INVESTIGATION OF SEMANTIC EFFECTS IN ODDBALL PARADIGM THROUGH EVENT RELATED POTENTIALS

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INVESTIGATION OF SEMANTIC EFFECTS IN ODDBALL PARADIGM THROUGH EVENT RELATED POTENTIALS

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ABSTRACT

INVESTIGATION OF SEMANTIC EFFECTS IN ODDBALL PARADIGM THROUGH EVENT RELATED POTENTIALS

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In this study, the effect of semantic information processing was investigated by the oddball paradigm, by presenting consecutive Turkish words or word-like non-words while EEG signals are recorded. In an oddball paradigm, a series of events are presented of which one class is rarer than the other. Subjects are asked to respond to the infrequent stimuli (e.g. press a button, or count the number). The event related potential (ERP) component P300 obtained from EEG is considered as the marker of this attention capturing paradigm. P300 is obtained consistently for both visual and verbal stimulus. On the other hand, the ERP component N400 is consistently associated with semantic processing in neurolinguistics. Additionally, Late Positive Component (LPC) is a marker for the top-down attention mechanism during word comprehension. Moreover, there are other components, called early ERPs, which occur between 100-200 ms after the stimulus onset. These components orthographically and phonologically reflect low-level features of words. The target words chosen for our study are strictly limited to belong to a neutral category and not consist of any emotional content, to rule out emotional interference in semantic processing. Based on the ERP components that were obtained from this study, the LPC potential exhibited for words had higher amplitude than that of non-words consistently and statistically significantly. However, our study was confounded with the heterogeneity of non-words because some of the non-words were non-sense letter sequences while others were pseudowords. Due to this, although we observed the P300 and N400 ERPs consistently for all stimuli, we did not find significant differences for these potentials between words and non-words. To the best of our knowledge, our investigation is one of the few studies conducted with EEG recordings in a task that involved lexical decision making in Turkish.

Keywords: Semantic Processing, P300, N400, Late Positive Component, Attention

ÖZ

SEYREK UYARAN PARADİGMASINDAKİ ANLAMSAL ETKİLERİN OLAY İLİŞKİLİ POTANSİYELLER İLE İNCELENMESİ

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Bu çalışmada, seyrek uyaran paradigması kullanılarak katılımcılara ardı ardına herhangi bir duygusal içeriği olmayan, Türkçe yüksüz (nötr) kelimeler ve kelimeyi andıran harf dizileri gösterilerek katılımcıların anlamsal işlemleme mekanizmalarının temel göstergesi EEG sinyalleri kayıt edilerek incelenmiştir. Seyrek uyaran paradigmasında, katılımcılara ardı ardına, sınıflardan biri diğerinden az sayıda olan uyaranlar sunulmaktadır. Katılımcılardan sayısı az olan uyaranın sayısını aklında tutması ya da o uyaran gelince elindeki tuşa basması istenir. EEG den elde edilen P300 olay ilişkili potansiyeli bu dikkat yakalama paradigmasının belirleyicisi olarak kabul edilmektedir. P300 potansiyeli, hem görsel hem de sözlü uyaranlar için tutarlılıkla ortaya çıkar. Diğer yandan, N400 potansiyeli dil işlemedeki anlamsal işlemleme ile ilişkilidir. Ayrıca LPC potansiyeli de kelime kavrama süresince var olan ‘yukarıdan aşağı’ dikkat mekanizmasının nörofizyolojik olarak belirleyicisi kabul edilmektedir. Bu potansiyellerin yanı sıra kelime gösterildikten 100-200 ms sonra oluşan ve kelimelerin alt düzey özelliklerini ortografik ve fonolojik yansıtan potansiyeller de mevcuttur. Bu çalışmada hedef uyaran olarak kullanılan kelimeler yüksüz (nötr) olup herhangi bir duygusal içeriğe sahip değildir. Bu kapsamda, çalışmada elde edilen olay ilişkili potansiyel sinyallerinde ‘yukarıdan aşağı’ dikkat mekanizmasının nörofizyolojik olarak belirleyicisi olan LPC potansiyelinin genlikleri hedef ve hedef olmayan grup arasında tutarlı olarak istatistiksel açıdan anlamlılık göstermiştir. Ancak çalışmada hedef olmayan uyaran olarak kullanılan anlamsız kelimelerin bazıları ortografik ve fonolojik olarak doğru iken bazı hedef olmayan uyaranlar ortografik ve fonolojik olarak düzgün değildir. Bu nedenden ötürü çalışma sonuçlarında seyrek uyaran paradigmasıyla ilişkili P300 potansiyeli ve anlamsal işlemleme ilgili olan N400 potansiyeli tüm uyaranlar için gözlemlenmekle birlikte, bu potansiyeller için hedef ve hedef olmayan uyaranlar arasında herhangi bir istatistiksel fark saptanmamıştır. Bildiğimiz kadarıyla, bu çalışma sözcüksel karar testinde Türkçe kelimeler ile yapılan az sayıda çalışmadan biridir.

Anahtar Kelimeler: Anlamsal İşlemleme**,** P300, N400, LPC, Dikkat

To My Unique Family

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LIST OF ABBREVIATIONS

ERP	Event Related Potential
CS	Central Sulcus
OL	Occipital Lobe
IPS	Intraparietal Sulcus
SPL	Superior Parietal Lobule
IPL	Inferior Parietal Lobule
POS	Parietooccipital sulcus
FL	Frontal Lobe
MFG	Middle Frontal Gyrus
IFG	Inferior Frontal Gyrus
STG	Superior Temporal Gyrus
TL	Temporal Lobe
TPJ	Temporoparietal Junction
A	Auricle
C	Central
LPC	Late Positive Component

CHAPTER 1

INTRODUCTION

Investigation of language networks has been an important research area in cognitive neuroscience. Brain circuits that are responsible for this most differentiated and unique faculty of humans has been explored with different functional neuro-imaging methods. Since language is a dynamic process that involves integration of various types of semantic and syntactic information, imaging methods with high temporal resolution are definitely advantageous to monitor the precise timeline of this cognitive function. Regarding imaging of language functions, EEG takes one step forward with its ability to measure event related potentials. Fabiani, Gratton and Coles (2000) define event related potentials (ERP) as a pattern of brain electrical activity that occurs in response to a particular stimulus event. In most cases, the voltage changes occurring within a particular epoch (time period) that is time-locked to a given stimulus are in the scale of microvolts and therefore too small to be reliably detected. This difficulty in capturing relevant response is resolved by taking the grand average of the responses that are given to the repetitive stimuli in ERP measurements.

EEG has been utilized in various domains of language research (Stefanatos, Phil & Osman, 2007; Polich, 1985; Kutas & Hillyard, 1980; Friederici, 2004). Word comprehension is among these domains and is important since it is directly associated with language acquisition (De Diego Balaguer et al., 2007). Baron-Cohen et al. (2010) determined that impaired word comprehension may be an indicator of neurodevelopmental defects in children and adolescents. Furthermore, word comprehension is disturbed in several mental disorders such as schizophrenia and Alzheimer's disease (Arnott, Sali & Copland, 2011; Masterson et al., 2007). Cognitive and developmental theories emphasize that assessing the nature of word comprehension is of particular importance: How and in which time course it occurs (Marlsen-Wilson, 1989). Lexical access refers to our ability to access the 'lexicon' that keeps the mental representations of items. Lexicon can easily be conceptualized as a 'mental dictionary'. However, apart from other dictionaries, lexicon does not consider written forms of words, rather employs their 'qualities'. Phonology, morphology, semantic or syntactic properties, frequencies of words as well as their emotional aspects may be playing a role in lexical access (Posner & Carr, 1992; Grainger & Jacobs 1996). Perhaps, since it is directly related to 'how we think', 'how we consider these qualities of items' is very important and is assessed by 'lexical decision tasks'. For instance, discerning words from pseudowords[1] or non-words[2] is a lexical decision which is previously used in psychology and psycholinguistics (Schacht & Sommer, 2009a; Fischler & Bradley, 2006; Rugg & Nagy, 1987).

Word comprehension requires low and high level cognitive functions. Event related potentials (ERPs) have great illuminative impact on measuring not only the time course but also electrophysiological and neuroanatomical correlates of this linguistic process (Dien, 2009). The earliest study involving use of this technique dates back to 1980, when Kutas and Hillyard (1980) investigated electrophysiological correlates of semantic processing.

Polich and Margala (1997) have introduced the oddball paradigm in which a series of events are presented such that one class is rarer than the other. Subjects are asked to count the number of the rarer stimuli and keep its number in mind or respond to the stimulus by pressing a button response. As a result of this paradigm, the ERP component P300 occurs with a 300 ms latency when the subject realizes the

[1] phonologically pronounceable, orthographically irregular/regular but meaningless words
[2] phonologically unpronounceable, orthographically irregular but meaningless words

difference between the normal (more frequent) and target (infrequent) stimuli presented in the oddball paradigm. Polich (1985) assessed the effect of semantically incongruent and congruent processing by conducting 2 different types of experiment with words and sentences in order to investigate the effect of P300 within an oddball paradigm. In an experiment, for the word series are presented to the subject in 2 different ways. Firstly, the word series end with the normal word in other words, the seventh word of the word serial belongs to the same category of the first six words (e.g. the category for 7 word task is flower, first 6 words are related to flower category but the seventh word is a car name). Secondly, the word series end with the odd word in other words, the seventh word of the word serial does not belong to the same category of the first six words. Subjects are instructed to indicate whether the word series ended appropriately or not with a button-press response. The findings suggest that the frequency of stimuli –particularly their rareness and novelty- have electrophysiological correlates that are associated with attentive functions.

ERP components detected before 300 ms, which marks initiation of attentive processes, are referred as early ERP components. Such components that occur as early as 100 ms are generally assumed to be associated with initial stages of data processing such as perception. Although these earlier components are not specific to a particular type of stimuli, they are important in the time course of lexical access. P100 which is a positive peak that occurs approximately 100 ms after the stimulus onset reflects very low-level perception of the visual stimuli. ERP results for the P1 amplitude are greater for words than non-words demarcating processes related to lexicality access (i.e. orthographical knowledge access in visual cortex) (Segalowitz & Zheng, 2009). N100 is the negative peak that occurs approximately between 80-180 milliseconds after the stimulus onset at the temporal and occipital sites (Breznitz, Shaul & Gordon, 2003). N100 is considered to be a marker for initiation of attention based events (Breznitz & Berman, 2003). The activation of N100 was found to be related to the discrimination of word stimuli and symbol strings namely shapes. So its amplitude was larger for words than nonsense strings (symbols, icons) with a scalp distribution mainly localized to the occipito-temporal cortex (Brem et al., 2006). P200, a positive peak that occurs approximately 200 ms after the stimulus onset, is thought to reflect perception, feature detection, working memory and syntactic processing. Furthermore, frontal P200 is considered to be associated with memory functions, whereas central P2 may reflect recall from long term memory to the working memory (Breznitz et al, 2003). Finally, the N200 component which is reported to attain its peak value around 250-270 ms is a semantic indicator and is thought to reflect the 'meaningfulness' of words: its amplitude is larger for words than non-words, hence its amplitude is proportional with the meaning of the stimuli (Dien, 2009). Furthermore, the latency of the N200 wave is proportional with the focus of attention (Breznitz et al, 2003). For the late ERP components, the Late Positive Potential (LPC) which occurs 400-800 ms after the stimulus onset is the neurophysiological indicator of the top-down attention function of the human brain during word recognition (Schacht & Sommer, 2009a; Polich, 1985). The LPC involved in attentional engagement, evaluation and memory encoding rather than semantic processing (Fischler & Bradley, 2006; Kissler, Herbert, Winkler & Junghofer, 2009). N400 which occurs 400 ms after the stimulus onset has been consistently found as the indicator of the semantic access (Kutas & Hillyard, 1980; Lau, Phillips & Poeppel, 2008; Federmeier & Laszlo, 2009; Fischler and Bradley, 2006; Polich, 1985)

The purpose of this study is to understand the cognitive underpinnings of lexical access and semantic perception. To investigate the relationship between semantic processing and attention capturing mechanism of the human brain the verbal oddball paradigm is used. Particularly the goal of this thesis is to determine how we use our visual attentive resources while making a lexical decision task in which subjects differentiate meaningful, orthographically and phonologically regular words from meaningless, phonologically irregular but orthographically ir/regular: word-like non-words. While choosing the words, we made sure that the emotional categorization of the words are neutral, since it is known that emotional processes may interfere with semantic processing (Hoffmann et al., 2009; Scott et al., 2009). Target stimuli are taken from taken from Turkish Affective Norms Database, TUDADEN (Gökçay & Smith, 2011). TÜDADEN consists of affective word norms along the valence, arousal and dominance axes (Gökçay & Smith, 2011). Valence axes implies the negativeness and positiveness of the emotion, i.e. changes between unpleasant to pleasant feelings, on the other hand, arousal refers to how excited the subject is, and ranges from sleepiness/boredom to excessive excitement. Neutral words carry medium arousal and medium valence values. After generating a list of neutral words, standard stimuli are prepared as distorted, meaningless words which are obtained by randomly shuffling the letters of these target words.

The event related potential P300 can be obtained by both visual and verbal stimulus (Polich, 1985). On the other hand, the N400 potential, which has a negative peak occurring 400 ms after the stimulus onset is used to measure the semantic processing component of language processing. Our expectation in this study is that, both early components such as P100, N100, P200, N200 as well as the oddball marker P300 will be observed. Our main hypothesis is that, N400, and the Late Positive Component (P600) which are both related to the processing of the semantic validity and meaningfulness of the words will be more prominently obtained for words in comparison to non-words.

In the following, language related literature is reviewed in chapter 2; especially event related potentials of interest are examined. In chapter 3, the event related potential measurement methodology is explained in detail. In chapter 4, the findings of event related potentials for the word versus non-word oddball experiment we conducted are given. In chapter 5, interpretation on the findings is discussed and future work is explained.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

It is very critical to measure the brain response against sensory, cognitive and motor stimulus (Stefanatos, Phil & Osman, 2007). Event related potentials (ERPs), generated from the EEG signals that are time-locked to experimental stimuli, have high temporal resolution (Fabiani et al., 2000). Due to ERPs sensitive measurement of the brain response time as opposed to sensory, cognitive and motor stimulus, the investigation of brain's cognitive functions is possible.

2.1. Electroencephalography (EEG) and Event Related Potentials

In electroencephalography (EEG), electrodes are placed on the scalp and the pattern of voltage variation is measured over time. While each neuron generates an electrical field which differs over time, EEG measures the electrical activity of neurons through the scalp by electrodes. An electrode measures the cumulative and synchronized activity of many neurons (Figure 1). There are 4 types of EEG rhythms which are Alpha, Beta, Theta and Delta. Alpha rhythm is the EEG of an awake healthy person at rest. Its frequency changes between 8-13 Hz. Beta rhythm, for which frequency changes between 14-60 Hz is the indicator of mental activity and attention. Theta & Delta rhythms imply sleep, drowsiness. Their frequencies range between 4-7 Hz (Purves, 2004).

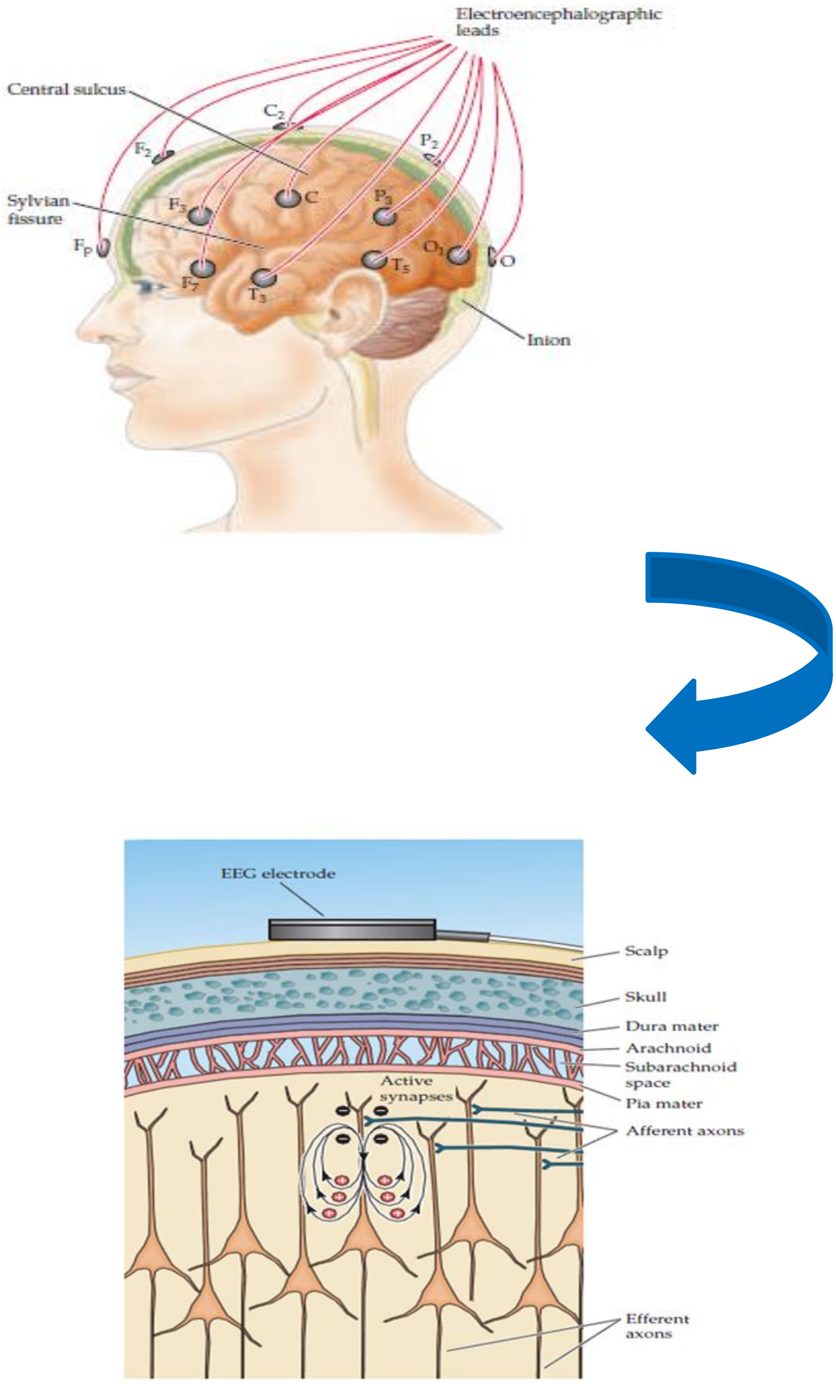

Figure 1 Sample EEG measurement through scalp (from Purves, 2004)

EEG electrodes have 19 standard positions distributed through the scalp as shown in figure 2 (Kuperberg 2004). Abbreviations are used for locating electrodes with respect to brain areas: A = auricle; C = central; Cz= vertex; F=frontal; Fp=frontal pole; O = occipital; P=parietal; T=temporal

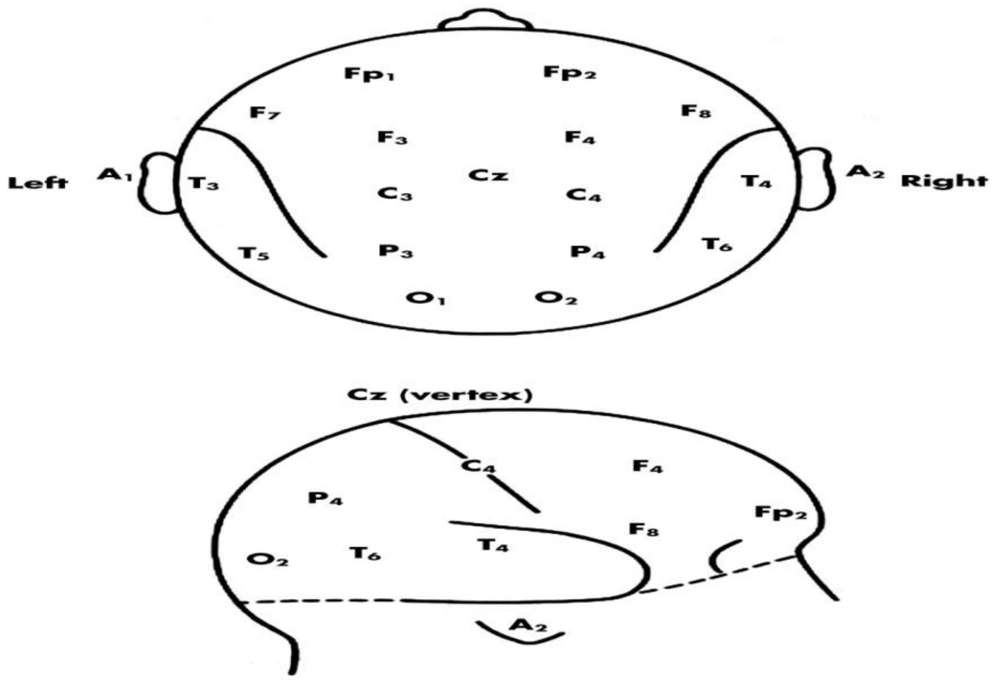

Figure 2 Standard placement of EEG recording electrodes at the top and sides of the head (from Kuperberg, 2004).

ERPs are generated from EEG recordings such that a particular stimulus event is time-locked to the EEG time series that succeeds it (Gratton and Coles, 2000). In other words, ERP is the on-going EEG voltage which occurs in response to a specific sensory, motor or cognitive stimulus. ERP signal is generated from EEG signal as follows:

- EEG is recorded from indicated locations of the head
- EEG signal is amplified and filtered
- Analog signal is converted into digital by sampling the potential at a high frequency (usually at least 100 Hz)

- Time locked EEG samples are averaged with respect to different stimulus categories in order to reduce signal to noise ratio in the final ERPs (a few mV)

The conversion process of EEG to ERP is given in figure 3 and 4.

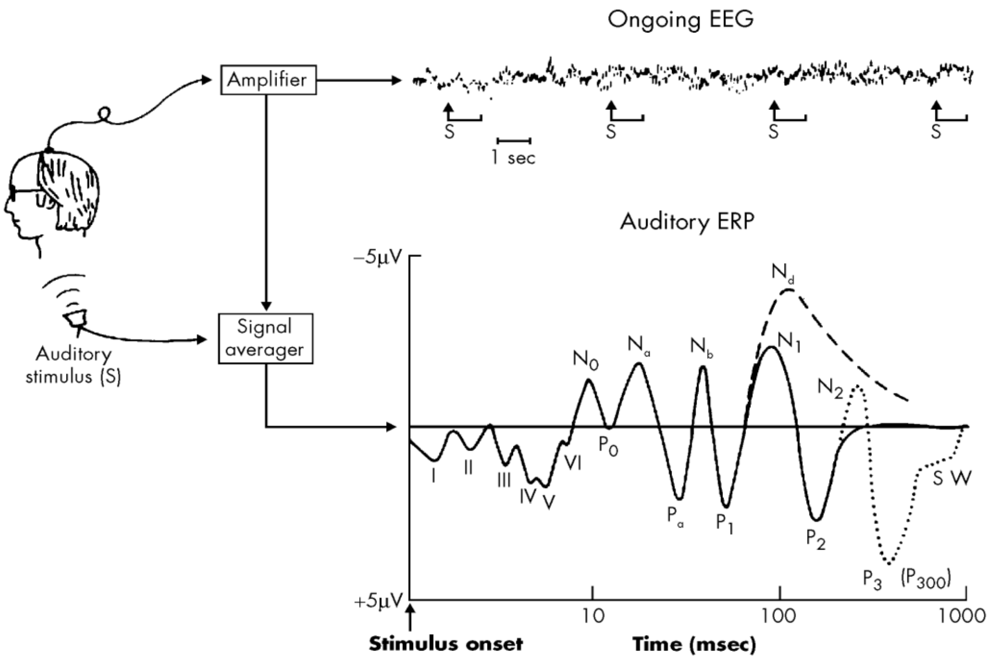

Figure 3 Sample EEG and ERP (from Kuperberg, 2004).

