,06
Low frequency	Positive	7,74	0,43	6,91	0,51	11,18	4,46	6,25	1,55
	Negative	2,08	0,66	7,11	0,39	9,71	2,92	5,55	1,10
	Neutral	5,04	0,27	4,50	0,31	7,57	2,90	6,05	1,43

3.3.2 Apparatus

The test items were shown on the computer screen using Tobii Studio (TS) 3.1.3 software while pupil data was recorded by Tobii Eye Tracking System (TETS) T120. All stimuli were presented by TS with 1280x1024 pixel resolution and pupillary responses were collected by TETS on a 17" TFT monitor under the control of Windows 7 based desktop computer in Human Computer Interaction (HCI) Laboratory in Middle East Technical University Computer Centre, with data rate of 60 Hz, tracking distance of 60 cm.

3.3.3 Procedure

The experiment took place in HCI Laboratory in dim light. After confirmation of their voluntarily participation with written consent (Appendix D), the participants were asked to fill in the demographic information (Appendix E), the BDI and the PANAS for mood assessment. Completion of admission procedure generally took 10 minutes.

The experiment was conducted in two succeeding parts, each including 240 stimuli. The experimental stimuli were equally divided into parts with the concern of word-pseudoword ratio, emotional values, and frequency distribution; therefore; each part comprised of 30 high frequency words (10 negative, 10 positive and 10 neutral), 30 low frequency words (10 negative, 10 positive and 10 neutral), and 60 pseudowords (Appendix F). The stimuli were presented in light gray uppercase letters (Arial font, font size 26) on the center of gray screen (R: 106 G: 106 B: 106) in pseudorandomized fashion. In order to minimize differences in luminance related to the stimuli length, all stimulus length was matched to 10 letter-size length by adding cross (+) equally at front and back of the stimuli. The order of the parts was counterbalanced between participants. 9-dot calibration of TETS was applied before starting the each part, and the participants were trained for each part with 10 practice stimuli differed from the experimental set.

The participants were instructed by the written information on the computer screen supported by the experimenter's verbal explanations. They were asked to classify the string of letters on the screen as word or pseudoword by pressing the specified keys on the keyboard as quickly and accurately as possible. The red label was placed on the left arrow key as correct key for pseudowords, and the blue label was placed on the right arrow key as correct key for words. The participant was supposed to press the red key when s/he saw a pseudoword on the screen or the blue key when s/he saw a word on the screen. In a single trial, a fixation cross (+) appeared at the center of the screen for 1500 ms. After the fixation cross, the stimulus was displayed on the screen for 3000 ms (see Figure 3.2 for experimental design). The participants were expected to response during the stimulus presentation, and their reaction times were recorded. The stimulus did not disappear with the response; it stayed on the screen throughout 3000 ms. The next trial started with the reappearance of the fixation cross. Since the participants were allowed to blink during the presentation of the fixation cross, pupil diameters throughout the stimulus display was used for analysis. The experiment lasted approximately 20 minutes.

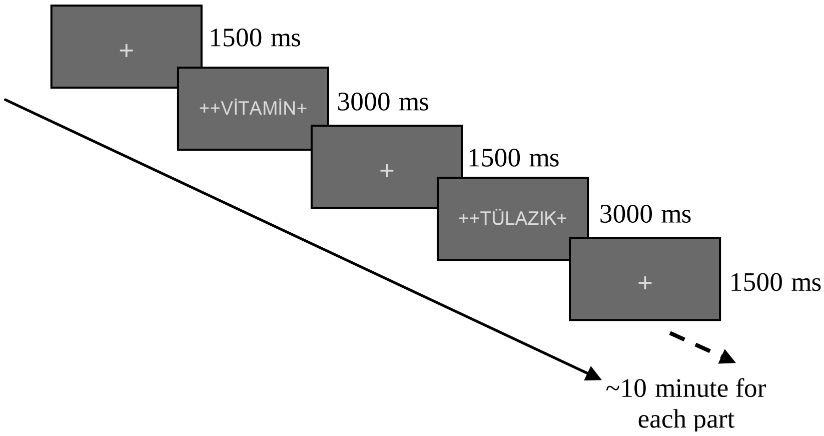

Figure 3.2 Lexical decision task design

3.3.4 Analysis

The analysis was conducted by separate 3x2 repeated measures of analysis of variances (rmANOVAs) for reaction times and pupil peak dilations. Emotion (3: positive, negative, neutral) and word frequency (2: high frequency, low frequency) were taken as experimental conditions. Bonforroni correction was applied for pairwise comparisons after significant main effects.

CHAPTER 4

RESULTS

4.1 Behavioral Data

For reaction time analysis, based on two standard deviations, reaction times above 1200 ms and below 400 ms were excluded as outliers. For below 400 ms exclusion criteria, there was no data loss. For above 1200 ms exclusion criteria, 5.83 % of data was lost. Only correct responses were included for the analysis, and 1.77 % of data was lost for this exclusion criteria. The participants who have missing data over 30 % are accepted as outliers. None of the participants were outlier and all of them were included in the analysis. Experimental conditions from both genders are analyzed together since no gender effects found among participants for word frequency ($F_{(1, 18)}$ = .846, p = .37), emotion ($F_{(2, 36)}$ =.003, p = .99) and interaction between frequency and emotion ($F_{(1.38, 24.89)}$ = 1.156, p = .32).

4.1.1 Reaction times of word and pseudowords

A paired samples t-test was applied to compare the reaction time change for word and pseudowords. On average, pseudowords (*M* = 788.26, *SE* = 19.32) have significantly longer reaction times than words (*M* = 724.06, *SE* = 19.52) during lexical decision task, $t_{(19)}$ = 5.63, p < .0001 and a large sized effect, d = *.74*.

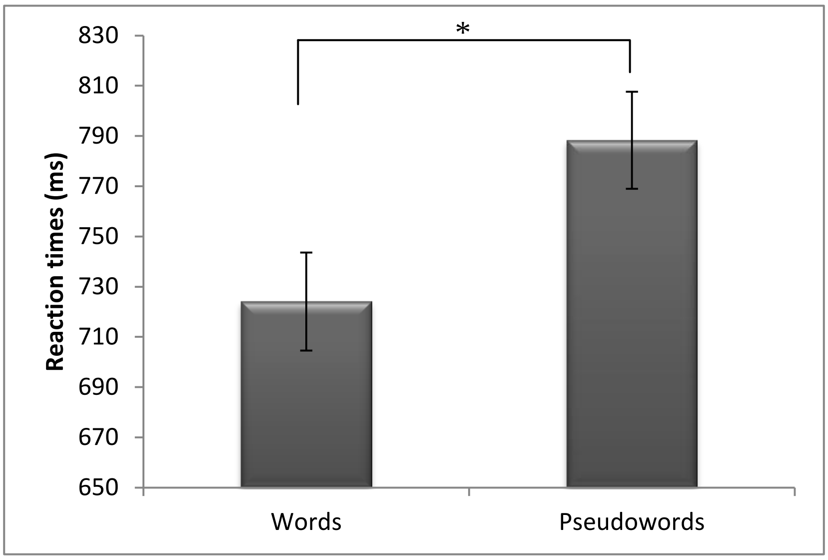

Figure 4.1 Reaction times of words and pseudowords: p < .0001
(error bars represent standard error)

4.1.2 Reaction times of frequency groups

Repeated measures of ANOVAs (3x2, 3: positive, negative, neutral valence; 2: high frequency, 2: low frequency) revealed that there was a significant main effect of word frequency on reaction times of the lexical decision task, $F_{(1, 19)} = 82.01$, $p < .0001$, $r = 1.00$. Contrasts revealed that high frequency words ($M = 701.11$, $SE = 18.96$) are recognized faster than low frequency words ($M = 747.02$, $SE = 20.36$) during lexical decision task, $F_{(1, 19)} = 82.01$, $p < .0001$, $r = 1.00$.

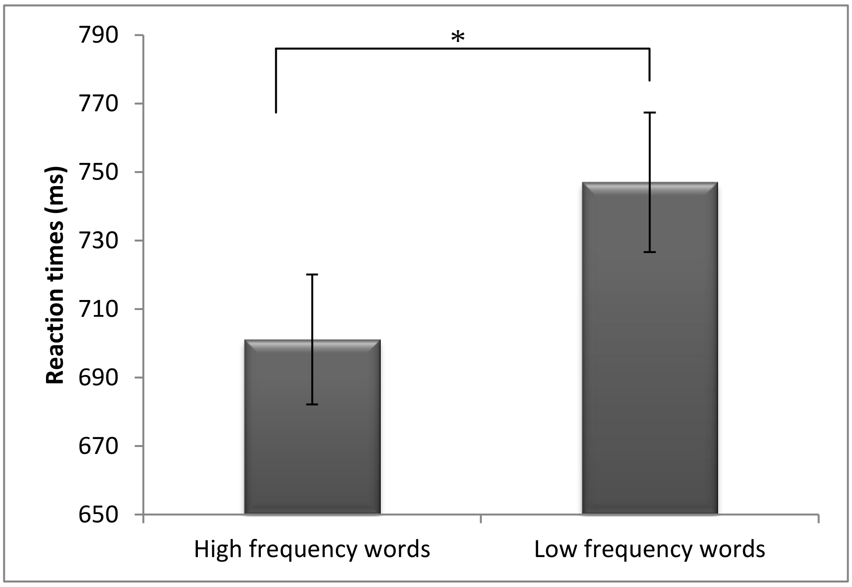

Figure 4.2 Reaction times of high and low frequency words: $p < .0001$ (error bars represent standard error)

4.1.3 Reaction times of emotion groups

Repeated measures of ANOVAs ((3x2, 3: positive, negative, neutral valence; 2: high frequency, 2: low frequency) revealed that there was a significant main effect of the emotion, $F_{(2, 38)} = 6.22$, $p = .005$, $r = .87$. Contrasts revealed that negative words have shorter reaction times than neutral words, $F_{(1, 19)} = 11.87$, $p = .008$, $r = .90$ but there was no significant difference between the reaction times of negative and positive words, $F (1, 19) = .00$, $p = 1.00$, $r = .05$. In addition, the reaction times of positive words were significantly different from neutral words, $F_{(1, 19)} = 7.49$, $p = .039$, $r = .74$.

4.1.4 Reaction times of the interaction of word frequency and emotion

Repeated measures of ANOVAs (3x2, 3: positive, negative, neutral valence; 2: high frequency, 2: low frequency) revealed that there was a significant interaction effect between word frequency and emotion, $F_{(1.39, 26.43)} = 10.19$, $p = .002$, $r = .97$. This

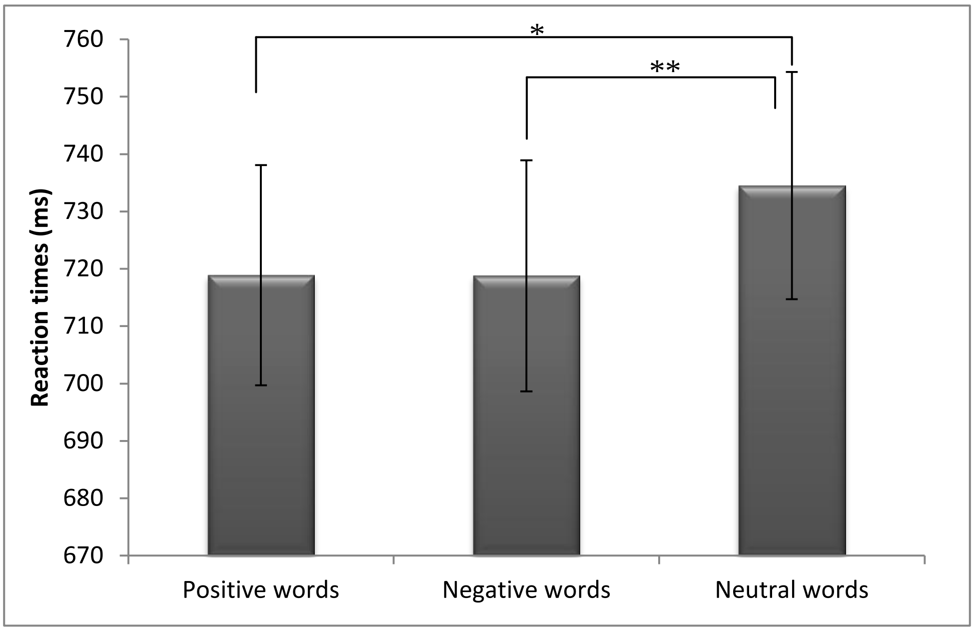

Figure 4.3 Reaction times of positive, negative and neutral words: * p = .039, ** p = .008 (error bars represent standard errors)

indicates that word frequency had different effect on people's reaction times in lexical decision task depending on the emotion of the words. Followed contrasts were performed comparing two frequency groups to each other and all emotion groups to each other. These revealed significant interactions when comparing high frequency words to low frequency words both for positive compared to negative words, $F_{(1, 19)} = 32.01$, $p < .0001$, $r = 1.00$, and positive to neutral words, $F_{(1, 19)} = 7.407$, $p = .014$, $r = .73$. Looking at the interaction graph, these effects reflect that high frequency (compared to low frequency) reaction times decreased significantly more for negative words than it did for positive words, and low frequency (compared to high frequency) reaction times increased significantly more for neutral words than it did for positive words. The remaining contrast revealed no significant interaction term when comparing high frequency to low frequency for negative to neutral words, $F_{(1, 19)} = .67$, $p = .42$, $r = .12$.

Reaction times for high frequency emotional groups

For high frequency words, repeated measures of ANOVAs (3: positive, negative, neutral valence) revealed that there was a significant main effect of the emotion, $F_{(1.42, 26.93)} = 4.49$, $p = .032$, $r = .62$. Contrasts revealed that negative words have shorter reaction times than neutral words, $F_{(1, 19)} = 8.89$, $p = .023$, $r = .80$, and positive words, $F_{(1, 19)} = 11.08$, $p = .011$, $r = .88$. On the other hand, the reaction times of positive words were not significantly different from neutral words, $F_{(1, 19)} = .00$, $p = 1.00$, $r = .05$.

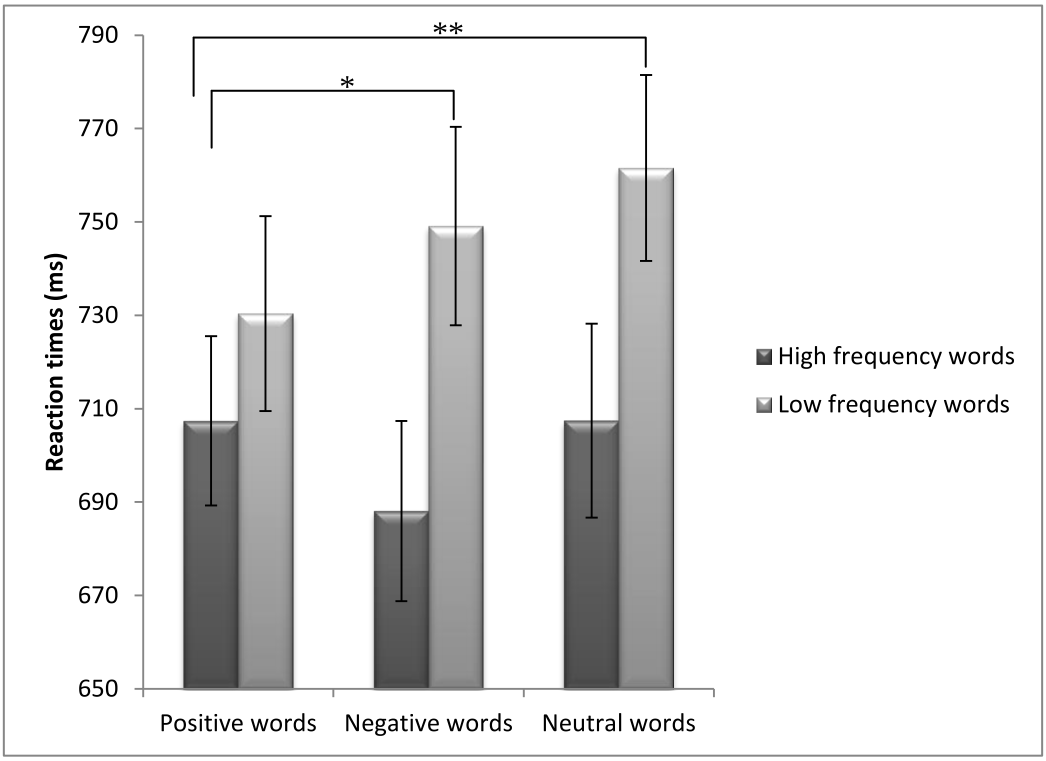

Figure 4.4 Reaction times of high and low frequency emotional words (positive, negative, neutral): * p < .0001, ** p = .014 (error bars represent standard error)

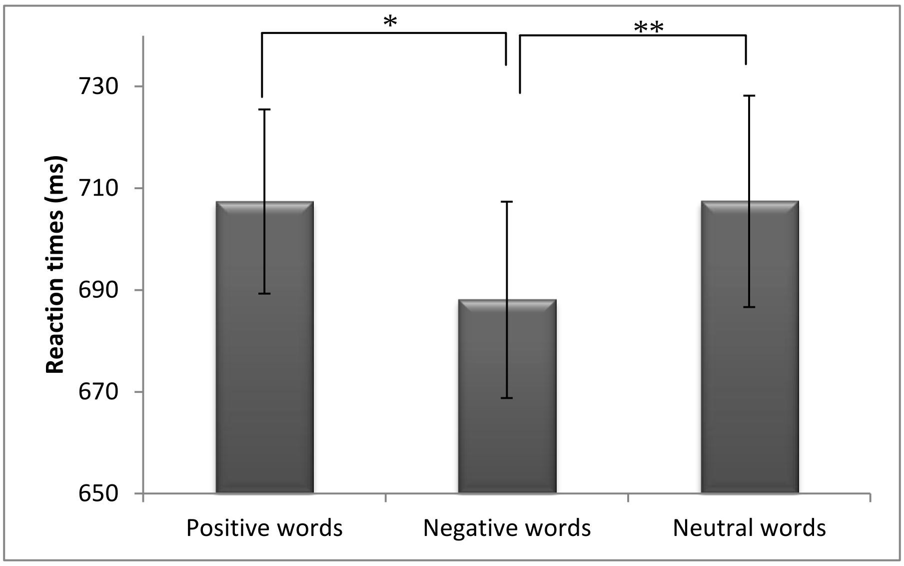

Figure 4.5 Reaction times of high frequency emotional words (positive, negative,neutral): * p = .023, ** p = .011 (error bars represent standard error)

Reaction times for low frequency emotional groups

For high frequency words, repeated measures of ANOVAs (3: positive, negative, neutral valence) revealed that there was a significant main effect of the emotion, $F_{(2, 38)} = 12.64$, $p < .0001$, $r = .99$. Contrasts revealed that positive words have shorter reaction times than neutral words, $F_{(1, 19)} = 22.40$, $p < .0001$, $r = .99$, and negative words, $F_{(1, 19)} = 8.60$, $p = .026$, $r = .79$. On the other hand, the reaction times of negative words were not significantly different from neutral words, $F_{(1, 19)} = 4\ .73$, $p = .13$, $r = .54$.