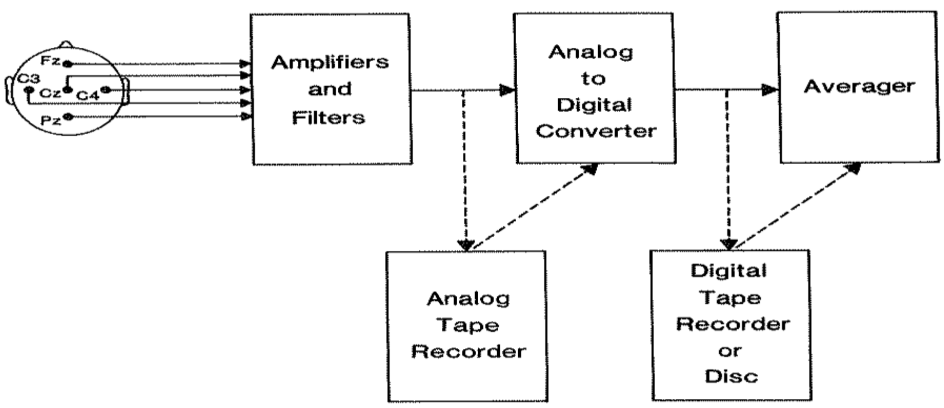

Figure 4 ERP Signal Generation (from Fabiani et al., 2000).

Stefanatos, Phil and Osman (2007) examined the history and development of EEG and ERPs and discussed the advantages of ERPs with respect to other imaging techniques such as functional magnetic resonance imaging (fMRI) or Positron Emission Tomography (PET). The temporal resolution of fMRI and PET functional magnetic resonance imaging (fMRI) or Positron Emission Tomography (PET) changes between seconds to multiples of seconds while the time resolution of EEG/ERPs are on the order of milliseconds.

Temporal windows extracted from the ERP waveform are differentiated and labeled according to their polarity: P for positive, N for negative. The latency of a peak in the signal amplitude demarcates the beginning of a temporal window (for ex. at 300 msec). The polarity as well as latency are mentioned in the name of the potential (Fox ex. P300, N400). In addition, the scalp distribution which is annotated in the label of each electrode identifies the location of the extracted time window. Each time component of the ERP is associated with specific cognitive processes. ERP components are classified as exogenous (sensory) and endogenous (cognitive) components. Exogenous (sensory) components are also referred as early components of ERP such as P100, N100 and P200, N200. Furthermore, they are elicited by the physical properties of the delivered external event. Endogenous components such as P300, N400, P600 are called late ERP components. Moreover, they are sensitive to changes in accordance with the state of the subject and the meaning of the stimulus. As a result, they provide millisecond recordings of neural response between stimulus its processing (Fabiani et al., 2000).

2.2. Language and Semantic Processing

Language is a remarkable tool for human being which provides them to interact with the outer world. This convenience is brought to us by courtesy of semantic memory part of the human brain. Semantic memory refers to the acquired knowledge that is related to the world including the names, relations, properties, associations, dissociations and appearance of objects, actions, as well as human behavior, opinions, beliefs and on. Moreover, it deals with the conceptual representations of the entities that are the cornerstones of our lives. An important property that is unique to humans' language is the representation of knowledge. By having such remarkable ability, they have opportunity to make manipulation and association among objects, concepts and individuals rather than only represent abstract forms of these concepts (Binder & Desai, 2011). The neuroanatomical layout of semantic network is shown in figure 5. In this figure yellow colors, including sensory, action, emotional systems serves as input to the red color regions including temporal and inferior parietal regions which store abstract forms of entities. Blue regions including dorsomedial and inferior prefrontal cortices are responsible for the selection of the incoming information from temporoparietal regions. Lastly, green regions including the posterior cingulate gyrus and adjacent precuneus may serve as an interface between semantic memory network and hippocampal memory. Right hemisphere has similar network but differences between left and right hemispheres still unidentified (from Binder & Desai, 2011)

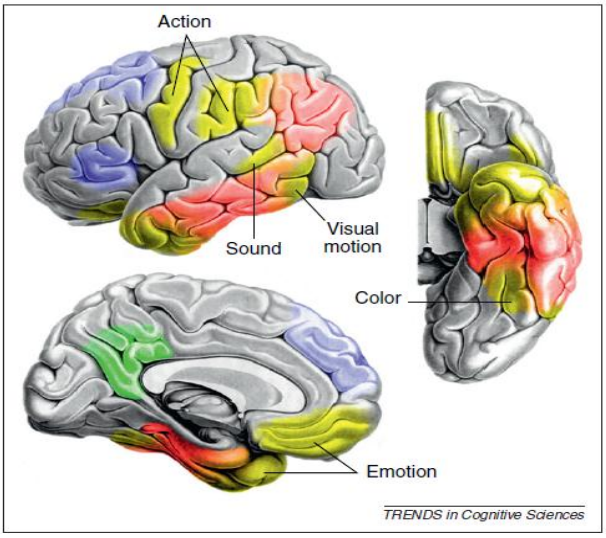

Figure 5 Left part of anatomical model of semantic processing in human based on a wide range of data (from Binder & Desai, 2011)

As a part of the entire language processing facility, reading is a noteworthy skill of the human beings which facilitates them to gather the meaning of words and phrases. Reading initiates with the eye perception in retina and goes to cerebral cortex of both hemispheres for the complex analysis, namely decoding and encoding (Barber & Kutas, 2007). To that extent, language processing has two fundamental information processing units: First, the long-term memory. Second, semantic, syntactic and discourse structures. In terms of processes, N400 has 2 hypothetical functions which are integration and lexical (word-form) access. The integration functionality regulates the semantic processing of the stimuli with the overall sentence context through the activation of the long term memory access of the relevant stimuli. On the other hand, lexical access explains the word form representations before semantic access is established. The amplitude of word-like non-words often facilitates larger N400 potentials with respect to words because of the difficulty during memory access (Lau, Phillips & Poeppel, 2008; Osterhout & Holcomb, 1995). Furthermore, as words activate the brain, amplitude of N400 is inversely proportional with the activation level of memory. In other words, words that cause less access, have bigger N400 amplitude, highly access words cause small N400 amplitudes (Osterhout & Holcomb, 1995). The brain structures that are involved in language processing are wide-spread as presented in figure 6.

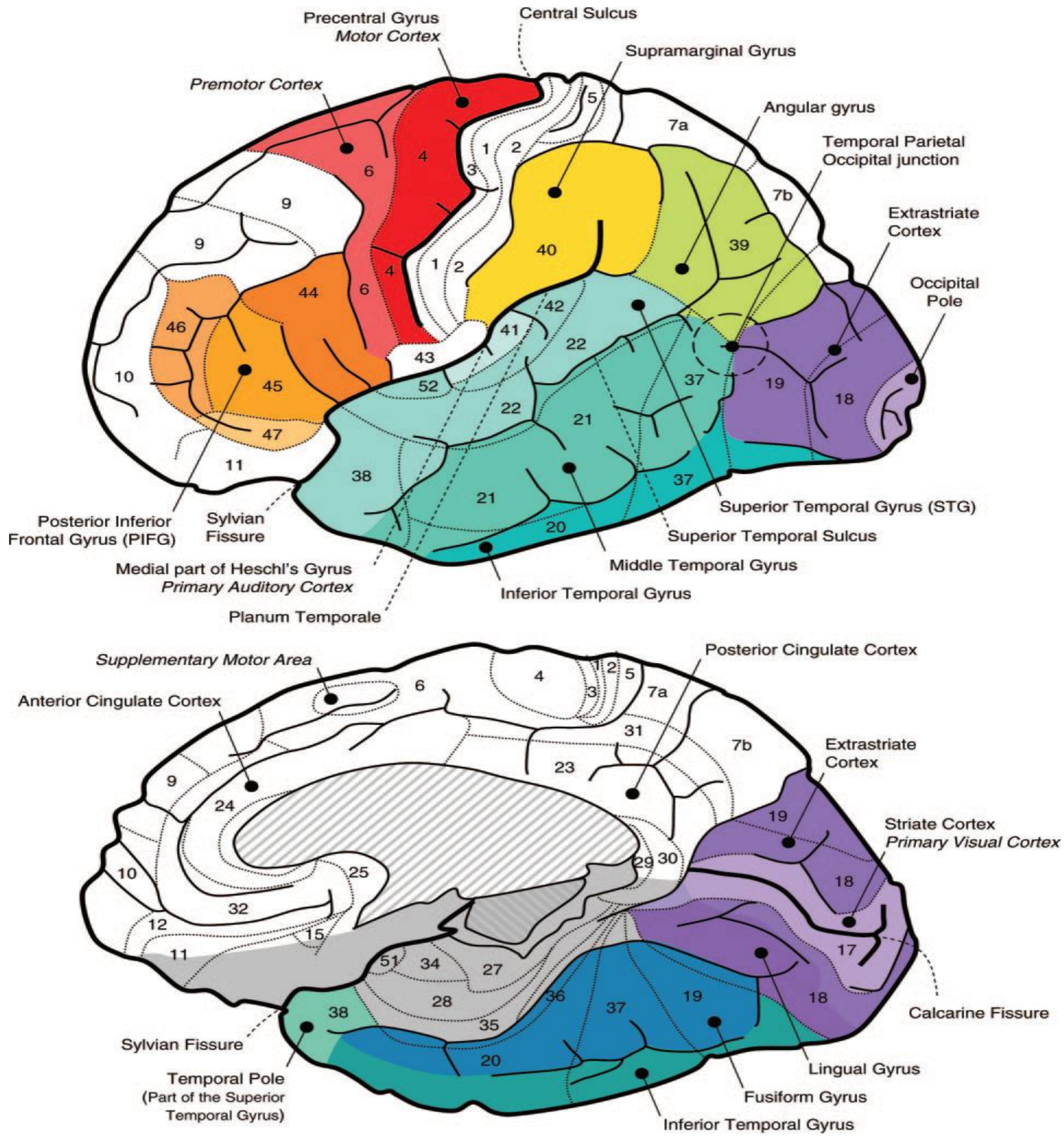

Figure 6 Coloured regions indicate language related anatomical components of the human brain, *Top*: lateral view of the left hemisphere of the human brain. *Bottom*: mid sagittal view of the right hemisphere (from Démonet, Thierry & Cardebat, 2005)

The workflow of the entire word recognition process can be seen in Figure 7. The neuroanatomical correlates of the flow of word recognition have been found various studies. Furthermore, these anatomical regions can be observed from figure 6. First of all, the initiation of word forms, so called extraction of familiar visual patterns (i.e. low-level feature extraction such as size and font), and visual word form processing(other than different visual forms) are associated with the primary visual cortex and extrastriate cortex respectively. The occipito-temporal lobe is activated during visual imagery. Moreover, the semantic access is neuroanatomically correlated with the middle temporal gyrus (MTG) specifically for the semantic access of words, the superior temporal sulcus is activated (STS). Anterior part of the middle temporal gyrus and inferior temporal gyrus are activated during semantic associations. The short term memory access has neuroanatomical correlates with the temporo-parietal junction (TPJ). The word retrieval is associated with middle frontal gyrus(MFG). Moreover, the articulatory associations (i.e. phonological processing) and motor output (i.e. hand movements) are neuroanatomically correlated with the precentral gyrus and motor cortex, supramarginal gyrus respectively. The posterior part of the superior temporal sulcus (STS) is activated during the integration of word or sentence meaning (Price, 2012)

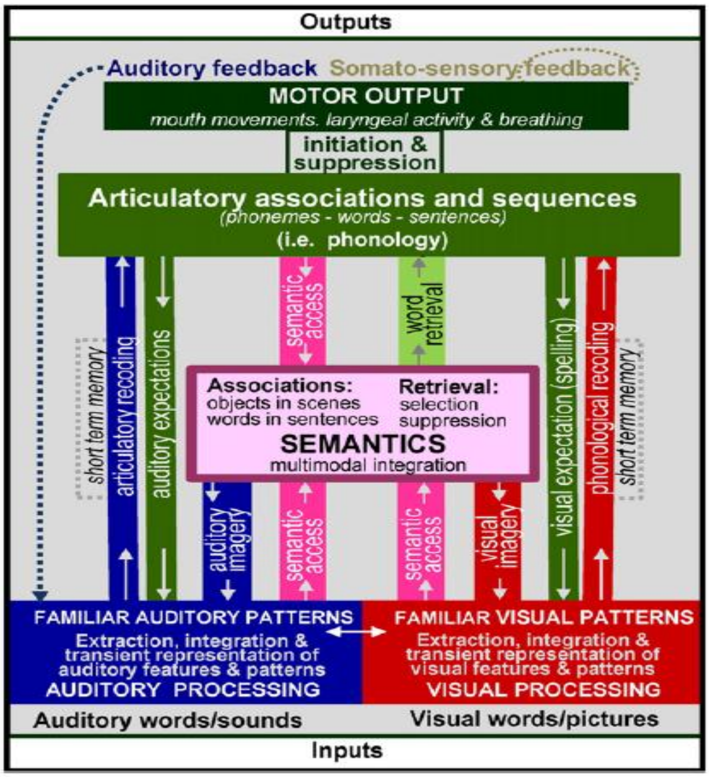

Figure 7 The flow of word recognition based on language studies (from Price, 2012)

2.3. Reading Comprehension Models

Bentin et al. (1999) divides reading comprehension into three steps: Ortographic processing, phonological analysis, and access of semantic information.

First step is visual feature extraction at the orthographic level such that

> ‘‘orthographic processing involves the computation of letter identity and letter position’’ (Grainger & Holcomb, 2009, p.130).

It is worthy to note that, identification of each letter within a string of letters is processed at the same time, with much more attention to the first and last letters (Grainger & Holcomb, 2009). In the case of alphabetic languages, e.g. Turkish, words are generated by combinations of letters. This generation process is composed of rules that are specific to the language itself. These rules are defined as orthography of a language which remarkably leads to word recognition (Grossi & Coch, 2005). Grainger and Jacobs (1996) discuss the role of orthography during reading. While readers look at a word as a set of letters, their brains process elementary operations such as computation of physical properties of words, their correspondence on the long term memory and choose the best matched candidate. Moreover, the phonological analyses are also performed at the lexical level. Phonology can be described as:

> ‘‘To connect the sounds of spoken language (phonology)
>
> to the strings of letter symbols printed on the page’’ (Grossi et al., 2005, p.343)

The sound analyses of written words are performed during phonological processing. Finally, if both orthographic and phonologic representations make sense, than the meaning is gathered through semantic memory of the brain.

Word recognition is one of the most popular research topics of the last two decades, questioning how exactly the aforementioned elementary operations are performed. The reading mechanism not only performs the decision of whether letters of string is a word not but also evaluates the properties of words that are mentioned above.

In order to learn this remarkable functionality mechanism of the human brain, the lexical decision making tasks is a practical method (Grainger and Jacobs, 1996). Lexical decision making discerns a word from non-word. During the lexical access there are important properties of words which are orthography, spelling, phonology, articulation, semantics and morphology (Posner and Carr, 1992).

Dilkina, McClelland and Plaut (2010) discuss the relation between lexical and semantic processing. Lexical access initiates the input word before the semantic activation whereas semantic access decodes the meaning of the relevant stimuli (Dien, Frishkoff, Cerbone & Tucker, 2003). According to the research review (Dilkina et al., 2010), there are two types of processing models. First one is based on mental lexicons. In order to distinguish the words from word-like non-words, the semantic access is not required, subjects directly comprehend words by judging whether the word is in their orthographic lexicon or not. If it belongs to the mental lexicon it is classified as word, if not it is non-word. The second model suggests that it is necessary to access the semantic system of the memory to decide the word and non-word forms. Lastly, they report that the second view is supported by several studies (for instance semantic dementia patients are not able to perform a lexical decision task that is highly correlated their semantic impairment (Dilkina et al., 2010). The second model infers that lexical and semantic processing are not separate processing units of the human brain.

Somewhat similarly, serial and parallel accounts of information processing also address how sub-processes in lexical and semantic access are intertwined. There are 2 types information processing modeling regarding reading comprehension in the literature that are controversial. A serial-cascaded model assumes the steps that are involved in word recognition are performed one after another. Whereas the parallel model assumes these operations are performed synchronously as given in Figure 8 (Pulvermüller, Shtyrov & Hauk, 2009). According to dual-route cascaded (DRC) model, there are two basic word processing operations which are initialized by the appearance of the printed word that work until the finalization of the semantic analysis.

To sum up, the importance of neurophysiological measurements during word recognition can be understood from:

> ‘‘One of the most intensely debated issues in psycholinguistics, at what latencies phonological, orthographic, lexical, syntactic and semantic information is first accessed, can therefore be addressed using neurophysiological means’’ (Pulvermüller et al., 2009, p.81).

According to wide literature, for the reading comprehension ‘‘orthographic analysis first peaks at about 200 ms, phonological analysis at about 300 ms semantic analysis at about 400 ms, and syntactic analysis at about 600 ms’’ (Dien,2009,p.12)

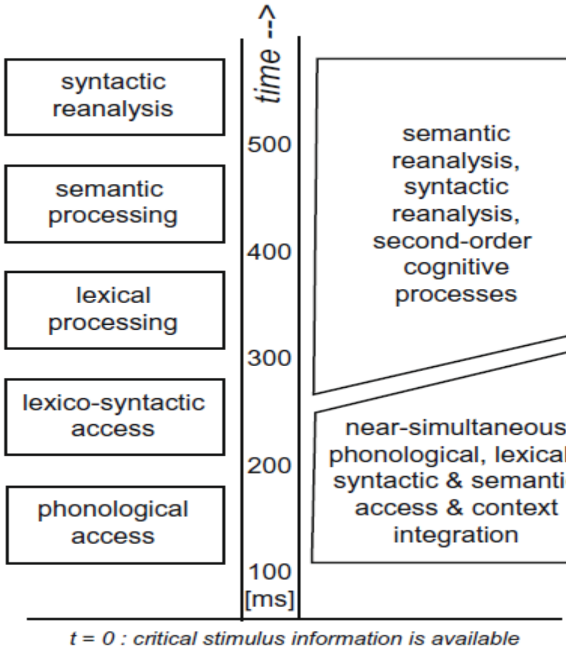

Figure 8 Serial (given at left) and parallel (given at right) processing models during language comprehension (from Pulvermüller et al., 2009)

2.4. Event Related Potentials in Word-Related Studies

Event related potentials have a great impact in measuring the time course of the linguistic process mentioned in section 2.3 (Dien, 2009). There are various brain regions involved in word identification as seen in figure 9 (Dien, 2009; Posner et al., 1992).

Peak latency	ERP	Anatomy	Function
100	P100	Extrastriate occipital	Low-level perception
150	P150-Cz	Inferior occipital cortex	Word shape
150–180	N170-PO7	Visual word form area	Bigram analysis
200	N2-P3	Fusiform semantic area	Lexical access
250	Recognition potential	Language formulation area?	Lexical selection and orthographic-phonological mapping
250–350	MFN/N300/P2/PMN	?	Phonological analysis?
300–350	N300-T3	Left supramarginal gyrus	Phonological store

Figure 9 Early latency event-related potentials for reading comprehension (Dien, 2009)

Barber and Kutas (2007) explain the time course of the word recognition process as follows: the stimulus type, in other words well-learned versus novel stimuli differentiation occurs 100 ms after the stimulus onset, the difference between orthographic and non-orthographic stimuli is recognized 150 ms later than the stimulus onset. Results from a few studies in which lexical decision is made (differentiating word versus non-words or/and pseudowords) present responses in this early time scale (100-200 ms) whereas consistent results from multiple studies indicate word frequency and lexicality effects 300 ms after the stimulus onset, in the range of 250-400 ms. Lexicality effect is revealed by the 300 ms negativity for orthographically and phonologically regular but nonexistent pseudowords or illegal non-words while discriminating them from meaningful words (Schacht & Sommer, 2009b). Moreover, phonology related information is activated between 250-450 ms. In addition, the word and sentence level interaction and morphosyntax recognition occurs between 300-450 ms time interval. Finally, decision making processes in top-down factors such as local sentence context occur in response to visual word recognition. Word recognition lasts hundreds of milliseconds after the word onset based on the steps presented in figure 10. The LPC (Positive potentials occurring after 500 ms) elucidates attentional engagement, evaluation and memory encoding rather than semantic processing (Fischler & Bradley, 2006; Kissler, Herbert, Winkler & Junghofer, 2009).

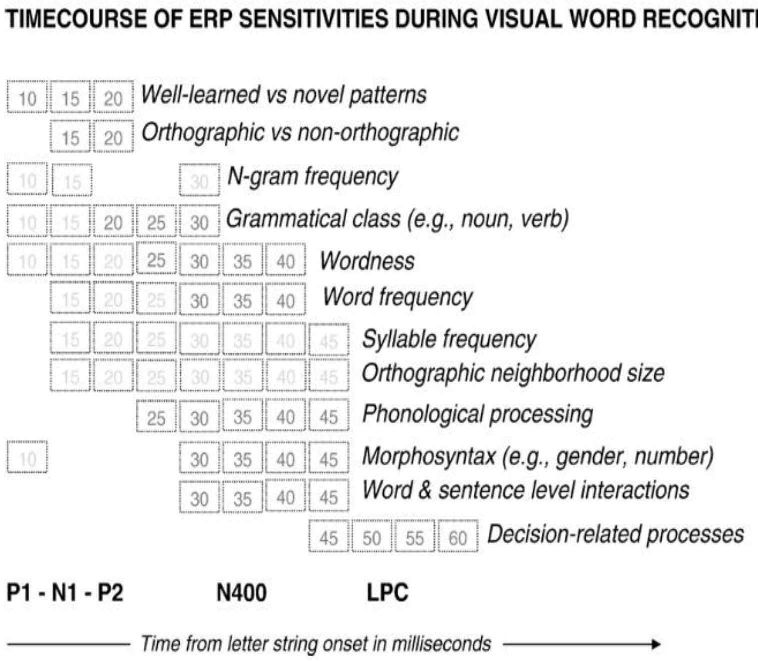

Figure 10 ERP time responses during visual word recognition. Dark Greys indicates findings from several laboratories, light shades are scarce in the reports. The numbers inside the squares denote time scale, for example, 10 means 100 (from Barber & Kutas, 2007)

Sereno and Rayner (2003) discuss the reading ability of human as ‘‘the visual comprehension of language’’ according to time course, mainly how and when the meaning of the word is activated. Regular readers can read 300 words per minute while word inputs enter to the brain through the retina. The penetration of word information to higher cortical regions takes approximately 60 ms after the word onset. Lexical processing starts after this penetration, elucidating the ERPs P1, N1, P2, and N2. The later cognition-related ERP components comes into play approximately 300 ms with P300 and continues by the N400 whose time scale changes between 300-500 ms. The time scale can be seen from figure 11.

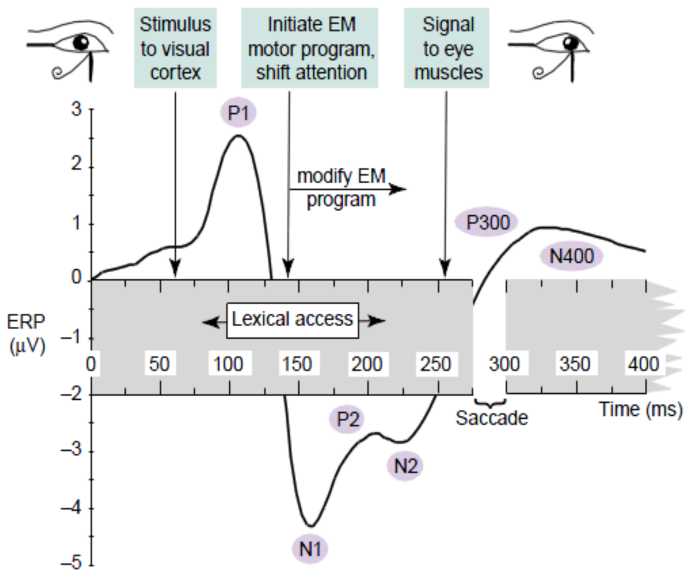

Figure 11 ERP time responses to the visual word recognition. (from Sereno et al.,2003)

2.4.1. Early ERP Components in Language Comprehension

There are several studies that replicate the late ERP components (P300, N400, Late Positive Component), although findings related to the the early components are limited. The difference between meaningful words and pseudowords is reported in the N100-P200 early components (Pulvermüller et al., 2009). Breznitz, Shaul and Gordon (2003) reveals that these early components may reflect early attention capturing mechanisms by detecting the physical features of the stimuli such as font, color, contrast.

P100 which is a positive peak occurring approximately 100 milliseconds after the stimulus onset reflects very low-level perception of the visual stimuli, thus it has its maximum value over posterior regions. The amplitude of P100 is larger for longer words, within the topography of electrode site PO8. Moreover, this potential has higher values in terms of amplitude for atypical words than typical words (Dien, 2009). Furthermore, Brem et al. (2006) notify that

> "An activation over the occipital scalp around 100 ms (P1/M100) is mainly sensitive to physical stimulus characteristics (visual contrast, luminance, size, etc.) and reflects activity of striate and extrastriate visual areas'' (p.822).

According to Brem et al. (2006) P100 findings, the amplitude for symbol strings (nonsense stimuli) is much higher than meaningful words. And this may arise due to the more allocated attention for the symbol strings. On the contrary, according to Segalowitz and Zheng (2009) findings, ERP results for the P1 amplitude greater for words than nonwords.

N100 is the negative peak occurring approximately between 80-180 milliseconds after the stimulus onset, which is predominantly picked up at the temporal and occipital sites (Breznitz, Shaul & Gordon, 2003). It may be the indicator of initiation of attention based events (Breznitz & Berman, 2003). The activation of N100 is the related to discrimination of word stimuli and symbol strings namely shapes. So its amplitude values are larger for words than non-sense strings (symbols, icons) with a scalp distribution of occipito-temporal cortex (Brem et al., 2006). According to Breznitz et al. (2003), its latency is proportional to age of subjects, i.e. the older the age, the later the response.

The P200 which is a positive peak occurring approximately 200 milliseconds after the stimulus onset is thought to reflect perception, feature detection, working memory and syntactic processing. Furthermore, frontal P200 may be associated with memory retrieval related operations, whereas central P2 may be reflect the word access from long term memory to the working memory (Breznitz et al, 2003).

The N200 component (RP: the recognition potential) which is reported as a recognition potential peaks around 250-270 ms (early 200). N200 is thought to reflect processes related to meaningfulness in semantic processing. In the case of word stimuli, it is reported that its amplitude is larger for words than non-words, in other words its amplitude is proportional with the recognition of the meaning of the stimuli (Dien, 2009). In addition, it is located over left temporal and occipital sites (Grossi & Coch, 2005). For the oddball paradigm, this component is observed for the rare, so called target stimuli, because of its responsiveness to the stimulus probability (Patel & Azzam, 2005; Frishkoff & Tucker, 2000). N200 is also reported as an indicator of early semantic access (Dien, Frishkoff, Cerbone & Tucker, 2003). Its latency is proportional with the focus of attention (Breznitz et al, 2003). According to Martín-Loeches (2007), real words' recognition potential exhibits higher amplitude than pronounceable non-words and letter strings, since subjects are more familiar with the stimuli (i.e. real words are more recognizable than pronounceable non-words and letter strings). Ortographic processing and letter recognition may also contribute to the recognition potential (Martín-Loeches et al., 2002).

2.4.2. Late ERP Components in Language Comprehension (N400)

The language related component of ERP is N400 which occurs approximately 400 ms after the word stimulus onset (Pulvermüller et al., 2009). This fundamental ERP component is firstly found as opposed to semantically incongruent sentence endings by Kutas and Hillyard (1980). They examined subjects' brain activity with respect to semantically incongruent sentences during natural sentence reading. In the experiment, subjects are given 7 word sentences. To establish semantic incongruity, the 7^{th} word of each sentence is made semantically irrelevant (For ex. 'He spread the warm bread with socks.'). As the control sentences, semantically correct sentences are used (For ex. 'It was his first day at work'.). As a result, the amplitude of N400 for the last word in semantically incorrect sentence structures is obtained as higher than semantically congruent sentences. In other words the negative peak which occured 400 ms after the stimulus onset, i.e. the target word, was larger for incongruent words as seen from Figure 12. This may be due to the semantic integration property: the integration of context is easier in the case of semantically congruent sentences (Lau et al., 2008).

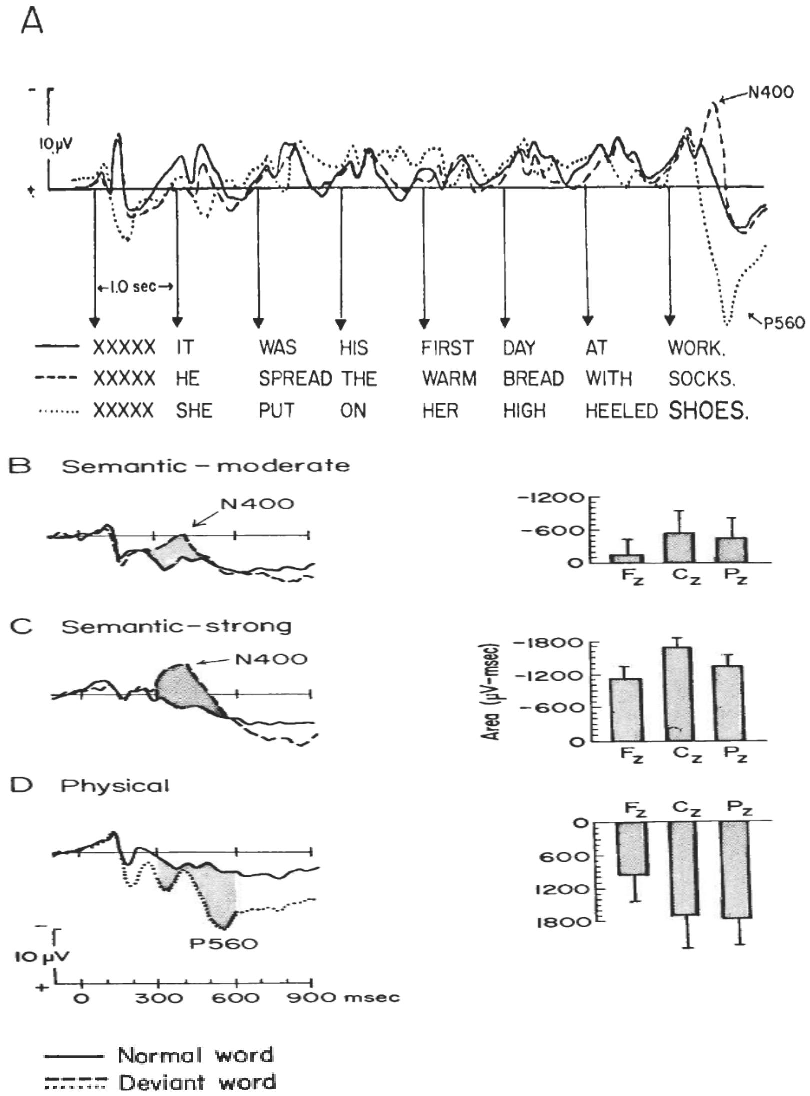

Figure 12 N400 ERP Component after the semantic processing (from Kutas et al., 1980)

The N400 language related component is not only elicited by sentences but it is also found by the single words including orthographically regular and pronounceable pseudowords (orthographically regular non-words, such as GORK) (Pulvermüller et al., 2009; Lau, Phillips & Poeppel, 2008; Federmeier & Laszlo, 2009). The non-words which do not keep track of the traditional language rules (i.e. orthographically and phonologically incorrect, e.g. ‘‘GHJ’’ or orthographically correct and phonologically unpronounceable) do not elicit N400 potential (Federmeier & Laszlo, 2009; Coch & Holcomb, 2003). The amplitude of this component is larger for pseudowords which have no meaning as opposed to meaningful words.

N400 is described as:

> ‘‘N400 which is best characterized as an index of semantic memory use during language comprehension and context integration’’ (Pulvermüller et al., 2009, p.82).

From the view point of the scalp topography, it is maximum at centroparietal region. Word-like non-words often present longer reaction times than words according to N400 findings (Lau, Phillips & Poeppel, 2008).

To assess the underlying cognitive mechanism of words, a classical lexical decision task in which subjects are told to categorize whether the string of letters are words or pseudowords is applied. Findings (Carretié et al., 2008) suggest that the LPC (P3b) is located in superior parietal lobe and it appears to be minimum at frontal sites. It has been consistently reported that it is an indicator of the top-down or goal directed visual attention (Schacht & Sommer, 2009a; Polich, 1985). That is to say, LPC is detected when top-down attention is engaged in word recognition:

> ‘‘Experiments manipulating the level of top-down attention while reading indicate that the parietal cortex reflects the recruitment of attentional processes when words are read’’ (Carretié et al., 2008, p.193).

Fischler and Bradley (2006) conducted an experiment with 150 words including pleasant, unpleasant and neutral, and 60 non-words. Moreover, participants are told to react non-words and not to words. As a result, their findings suggest that there is LPC after N400 which is minimal at frontal sites and maximum at parietal sites can be observed from figure 13.

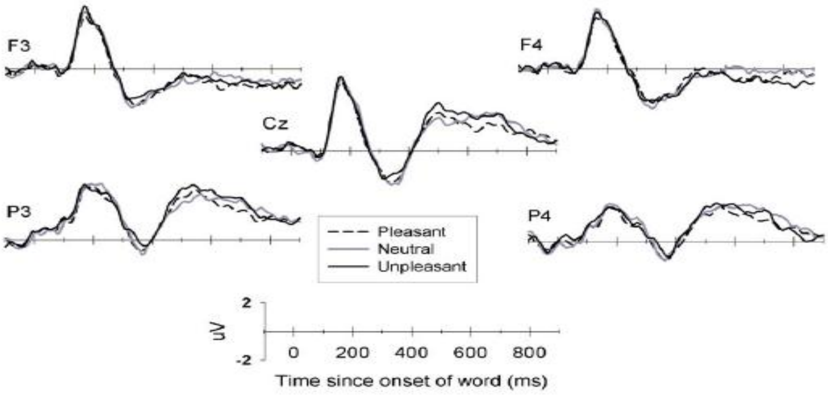

Figure 13 Event-related brain potentials at five scalp locations following presentation of affectively unpleasant, neutral, and pleasant words (from Fischler et al., 2006)

Polich (1985) assessed the effect of semantically incongruent and congruent processing by conducting 2 different types of experiment with sentences versus a series of words in order to investigate the relation between N400 and Late Positive wave that culminates just after the N400 in decision making processes. In the experiments, subjects are instructed to read either seven word sentences or a word series of seven words which are semantically related, in other words congruent, or semantically inappropriate, or so called incongruent. Subjects are instructed to indicate whether the sentences or word series ended in a semantically relevant manner with a button-press response. For the sentence reading paradigm, 7 word sentences are shown to the subject. So as to facilitate semantic incongruity, first 6 words of each sentence are semantically and syntactically appropriate for half of the sentences. The N400 ERP (400 msec negative latency) is detected for the stimulus in semantically inappropriate sentences; but this latency does not occur for the normal ending sentences. For the experiment with word series, seven words are presented where the first six words are from same category of the first six words but the seventh word is from another category (e.g. first 6 words are chosen from flower category but the seventh word is a car name) or all of the words are from the same category. This time the N400 component is observed for all cases. The resulting ERPs are presented in figures 14 and 15. For the second experiment, the P300 component in the decision making task is obtained in a more precise manner as opposed to first experiment as a late positive component.

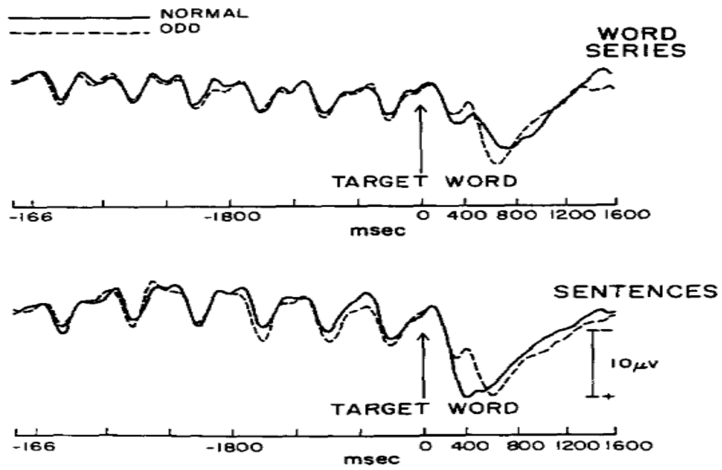

Figure 14 N400 ERP signal ODD: word series/sentences ending with semantically incongruent word. NORMAL: word series/sentences ending with semantically congruent word (from Polich, 1985)

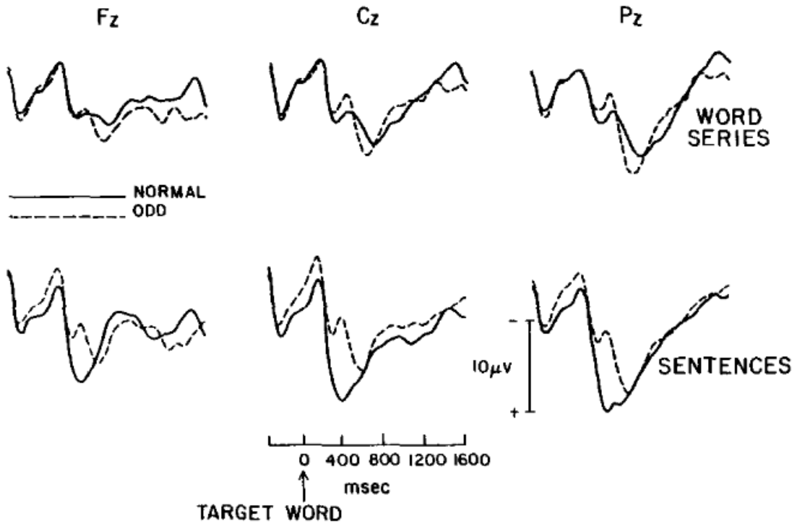

Figure 15 N400 and Late Positive Component (from Polich, 1985)

Friederici (2004) also discussed the ERP components which are related to brain's language network. The effect of syntactic and semantic language processing is examined over the N400, P600 components. N400 stands for the negative peak at around 400 ms after the target stimuli, highly correlated with lexical-semantic processing. This component is observed both right and left hemisphere of the brain, but in the case of visually presented words, the amplitude is higher for the right hemisphere. While N400 is associated with early processes of syntactic integration, P600 is detected for complex syntactic integration such as ambiguous phrases.

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2.4.3. Role of Attention in Language Comprehension (P300 and Late Positive Component)

Selective attention represents processing of information such that relevant stimuli are extracted while others are neglected (Fabiani et al., 2000). The P300 ERP is a marker of cognitive processing related to attention such as updating mental representations such as working memory. Remarkably, P300 is a signature of the "Oddball Paradigm". This paradigm is administered using a single category stimulus, two category stimuli or three category stimuli. When there is a single type of stimuli, the subject is expected to detect the stimulus every time it is presented. For traditional two stimulus oddball, there is a standard stimulus that is presented to the subject frequently, along with target stimuli shown infrequently. The subject is expected to respond to the target category which elicits a higher P300 signal in comparison to the standard category as seen in figure 16. In the case of three stimulus oddball, the target stimuli is shown rarely along with the frequent standard stimuli and infrequently presented distractor stimuli eliciting responses shown in figure 17. In every type of the paradigm, subjects are told to respond either by counting the numbers of target stimuli or by pressing a button after seeing the target stimuli while ignoring others (Polich et. al, 2007).

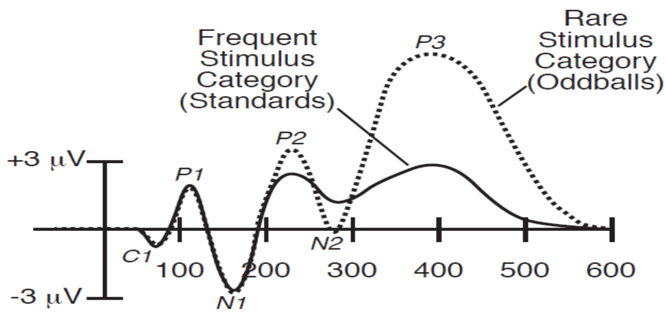

Figure 16 ERP waveforms facilitated by standard and oddball stimuli in a visual oddball paradigm (from, Luck,in press)

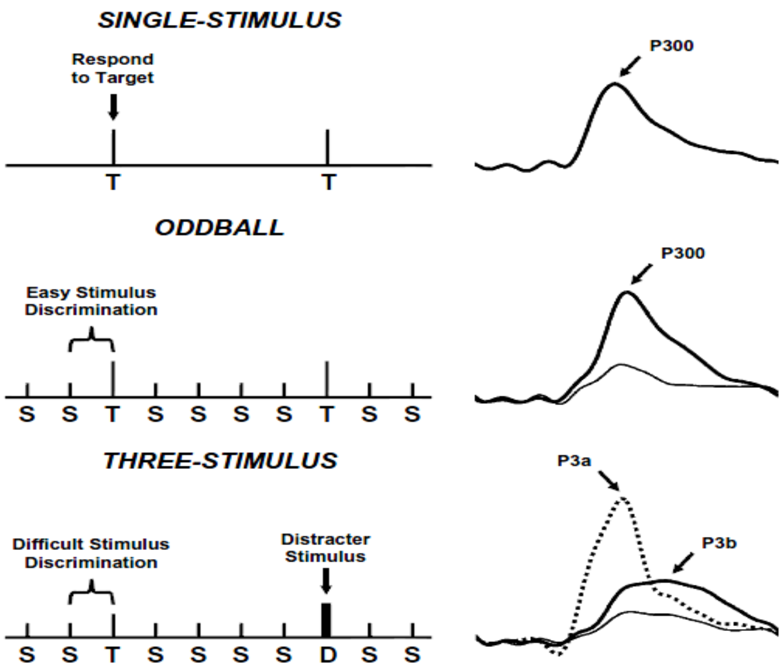

Figure 17 Different types of stimuli in Oddball Paradigm (from Polich et. al, 2007).

In the case of three stimulus oddball, P300 have two components which are called P3a and P3b respectively. P3a reflects the responses derived from attention processing after sensory input is received. On the other hand, P3b reflects memory access after attentional processing is already engaged. P3a appears when the frontal lobe attention is required whereas P3b is produced in the case of requirement of attention for memory updating operations from parietal cortex.

> ''Parietal cortex, situated at the intersection of visual, auditory, and tactile cortices at the 'crossroads of the brain' is 'association' or tertiary cortex'' (Behrmann, Geng &Shomstein, 2004, p.212).

It plays an important role in converting sensory information to a motor response by regularizing attention, mental updating, locational representation (Behrmann, Geng & Shomstein, 2004). For example, in the three stimulus oddball the detection of the distractor produces P3a, the counting of target stimuli elicits P3b (P300) so called late positive component. The anatomical correlates of P3a and P3b can be observed from figure 18(a) and figure 18(b) (Polich et. al, 2006).

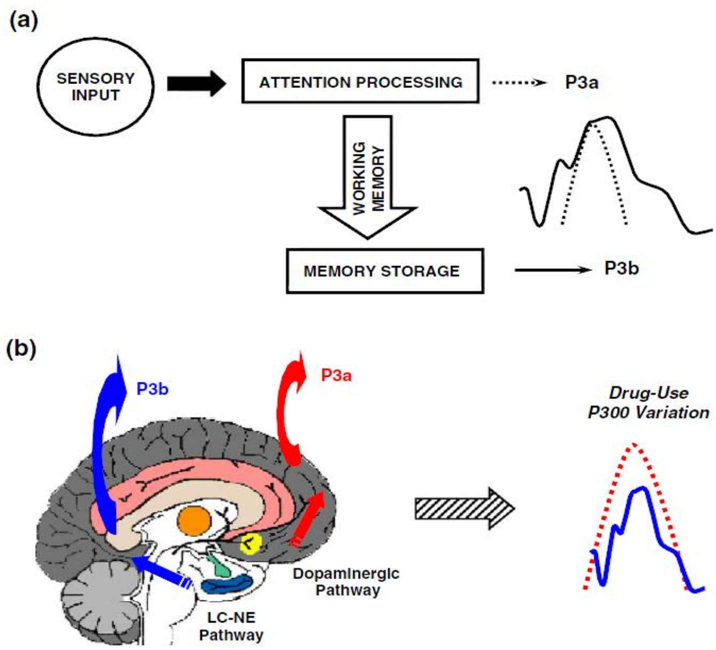

Figure 18 P3a and P3b components of P300 (from Polich & Criado, 2006)

The context updating mechanism of P300 begins with acquiring the input, if it is different from the previous stimuli then P300 emerges, if it is not, then the current mental state is conserved in accordance with the sensory evoked potentials namely, N100, P200, N200 as shown in figure 19. The latency of the P300 is highly correlated with the cognitive efficiency of the brain, namely the speed of the task performance whereas the amplitude of P300 elucidates the activation level of the brain in terms of the necessary attentional resources for the specific task (Polich & Criado, 2006; Polich, 2007; Polich & Margala 1997).

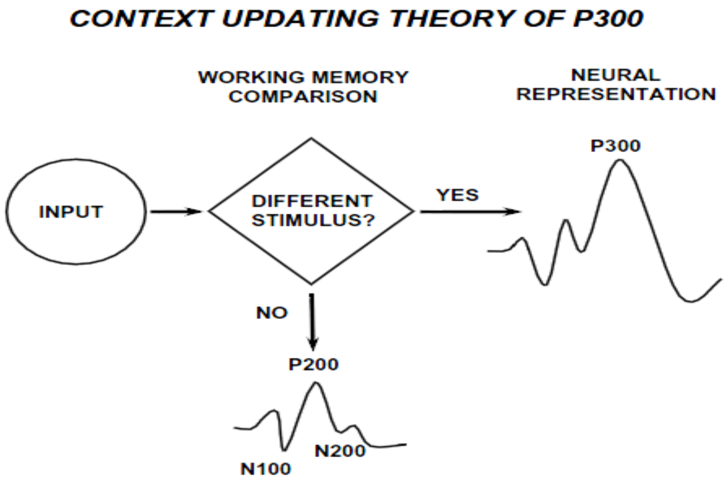

Figure 19 Context Updating Theory of P300 (from Polich, 2007**)**

The P300 positive peak occuring after the stimulus onset is investigated to understand whether the probability of the rarer (target) event is directly proportional to the amplitude of the P300 component or not (Polich and Margala, 1997). As a result, it is found that as the probability of the event increases the amplitude of the P300 decreases. When stimulus frequency increases, the remaining time of that stimulus in immediate memory is higher than other stimuli, so the updating operation does not have to be made each time as in the case of rare (target) stimuli, yielding smaller P300 amplitudes.

The complexity of the task effects the latency of P300: the more complex the evaluation of the task (i.e. decision making), the more delayed the peak latency

(Kutas & Petten, 1988). Latency serves as some sort of index of cognitive capability (Polich & Margala, 1997, p.175).