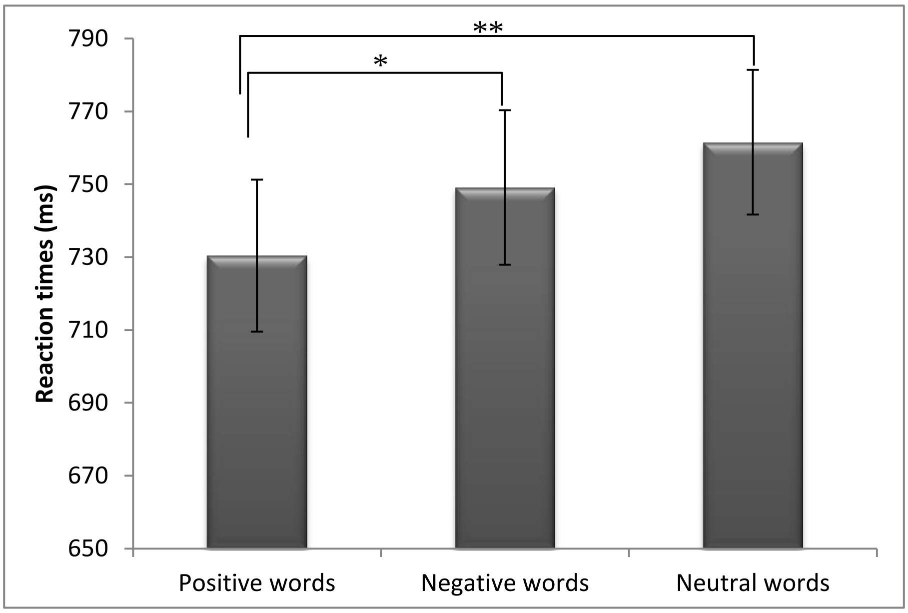

Figure 4.6 Reaction times of low frequency emotional words (positive, negative, neutral): * $p = .026$, ** $p < .0001$ (error bars represent standard error)

Table 4.1 Lexical decision performance data for reaction times in ms (RT) and error rates (Error)

		Behavioral data			
		RT		Error	
Groups		*M*	*SD*	*M*	*SD*
High frequency	Positive	689.61	79.66	0.15	0.36
	Negative	669.92	84.49	0.05	0.22
	Neutral	690.99	93.93	0.20	0.41
Low frequency	Positive	717.50	95.16	0.20	0.41
	Negative	726.43	91.72	0.65	0.99
	Neutral	746.43	86.30	0.80	1.06
Pseudo		779.51	84.45	2.20	2.91

4.2 Physiological Data

For pupil dilation analysis, the data points gathered during the lexical decision task was used disregarding periods during fixation crosses. Thus, for each trial, 180 (60 Hz x 3 s) data points were obtained. These pupillary responses were preprocessed with the help of a computer algorithm written in MATLAB (R2014b). First of all, major eye blinks were detected and excluded from the data. 7.15 % of the data was lost for excessive eye blink. The exclusion criterion was more than 30% of the data of a participant. In this study, no participant was an outlier. After the exclusion, smaller artifacts were processed by linear interpolation separately trial by trial for both eyes. Baseline pupil diameter was defined as the first data point of each trial and it was subtracted from the rest of the samples of the trial one by one. After subtraction, the trials without light reflex and the trials which did not show dilation over the initial baseline was discarded in order to eliminate outliers. 14.05 % of the data was lost for light reflex exclusion criteria and 31.15 % of the data was lost for dilation under baseline exclusion criteria. Since the pupil size of right and left eyes was expected to be correlated for healthy people, data from right and left eye for each trial was averaged after checked whether they were correlated above r =.80. At the final step, pupillary responses for each trial were smoothed by using a moving average filter with window size 5. The peak dilation was extracted and used for the analysis of experimental conditions. On the other hand, mean pupil diameters were extracted and used for word-pseudoword comparison. Experimental conditions from both genders are analyzed together since no gender effects found among participants for word frequency ($F_{(1, 18)} = .025$, $p = .88$), emotion ($F_{(2, 36)} = .806$, $p = .46$) and interaction between frequency and emotion ($F_{(2, 36)} = .091$, $p = .91$).

4.2.1 Pupillary responses of words and pseudowords

A paired samples t-test was applied to compare pupil size change for word and pseudowords. On average, pupil size for pseudowords (*M* = .18, *SE* =.01) does not significantly differ from pupil size for words (*M* =.17, *SE* =.01) during lexical decision task, $t_{(19)} = 1.64$, $p < .125$ with a small sized effect, $d = .02$.

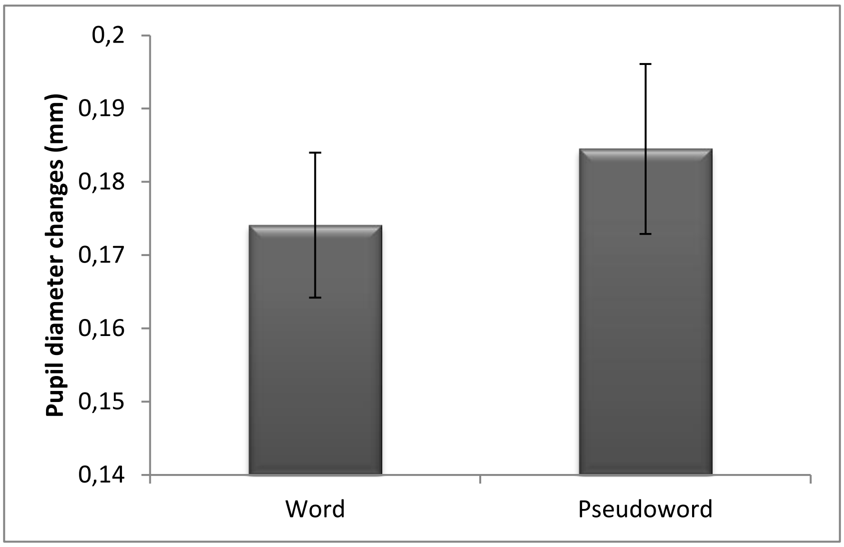

Figure 4.7 Pupil diameter changes of participants for words and pseudowords (error bars represent standard error)

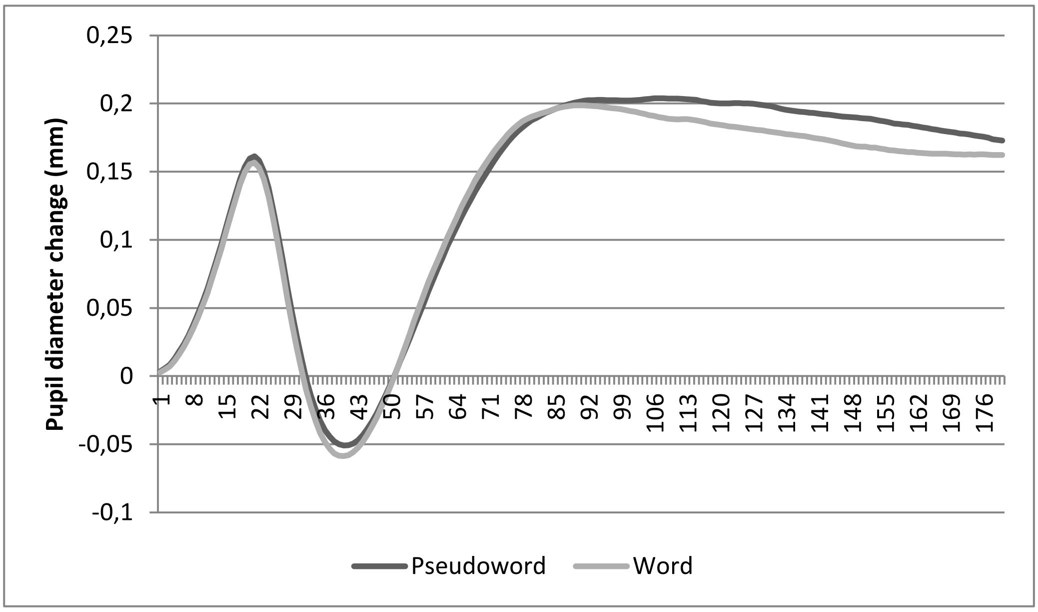

Figure 4.8 Pupil diameter changes for words and pseudowords (x axis: each data point corresponds to 1/60 seconds)

4.2.2 Pupillary responses of frequency groups

Repeated measures of ANOVAs (3x2, 3: positive, negative, neutral valence; 2: high frequency, 2: low frequency) revealed that there was no significant effect of word frequency on pupilllary responses during lexical decision task, $F_{(1, 19)}$ =.36, p = .56, r =.09.

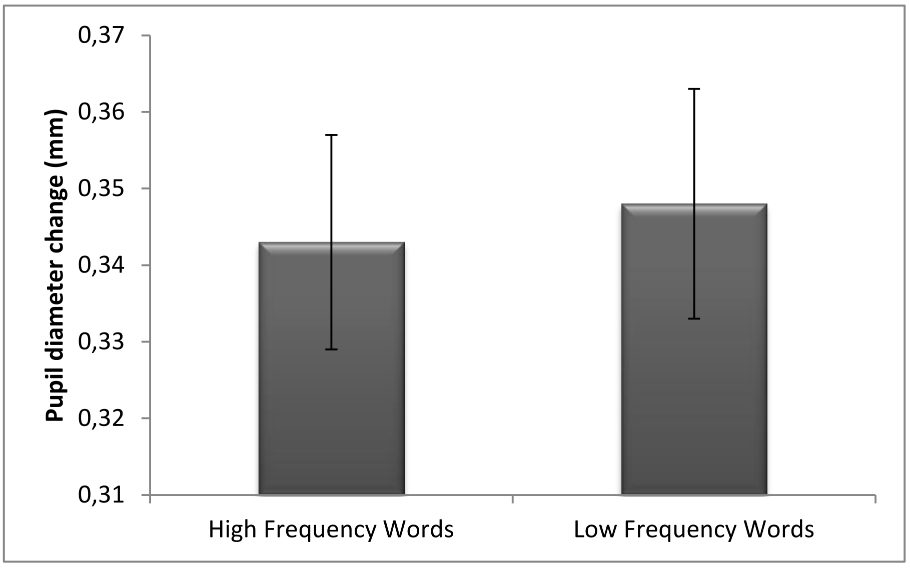

Figure 4.9 Pupil diameter changes of participants for high and low frequency words (error bars represent standard error)