2.4.4. Bottom-up and Top-Down Attention Approaches

According to neuropsychological findings, reading has strong relationship with attention especially in the right parietal lobe. Besides this the parietal lobe has an important role on word recognition (e.g. words with different format letters, upper and lower case letters) as suggested by attentional resource management (Braet & Humphreys, 2006). Moreover, parietal cortex accomplishes this role by participating in two different aspects of attentive processing: First one is bottom-up (i.e. ‘attentional capture’) which is created by the recognition of the ‘intrinsic’ feature of the stimuli. This recognition process is accomplished by the saliency of the stimulus. Second one is the top-down mechanism which operates in a goal-directed fashion, as a consequence of the explicit will of an organism (Behrmann, Geng & Shomstein, 2004, p.212)

Parietal lobe is located posteriorly to the central sulcus and superiorly to the occipital lobe. Parietal lobe is segregated by the intraparietal sulcus (IPS) into the superior parietal lobule (SPL) and the inferior parietal lobule (IPL). On the medial view, SPL’s extension anterior to the parietooccipital sulcus (POS), is called the pre-cuneus. The frontal lobe (FL) is seperated into the middle frontal gyrus (MFG) and the inferior frontal gyrus (IFG). The superior temporal gyrus (STG) is located in the superior part of the temporal lobe (TL) and ends at the temporoparietal junction (TPJ) as can be viewed from figure 20 (Behrmann, Geng & Shomstein, 2004).

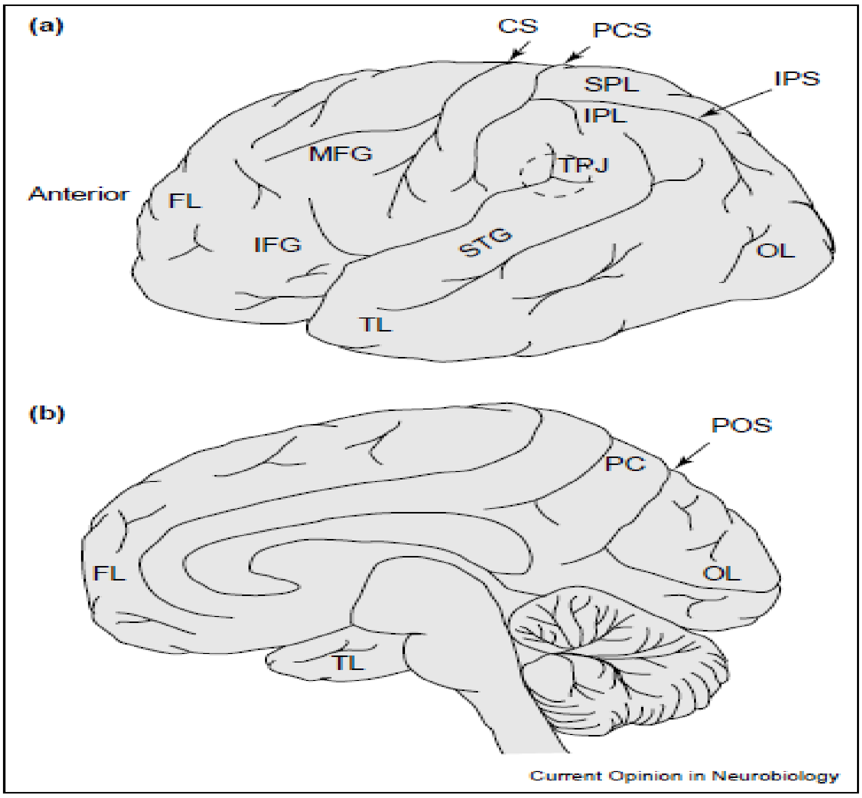

Figure 20 Neuroanatomical regions involved in bottom-up and top-down attention (a) Lateral view of human brain (b) Medial view of the human brain.

Central Sulcus (CS), occipital lobe (OL), intraparietal sulcus (IPS), superior parietal lobule (SPL), the inferior parietal lobule (IPL), parietooccipital sulcus (POS), frontal lobe (FL), middle frontal gyrus (MFG) and the inferior frontal gyrus (IFG), superior temporal gyrus (STG), temporal lobe (TL), temporoparietal junction (TPJ) (from Behrmann, Geng & Shomstein, 2004)

As mentioned earlier, attention capturing has two aspects: First one is bottom-up, second is top-down.

Bottom-up attention is driven by sensory input, and involves perception of relevant stimuli via feature and saliency maps (Corbetta & Shulman, 2002). As seen from figure 21, first of all the low level features are extracted in parallel (e.g. for the image, color, orientation; intensity including spatial information is detected). After, feature maps are constructed, the saliency map is created for the high level perception of the stimuli by combining feature maps (Itti & Koch, 2001). According to several fMRI studies, the bottom-up attention capturing mechanism is neuroanatomically correlated with the temporoparietal junction (TPJ; see Figure 20 (a)). Right lateralized TPJ becomes activated in response to the unexpected, infrequent, salient stimulus (Behrmann, Geng & Shomstein, 2004). For example, when the subject walks on the road, he immediately detects a red hat in a crowd of people without prior instruction, because this red hat automatically grabs their attention due to saliency. Another task may be detecting red hat in a crowd of people when subjects view a series of pictures. In this type of task, subjects are instructed to differentiate specified stimulus with their own cognitive effort (Itti & Koch, 2001). For the second task, the frontal lobe, visual areas are integrated to the circle. This requires the activation of the top-down attention. In the case of top-down approach, information is processed from more a complicated form down to a simpler form, based on previous experience (Corbetta & Shulman, 2002). For the neuroanatomical correlates of the top-down attention, the superior parietal lobule (SPL; see Figure 20) and the precuneus (PC; see Figure 20) regions are activated (Behrmann, Geng & Shomstein, 2004). For the summary of bottom-up, top down and object recognition schema see Figure 22.

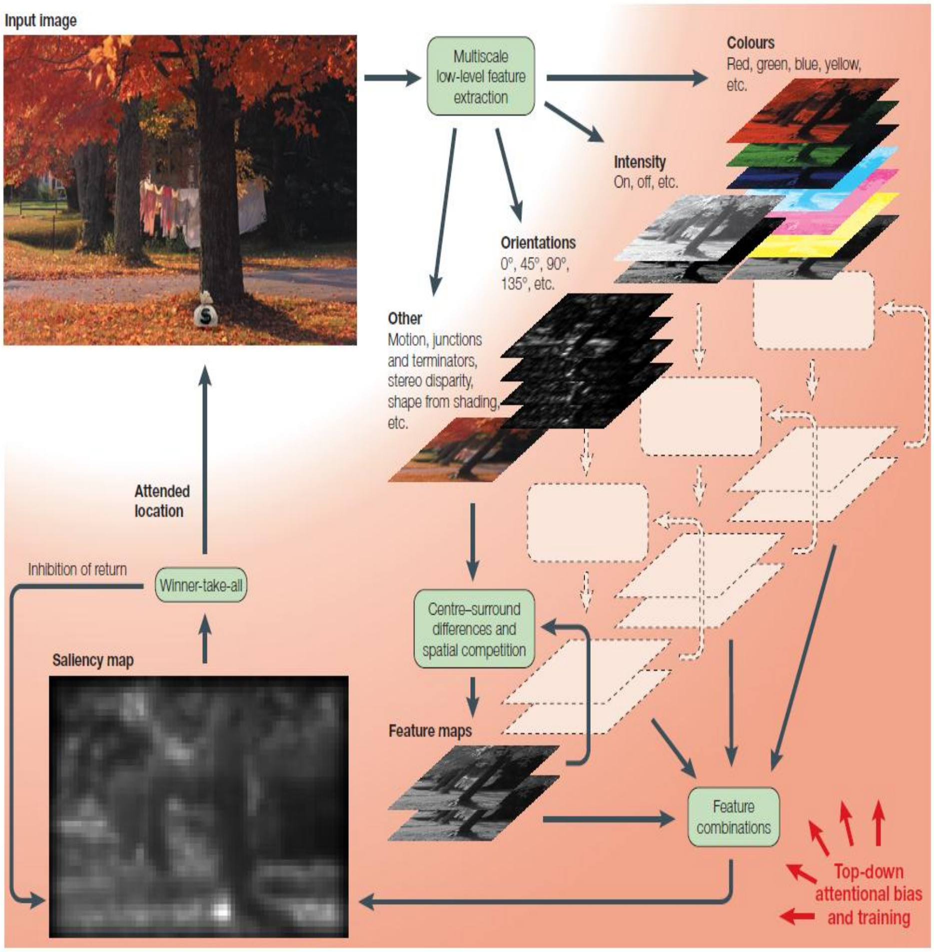

Figure 21 Bottom-up attention flow schema (from Itti & Koch, 2001)

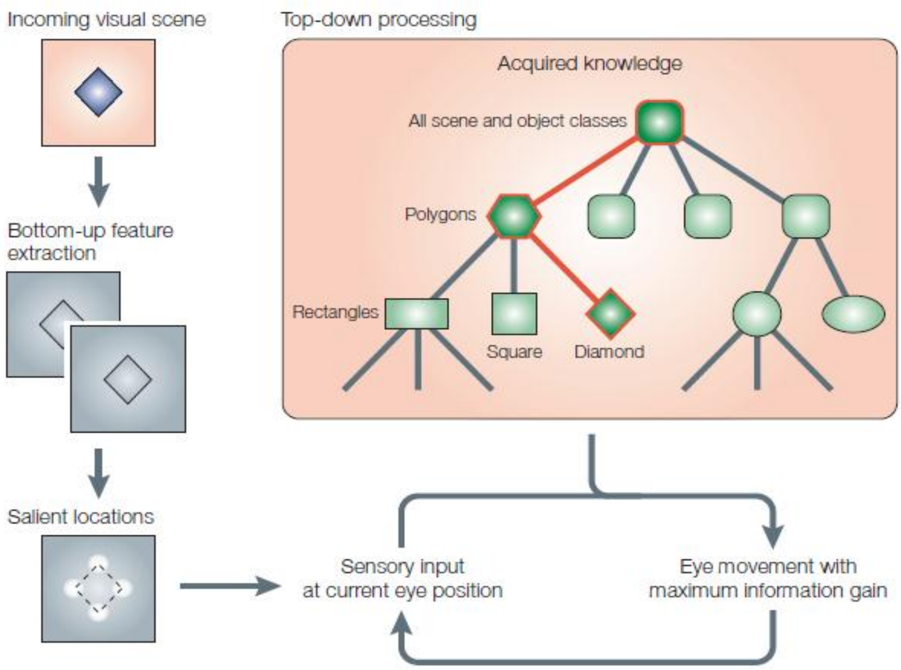

Figure 22 Attention grabbing and object recognition schema (from Itti & Koch, 2001)

2.5. Motivation of the current study & Hypothesis

The current study investigates electrophysiological information processing in lexical decisions. Although electrophysiological correlates of early and late stages of general lexical data processing have well been documented before, we are particularly interested in the application of lexical decisions to Turkish words. Therefore, our aim is to determine the interplay of pre-attentive, attentive and semantic electrophysiological correlates of lexical information processing during a simple lexical decision task where the subject is required to differentiate words from non-words. P100, N100, P200 and N200 are assumed to indicate pre-attentive time scale of visual word recognition process. N200, which is the marker for ‘wordness’ (i.e. recognition of a word) of the stimuli is expected to have higher amplitudes for target group as opposed to non-targets. Since its latency is proportional to the focus of attention, targets are expected to have higher latencies than non-targets. For the late components of ERP, meaningful words are expected to evoke smaller amplitudes as opposed to non-words for the marker of semantic processing (i.e. N400). For the latency factor of N400, non-words are expected to represent longer latencies as opposed to words. As the indicator of oddball paradigm, for the target stimuli (i.e. words), P300 potential is expected to have much higher latency and amplitudes than non-target stimuli (i.e. non-words). For the late-positive component, we expected to have significantly higher amplitude values for target stimuli as opposed to non-target stimuli. And the latency values of target stimuli should be longer than non-targets since its proportional to cognitive processing.

CHAPTER 3

METHOD

This research is conducted at Dokuz Eylül University, Faculty of Medicine, Department of Biophysics, and Brain Biophysics Research Laboratory. Additionally, it is approved by Middle East Technical University and Dokuz Eylül University, Faculty of Medicine Institutional Review Boards (Appendix C).

3.1. Participants

A total of 21 subjects were enrolled as participants after having signed the written informed consent. The subjects were volunteering adults. The only inclusion criterion was to agree to participate in the study. The exclusion criteria were; (i) having a psychiatric disorder, (ii) having a neurological disorder or a general medical condition as well as (iii) any ophthalmologic problem that may interfere with the sight of the subject (rather than corrected refractory anomalies). Due to the noisy patterns of signals, 1 subject is excluded from study. Socio-demographic characteristics of the participants are presented in Table 1. The mean age was 25.8±4.16. Nine of the participants were male. Eighteen of them were right handed two of them were left handed as ascertained by the Edinburgh Handedness Inventory (EHI) (Oldfield, 1971) (Appendix D, Appendix E).

3.2. Stimulus Materials

The words were chosen according to their arousal and valence: words with neutral arousal and valence were used for the experiment (Appendix A). Neutral value intervals were determined according to valence and arousal values. In detail, the words are chosen such that they had valence and arousal values within the range of 4.0-5.0. While choosing words from the TUDADEN word database, abstract and mono syllabic words are ignored so as to standardize the perception of stimuli. Characteristics of the words we employed are presented in Table 2.

Table 1 Socio-demographic characteristics of the sample (N=20)

Age (mean±SD)	25.8±4.16
Gender (m/f)	9/11
Handedness (EHI score) (mean±SD)	66±61.33

SD: Standard deviation, m:male, f:female, EHI: Edinburgh Handedness Inventory

Table 2 Characteristics of the word stimuli

Arousal value (mean±SD)	4.74±1.84
Valence value (mean±SD)	5.20±1.71

3.3. Stimulus Design and Procedure

As the traditional two stimulus oddball paradigm, the target stimuli were presented to the subject with the probability of p= 0.25. Target stimuli were words chosen from TUDADEN. The standard stimuli were non-words which were produced from the scrambled versions of target words[3]. Probability for standard stimuli were p=0.75. The standard stimuli were orthographically illegal. All stimuli were presented at the center of 17 inch PC-monitor in white 40 pt letters on dark grey background with 400 ms duration. The inter stimulus interval (ISI) was randomized to range within the 2000-3000 ms between stimuli. Fixation cross '+' was used as the baseline between the repeating stimuli. 24 target stimuli were presented with respect to 72 standard stimuli, thus a total of 192 stimuli presentations in 2 repetitions. We did not allow two consecutive stimuli to be target, whereas non-target stimuli were allowed to repeat 3 to 5 times in a raw. Sample design of the verbal oddball experiment can be seen from figure 23. The time duration of this experiment was approximately 10 minutes.

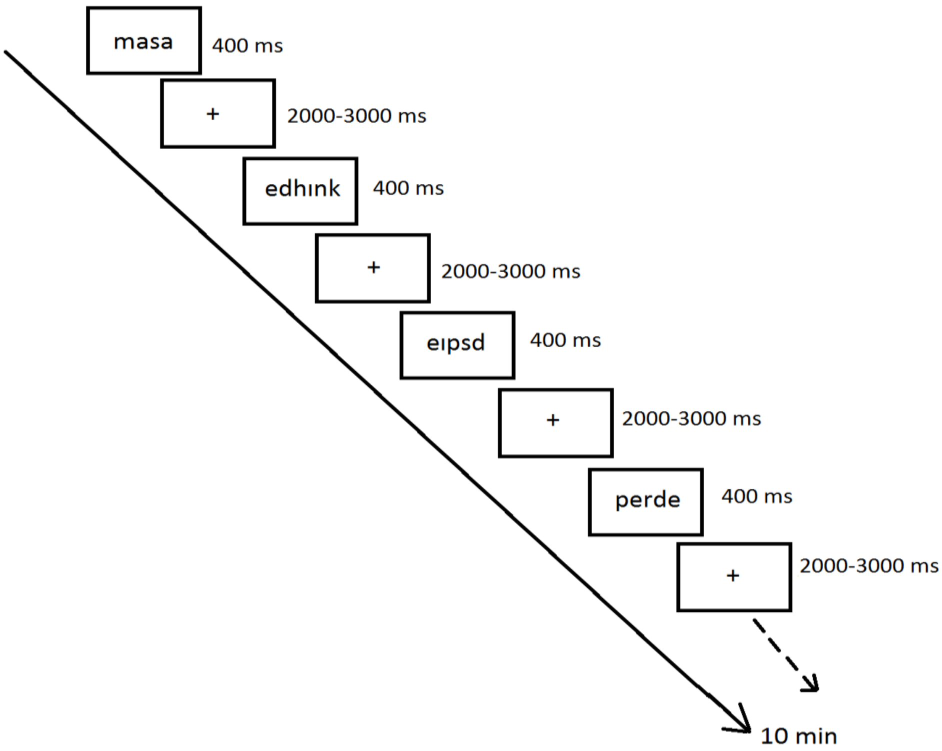

Figure 23 Verbal Oddball Paradigm Design

[3] The scrambled versions of standard words are obtained after scrambling the letters of the target (meaningful) words and then each second vowel and consonant letter is replaced with the consecutive letter of this vowel and consonant letter from the alphabet.

3.4. Stimulus Presentation

The oddball task was applied in a shielded room isolated from electrical and magnetic fields. The investigator who carried out the EEG recordings briefly introduced the task to the subjects. Before the experiment, accompanied by the researcher, participants performed a training session. According to the subjects' head perimeter, Quikcap was placed on their head (for the displacement of electrodes on cap see figure 24). Participants were instructed to press the button only when they decide the stimulus is a meaningful word, and ignore meaningless ones. Furthermore, the subjects were told not to think of any other ideas as well as to avoid moving their heads (e.g. eye blinking, chewing, talking etc.).

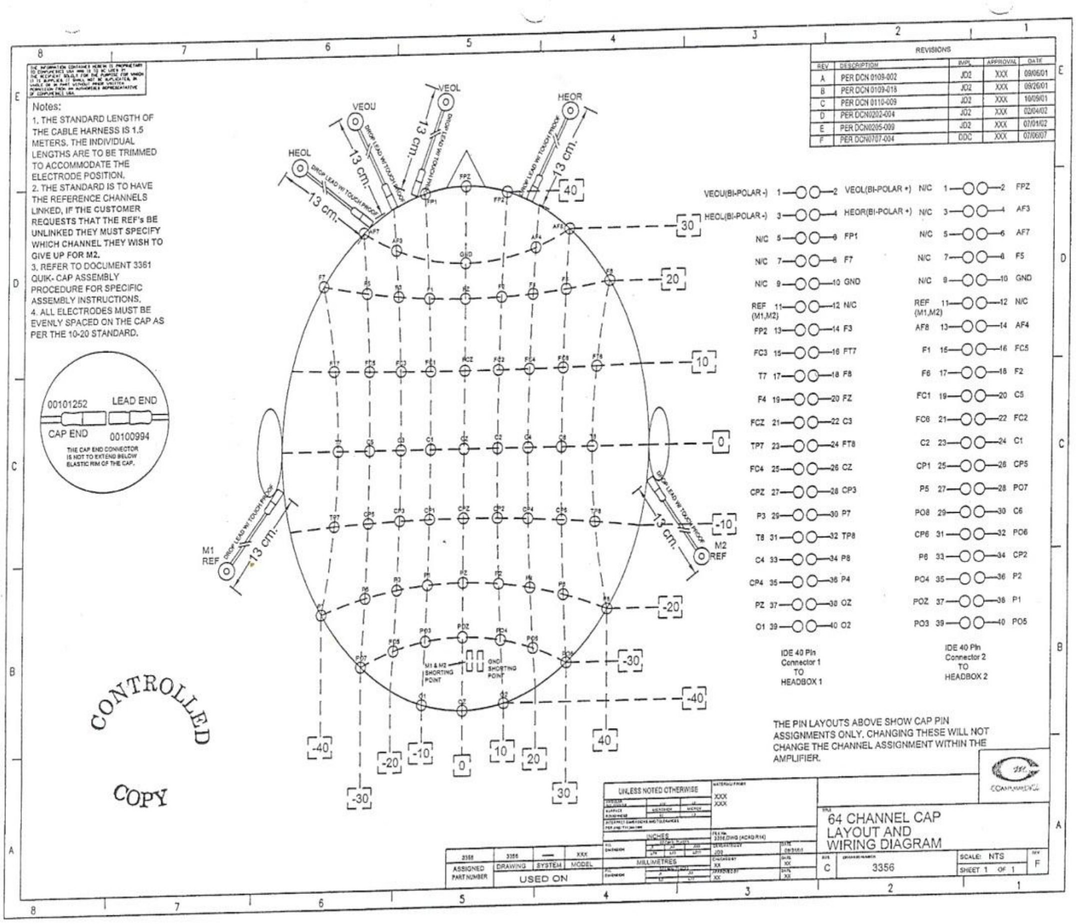

Figure 24 Sample Quik Cap

3.5. Electroencephalographic Data Acquisition

Electroencephalography (EEG) was recorded from 64 electrode sites including Fz, Cz, Pz, Oz,AF3/4, AF7/8,FT7/8,FC5/6, FC3/4, FC5/6, FC1/2, FP1/2, FPz, F3/4, F7/8, F5/6, C1/2, C3/4, C5/6, TP7/8, CP1/2, CP3/4, CP5/6, T7/8, P3/4, P1/2, P5/6,P7/8,PO1/2, PO3/4, PO5/6,O1/2 by the NEUROSCAN SynAmps Amplifiers and Software©. The electroencephalogram was recorded via Ag/AgCl electrodes at the above mentioned sites according to the extended 10–20 system with left and right mastoid reference. The electrodes embedded within an electrode cap served as ground. Additionally, there were external electrodes which were placed below, upper and lateral parts of eyes. These electrodes served as vertical and horizontal electrooculograms (EOG) to record the eye movements during the EEG data acquisition. Two additional reference electrodes were placed at left and right earlobes. During recording these references' electrical potential was assumed as '0' (zero) and the signals which were gathered from other electrodes were referenced according to these two reference electrodes. The impedance of all electrodes was kept under 5 kΩ by using ECI electrode gel. Data was acquired with SynAmps Amplifiers© at a band pass of 0.015–70 Hz with a notch filter (50Hz); sampling rate was 1000 Hz

3.6. ERP Analysis

The ERP analysis is made with the Neuroscan Software©. NEUROSCAN© is a toolbox for processing continuous and event-related EEG. To investigate the time locked signal the recorded EEG was divided into 2000 ms epochs. Each epoch was divided into two equal intervals by the stimulus. Amplitude changes larger than 50mV are presumed to be associated with facial movements or eye blinks and were automatically rejected using the SPATIAL SVD Algorithm of the Neuroscan Software©. Secondly, baseline correction was applied according to activations in pre-stimulus intervals. After the baseline correction, the EEG signals were passed from band-pass filter on zero-phase shift mode. Finally all signals were averaged by using the Average Module of the Neuroscan Software©.

P100, N100, P200, N200, P300, N400 and Late Positive Component were measured from FZ, CZ, PZ, OZ electrode sites in terms of both amplitude and latency. Based on the previous literature (Rozenkrantsa et al., 2008; Bernat, Bunce & Shevrin, 2001, Hoffmann, Kuchinke, Tamm, L.-H. Võ & Jacobs, 2009; Sereno et al., 2003), we designated the time interval as a descriptive for each ERP component as follows:

- P1:70-130 msec
- N1:120-160 msec
- P2:160-220 msec
- N2: 200-300 msec
- P300: 220-800 msec
- N400: 300-500 msec
- Late Positive Component (LPC): 400-800 msec

In order to measure the amplitudes, first of all, the grand averages of 20 subjects were taken into consideration. For all CZ, PZ, OZ and FZ grand averaged signals, peak values that resided between the aforementioned signal time intervals were labeled as P1, N1, P2, N2, P3, N400 and LPC (figure 26,27,28,29,30,31,32,33). Some of these components, especially the P100 and N100 were missing in grand average graphs since they were near to zero, but they were observed in individual signals. After obtaining these grand averaged and labeled signals, for each subject, the baseline corrected, artifact rejected, filtered and averaged EEG signal's peak amplitudes are gathered according to these sample grand average signals. A sample base to peak measurement which we used as a guide is presented in Figure 25. For instance, to measure the P100 amplitude of the specific subject for the target group and electrode CZ, the maximum peak amplitude was measured for the time interval between 70-130 seconds as well as in regards to the grand average latency and amplitude of the P100. This procedure was repeated for all components of interest.