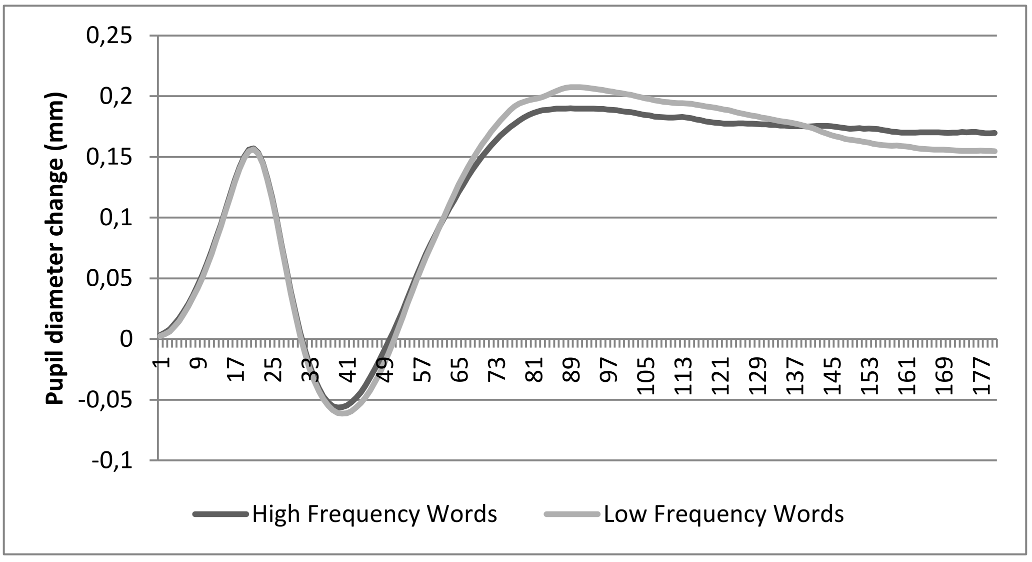

Figure 4.10 Pupil diameter changes for high and low frequency words (x axis: each data point corresponds to 1/60 seconds)

4.2.3 Pupillary responses of emotion groups

Repeated measures of ANOVAs (3x2, 3: positive, negative, neutral valence; 2: high frequency, 2: low frequency) revealed that there was no significant effect of emotion on pupilllary responses during lexical decision task, $F_{(2, 38)}$ =.19, p = .83, r =.08.

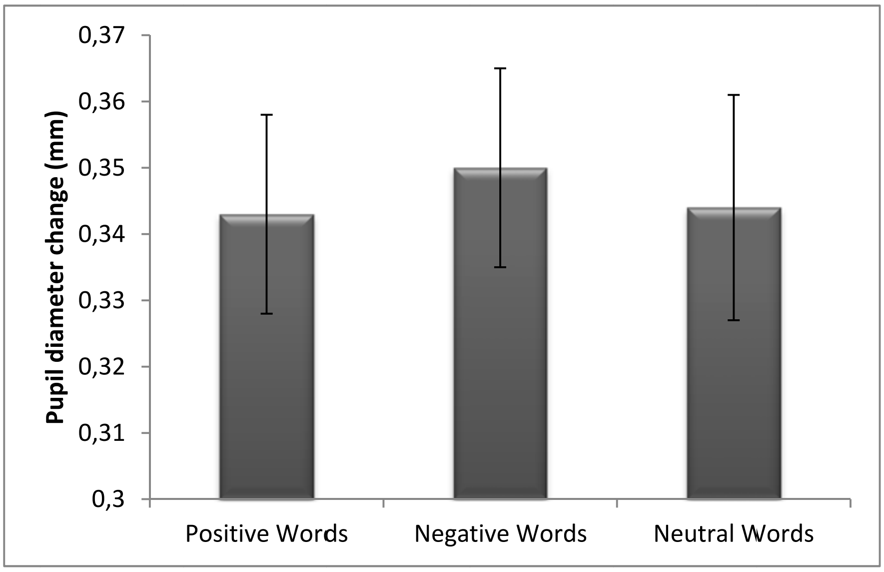

Figure 4.11 Pupil diameter changes of participants for positive, negative and neutral words (error bars represent standard error)

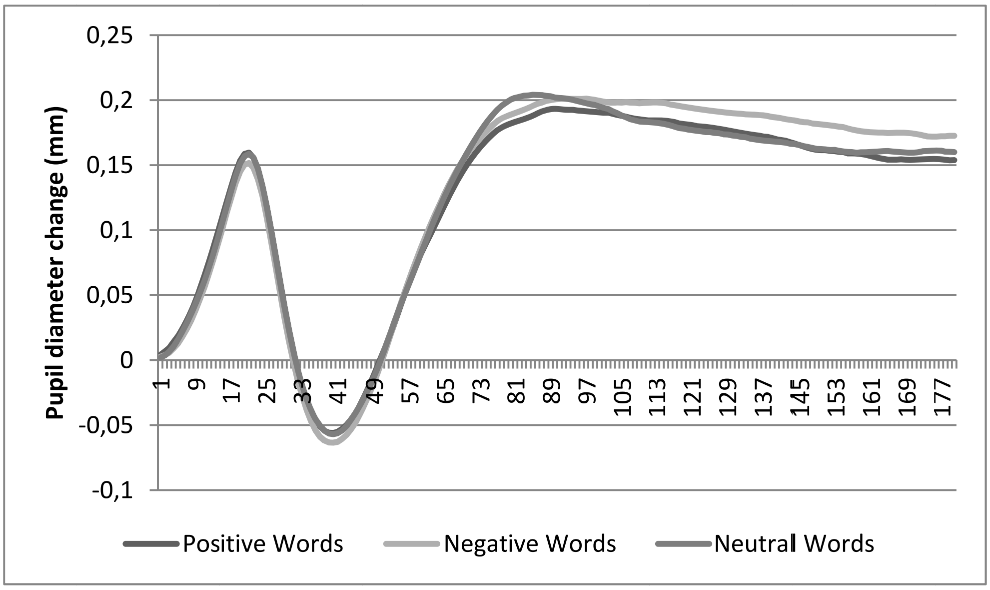

Figure 4.12 Pupil diameter changes for positive, negative and neutral words (x axis: each data point corresponds to 1/60 seconds)

4.2.4 Pupillary responses of the interaction of word frequency and emotion

Repeated measures of ANOVAs (3x2, 3: positive, negative, neutral valence; 2: high frequency, 2: low frequency) revealed that there was no significant interaction effect of word frequency and emotion on pupilllary responses during lexical decision task, $F_{(2, 38)}$ =.03, p = .96, r =.05.

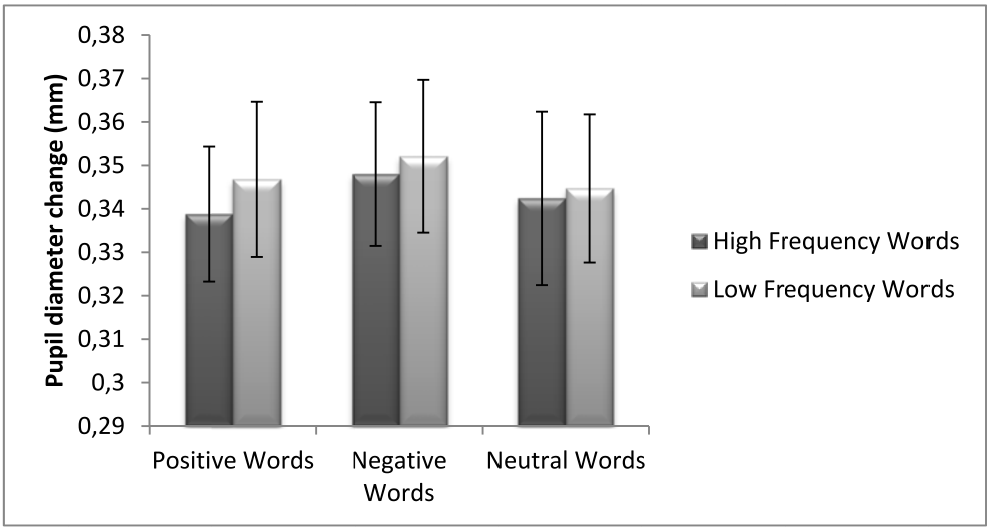

Figure 4.13 Pupil diameter changes of participants for high and low frequency emotional words (positive, negative, neutral) (error bars represent standard error)

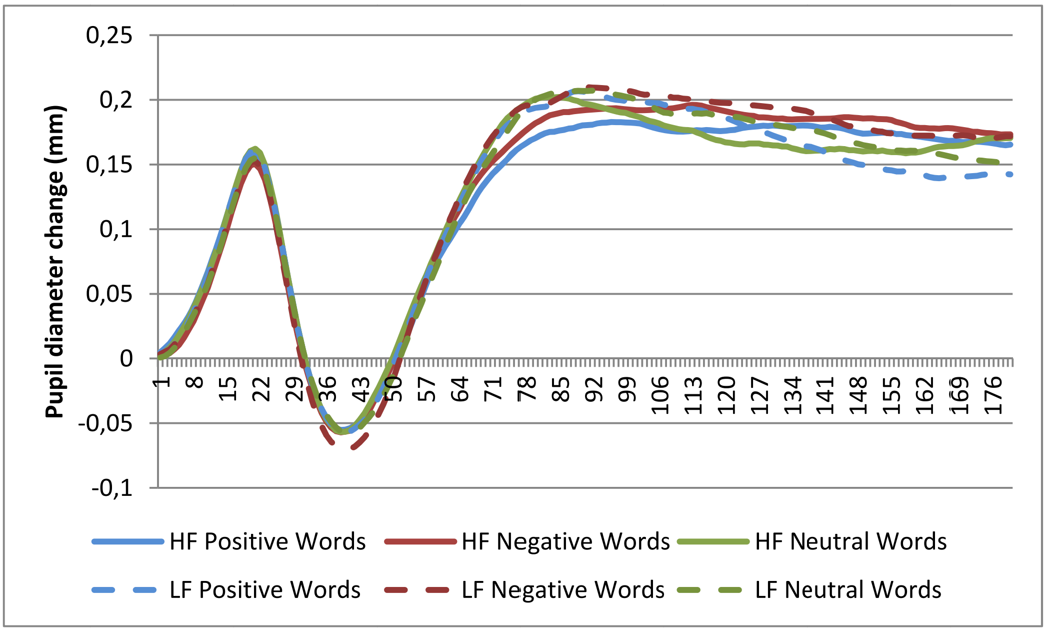

Figure 4.14 Pupil diameter changes for high and low frequency emotional words (positive, negative, neutral) (x axis: each data point corresponds to 1/60 seconds)

Table 4.2 Pupillary responses during lexical decision task in mm

Groups		Physiological data	
		Pupil dilation	
		M	*SD*
High frequency	Positive	0.338	0.069
	Negative	0.348	0.074
	Neutral	0.342	0.089
Low frequency	Positive	0.346	0.079
	Negative	0.352	0.078
	Neutral	0.344	0.076
Pseudo		0.349	0.070

In sum, RT analysis revealed significant differential effects for word groups with high/low frequency as well as positive, negative and neutral emotions. However, pupillary responses did not reveal any significant differences between these factors during the lexical decision task with Turkish words.