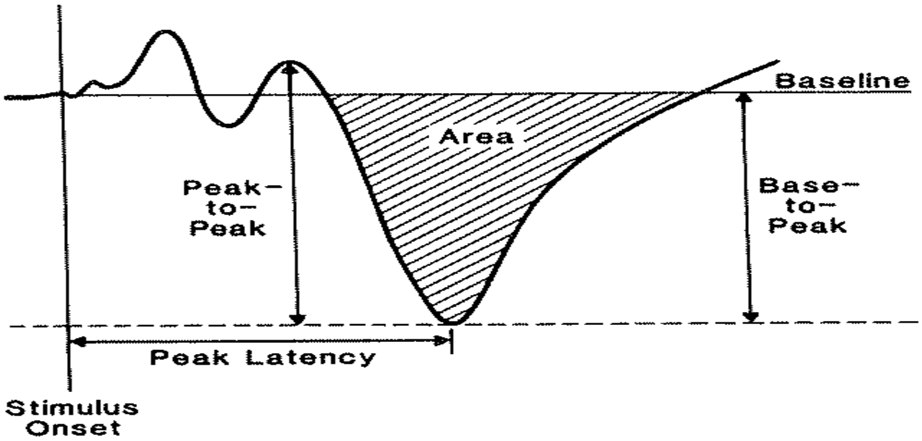

Figure 25 Sample Base-to-peak Measurement (from Fabiani et al., 2000)

The reason why we considered the grand average measurements of the group is to prevent observational bias. For instance, the time intervals for P300 and Late Positive Component are between 220-800 and 400-800 respectively and may overlap. Grand average replacements of the corresponding potentials were informative to determine the electrophysiologic identity of the peaks. Specifically, the latency calculation is based on calculating the time elapsed after the stimulus onset to the P1, N1, P2, N2, P3, N400, LPC peaks. In brief, both latency and amplitude were measured from each subject's averaged EEG signal. In figures 26, 27, 28, 29, 30, 31, 32, 33 in the following, measurement of ERPs from the grand average signals are given separately for target and non-target categories. In Appendix B the event related potentials labeled according to corresponding time intervals from grand-average of CZ, FZ, PZ and OZ electrode sites for both target and non-target groups can be observed.

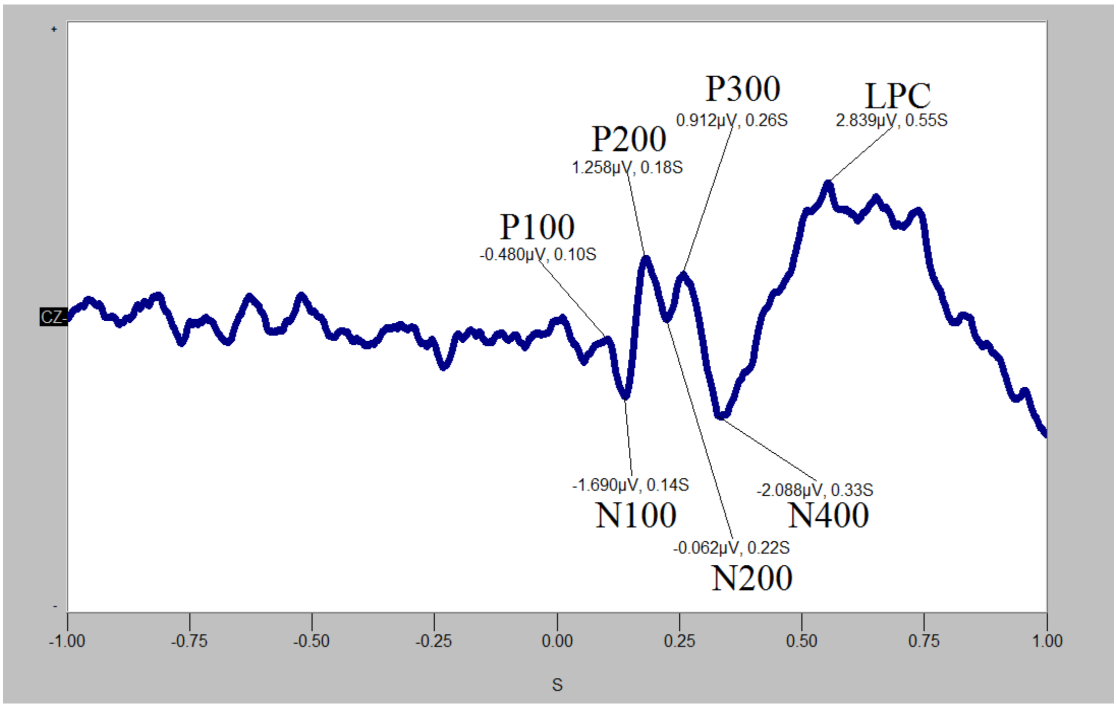

Figure 26 CZ Electrode Measurement for target group

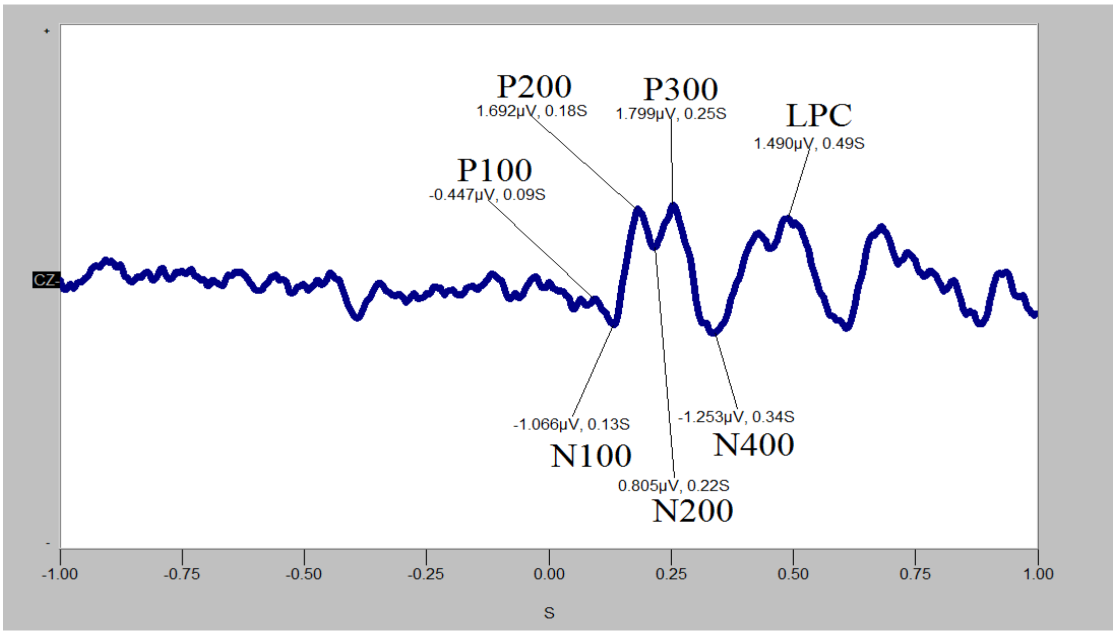

Figure 27 CZ Electrode Measurement for non-target group

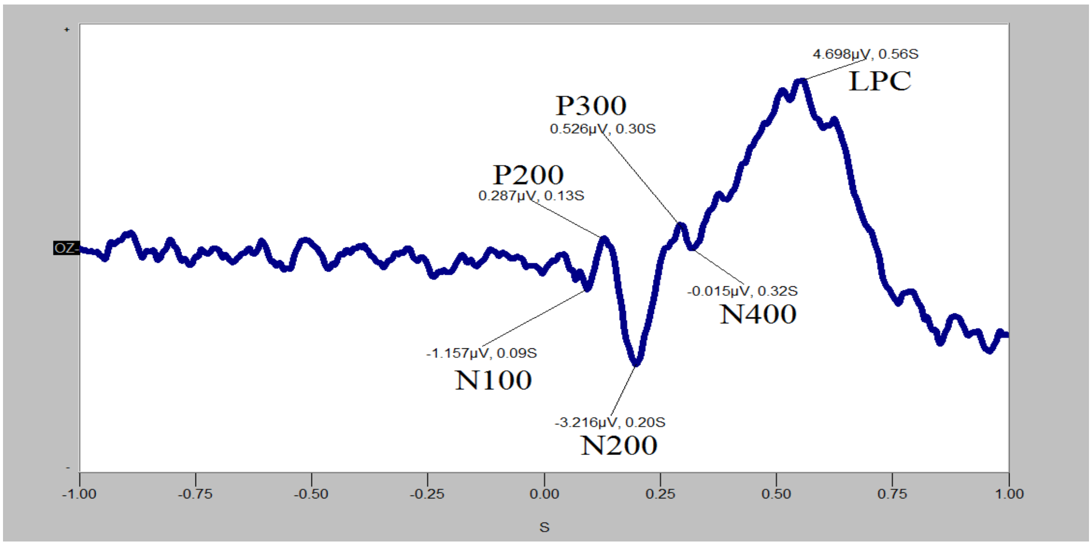

Figure 28 OZ Electrode Measurement for target group

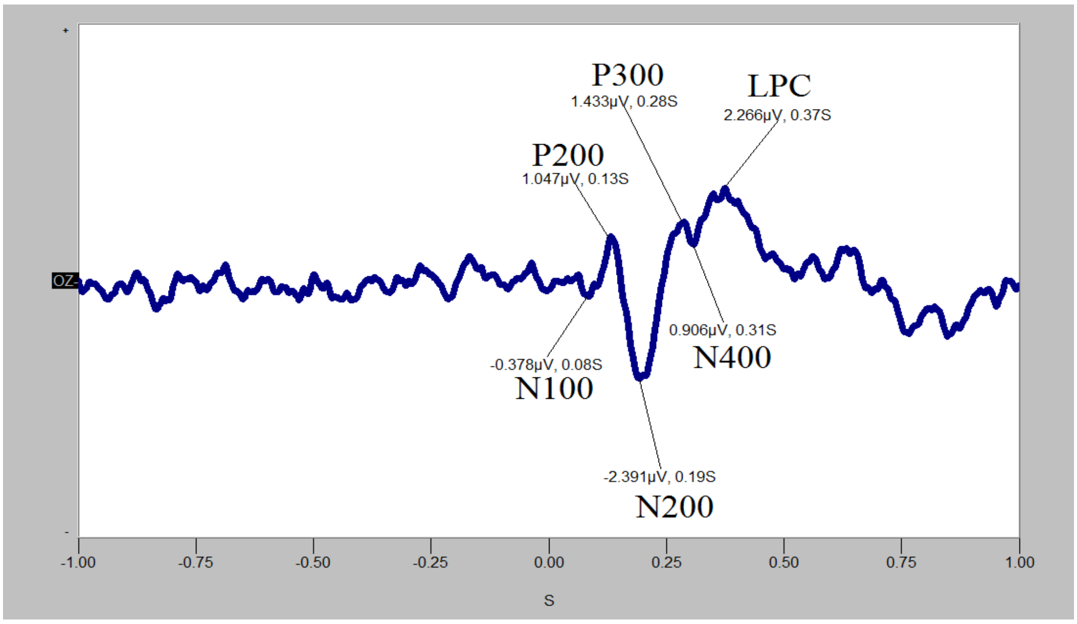

Figure 29 OZ Electrode Measurement for non-target group

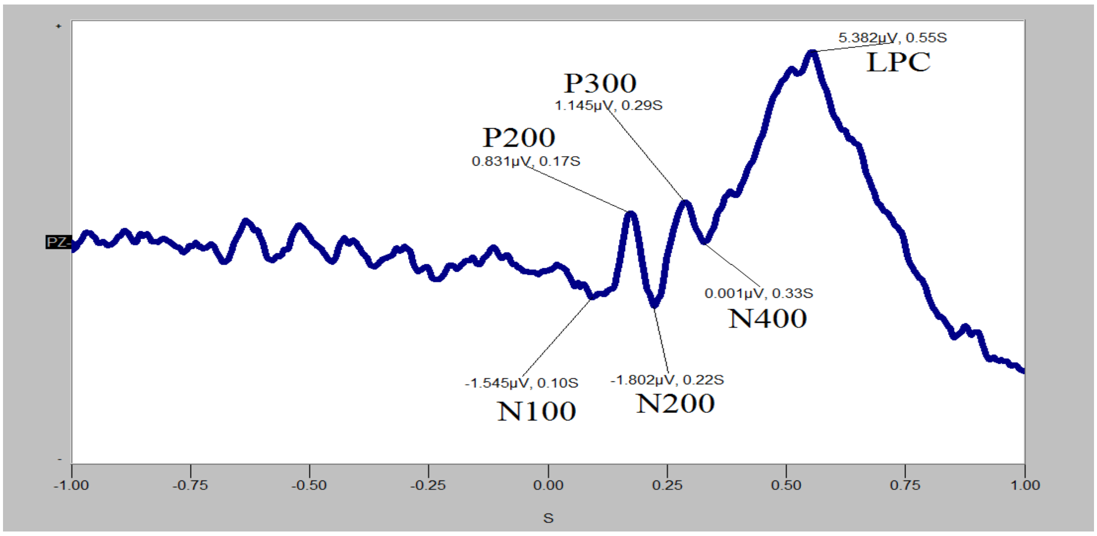

Figure 30 PZ Electrode Measurement for target group

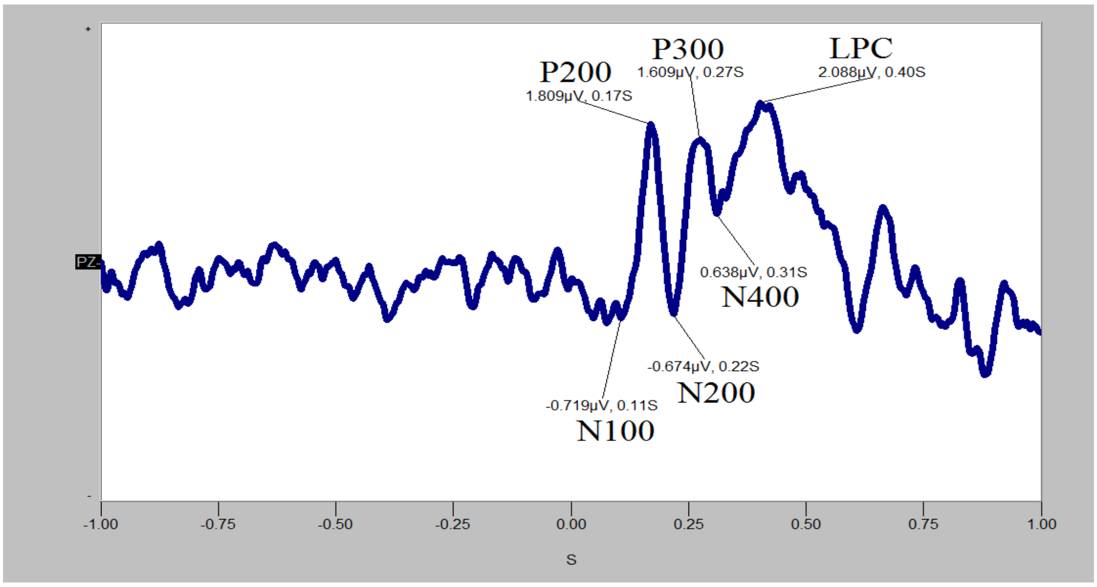

Figure 31 PZ Electrode Measurement for non-target group

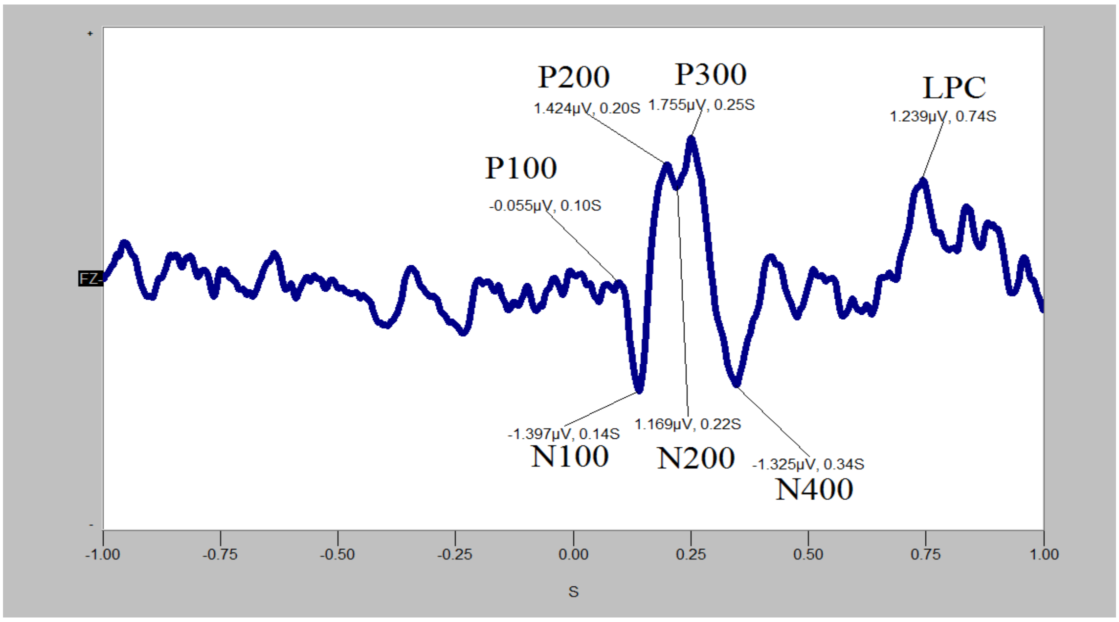

Figure 32 FZ Electrode Measurement for target group

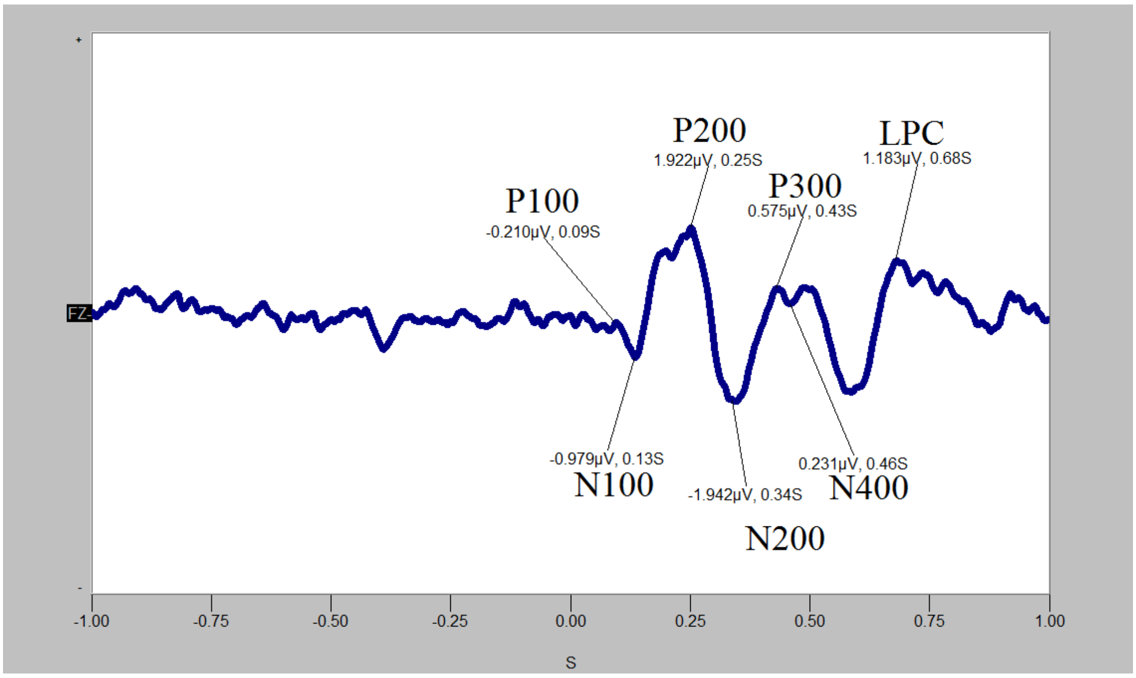

Figure 33 FZ Electrode Measurement for non-target group

CHAPTER 4

RESULTS

In this chapter the ERPs of interest defined as P100, N100, P200, N200, P300, N400 and LPC amplitude and latencies, recorded at PZ, FZ, CZ, OZ electrode sites for the target, and non-target stimuli groups are going to be presented. The results are shown from individual electrodes. The grand average peak measurements that are aforementioned in methods chapter are shown. Subsequently, for the late positive component the inter-reliability analysis results are presented.

4.1. Grand-Average and Statistical Results for the Electrode PZ

The ERP signal that is generated from the PZ electrode site is given in figure 34.

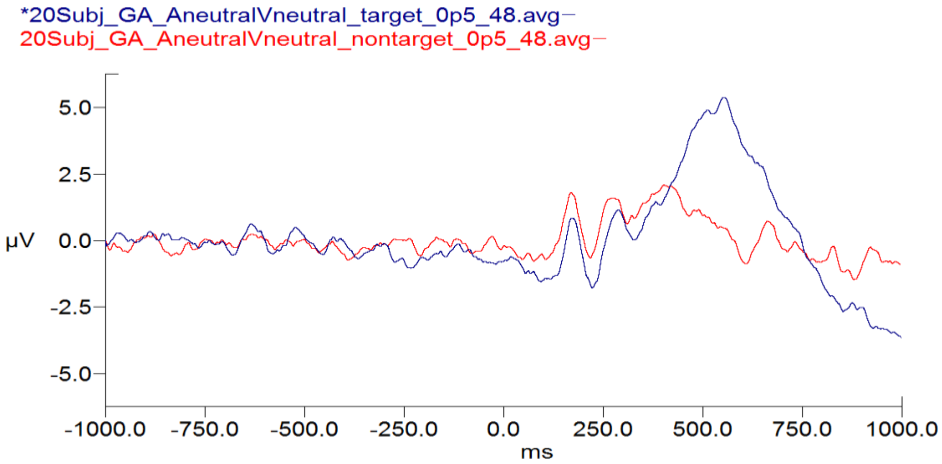

Figure 34 Target and Non-target neutral group grand averages for electrode PZ

Target and non-target stimuli groups were compared for the electrophysiological amplitude and latency with 2 factor Multivariate Analysis of Variance (MANOVA): Target/Non-target X Amplitude, Target/Non-target X Latency.

MANOVA revealed that P100 amplitudes ($F(1, 30) = 1.827$, $p>.05$) and P100 latencies ($F(1, 30) = 0.330$, $p>.05$) were not different between the two stimuli groups.

The difference among target and non-target groups for the N100 potential's amplitude ($F(1, 32) = 4.083$, $p=.052>.05$) was on the verge of significance at $\alpha=0.05$ level, but the N100 latency was comparable between the two types of stimuli ($F(1, 32) = 0.008$, $p>.05$).

P200 potential's amplitude, as well as its latency were not different between the target and non-target stimuli groups ($F(1, 32) = 0.341$, $p>.05$, ($F(1, 32) = 0.389$, $p>.05$ for the amplitude and latency values respectively).