CHAPTER 5

DISCUSSION

In this thesis, it was aimed to investigate the possible interaction effect of word frequency and emotional motivation on reaction times of visual word recognition. Alongside with behavioral measures, the physiological response was also observed with the help of pupil dilation measurements.

At the end of the experiment, **hypotheses 1 (related to the reaction times), 2, 3** and **5** were confirmed; however, **hypotheses 1 (related to the pupil dilation), 4,** and **6** were not confirmed. For convenience, these hypotheses are listed below, and an overview showing all results is presented in Table 5.1.

Table 5.1 Result of hypotheses for reaction times and pupillary responses

Hypotheses	**Significance**	**Finding**
H1, Reaction times: Word < Pseudowords Pupil dilation: Pseudowords > Words	p <.0001 p = .125	Confirmed Not confirmed
H2, Reaction times: Emotional words < Neutral words	p = .003	Confirmed
H3, Reaction times: Positive words = Negative words	p = 1.00	Confirmed
H4, Pupillary responses: Sympathetic system: Emotional words > Neutral words	p = .83	Not confirmed
H5, Reaction times: High frequency words < Low frequency words	p < .0001	Confirmed
H6, Pupillary responses: Low frequency > High frequency	p = .56	Not confirmed

In this study, in order to control semantic features, pseudowords were chosen orthographically and phonologically similar to words. **Hypothesis 1** confirmed that words are recognized faster than pseudowords. This finding is convenient with the word superiority effect on visual word recognition (Reicher, 1969; Wheeler, 1970). On the other hand, it is also supported by the prediction of cognitive models: the DRC, CDP+ and triangle. According to the cognitive models of word recognition, these slower reaction times could have resulted from either zero frequency or semantic acces of pseudowords. The DRC and CDP+ suggest that pseudoword processing is slower and more effortful than words since pseudowords have no access for semantic component, and they have zero frequency. On the other hand, the triangle model suggests that pseudowords are processed almost like the words for orthographic process since they have similar orthography with the words. Nevertheless, their semantic processing requires more effort and time since they do not have meaning. Thus, in order to investigate this process clearly, the pupil response is collected since the reaction time measurements give the output of the process rather than its components. Although the pupil mean dilations did not show any significant difference between pseudowords and words, the pupil dilation trend is correlated with the prediction of the triangle model. The maximum peak dilations are almost similar both for pseudowords and word groups. After maximum peak, pupil size of pseudowords turns back to its initial state slower than words. Thus, if this slower constriction is related with effortful semantic processing, this can be accommodated by the triangle model, as it suggests similar orthographic processing but different semantic processing for pseudowords.

This study resulted with shorter reaction times for high frequency words compared to low frequency words. This finding confirms **hypothesis 5**, and it is consistent with the previous theories and studies which emphasize that word frequency is the most robust predictor of the visual word recognition performance (Whaley, 1978). The cognitive models of word recognition, the DRC, CDP+ and the triangle models interpret this finding as low frequency words need more effort to process since familiarity strengthens the relationship between orthography and semantic representation. Thus, this finding is correlated with the role of frequency on the rule construction of three cognitive models. Furthermore, this effect of frequency is consistent with the findings of Kuchinke et. al. (2007), Scott et. al. (2009), and Nakic et.al. (2009), although the words used in these studies and the current study are different in terms of semantic features such as emotion values, and concreteness.

Alongside with word frequency effect, the main effect of emotion can be studied when the participants deal with a task which does not require emotion recognition. As stated on **hypothesis 2**, the emotional words were responded faster than the neutral words. This finding supported the theory of motivated attention and affective states (Lang, Bradley, Cuthbert, 1990, 1997) suggesting that the motivationally significant stimuli catch and hold the attention regardless of polarity. The semantic features of the data was tried to be matched for two main emotion groups, especially for arousal. Thus, high arousal facilitated the processing of emotional words rather than neutral ones. This main effect of emotion is consistent with the study of Kousta, Vinson, and Vigliocco (2009) which suggested that control of other semantic features, especially arousal (degree of emotional activation), removes the asymmetry between the processing of negative and positive stimulus. Similar reaction times for positive and negative words confirmed **hypothesis 3** in terms of arousal. On the other hand, this result is in contradiction with the congruency theory of emotion and positivity advantage. The congruency theory of emotion suggest that negative words used in this study are congruent with high arousal-negative valence while positive words are incongruent with high arousal – positive valence. This suggestion means that negative words can initiate quick avoid while positive words need low arousal to initiate quick approach. Thus, the congruency theory of emotion predicted that negative words would get shorter reaction times than positive words. Our results did not support this theory. The positivity advantage suggests that positive words are generally used more than negative words in daily speech; therefore, positive words would get shorter reaction times than negative words. Our results did not support this advantage either. The effect of congruency theory of emotion and positivity advantage may be inhibited by word frequency since the emotional stimuli include both low and high frequency words on purpose. On the other hand, when looked for the cognitive models, they do not have the capacity to interpret the effect of emotion. Still, assumptions done by considering the existing models could be useful to explain the similarity between positive and negative high arousing words. If semantic processing is facilitated by emotion, the emotion unit for semantic component of cognitive models can be implemented, as emotional words activate this unit. Correlated with this, the neutral words will be processed slower and with more effort since they cannot engage the emotion unit. Thus, the shorter reaction times for emotional words would support the idea of emotion unit implementation for semantic component of the models. Nevertheless, the emotion unit should be well designed to cover emotional factors (valence and arousal) in order to clarify the processing of positive and negative words.

In addition, the reaction time findings revealed significant interaction between word frequency and emotion. For high frequency, only negative words had faster response times, and there was no significant difference between positive and neutral words. The shorter reaction times for negative words are consistent with the study of Nakic et. al. (2009). They reported that high frequency high arousal combination is the best condition for negative words to activate quick avoidance behavior. Nevertheless, in the study of Nakic et. al. (2009), there was no positive words to compare with. This negative advantage over positive supports the congruency theory of emotion, as it suggests negative words used in this study are congruent, and so they can initiate quick avoid (Robinson et. al., 2004). In contrast to congruency theory of emotion, this finding is inconsistent with positivity advantage. Unkelbach et. al. (2008) suggested the density hypothesis in order to explain positivity advantage. According to this hypothesis, since positive words have similar semantic representations, a single positive word activates the other positive words more or less. This semantic similarity presents an advantage even for unfamiliar positive words. Although this hypothesis is not supported by the reaction times of positive words, it could be suggested that maybe this semantic similarity is not valid only for positive words but also for negative words. High frequency negative words used in this study could be evaluated as semantically similar with the existence of words like “bomba, korku, terrorist, ceset, işkence, kavga”. Thus, it could be assumed that for this experimental condition, negative words were semantically similar compared to the list of positive words and they got shorter reaction times. In addition, this hypothesis suggests another assumption. Since human beings tend to be in positive mood, the high frequency negative words become unexpected “new object” in the environment, and so, they were realized earlier than positive words. Alongside with these suggestions, semantic processing of the cognitive models is correlated with the density hypothesis. For the models, semantically familiar words have strong connection between their orthography and semantic representation in order to achieve correct discrimination of words. Thus, this strong connection makes the semantic processing faster and effortless. If negative words in this study are semantically similar, then, shorter reaction times for them are predicted by three cognitive models.

For low frequency words, positive words had the fastest response times, and at the same time, negative words had faster response times than neutral words. The reaction time trend of low frequency words were consistent with the literature and supported the facilitator role of positive affect (Estes and Adelman, 2008; Unkelbach et al., 2008). The cognitive models predict that if emotion facilitates semantic processing, its effect will be observed better for low frequency words. Since processing of low frequency words requires more time and effort, any factor could be facilitator in order to overcome this effort. Thus, three cognitive models of word recognition predict that density hypothesis (Unkelbach et. al., 2008) will be supported, as their mechanism is correlated with familiarity effect. If the advantage of positive words is related with their semantic similarity, then, three cognitive models predict that positive word will have shorter reaction times than negative words. In addition, Pollyanna hypothesis (Boucher and Osgood, 1969) suggests that people tend to be in positive mood and so they are more familiar to positive stimulus rather than negative stimulus. Thus, this familiarity of positivity provides quick response to positive stimulus. On the other hand, the lateness of negativity supported the assumption that negative stimulus hold the attention longer than positive and neutral; therefore, the task demand is delayed for a while (Fox, Russo, Bowles, and Dutton, 2001). These findings of current study for low frequency negative words are consistent with the study of Rothermund, Wentura and Bak (2001) in which they also found delayed responses for negative stimulus.

In contrast to findings of reaction time, the physiological responses did not show any significant effect of neither frequency nor emotion during lexical decision task. The pupil size did not change under the effect of experimental conditions and caused us to reject **hypotheses 1 (related to the pupil response), 4, and 6**. These findings are inconsistent with the study of Kuchinke et. al. (2007) and Bayer et. al.

(2015) who found significant pupillary responses for cognitive load in lexical decision task. Although the results were insignificant, our pupil sizes were in a similar range with these studies, in which the effect is quite small. Still the trend of the pupil dilation could give some clues about the pupil physiology during the lexical decision task. In the review of Beatty (1982), the effect of cognitive load on pupil size is described by based on several studies. The pupil starts to dilate with the presentation of mental task, maintains its progress until the response of the task, and reaches its maximum peak. Then, with the response, it gradually constricts back to its original state. The same trend was also observed in our study. This trend of cognitive load is consistent with the effort factor of three cognitive models of word recognition, the DRC, CDP+ and triangle models. The models predict that low frequency words will get higher pupil size than high frequency words, as processing of low frequency words requires more time and effort. Despite the insignificant maximum peak dilations, low frequency words tend to get higher pupil dilation and correlate well with the prediction of models. On the other hand, for emotion, the models predict that if emotion is effective for semantic processing, neutral words will get higher pupil dilation since their processing will be longer and effortful because their lack emotion. Nevertheless, in contrast to this prediction of the models, negative words tend to get higher pupil size. This trend supports that negative words activates amygdala, and then sympathetic pathway triggers pupil dilation. This possible amygdala activation of negative words support the study which states that amygdala is activated mostly by negative stimulus compared to positive stimulus (Zald, 2003). Thus, although the maximum peak dilations did not show any significant effect, the trend of pupil size change suggests that frequency and emotion could be effective factors for semantic processing. Nevertheless, pupil dilation is not a good measurement for words in order to observe this process. It could be assumed that words may not be as strong stimuli as pictures or sounds to be able to affect pupil size. The data loss for initial baseline exclusion criteria supports this assumption, as pupil size of quite a few words did not come over baseline after light reflex. In addition, the effect of words on the pupil and the data loss could be explained with light reflex fight. The primary function of the pupil is to regulate light entrance into the eye and so the pupil size autonomously changes with the intensity of light. By considering this function, the presentation of experimental stimulus has critical role on the pupillary responses. In our study, the words in light grey letters were presented on the dark grey screen. Thus, this bright luminance of the letters might have forced the pupil to constrict. Thus, the effect of word frequency and emotion could have been lost in the fight of light.

Limitations and future work

Although this study aims to control many variables, there are still some limitations concerning selected stimuli, experimental design and data analyses. First of all, experimental stimuli are controlled for arousal, valence, word frequency and word length. Nevertheless, it is known that there are other semantic factors affecting the word recognition (Binder et. al, 2005). For a detailed observation for semantic processing, words should also be controlled for concreteness, and semantic similarity which shows how many associations they can prime.

After preprocessing of pupil dilation data, quite a few words did not initiate a valid pupil dilation response after light reflex. This could be due to the luminance of screen. Therefore, for a robust experiment design, a variety of color combinations for the letters and background can be tested. In addition, the light reflex is affected from length of the words. In order to develop a method for word length balance, the luminance of the letters can be tested. For analysis, we used only maximum peak dilations. Peak latency analysis and itemwise analysis may reveal other types of pupil responses.

Finally, the pupil trend of negative words suggests that negative words might trigger sympathetic pathway rather than positive words. If this activation took longer for negative stimuli, then, the following stimulus might have beeen captured by this effect. Therefore, a new study can be conducted in order to observe whether such negative captivity effect exists.

CHAPTER 6

CONCLUSION

In this thesis, we investigated the possible effects word frequency and emotion during Turkish word recognition process in a lexical decision task. For this purpose, we conducted an eye tracking study and recorded pupillary responses as well as reaction times.

In order to contrast words versus pseudowords, pseudowords that are orthographically similar to the words were used as experimental stimuli. The pseudowords got longer reaction times than the words in agreement with the prediction of the DRC, CDP+ and triangle models. Although statistical significance was not reached, pupil dilation of pseudowords took longer than words. This trend was only predicted by the triangle model, as it suggested that for orthographic processing words were processed similarly to pseudowords but for semantic processing pseudowords required more time and effort. This suggests that the triangle model may be more appropriate to investigate the semantic processing.

For word frequency, we divided the experimental stimuli in two groups: high frequency and low frequency. The low frequency words got slower reaction times than high frequency. This finding supported the prediction of the DRC, CDP+ and triangle models. Alongside with the reaction times, low frequency words tended to initiate higher pupil size, replicating the literature (Kuchinke et. al., 2007). It suggests that frequency is a main robust factor affecting the word processing.

For emotion, the words were divided into three groups as positive, negative and neutral (arousal values were high for emotional words and neutral for neutral words). The emotional words got shorter reaction times regardless of their polarity, replicating the literature (Kousta et. al.,2009). This was correlated with the theory of motivated attention and affective states (Lang, Bradley, Cuthbert, 1990, 1997) as it suggested emotionally motivated words got quick attention and so they were responded quickly. If this advantage is related with emotion, then, semantic processing is facilitated by emotion. Nevertheless, all three cognitive models are not adequate to interpret emotion effect on semantic processing. Therefore, it could be suggested that correlated with finding of reaction time, an emotion unit may be implemented for cognitive model. With this implementation, they could assume that neutral words would require more time and effort for semantic processing since they lack emotion. While negative words tended to initiate higher pupil size, this finding was not significant. Under these experimental conditions, their semantic features may not be strong as to be able change body physiology.

For word frequency and emotion interaction, six experimental conditions were compared. Among high frequency words, only negative words got shorter reaction times. This suggests that the density hypothesis may be not valid for only positive words but also some negative words may be semantically similar. Among low frequency words, positive words got the shortest reaction times, and negative words got shorter reaction times than neutral words. This suggests that positive words may have advantage to respond quickly since human beings tend to be in positive mood. In addition, the density hypothesis may be valid for positive words in this experimental condition. Moreover, if any emotion unit is implemented for cognitive models, it is suggested that this unit could be controlled by the density hypothesis. The semantic familiarity could be a significant factor for semantic processing. However, since we did not control semantic similarity of experimental stimuli, these suggestions related to the density hypothesis need to be tested with future work.

Our study opens possibility for conducting other types of future work as well. For behavioral data, we conducted only reaction time analysis. With accuracy analysis, the effect of low/high frequency or emotional conditions may reveal new findings. Since only written words are used in this study, the word recognition process can be tested with auditory words during lexical decision task.

To summarize, it can be said that low frequency resulted with longer reaction times and higher pupil dilation trend. The emotional words were responded faster than neutral ones; and emotion showed significant interaction with word frequency. In this interaction, for high frequency, only negative words got shorter reaction times while, for low frequency, positive word got the shortest reaction times. On the other hand, in contrast to reaction times, the pupil response did not show any significant effect of experimental factors.

The reaction time results verify our current knowledge regarding the effect of word frequency and emotion on semantic processing of visual word recognition. Although the human beings have learnt to control their behaviors, the primitive mechanisms – emotions - have still influence on the possible reactions by delaying or facilitiating them.

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APPENDIX A:

BECK DEPRESSION INVENTORY

Aşağıda, kişilerin ruh durumlarını ifade ederken kullandıkları bazı cümleler verilmiştir. Her madde, bir çeşit ruh durumunu anlatmaktadır. Her maddede o ruh durumunun derecesini belirleyen 4 seçenek vardır. Lütfen bu seçenekleri dikkatle okuyunuz. Son bir hafta içindeki (şu an dâhil) kendi durumunuzu göz önünde bulundurarak, size en uygun ifadeyi bulunuz. Daha sonra o maddenin yanındaki harfin üzerine (X) işareti koyunuz.

1. (a) Kendimi üzgün hissetmiyorum.
(b) Kendimi üzgün hissediyorum.
(c) Her zaman için üzgünüm ve kendimi bu duygudan kurtaramıyorum.
(d) Öylesine üzgün ve mutsuzum ki dayanamıyorum.

2. (a) Gelecekten umutsuz değilim.
(b) Geleceğe biraz umutsuz bakıyorum.
(c) Gelecekten beklediğim hiçbir şey yok.
(d) Benim için bir gelecek yok ve bu durum düzelmeyecek.

3. (a) Kendimi başarısız görmüyorum.
(b) Çevremdeki birçok kişiden daha fazla başarısızlıklarım oldu sayılır.
(c) Geriye dönüp baktığımda, çok fazla başarısızlığımın olduğunu görüyorum.
(d) Kendimi tümüyle başarısız bir insan olarak görüyorum.

4. (a) Her şeyden eskisi kadar zevk alabiliyorum.
(b) Her şeyden eskisi kadar zevk alamıyorum.
(c) Artık hiçbir şeyden gerçek bir zevk alamıyorum.
(d) Bana zevk veren hiçbir şey yok. Her şey çok sıkıcı.

5. (a) Kendimi suçlu hissetmiyorum.
(b) Arada bir kendimi suçlu hissettiğim oluyor.
(c) Kendimi çoğunlukla suçlu hissediyorum.
(d) Kendimi her an için suçlu hissediyorum.

6. (a) Cezalandırıldığımı düşünmüyorum.
(b) Bazı şeyler için cezalandırılabileceğimi hissediyorum.
(c) Cezalandırılmayı bekliyorum.
(d) Cezalandırıldığımı hissediyorum.

7. (a) Kendimden hoşnutum.
(b) Kendimden pek hoşnut değilim.
(c) Kendimden hiç hoşlanmıyorum.
(d) Kendimden nefret ediyorum.

8. (a) Kendimi diğer insanlardan daha kötü görmüyorum.
(b) Kendimi zayıflıklarım ve hatalarım için eleştiriyorum.
(c) Kendimi hatalarım için çoğu zaman suçluyorum.
(d) Her kötü olayda kendimi suçluyorum.

9. (a) Kendimi öldürmek gibi düşüncelerim yok.
(b) Bazen kendimi öldürmeyi düşünüyorum, fakat bunu yapmam.
(c) Kendimi öldürebilmeyi isterdim.
(d) Bir fırsatını bulsam kendimi öldürürdüm.

10. (a) Her zamankinden daha fazla ağladığımı sanmıyorum.
(b) Eskisine göre şu sıralarda daha fazla ağlıyorum.
(c) Şu sıralarda her an ağlıyorum.
(d) Eskiden ağlayabilirdim, ama su sıralarda istesem de ağlayamıyorum.

11. (a) Her zamankinden daha sinirli değilim.
(b) Her zamankinden daha kolayca sinirleniyor ve kızıyorum.
(c) Çoğu zaman sinirliyim.
(d) Eskiden sinirlendiğim şeylere bile artık sinirlenemiyorum.

12. (a) Diğer insanlara karşı ilgimi kaybetmedim.
(b) Eskisine göre insanlarla daha az ilgiliyim.
(c) Diğer insanlara karşı ilgimin çoğunu kaybettim.
(d) Diğer insanlara karşı hiç ilgim kalmadı.