There is no statistical significance among target and non-target groups neither for the N200 potential's amplitude ($F(1, 32) = 2.759$, $p>.05$) nor for the latency ($F(1, 32) = 0.910$, $p>.05$).

There is no statistical significant result among target and non-target groups for the P300 potential's amplitude (F (1, 32) = 0.420, p>.05) and for the latency (F (1, 32) = 0.766, p>.05).

There is no statistical significance among target and non-target groups neither for the N400 potential's amplitude (F (1, 32) = 0.028, p>.05) nor for the latency (F (1, 32) = 0.587, p>.05).

There is a remarkable statistical significance among target and non-target groups for the LPC potential's amplitude (F (1, 32) = 16.399, p=0<.05) but no statistical significance for the latency (F (1, 32) = 2.085, p>.05).

The summary of statistical results is given in Table 3 for amplitudes and Table 4 for latencies.

Table 3 The comparison of two stimuli types for the ERP amplitudes per electrode

ERP amplitude (mVol), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	-0.1767±1.2	0.4164±1.27	F=1.827, p=0,187
N100	**-2.90±1.84**	**-1.73±1.52**	**F=4.083, p=0.052**
P200	2.94±2.69	3.47±2.60	F=0.341, p=0.563
N200	-2.59±2.2	-1.37±2.06	F=2.759, p=0.106
P300	2.67±2.18	3.19±2.59	F=0.420, p=0.531
N400	-1.14±2.42	-1.27±2.11	F=0.028, p=0.869
LPC amplitude	**7.27±2.79**	**3.77±2.21**	**F=16.399, p=0***

SD: Standard Deviation, *:Statistically significant

Table 4 The comparison of two stimuli types for the ERP latencies per electrode

ERP latency (ms), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	101.867±21.74	97.176±24.15	F=0.33, p=0.57
N100	133.29±20.95	134.23±36.78	F=0.008, p=0.928
P200	179.76±30.032	187.82±43.98	F=0.389, p=0.537
N200	230.35±36.419	245.41±53.96	F= 0.910, p=0.347

P300	290.18±35.209	304.24±56.109	F=0.766, p=0.388
N400	368.00±64.686	387.06±79.588	F= 0.587, p=0.449
LPC	536.94±73.66	491.41±107.117	F=2.085, p=0.158

SD: Standard Deviation, *:Statistically significant

4.2. Grand-Average and Statistical Results for Electrode CZ

The ERP signal that is generated from the CZ electrode site is given in figure 35.

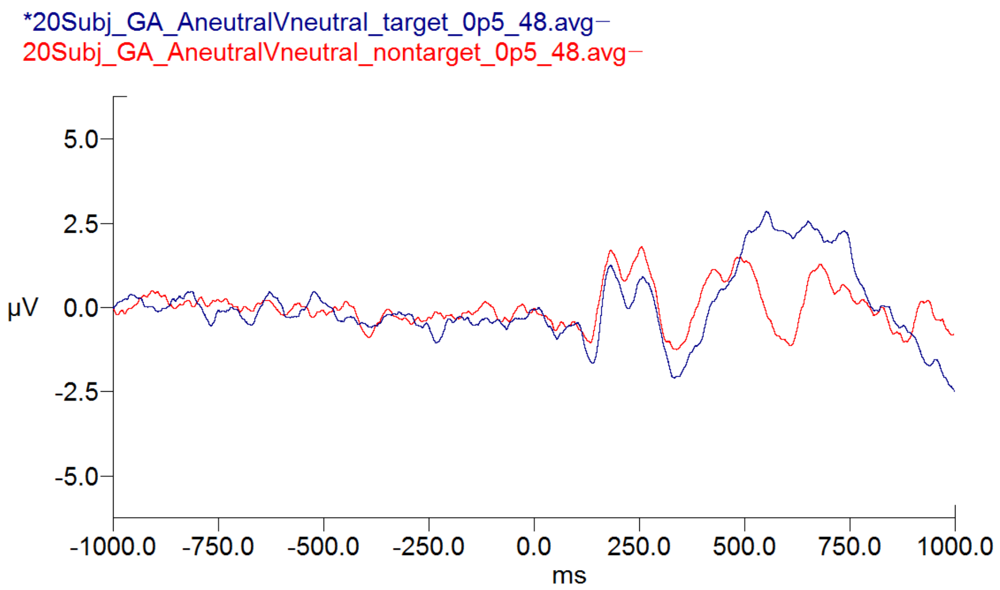

Figure 35 Target and Non-target neutral group grand averages for electrode CZ

According to MANOVA results of electrode, P100 amplitudes (F (1, 32) = 0.002, p>.05) and P100 latencies (F (1, 32) = 0.105, p>.05) were not different between the two stimuli groups.

N100 potential's amplitude, as well as its latency were not different between the target and non-target stimuli groups (F (1, 32) = 1.060, p>.05), (F (1, 32) = 2.285, p>.05) for the amplitude and latency values respectively.

There is no statistical significance among target and non-target groups neither for the P200 potential's amplitude ($F(1, 32) = 0.381$, $p>.05$) nor for the latency ($F(1, 32) = 0.146$, $p>.05$).

There is no statistical significance among target and non-target groups neither for the N200 potential's amplitude ($F(1, 32) = 0.853$, $p>.05$) nor for the latency ($F(1, 32) = 0.008$, $p>.05$).

There is no statistical significance among target and non-target groups for the P300 potential's amplitude ($F(1, 32) = 0.013$, $p>.05$) and for the latency ($F(1, 32) = 0.001$, $p>.05$).

N400 potential's amplitude, as well as its latency were not different between the target and non-target stimuli groups ($F(1, 32) = 2.072$, $p>.05$) for amplitude and ($F(1, 32) = 0.534$, $p>.05$) for the latency.

There is a remarkable statistical significance among target and non-target groups for both the LPC potential's amplitude ($F(1, 32) = 7.416$, $p=0.010<.05$) and the latency ($F(1, 32) = 10.097$, $p=0.003<.05$).

The summary of statistical results is given in Table 5 for ERP amplitudes and Table 6 for ERP latencies.

Table 5 The comparison of two stimuli types for the ERP amplitudes per electrode

ERP amplitude (mVol), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	0.12±1.46	0.10±0.94	F=0.002, p=0.963
N100	-2.66±1.39	-2.21±1.18	F=1.060, p=0.311
P200	2.64±2.4	3.12±2.11	F=0.381, p=0.541
N200	-1.36±1.77	-0.69±2.42	F=0.853, p=0.363
P300	1.94±1.55	2.02±2.24	F=0.013, p=0.909
N400	-3.42±2.05	-2.39±2.11	F=2.072, p=0.160

LPC amplitude	5.44±2.08	3.52±2.02	F=7.416, p=0.01*

SD: Standard Deviation, *:Statistically significant

Table 6 The comparison of two stimuli types for the ERP latencies per electrode

ERP latency (ms), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	96.41±15.448	94.47±19.249	F=0.105, p=0.748
N100	139.41±17.706	127.82±26.18	F=2.285, p=0.140
P200	193.06±34.363	188.35±37.318	F= 0.146, p=0.705
N200	239.41±42.69	240.94±54.53	F= 0.008, p=0.928
P300	294.12±50.017	294.76±55.460	F=0.001, p=0.972
N400	393.88±63.881	376.12±77.277	F=0.534, p=0.470
LPC	**574.47±78.250**	**482.53±90.053**	**F=10.097,p=0.003***

SD: Standard Deviation, *:Statistically significant

4.3. Grand-Average and Statistical Results for Electrode FZ

The ERP signal that is generated from the FZ electrode site is given in figure 36.

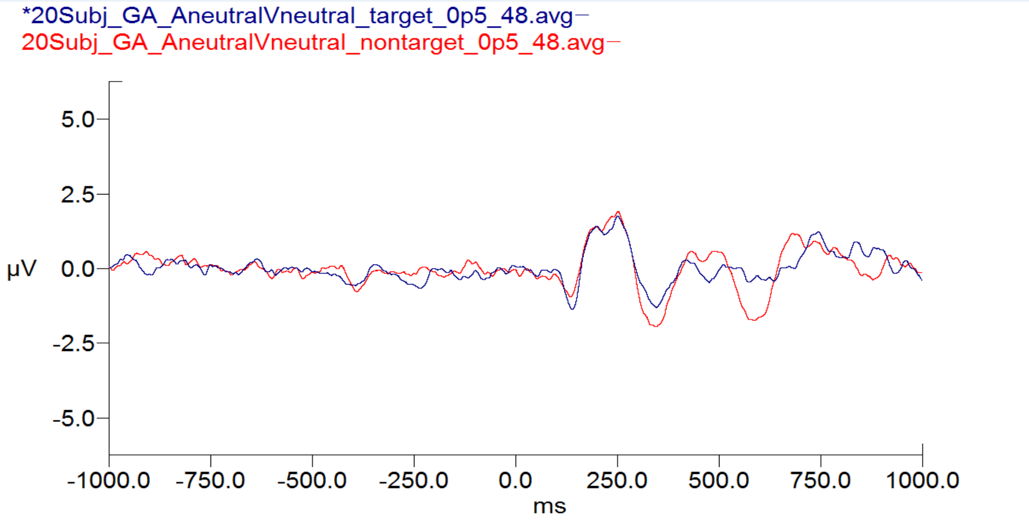

Figure 36 Target and Non-target neutral group grand averages for electrode FZ

According to results of MANOVA, P100 amplitudes ($F(1, 31) = 0.253$, $p>.05$) and P100 latencies groups ($F(1, 31) = 0.027$, $p>.05$) were not different between the two stimuli.

There no statistical significance among target and non-target groups for the N100 potential's amplitude ($F(1, 31) = 1.487$, $p>.05$) and for the latency ($F(1, 31) = 0.09$, $p>.05$).

There is no statistical significance among target and non-target groups neither for the P200 potential's amplitude ($F(1, 31) = 0.016$, $p>.05$) nor for the latency ($F(1, 31) = 0.010$, $p>.05$).

There is no statistical significance among target and non-target groups for the N200 potential's amplitude ($F(1, 31) = 1.919$, $p>.05$) and for the latency ($F(1, 31) = 0$, $p>.05$).

There is no statistical significance among target and non-target groups for the P300 potential's amplitude ($F(1, 31) = 0.023$, $p>.05$) and for the latency $F(1, 31) = 0.994$, $p>.05$).

There is no statistical significance among target and non-target groups for the N400 potential's amplitude ($F(1, 31) = 0.570$, $p>.05$) and for the latency ($F(1, 32) = 1.756$, $p>.05$).

There is no statistical significance among target and non-target groups for the LPC potential's amplitude ($F(1, 31) = 0.071$, $p>.05$) and for the latency ($F(1, 31) = 0.096$, $p>.05$).

The summary of statistical results is given in Table 7 for ERP amplitudes and Table 8 for ERP latencies.

Table 7 The comparison of two stimuli types for the ERP amplitudes per electrode

ERP amplitude (mVol), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	0.38±1.08	0.23±0.53	F=0.253, p=0.619
N100	-1.94±1.33	-1.44±0.98	F=1.487, p=0.232
P200	2.17±1.51	2.1±1.66	F=0.016, p=0.900
N200	-0.66±1.64	-1.55±2.04	F=1.919, p=0.176
P300	2.04±1.90	2.14±1.84	F=0.023 , p=0.881
N400	-2.38±1.66	-2.86±1.92	F=0.570, p=0.456
LPC amplitude	1.95±1.616	2.12±2.19	F= 0.071, p=0.792

SD: Standard Deviation, *:Statistically significant

Table 8 The comparison of two stimuli types for the ERP latencies per electrode

ERP latency (ms), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	93.24±16.502	94.25±19.227	F=0.027, p=0.872
N100	133.06±23.288	130.88±17.914	F=0.09, p=0.766
P200	190.18±32.096	188.88±42.614	F=0.010, p=0.921
N200	251.47±61.155	251.25±73.571	F=0, p=0.993
P300	306.29±58.311	334.37±99.416	F=0.994, p=0.326
N400	385.18±73.366	428.06±110.023	F=1.756, p=0.195
LPC	531.18±100.447	543.06±119.142	F= 0.096, p=0.758

SD: Standard Deviation, *:Statistically significant

4.4. Grand-average and Statistical Results for Electrode OZ

The ERP signal that is generated from the OZ electrode site is given in figure 37.

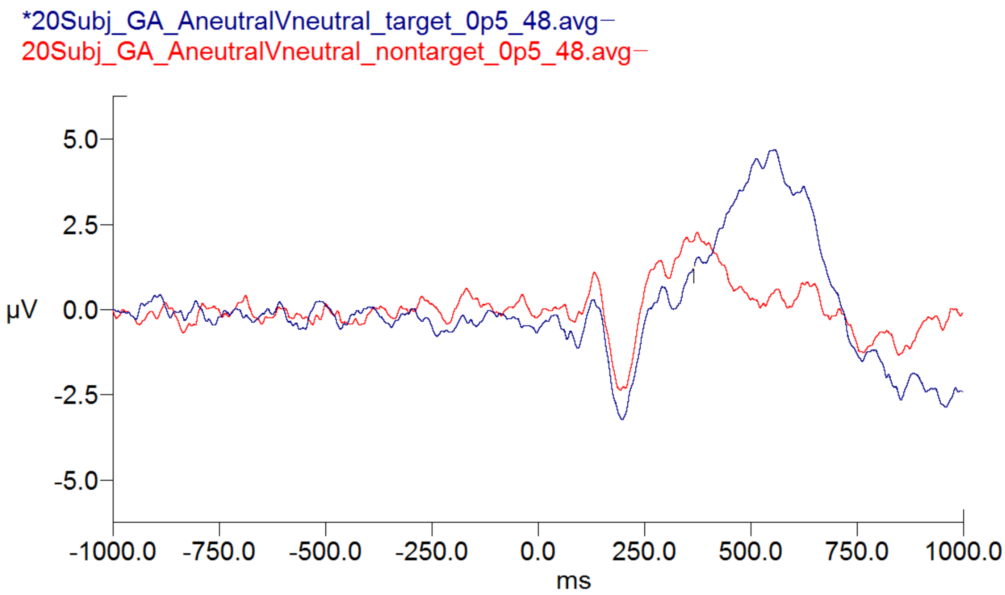

Figure 37 Target and Non-target neutral group grand averages for electrode OZ

According to MANOVA results, the difference among target and non-target groups for the P100 potential's amplitude (F (1, 31) = 3.596, p=0.068>.05) was at the verge of significance at α=0.05 level, but the P100 latency was comparable between the two types of stimuli (F (1, 31) = 0.915, p>.05).

There no statistical significance among target and non-target groups for the N100 potential's amplitude (F (1, 31) = 0.196, p>.05) and for the latency (F (1, 31) = 1.405, p>.05).

P200 potential's amplitude, as well as its latency were not different between the target and non-target stimuli groups (F (1, 31) = 0.286, p>.05), (F (1, 31) = 2.223, p>.05) for the amplitude and latency values respectively.

The difference among target and non-target groups for the N200 potential's amplitude (F (1, 31) = 3.053, p>.05) was at the verge of significance at α=0.05

level, but the N200 latency was comparable between the two types of stimuli (F (1, 31) = 0.169, p>.05).

There is no statistical significance among target and non-target groups for the P300 potential's amplitude (F (1, 31) = 0.452, p>.05) and for the latency F (1, 31) = 0.228, p>.05).

There is no statistical significance among target and non-target groups for the N400 potential's amplitude (F (1, 31) = 0.221, p>.05) and for the latency (F (1, 32) = 0.724, p>.05).

There is a remarkable statistical significance among target and non-target groups for the LPC potential's amplitude (F (1, 31) = 11.328, p=0.002<.05) but the difference among target and non-target groups for the LPC potential's latency (F (1, 31) = 3.618, p=0.067>.05) was just at the verge of significance at α=0.05 level.

The summary of statistical results is given in Table 9 for ERP amplitudes and Table 10 for ERP latencies.

Table 9 The comparison of two stimuli types for the ERP amplitudes per electrode

ERP amplitude (mVol), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	**0.20±1.39**	**1.17±1.52**	**F=3.596, p=0.068**
N100	-1.61±1.27	-1.36±1.94	F=0.196 , p=0.661
P200	1.93±1.95	2.28±1.80	F= 0.286 , p=0.597
N200	**-4.62±2.89**	**-2.82±3.01**	**F=3.053, p=0.09**
P300	2.4±2.38	2.93±2.09	F=0.452, p=0.506
N400	-1.13±2.53	-0.79±1.35	F=0.221, p=0.642
LPC amplitude	**6.34±3.06**	**3.54±1.32**	**F=11.328,p=0.002***

SD: Standard Deviation, *:Statistically significant

Table 10 The comparison of two stimuli types for the ERP latencies per electrode

ERP latency (ms), (mean±SD)	**Target Stimuli**	**Non-target Stimuli**	**MANOVA Statistics**
P100	92.62±23.77	101.94±30.843	F=0.915, p=0.346
N100	114.53±28.289	128.13±37.257	F= 1.405, p=0.245
P200	149.24±34.849	170.44±46.352	F=2.223, p=0.146
N200	210.59±43.255	216.31±36.136	F=0.169, p=0.684
P300	294.65±48.884	286.69±46.838	F=0.228, p=0.637
N400	356.82±46.656	380.25±102.894	F=0.724, p=0.401
LPC	**529.76±80.60**	**463.31±117.74**	**F=3.618, p=0.067**

SD: Standard Deviation, *:Statistically significant

4.5. ERP Measurement Results:

The results that are measured from individual subjects are potential of interest amplitude and latency. The mean amplitude and latency results are shown below for CZ, PZ, FZ and OZ for both target and non-target groups.

4.5.1. Amplitudes

The amplitude values for P100 signals indicate that for the electrode OZ, the mean amplitude of non-target group is marginally significantly larger than targets, for the PZ electrode site, target group responses were mostly non-observable, but assumed through manual intervention as observed from figure 38.

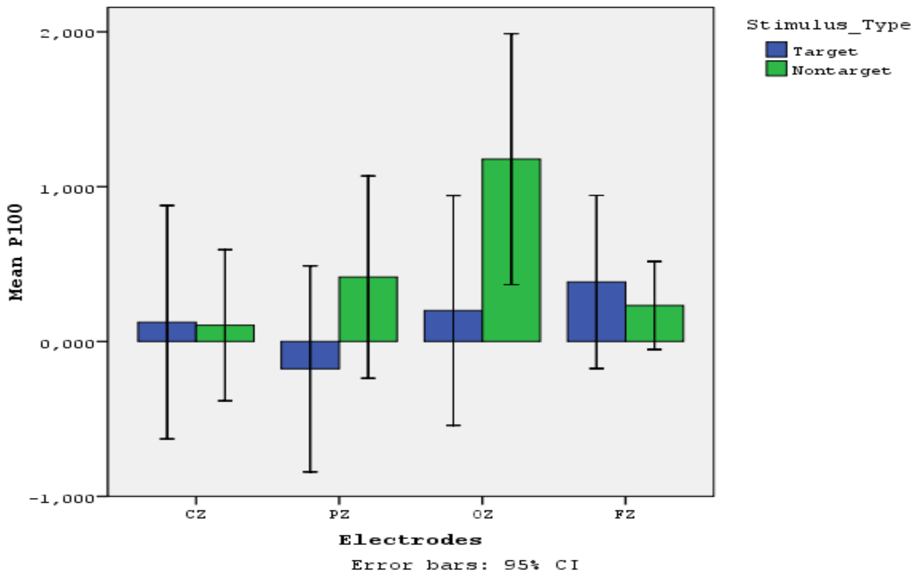

Figure 38 Mean values of P100 amplitude measurements for electrodes CZ, PZ, OZ, FZ

According to the results of the N100 amplitude measurements, for the electrode PZ, the mean amplitude of target group is marginally significantly larger than non-targets, as observed from figure 39.

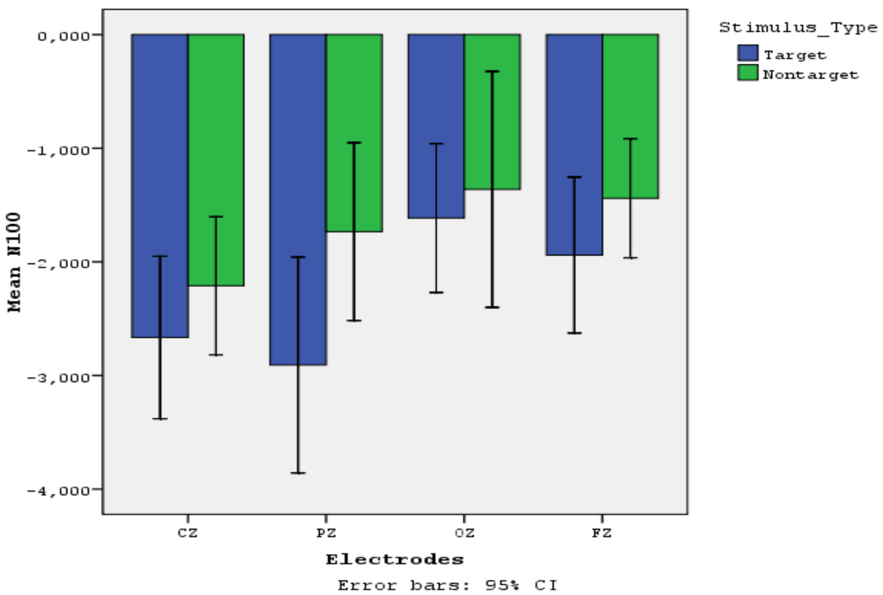

Figure 39 Mean values of N100 amplitude measurements for electrodes CZ, PZ, OZ, FZ

The amplitude values for P200 signals reveal no significant difference across any electrodes between target and non-target groups as observed from figure 40.

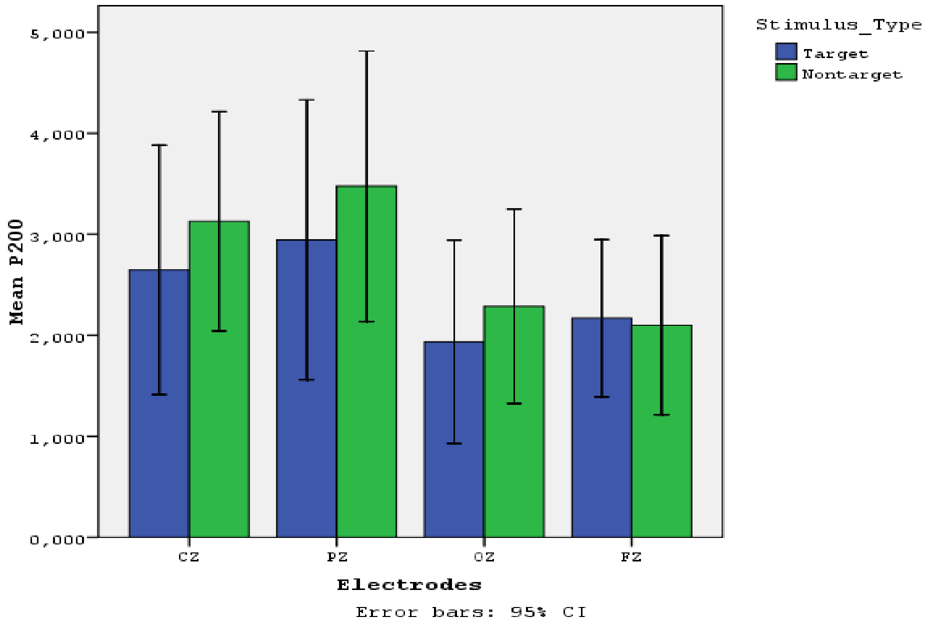

Figure 40 Mean values of P200 amplitude measurements for electrodes CZ, PZ, OZ, FZ

The amplitude values for N200 signals reveal marginally significant difference for OZ between target and non-target groups as observed from figure 41.

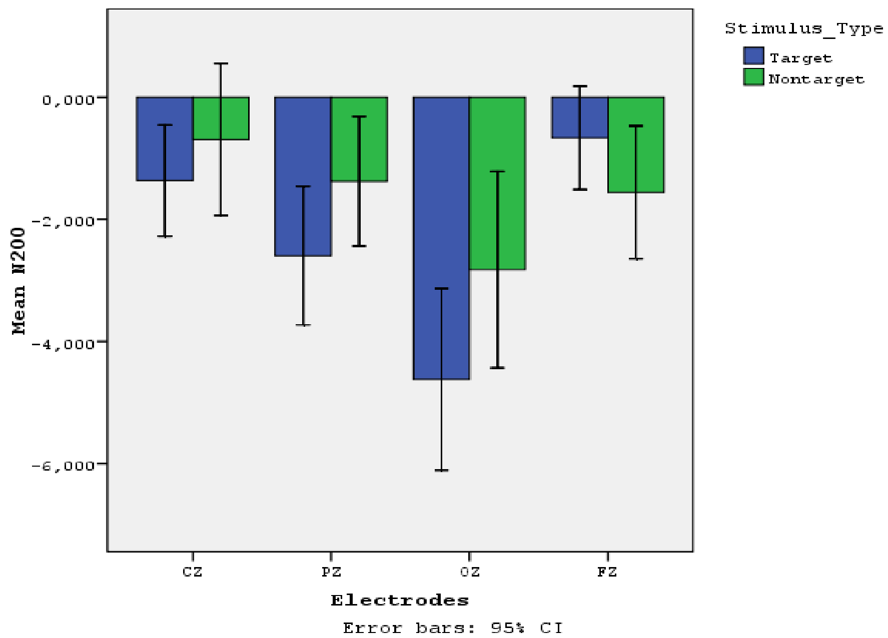

Figure 41 Mean values of N200 amplitude measurements for electrodes CZ, PZ, OZ, FZ

In the case of attention related P300 amplitude values, there was no significant difference between target and non-target groups across any electrodes. Although not significantly different, the maximum amplitudes are obtained on PZ electrode site as expected. Results are shown in Figure 42.

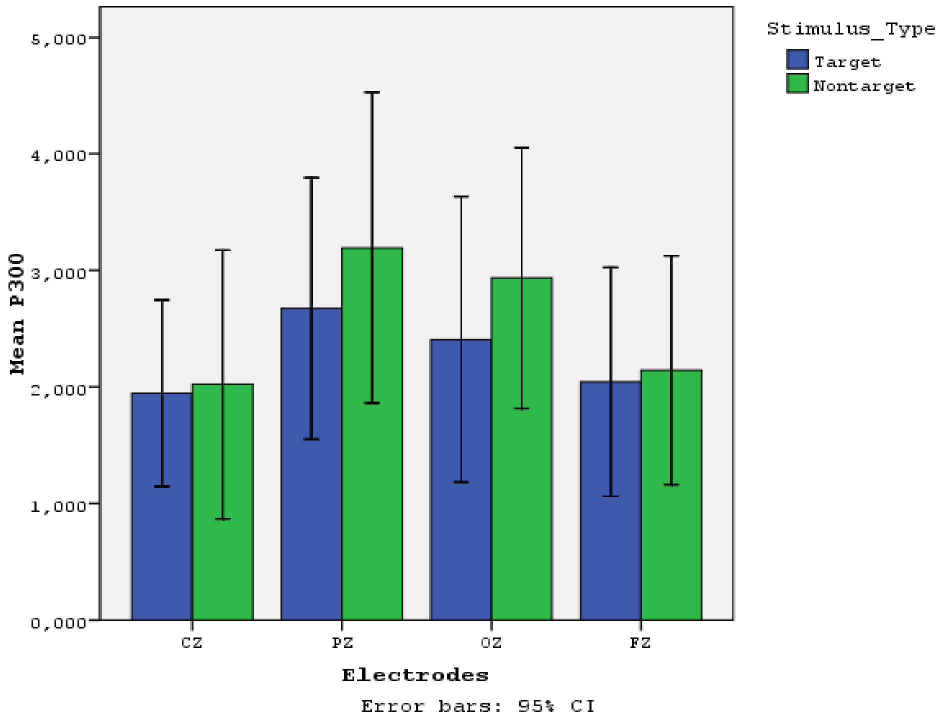

Figure 42 Mean values of P300 amplitude measurements for electrodes CZ, PZ, OZ, FZ

For the language related N400 component, no significant difference was found between target and non-target categories for any electrodes as observed from figure 43.

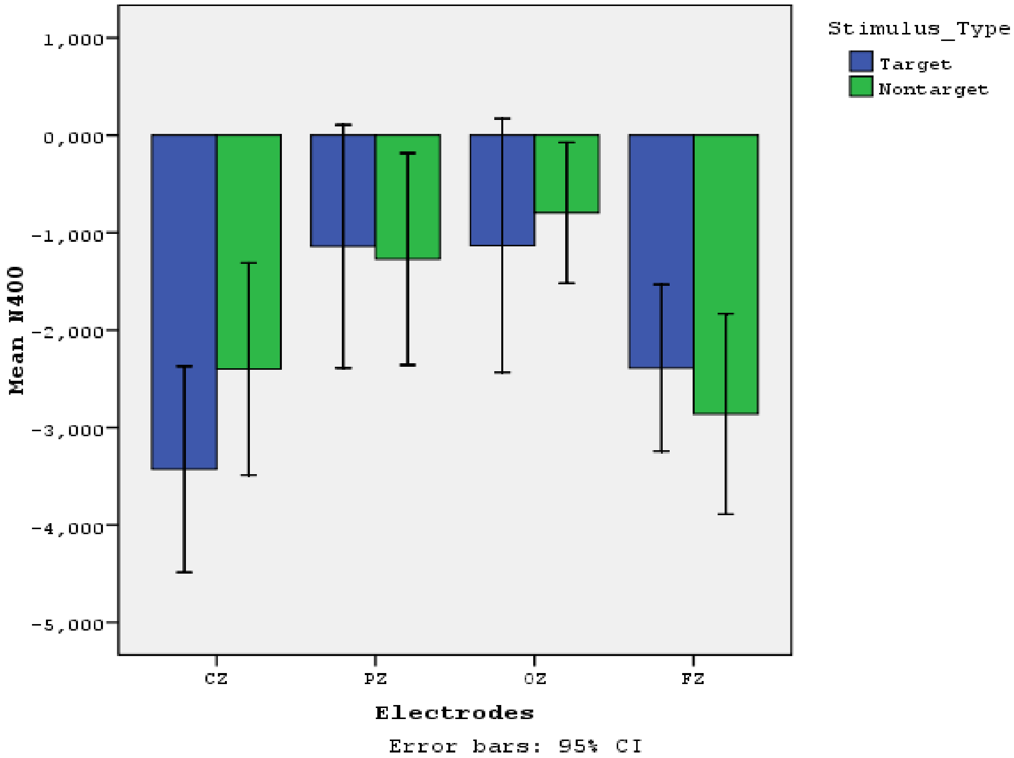

Figure 43 Mean values of N400 amplitude measurements for electrodes CZ, PZ, OZ, FZ

For the LPC which is an indicator of top-down attention mechanism, there is significant difference between target and non-target groups for all electrodes except FZ as observed from figure 44.

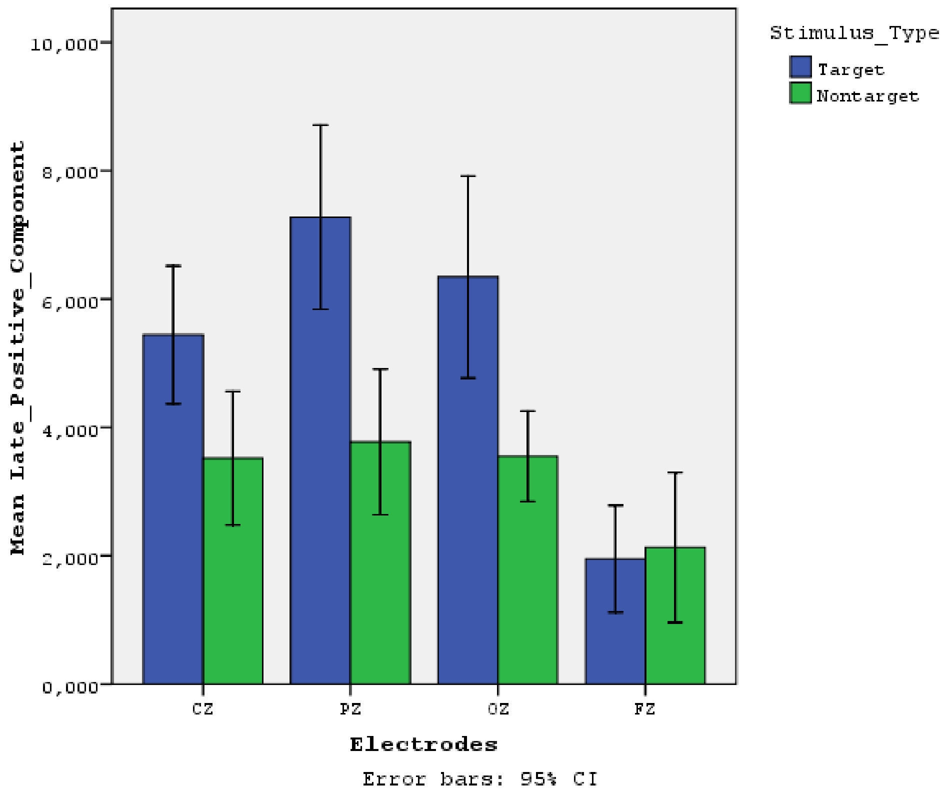

Figure 44 Mean values of LPC amplitude measurements for electrodes CZ, PZ, OZ, FZ

4.5.2. Latency

There is no difference between targets and non-targets for P100 latency including all the electrodes as observed from figure 45.

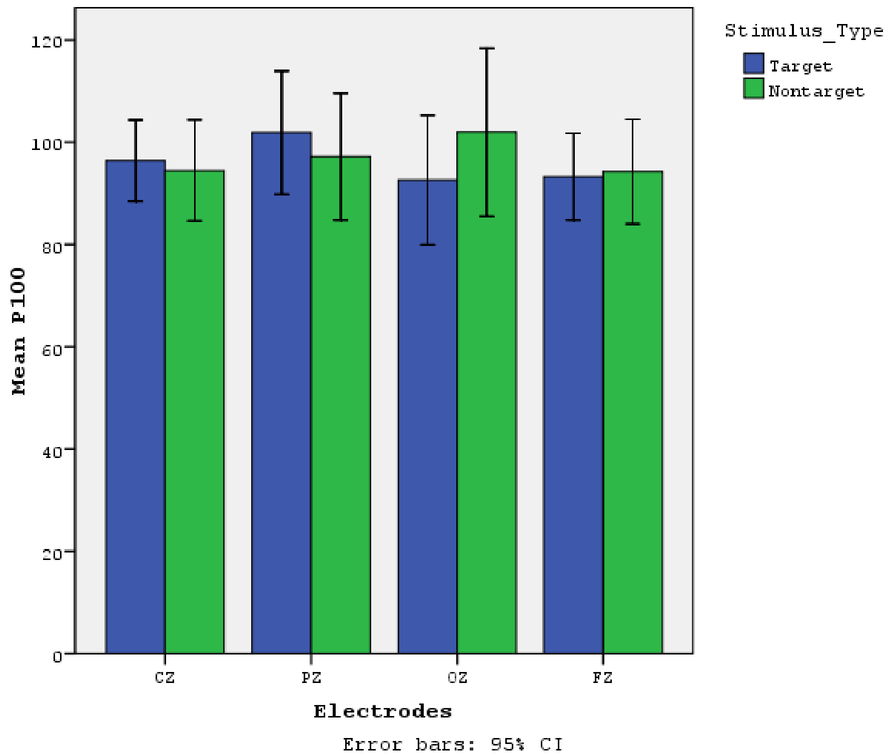

Figure 45 Mean values of P100 latency measurements for electrodes CZ, PZ, OZ, FZ

There is no difference between targets and non-targets for N100 latency including all the electrodes as observed from figure 46.

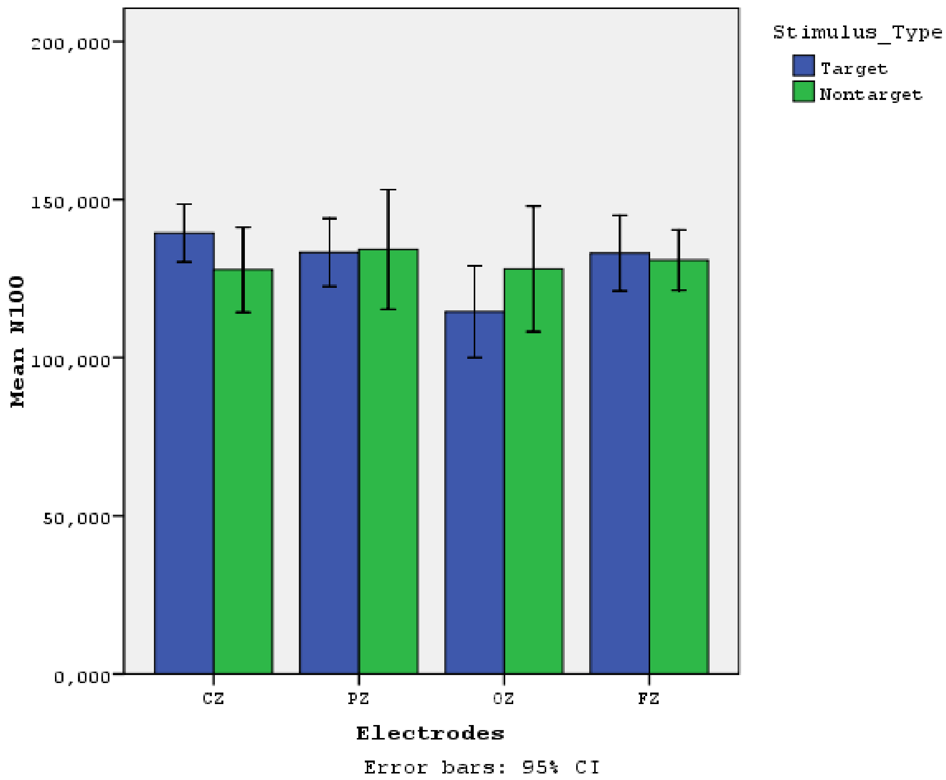

Figure 46 Mean values of N100 latency measurements for electrodes CZ, PZ, OZ, FZ

There is no difference between targets and non-targets for P200 latency including all the electrodes as observed from figure 47.

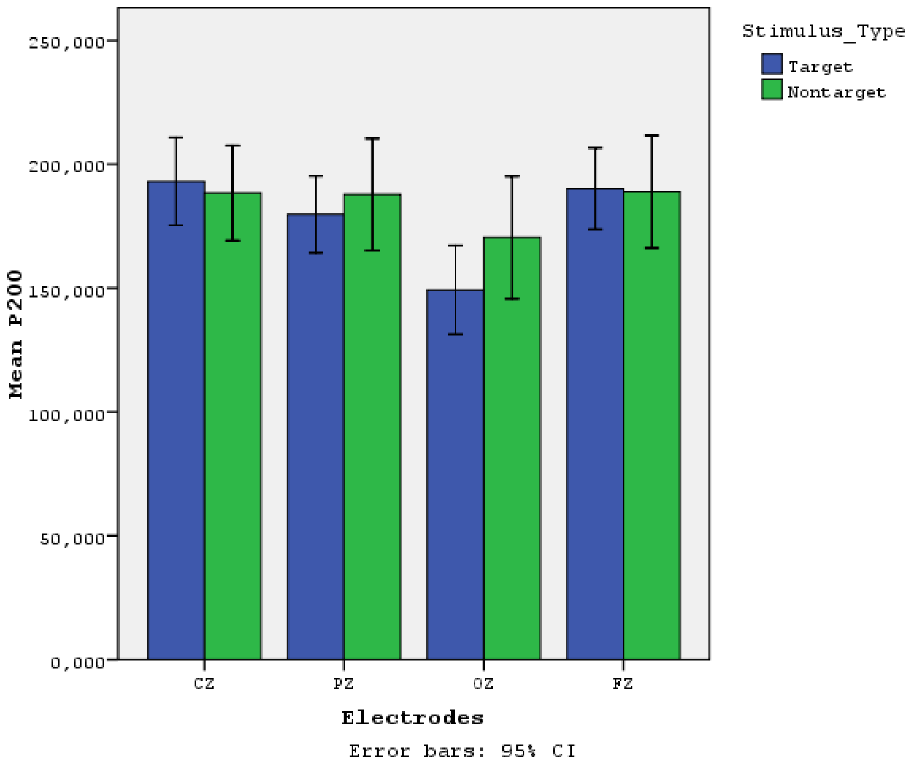

Figure 47 Mean values of P200 latency measurements for electrodes CZ, PZ, OZ, FZ

N200 latency signals do not differ much across electrodes for target versus non-target groups as observed from figure 48.

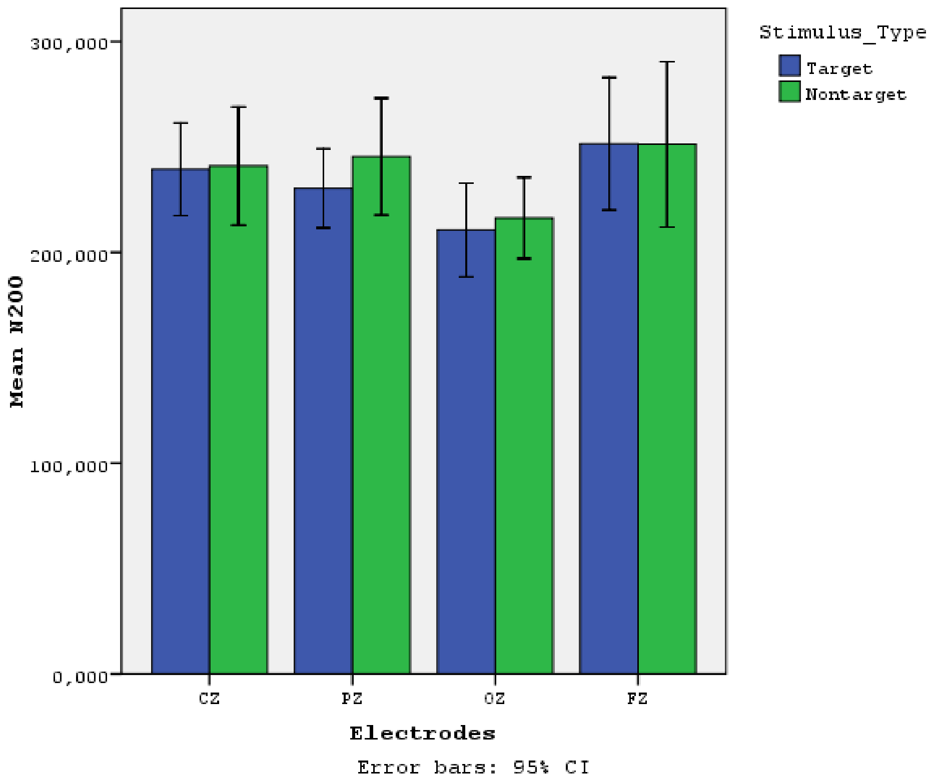

Figure 48 Mean values of N200 latency measurements for electrodes CZ, PZ, OZ, FZ

As the attention grabbing indicator of P300, P300 latency signals do not differ much across electrodes for target versus non-target groups as observed from figure 49.

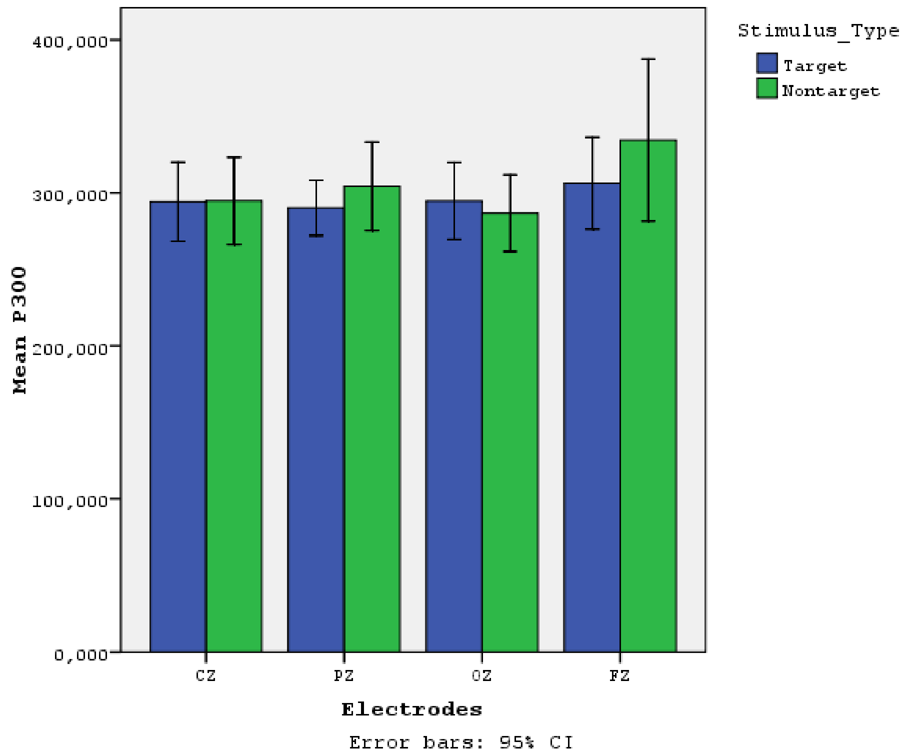

Figure 49 Mean values of P300 latency measurements for electrodes CZ, PZ, OZ, FZ

The latency values for N400 signals indicate no significant difference across electrodes for target versus non-target groups as observed from figure 50.

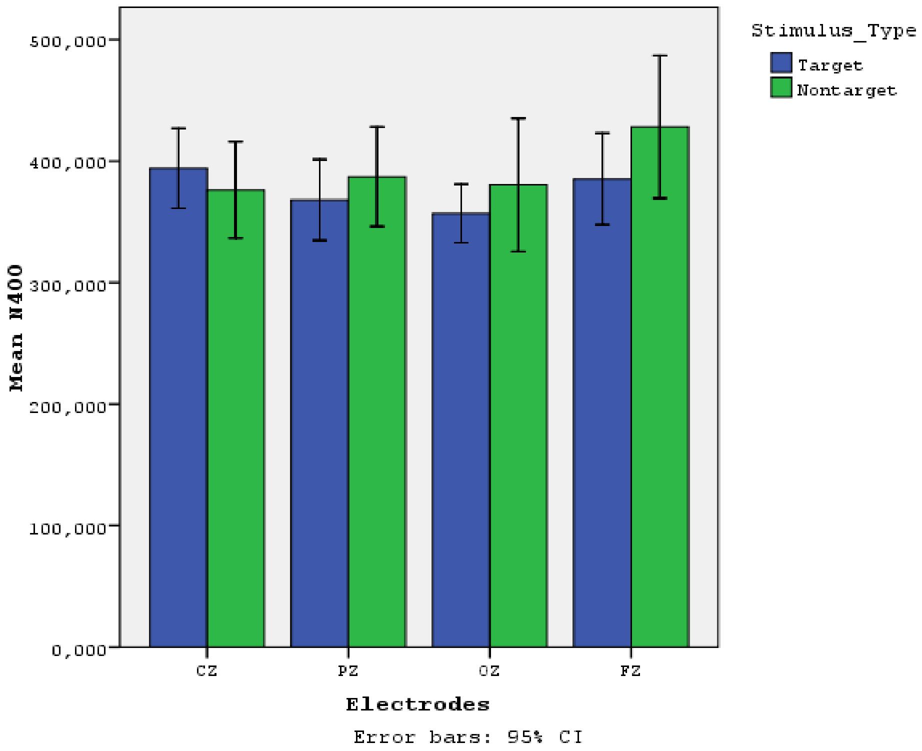

Figure 50 Mean values of N400 latency measurements for electrodes CZ, PZ, OZ, FZ

The latency values for LPC signals indicate that the mean latency of target group is significantly larger than non-targets for the electrode CZ, and marginally significantly larger for OZ as observed from figure 51.