13. (a) Kararlarımı eskisi kadar kolay ve rahat verebiliyorum.
(b) Şu sıralarda kararlarımı vermeyi erteliyorum.
(c) Kararlarımı vermekte oldukça güçlük çekiyorum.
(d) Artık hiç karar veremiyorum.

14. (a) Dış görünüşümün eskisinden daha kötü olduğunu sanmıyorum.
(b) Yaslandığımı ve çekiciliğimi kaybettiğimi düşünüyor ve üzülüyorum.
(c) Dış görünüşümde artık değiştirilmesi mümkün olmayan olumsuz değişiklikler olduğunu hissediyorum.
(d) Çok çirkin olduğumu düşünüyorum.

15. (a) Eskisi kadar iyi çalışabiliyorum.
(b) Bir işe başlayabilmek için eskisine göre kendimi daha fazla zorlamam gerekiyor.
(c) Hangi iş olursa olsun, yapabilmek için kendimi çok zorluyorum.
(d) Hiçbir iş yapamıyorum.

16. (a) Eskisi kadar rahat uyuyabiliyorum.
(b) Şu sıralarda eskisi kadar rahat uyuyamıyorum.
(c) Eskisine göre 1 veya 2 saat erken uyanıyor ve tekrar uyumakta zorluk çekiyorum.
(d) Eskisine göre çok erken uyanıyor ve tekrar uyuyamıyorum.

17. (a) Eskisine kıyasla daha çabuk yorulduğumu sanmıyorum.
(b) Eskisinden daha çabuk yoruluyorum.
(c) Şu sıralarda neredeyse her şey beni yoruyor.
(d) Öyle yorgunum ki hiçbir şey yapamıyorum.

18. (a) İştahım eskisinden pek farklı değil.
(b) İştahım eskisi kadar iyi değil.
(c) Şu sıralarda iştahım epey kötü.
(d) Artık hiç iştahım yok.

19. (a) Son zamanlarda pek fazla kilo kaybettiğimi sanmıyorum.
(b) Son zamanlarda istemediğim halde üç kilodan fazla kaybettim.
(c) Son zamanlarda istemediğim halde beş kilodan fazla kaybettim.
(d) Son zamanlarda istemediğim halde yedi kilodan fazla kaybettim.

Daha az yemeye çalışarak kilo kaybetmeye çalışıyorum.
Evet ( ) Hayır( )

20. (a) Sağlığım beni pek endişelendirmiyor.
(b) Son zamanlarda ağrı, sızı, mide bozukluğu, kabızlık gibi sorunlarım var.
(c) Ağrı, sızı gibi bu sıkıntılarım beni epey endişelendirdiği için başka şeyleri düşünmek zor geliyor.
(d) Bu tür sıkıntılarım beni öylesine endişelendiriyor ki, artık başka hiçbir şey düşünemiyorum.

21. (a) Son zamanlarda cinsel yaşantımda dikkatimi çeken bir şey yok.
(b) Eskisine oranla cinsel konularla daha az ilgileniyorum.
(c) Şu sıralarda cinsellikle pek ilgili değilim.
(d) Artık cinsellikle hiçbir ilgim kalmadı.

APPENDIX B

POSITIVE AND NEGATIVE AFFECT SCALE

Bu ölçek farklı duyguları tanımlayan bir takım sözcükler içermektedir. Şu anda nasıl hissettiğinizi düşünüp her maddeyi okuyun. Uygun cevabı her maddenin yanında ayrılan yere (puanları daire içine alarak) işaretleyin. Cevaplarınızı verirken aşağıdaki puanları kullanın.

1. Çok az veya hiç
2. Biraz
3. Ortalama
4. Oldukça
5. Çok fazla

1. İlgili	1	2	3	4	5
2. Sıkıntılı	1	2	3	4	5
3. Heyecanlı	1	2	3	4	5
4. Mutsuz	1	2	3	4	5
5. Güçlü	1	2	3	4	5
6. Suçlu	1	2	3	4	5
7. Ürkmüş	1	2	3	4	5
8. Düşmanca	1	2	3	4	5
9. Hevesli	1	2	3	4	5
10. Gururlu	1	2	3	4	5
11. Asabi	1	2	3	4	5
12. Uyanık (dikkati açık)	1	2	3	4	5
13. Utanmış	1	2	3	4	5
14. İlhamlı (yaratıcı düşüncelerle dolu)	1	2	3	4	5
15. Sinirli	1	2	3	4	5
16. Kararlı	1	2	3	4	5
17. Dikkatli	1	2	3	4	5
18. Tedirgin	1	2	3	4	5
19. Aktif	1	2	3	4	5
20. Korkmuş	1	2	3	4	5

APPENDIX C

ETHICAL APPROVAL FORM

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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02 OCAK 2017

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Yrd. Doç. Dr. Didem GÖKÇAY;

Danışmanlığını yaptığınız yüksek lisans öğrencisi Sahura ERTUĞRUL' un ***"Duygusal Kelimelerle Sözcüksel Karar Çalışması: Göz Bebeği Ölçümleri"*** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2016-FEN-070** protokol numarası ile **02.01.2017 – 31.12.2017** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Canan SÜMER
İnsan Araştırmaları Etik Kurulu Başkanı

Prof. Dr. Mehmet UTKU
İAEK Üyesi

Prof. Dr. Ayhan SOL
İAEK Üyesi

Prof. Dr. Ayhan Gürbüz DEMİR (4.)
İAEK Üyesi

Doç. Dr. Yaşar KONDAKÇI
İAEK Üyesi

Yrd. Doç. Dr. Pınar KAYGAN
İAEK Üyesi

Yrd. Doç. Dr. Emre SELÇUK
İAEK Üyesi

APPENDIX D

CONSENT FORM

Orta Doğu Teknik Üniversitesi Enformatik Enstitüsü Sağlık Bilişimi Bölümü öğretim üyelerinden Y. Doç. Dr. Didem GÖKÇAY danışmanlığında yürütülen ve Bilişsel Bilimler yüksek lisans öğrencisi Sahura ERTUĞRUL'un tez çalışması kapsamındaki "Duygusal Kelimelerle Sözcüksel Karar Çalışması: Göz Bebeği Ölçümleri" adlı araştırmaya katılmak için seçildiniz. Çalışmaya katılım gönüllülük esasına dayalıdır. Çalışma süresi yaklaşık yarım saat olarak planlanmıştır. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyoruz.

Bilgileri okuyup anladıktan sonra araştırmaya katılmak isterseniz lütfen bu formu imzalayınız.

Günlük hayatımızda insanlarla iletişimimizin önemli bir kısmını sanal ortamda yazılı olarak yapmaktayız. Düşüncelerimizi ifade ederken kullandığımız kelimelerin anlamsal özelliklerinin etkisi bir dizi çalışma tarafından gösterilmiştir. Bu çalışmada da farklı kelime grupları arasında bu özelliklerin (örneğin; sıklık) kelime tanıma üzerine etkisi araştırılacaktır. Çalışma sırasında sizden yaklaşık 250 kelime değerlendirmeniz istenmektedir. Değerlendirmeyi şu şekilde yapmanız gerekmektedir: Karşınızdaki ekranda beliren harf dizisi eğer 'KALEM' gibi anlamlı bir kelime ise 'MAVİ', 'KANEŞ' gibi anlamsız bir kelime ise 'KIRMIZI' tuşa mümkün olduğunca hızlı bir şekilde basarak değerlendiriniz.

Bu çalışmada gözbebeği büyümesini ve hareketlerini takip edip kayıt altına almak için bir göz izleme cihazı kullanılmaktadır. Bu cihazlar insan sağlığı ya da ruhsal durumu açısından en ufak bir risk teşkil etmemektedir.

Çalışmayı tamamladığınız takdirde, kimlik bilgileriniz çalışmanın herhangi bir aşamasında açıkça kullanılmayacaktır. Doldurduğunuz anketlere verdiğiniz cevaplar ve araştırma süresince görsel cihaz kullanılarak edinilen her türlü bilgi yalnızca bilimsel amaçlar için kullanılacaktır. Bilgileriniz hiçbir kimse ile ya da ticari bir amaç için paylaşılmayacaktır. Çalışmaya katılmayı kabul ettiğiniz takdirde, deneyin işleyişi hakkında bilgilendirileceksiniz. Çalışma hakkında daha fazla bilgi edinmek için aşağıda belirtilen araştırmacılarla iletişime geçebilirsiniz.

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"Duygusal Kelimelerle Sözcüksel Karar Çalışması: Göz Bebeği Ölçümleri" çalışması hakkında bilgilendirildim. Çalışmayı istediğim zaman terk edebileceğimi ve bana ait kişisel bilgilerle beraber benden toplanan kişisel değerlendirmelerin hiçbir zaman açıkça kullanılmayacağını biliyorum. Bu çalışmaya gönüllü olarak katılıyorum.

Ad, Soyad:
Tarih:
İmza:

APPENDIX E

DEMOGRAPHIC INFORMATION FORM

Kişisel Bilgiler:

Ad Soyad:____
Doğum Yılınız:____
Cinsiyetiniz: Kadın:☐ Erkek:☐ Belirtmek istemiyorum:☐
Medeni haliniz: Evli:☐ Bekâr:☐ Dul:☐ Boşanmış:☐
Eğitim durumunuz:
Lisans öğrencisi: ☐
Yüksek lisans öğrencisi:☐
Doktora öğrencisi:☐

Geçirdiği Önemli Rahatsızlıklar (özellikle psikiyatrik, nörolojik veya psikolojik):

Daha önce önemli bir rahatsızlık geçirdiniz mi? Evet:☐ Hayır:☐
Evet ise adı:____
Halen kullanmakta olduğunuz ilaç: Var:☐ Yok:☐
Varsa ilacın/ilaçların adı: ______________________________________
Uzun süre kullanıp bıraktığınız ilaç: Var:☐ Yok:☐
Varsa ilacın/ilaçların adı: ______________________________________
Varsa kullanım süreci:____

Aşağıdaki soruya cevap verirken üç kriterde en çok hangi elinizi kullandığınızı belirtiniz.

	Sağ El	**Sol El**
Yazarken		
Makas kullanırken		
Diş fırçalarken		

APPENDIX F

SELECTED STIMULI FROM TUDADEN

PART 1:

Frequency	OLD20	Pseudoword	Word	Valence M	Valence STD	Arousal M	Arousal STD
289,30	1,50	bova	bina	4,75	1,47	4,18	1,75
284,97	2,45	teşrite	tehlike	2,21	1,47	8,42	1,07
277,46	1,60	şaks	şans	7,96	1,34	7,18	1,91
264,13	2,95	görukçü	görüntü	5,75	1,38	4,88	1,69
258,25	1,45	maga	kafa	5,18	1,56	4,51	1,63
238,75	2,00	acati	aşama	5,00	1,25	4,73	1,79
226,81	2,00	dopka	dosya	4,94	1,12	4,40	1,67
219,40	1,80	taron	salon	5,31	1,61	4,37	1,86
231,562	3,80	gernonal	personel	5,08	1,51	4,38	1,54
195,68	1,55	tada	masa	5,63	1,27	4,04	1,96
168,07	2,65	yeveran	heyecan	7,43	1,23	7,18	1,84
161,25	1,90	kurbu	korku	1,79	1,05	7,98	1,48
151,47	2,65	intefi	istifa	2,46	1,61	6,73	1,99
139,89	2,65	hemerek	yetenek	7,75	1,29	6,45	1,98
139,19	1,95	laher	zafer	8,27	1,16	7,75	1,79
132,68	1,95	imcal	işgal	2,02	1,35	6,79	2,27
128,45	3,90	teröcapt	terörist	1,63	1,39	7,22	2,20
115,40	1,90	ciğde	cadde	5,32	0,84	4,49	1,82
114,37	2,90	asancaf	avantaj	7,45	1,60	6,37	2,11
113,76	1,50	galak	yalan	1,93	1,17	6,42	1,93
103,80	3,55	sompriz	sürpriz	8,29	0,94	7,90	1,66
98,70	1,85	davk	dans	7,69	0,99	7,18	1,80
88,95	1,85	zeşk	zevk	8,37	0,98	7,61	1,93
88,55	2,90	imsince	işkence	1,14	0,45	7,90	2,21
57,16	2,00	bevo	depo	5,29	1,18	4,51	1,46
64,91	2,65	orgenk	orgazm	7,63	1,86	8,22	1,21
60,77	3,65	hirrimat	hürriyet	8,08	1,20	6,25	1,84
57,71	1,75	kabit	katil	1,61	1,20	7,39	2,11
51,62	3,90	sükançil	skandal	2,02	1,22	7,47	1,78
50,79	1,95	böğak	bıçak	2,90	1,70	6,71	1,87
19,64	2,80	kavarom	kazanım	7,83	1,24	6,62	2,16

16,98	1,80	biruk	doruk	7,10	1,65	6,91	2,42
16,61	2,50	kantafa	karmaşa	2,98	1,48	6,67	2,01

Frequency	**OLD20**	**Pseudowords**	**Word**	**Valence M**	**Valence STD**	**Arousal M**	**Arousal STD**
13,05	1,90	kebef	kebap	8,08	1,57	7,00	2,29
13,00	1,95	hahuz	haciz	1,30	0,71	6,94	2,37
12,17	2,00	vasçet	vahşet	1,33	0,67	7,40	2,15
11,87	1,85	şevrik	şenlik	8,17	1,36	7,65	1,64
5,227	2,95	onoper	otogar	4,92	1,55	5,45	1,95
11,63	2,40	etrila	istila	2,69	2,04	7,02	1,93
9,97	2,05	nanize	cazibe	7,71	1,50	6,94	1,90
9,63	1,95	asrip	akrep	2,51	1,85	7,59	1,99
9,52	1,75	barö	balo	7,43	1,55	6,73	2,02
9,19	2,65	ıcürük	öpücük	8,10	1,11	7,72	2,11
8,88	1,95	doktu	dolgu	4,46	1,44	4,66	1,71
8,02	2,90	kasença	kasırga	2,55	1,33	7,58	1,49
7,98	1,55	kiya	koma	1,19	0,57	7,50	2,24
12,17	1,1	daba	baca	5,25	1,77	4,13	2,32
7,22	3,20	çarancaz	parantez	5,20	1,11	4,60	1,65
7,21	1,90	çuzu	pusu	2,35	1,53	7,35	1,79
7,15	2,60	çalekçi	galaksi	7,06	1,72	6,72	2,18
6,57	3,10	dezirciş	demirbaş	5,21	1,68	4,33	1,53
6,44	3,45	yişlanta	pırlanta	7,75	1,34	7,20	2,38
6,24	1,95	kernak	kervan	5,41	1,22	4,88	1,74
6,19	1,95	karkun	karton	4,81	0,87	4,46	1,25
6,15	3,80	tebeşsuş	tebessüm	8,51	0,79	6,53	2,49
5,98	3,75	kıssimer	kursiyer	4,86	1,43	4,40	1,28
5,47	2,45	yebelen	heyelan	1,84	0,96	6,75	2,15
6,01	2,65	kücrit	kibrit	4,82	1,58	4,73	2,23
5,06	2,90	eğruya	eşkıya	2,39	1,91	6,51	2,16
5,01	1,45	deke	bere	5,43	1,49	4,20	1,70

PART 2:

Frequency	OLD20	Pseudowords	Word	Valence M	Valence STD	Arousal M	Arousal STD
285,06	1,55	çaza	hata	2,23	1,42	6,38	1,85
266,69	1,80	zakim	rakam	5,35	1,13	4,37	1,51
264,03	1,85	mikak	sokak	5,51	1,19	4,80	1,85
250,96	1,95	lonte	liste	4,96	1,10	4,14	1,56
238,74	1,70	kakil	kanal	5,31	1,70	5,06	1,83
220,57	1,95	boşit	boyut	5,43	1,21	4,84	1,86
213,50	2,35	kiğrik	kimlik	5,52	1,52	4,58	1,61
111,115	2,2	rorüm	forum	5,88	1,30	5,00	1,91
185,49	1,95	keleti	kelime	5,94	1,42	4,29	1,96
183,44	2,25	yamire	hazine	7,92	1,23	7,53	1,70
179,42	3,90	palesinet	galibiyet	7,73	1,87	7,37	1,73
168,85	3,50	festişiz	festival	8,33	0,89	7,49	1,75
164,29	2,75	menzese	malzeme	5,20	0,78	4,26	1,55
159,35	2,35	koncir	konser	7,65	1,42	7,33	1,89
158,93	2,85	etvife	endişe	1,85	1,10	7,10	2,00
142,27	2,20	bülba	bomba	1,58	1,28	8,30	1,40
128,59	1,80	katfa	kavga	1,85	1,24	7,88	1,68
121,10	2,50	şikamet	cinayet	1,38	1,21	7,54	2,11
116,85	2,60	şömhe	şüphe	2,22	1,59	7,34	1,93
101,11	1,95	alpu	arzu	7,40	1,47	7,32	1,94
95,46	1,90	dezer	demir	4,89	1,23	4,34	1,79
95,00	2,00	yanlon	yangın	1,82	1,03	7,04	2,15
89,81	2,35	yevike	hediye	8,16	1,02	7,48	1,75
82,74	2,50	kaminç	kazanç	7,96	1,24	6,82	1,63
51,952	1,950	leyet	ceset	1,498	1,190	6,927	2,103
73,12	1,80	bacir	bahar	7,80	1,12	6,29	2,22
71,41	1,95	çahret	gayret	8,06	0,92	7,29	1,61
63,11	1,75	seşt	seks	7,71	1,79	8,21	1,55
52,19	2,45	hanacat	hakaret	1,68	1,00	6,87	2,13
50,86	2,00	inbiz	infaz	1,36	0,92	7,33	2,09
17,40	3,55	girinsef	prenses	7,64	1,55	6,24	2,22
16,06	1,80	asem	azim	7,82	1,15	6,78	1,98
15,17	1,85	elmeç	elmas	7,00	2,17	6,78	1,94
14,83	1,95	kurik	kürek	4,94	1,24	4,19	1,86
14,30	4,70	puromütren	promosyon	8,02	1,25	7,08	1,64
12,85	2,00	mupan	tufan	2,66	1,39	7,42	1,75

Frequency	OLD20	Pseudoword	Word	Valence M	Valence STD	Arousal M	Arousal STD
12,27	1,95	zülen	şölen	8,30	0,89	7,90	1,22
12,25	1,80	şinç	linç	1,44	0,99	7,31	2,03
12,16	1,95	nefice	rehine	1,76	1,06	7,28	1,95
10,99	3,90	meşıminet	mezuniyet	7,85	1,84	7,78	1,88
10,46	2,80	karevra	karizma	7,20	1,59	6,65	1,88
10,36	1,80	ratet	lanet	1,42	0,74	7,04	2,20
10,12	2,95	otuvri	otopsi	2,10	1,85	7,65	2,28
9,37	3,10	örondek	örümcek	3,31	1,52	6,51	1,60
8,36	1,55	gaha	paça	4,58	1,51	4,25	1,67
7,98	2,65	tedeksi	tetikçi	1,90	1,37	7,19	1,97
7,61	2,95	ittivet	iltifat	7,96	1,17	6,41	2,04
7,58	2,00	çarav	haraç	1,60	0,89	6,48	1,84
7,37	1,95	marüt	barut	3,02	2,20	6,71	2,21
7,33	2,95	çimikge	çizelge	5,30	1,42	4,76	1,49
7,28	1,65	lati	cani	1,33	0,62	7,31	2,01
7,21	2,65	sarvane	tersane	5,16	1,62	4,56	1,86
6,90	1,70	ciye	pide	7,94	1,29	6,31	2,22
6,84	3,25	maranyıl	marangoz	5,50	1,64	4,36	1,71
6,44	2,00	sasiç	sayaç	4,92	1,02	4,43	1,49
14,385	2,00	nırpa	fırça	4,94	1,73	4,33	2,21
6,15	1,80	galit	halat	4,98	0,67	4,73	1,45
5,18	1,95	tekite	teneke	4,98	0,83	4,31	1,54
5,17	3,80	konzekşe	konserve	5,08	1,34	4,20	1,61
2,49	2,10	nekalı	şelale	7,38	1,56	6,20	2,41