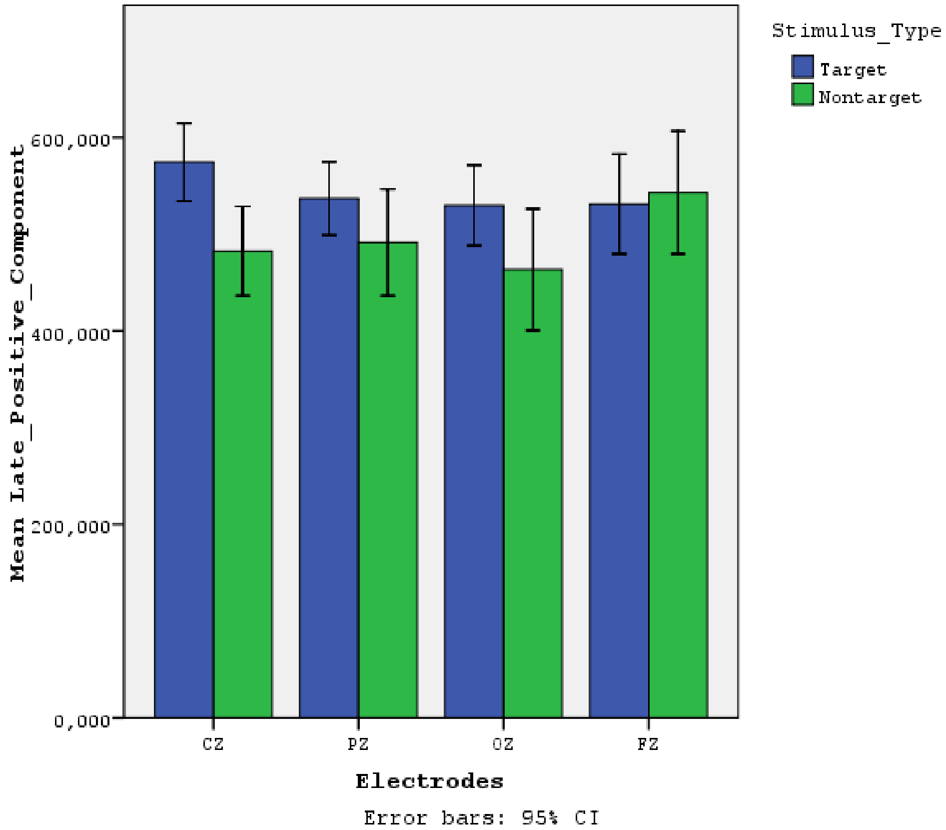

Figure 51 Mean values of LPC latency measurements for electrodes CZ, PZ, OZ, FZ

4.6. Inter-rater Reliability Results

Inter-rater reliability reveals the degree of consensus among human raters. Using inter-rater reliability, we wanted to validate our results on the most significant ERP component for which we observed statistical significance between target and non-target categories. The late positive component is measured by two different raters so as to make an inter-rater reliability analysis. The Pearson correlation coefficient is used as the measurement quantity. The measurements from all electrodes that are grouped according to their category are included to the calculation of Pearson correlation coefficient. As seen in table 11 below, we obtained very strong correlation between the raters for target amplitudes and latencies.

Table 11 Inter-rater reliability results for LPC measurement

	Pearson correlation coefficient (r)	Number of measurement (n)	Probability (p)	Result
Non-target Latency	0.155	57	0.250	no correlation
Non-target Amplitude	0.351	57	0.007	moderate correlation
Target Amplitude	0.983	64	0.000	very strong correlation
Target Latency	0.653	64	0.000	strong correlation

CHAPTER 5

DISCUSSION AND CONCLUSION

Our fundamental finding shows that except for the FZ electrode, LPC amplitude exhibits statistically significant result between meaningful words and word-like non-words. The inter-rater reliability analysis confirms the correctness of our LPC measurements. According to our results on inter-rater reliability, there is a high correlation for target amplitude and latency between 2 raters. In the case of non-target amplitude there is a moderate correlation.

According to our findings, for the potential LPC so called P3b, there is a statistical significance between target and non-target groups for the electrode sites CZ, PZ and OZ. This is replicated in many lexical decision studies (Schacht & Sommer, 2009a; Polich, 1985; Bradley et al., 2006). Moreover, parietal lobe has an important role on word recognition (e.g. words with different format letters, upper and lower case letters) in top-down attentive processes (Braet & Humphreys, 2006; Carretié et al., 2008). According to literature LPC (P3b) is localized in superior parietal lobe and it appears to be minimum at frontal sites (Schacht & Sommer, 2009a; Polich & Criado, 2006; Polich, 2007; Polich & Margala 1997). So this is consistently verified by our result: highest amplitude values are found at electrode PZ for the target group but no statistical significance between target and non-target for the electrode FZ. The top-down attention mechanism is initiated by task requirements given to the subjects as in the case of our experiment. In our experiment subjects were told to discriminate meaningful words from non-words by pressing a button. From the point view of top-down approach, when subjects saw the stimuli, they initially recognize the word and this corresponds to the activation on early ERP components (i.e. N100,P100,N200,P200). Then they make a judgment whether it is meaningful or meaningless, this is related to the late ERP components (P300, N400, LPC). At the time they make such differentiation, as seen from the results the meaningful words captures their attention. Moreover, their attentive resources neurophysiologically present the LPC which is apparently higher for the target group. The source of this activation is the superior parietal lobe (Behrmann, Geng & Shomstein, 2004). Since subjects evaluate the target group, their latencies are delayed due to the complexity involved in word meanings (Kutas & Petten, 1988). The latencies for target group which are longer for electrodes CZ, PZ and OZ – while being marginally significant for the OZ electrode- verify this.

For a few ERP components such as P100, N100, N200 we found marginally significant results. Especially in the case of N200 potential, which is associated with recognition of meaningful stimuli, there is marginally significant difference between target versus non-target categories at the OZ electrode site (Grossi & Coch, 2005; Dien, 2009). This topography is verified with the literature findings which illustrate N200 neuroanatomical correlates located over left temporal and occipital sites (Grossi & Coch, 2005). For the other electrodes, the results do not indicate any statistical significance between target and non-target groups. Although not significant, all amplitude values for the target group are higher than non-target group except the electrode site FZ. Probably, the subjects' evaluation of legitimate words in terms of their familiarity as well as the regularity of orthographic representation is factors in this observed difference (Martín-Loeches, 2007; Martín-Loeches et al., 2002).

Some of the ERP components did not reveal significant difference across target or non-target categories, but it is still important to discuss our findings in reference to P300 and N400 because these ERPs are markers for oddball and semantic processing respectively. As the indicator of oddball paradigm, for the target group (i.e. meaningful words), P300 potential is expected to have much higher latency and amplitudes than non-target group (i.e. non-words). But according to results, for all electrode sites, the non-target group's P300 amplitude is higher than targets. By debriefing the subjects, we concluded that this is due to the subjects' naming effort for non-targets. According to debriefing, although subjects were instructed to respond only to meaningful words, they explained that they tried to reproduce different words from non-words or some of the non-words reminded them different words which have a similar orthographic representation.

Words are expected to have less amplitude than non-words in N400 potential, due to semantic processing. In the literature for the non-words which do not obey traditional language rules (i.e. orthographically and phonologically incorrect letter sequences such ''GHJ'' or orthographically correct and phonologically unpronounceable letters) N400 potential is not elicited (Federmeier & Laszlo, 2009; Coch & Holcomb, 2003). Since the integration functionality of N400 is obsolete for such non-words, phonological processing does not work (Osterhout & Holcomb, 1995). But in our study, we generated the non-words by shuffling the words and in an unprecedented way, some of the non-words turned out to be pronouncable and ortographically regular (e.g. REPEK, ŞIFKO). As a result, these non-words elicited N400 potential as supported with the literature findings of pseudo-words such as GORK (Pulvermüller et al., 2009; Lau, Phillips & Poeppel, 2008; Federmeier & Laszlo, 2009). The amplitude of word-like nonwords often facilitates larger N400 potentials with respect to words because of the difficulty during memory access (Lau, Phillips & Poeppel, 2008; Osterhout & Holcomb, 1995). In theoretical view, since pseudowords mostly resemble words, they are even comprised of regular orthographic and phonological representation like words (e.g. ŞİFKO has common representation with ŞİŞKO) (Federmeier & Laszlo, 2009). Therefore, for the electrode sites, PZ and FZ, our observation that non-targets have higher amplitudes than targets leads to plausible interpretations. This finding is consistent with the literature which explains it as the amplitude of word-like non-words often facilitates larger N400 potentials with respect to words because of the difficulty during memory access (Lau, Phillips & Poeppel, 2008; Osterhout & Holcomb, 1995). Furthermore, for the latency factor of N400, in the literature, non-words are expected to represent longer reaction time as opposed to words (Lau, Phillips & Poeppel, 2008). We observed the same effect, although the difference between our targets and non-targets did not reach significance. Unfortunately having a heterogenous set of non-words confounded our study with respect to our hypothesis regarding the N400 component.

5.1. Limitations of the study:

In this experiment, since non-target stimuli was comprised of orthographically regular and irregular and phonologically pronounceable and unpronounceable words, the differentiation between words and non-words especially in terms of orthographical and phonological components were not clearly detected. The participant population was not homogeneous in terms of being monolingual or bilingual. Some subjects attempted to reproduce words from non-words in a unpredictable way. Overall, although we are certain regarding the word processing effects, the way non-words are processed across individual participants differed variably, making it hard to detect processing differences for non-words.

5.2. Future Work

In the future, to identify the difference between target and non-target categories better, we need faster stimulus presentation. This way non-instructed additional efforts spent by the subjects for non-words will be prohibited.

Non-words should be prepared by standardizing against the orthographic and phonologic representations of the meaningful words. Moreover, the non-words should be more scrambled (e.g. orthographically irregular and phonologically unpronounceable).

In order to obtain a prominent oddball effect for the target group, a single standard stimulus may be used as the standard stimuli instead of several scrambled non-words reproduced from target words.

The participants of the experiment may be chosen by considering some standard test scores (For ex. ALES) so as to reduce the personal variance in word processing. Additionally, if a subject is bilingual then it is more probable that s/he may reproduce a word from non-word, or a non-word may remind a meaningful word to him/her. Consequently, in the future studies monolingual participants may preferable for involvement in the study. The number of participants should be increased so as to improve the marginally significance results of ERP signals. In other words, the results which are at the verge of significance may be enhanced by admitting more subjects to the experiment.

To investigate processing differences between target and non-target groups, behavioral analysis may be done by considering the reaction times of subjects.

To sum up the results of our study, in general there is no statistical significance between target and non-targets in prominent ERP components other than LPC. LPC is an important factor for measuring top-down attention, and we verified that our experiment worked correctly because subjects followed the instructions and by pressing a button when they recognized a legitimate meaningful word, they generated the LPC for CZ, PZ and FZ electrodes. On the other hand as the result of oddball paradigm, all target and non-targets are expected to have P100, N100, P200, N200, P300, N400 and LPC (Polich, 2007; Luck, in press). Based on our electrophysiological results, P100, N100, P200, N200, P300, and N400 were observed consistently during lexical decision, although we did not find significant results for their difference between the target and non-target categories. The complexity of the non-words in our experiment might have resulted in a complex lexical processing of the non-target category, thereby yielding similar effort to target words.

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APPENDICES

APPENDIX A: TUDADEN WORD LIST

Word List

The following word list is constructed from TUDADEN, 24 words from neutral category are chosen. For each category, first word indicates the odd (target) stimuli and other 3 consecutive words indicate the standard stimuli

masa,aesn,aemş,snae

değnek,edhınk,ğlndeı,dhnkeı

çekiç,kedço,çdeok,ekodç

yakıt,yykao,kıibt,kaizt

kemik,knkiı,iıknk,knikı

bagaj,abğej,ajğbe,jaçge

işçi,ioçt,ioşd,şdio

asansör,aspseör,sasnesö,rauşsan

perde,eıpsd,edrır,pseıd

çerçeve,eırdvçe,evsçıçe,ryççeıe

berber,eırsbb,ebcrır,bseıbr

demir,eodsm,diısm,meosd

sandık,daişkn,dlsıen,spıekd

avuç,açüy,uvde,ueçy

ekran,neelr,repek,akıpr

ticaret,irçttıa,csittıa,riçtıta

ilaç,çiem,lide,çmie

metal,tmmaı,lveem,lvmee

tırnak,nlaitr,ıervkn,ksnıte

kamyon,maöznk,aökzmn,mozken

kaya,kzae,kaez,akez

koridor,ooksord,oorlrdo,rldooro

heykel,ekıjyl,yeıjlk,hmeıky

dikiş,idlşo,şifko,şldio

APPENDIX B: ERP MEASUREMENTS

The empty entries were not measured due to some noisy signals. The definitions of entry signals are given below.

P100: Amplitude of P100

LatP100: Latency of P100

N100: Amplitude of N100

LatN100: Latency of N100

P200: Amplitude of P200

LatP200: Latency of P200

N200: Amplitude of N200

LatN200: Latency of N200

P300: Amplitude of P300

LatP3: Latency of P300

N400: Amplitude of N400

LatN4: Latency of N400

LatePos: Amplitude of LPC

Lat LP :Latency of LPC

1. Target Group

CZ:

CZ														
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	0,204	107	-4,436	156	1,154	230	-1,272	264	1,35	307	-1,98	354	5,663	656
4	1,8	107	-0,31	156	0,799	175	-1,31	226	3,857	278	-4,223	505	5,912	660
5														
6	1,86	90	-1,3	135	3,518	182	-1,746	234	2,171	363	-1,561	529	2,696	664
7	1,996	106	-1,176	155	1,808	205	-0,286	234	1,176	259	-4,427	345	3,71	480
8	0,166	79	-3,684	131	4,285	182	-0,568	221	-0,354	227	-8,251	331	7,33	525
9	-1,516	88	-2,482	124	5,829	164	-0,982	205	3,752	259	-1,533	324	7,286	419
10	-0,951	101	-2,786	124	2,712	171	-3,67	221	2,32	293	-0,537	336	4,097	511
11	-0,752	89	-3,514	146	1,825	190	-1,74	237	3,022	278	-4,48	400	7,968	604
12	1,786	106	-4,145	149	2,229	187	-5,472	279	-0,366	387	-2,644	430	4,798	559
13	1,602	125	-3,414	186	2,294	280	-1,883	333	0,929	367	-0,83	412	5,219	541
14	-0,09	101	-3,089	124	4,014	261	-0,61	329	1,687	383	-4,11	477	3,399	698
15	-2,816	79	-4,155	110	5,117	173	-0,545	214	5,081	268	-3,789	322	8,87	561
16	-0,399	76	-2,523	130	3,433	183	-0,109	221	0,906	255	-6,105	360	5,569	696
17	1,284	74	-0,783	136	3,787	203	2,006	230	2,781	268	-3,224	434	3,325	541
18	0,237	125	-1,032	143	5,979	172	0,73	241	2,408	295	-1,454	363	3,59	552
19	-0,161	90	-1,778	128	0,305	174	-1,771	224	-0,375	251	-3,473	409	3,623	573
20	-2,131	96	-4,716	137	-4,054	150	-4	157	2,734	262	-5,669	365	9,449	526

PZ:

PZ													
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	0,764	127	-7,093	170	1,448	202	1,138	260	6,605	311	3,114	374	4,175	660
4	-0,504	105	-0,982	114	0,347	165	-1,426	192	4,998	302	-4,182	530	4,384	658
5														
6	1,372	88	-4,38	135	4,383	182	-5,124	255	1,873	302	-1,928	426	5,381	604
7	0,449	117	0,218	128	0,955	145	0,19	191	1,75	279	-3,484	338	6,034	480
8	-0,704	79	-2,807	119	5,422	180	-1,766	245	-0,204	207	-3,933	320	9,447	509
9			-2,498	97	7,984	160	-6	212	2,567	275	1,483	293	12,827	419
10	-1,872	110	-2,598	133	4,812	171	-4,183	221	3,125	291	0,378	318	9,683	511
11	-0,152	78	-3,267	145	1,496	181	-3,504	235	4,038	289	-3,292	401	9,309	606
12	-2,032	101	-3,731	133	5,15	185	-5,456	273	0,585	338	0,485	396	8,472	541
13	2,24	130	-4,724	184	2,522	282	-2,408	331	1,116	371	-1,833	412	7,487	546
14	-0,206	104	-2,939	124	-0,878	149	-3,373	173	1,675	261	0,053	282	3,491	383
15			-3,804	110	6,034	180	-0,093	223	4,187	282	0,2	322	9,227	554
16	-0,6	61	-3,871	119	3,456	174	-5,497	219	-0,437	273	-2,708	293	4,343	494
17	-0,83	116	-1,762	137	0,12	163	-3,047	210	6,545	275	-3,312	432	6,117	544
18	0,981	127	-0,102	145	6,366	172	-1	235	4,662	293	3,663	345	6,954	494
19	0,03	114	-0,83	141	0,08	172	-2,494	219	1,54	320	-2,703	416	4,613	566
20	-1,587	71	-4,263	132	0,369	193	-0,061	222	0,84	264	-1,397	358	11,715	559

OZ:

OZ													
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	0,437	81	-0,948	92	5,57	120	-10,998	183	4,199	255	2,403	409	2,932	664
4	-0,861	107	-1,497	123	-0,343	139	-1,36	156	1,225	302	-0,617	385	6,248	626
5														
6	1,498	77	-0,348	110	2,401	149	-4,933	257	2,004	297	-3,397	336	5,071	628
7	1,624	137	-2,523	176	1,479	225	-2,075	322	0,521	369	-2,471	399	4,28	538
8	1,325	79	-0,231	88	2,871	104	-4,531	198	-0,065	259	-4,516	315	6,714	428
9	-0,34	84	-0,86	95	1,072	124	-8,22	203	0,683	261	-1,927	286	9,07	417
10	-1,608	119	-1,782	135	4,897	169	-2,924	223	4,456	354	3,065	394	9,434	556
11	-0,361	81	-3,323	143	1,417	181	-3,51	235	4,017	289	-3,072	403	9,317	606
12			-3,192	97	4,007	173	-2,381	239	4,356	342	3,231	381	7,403	538
13	-1,336	81	-1,997	94	4,364	128	-7,355	179	-0,348	356	-2,417	414	5,408	542
14	-0,477	106	-2,613	122	0,684	149	-3,647	223	2,241	315	-0,818	358	2,495	419
15	0,235	122	-3,134	151	1,08	212	-1,428	248	1,257	286	-0,112	320	6,981	529
16	-0,369	72	-2,08	107	1,532	143	-7,285	204	0,01	266	-2,32	318	3,735	495
17	1,894	74	0,2	99	0,646	118	-8,96	199	9,249	275	-4,706	345	1,781	503
18	3,319	130	1,023	152	1,3	168	-1,935	195	2,955	293	2,199	316	7,222	403
19	-0,2	60	-1,418	74	2,12	130	-3,758	184	2,749	324	-1,044	414	5,634	609
20	-1,572	72	-2,716	89	-2,2	105	-3,265	132	1,425	166	-2,731	273	14,106	505

FZ:

FZ														
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	-0,302	105	-3,953	141	2,202	217	-3,581	354	-0,272	398	-4,592	486	3,231	649
4	1,042	107	-1,731	186	-0,043	212	-0,791	224	4,074	293	-3,15	517	2,994	736
5														
6	2,259	104	0,153	135	2,535	182	0,027	293	0,48	322	-0,181	340	1,216	604
7	0,479	95	-0,335	117	1,377	196	0,008	230	0,885	255	-1,99	295	1,959	498
8	0,841	79	-4,258	140	2,34	194	0,989	221	2,224	245	-5,473	336	0,752	493
9	-0,597	83	-2,931	128	3,683	171	2,709	198	5,774	252	-0,357	331	2,271	417
10	-0,302	97	-2,122	144	0,959	171	-2,425	218	2,243	297	0,72	336	2,846	410
11	0,494	94	-1,934	152	2,227	197	-0,871	242	2,506	275	-2,339	394	2,564	591
12	1,108	110	-2,325	149	0,682	189	-2,914	349	0,502	412	-1,12	430	2,59	559
13	0,729	92	-2,569	148	1,699	177	1,23	188	4,731	260	-1,823	345	3,081	508
14	0,018	97	-2,317	124	2,705	209	-1,648	327	0	383	-2,85	532	3,222	716
15	-2,229	79	-2,978	101	2,741	173	-1,353	212	5,385	273	-2,888	333	3,9	412
16	0,369	60	-0,465	87	0,02	105	-1,561	136	2,257	260	-3,469	335	0,495	445
17	2,562	63	0,517	98	5,748	203	-2,096	293	1,988	403	-4,623	470	-2,788	497
18	0,02	121	-1,163	137	3,969	188	0,335	275	0,855	309	-1,215	363	0,328	441
19	0,235	89	-1,95	136	0,688	181	-0,26	208	0,556	250	-2,158	340	1,435	526
20	-0,191	110	-2,633	139	3,365	268	0,873	307	0,545	320	-3,093	365	3,073	528

Rater 2 Measurements for LPC

CZ		
subj no	Late Pos	Lat LP
1	6,479	722
2	6,316	553
3	5,726	659
4	5,916	659
5	6,321	531
6	2,723	663
7	3,725	480
8	7,33	525
9	7,302	419
10	4,118	510
11	7,996	602
12	4,851	557
13	4,837	506
14	3,489	717
15	9,065	557
16	5,575	695
17	3,325	541
18	3,653	551
19	3,656	571
20	9,449	526

PZ		
subj no	Late Pos	Lat LP
1	4,217	557
2	9,516	510
3	4,188	661
4	4,387	656
5	7,585	517
6	5,486	603
7	6,052	478
8	9,508	513
9	12,948	416
10	9,71	510
11	9,339	605
12	8,472	541
13	7,487	546
14	2,166	635
15	9,217	553
16	4,492	642
17	6,134	542
18	7,239	446
19	4,638	563
20	11,734	557

OZ		
subj no	Late Pos	Lat LP
1	3,32	592
2	7,314	552
3	5,661	452
4	6,248	625
5	7,254	621
6	5,071	628
7	4,302	537
8	7,226	513
9	9,094	417
10	9,457	555
11	9,32	604
12	7,43	538
13	5,448	540
14	2,338	634
15	6,988	528
16	3,751	494
17	2,576	625
18	7,293	400
19	5,634	609
20	14,163	503

FZ		
subj no	Late Pos	Lat LP
1	5,938	747
2	1,69	554
3	3,231	649
4	2,704	667
5	3,203	520
6		
7	1,962	496
8	0,776	492
9	2,28	417
10	2,846	411
11		
12	2,633	558
13	3,192	506
14	3,253	714
15	3,514	571
16	3,415	728
17		
18		
19	1,442	524
20	3,079	527

2. Non-Target Group

CZ:

CZ													
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	0,068	105	-3,676	139	3,891	244	0,849	275	4,12	336	-2,957	463	5,312	655
4	0,11	89	-0,425	107	2,958	181	-0,364	226	2,923	251	-0,962	336	4,033	429
5														
6	-0,701	85	-2,438	127	2,783	168	-0,147	228	1,956	302	0,848	318	5,51	441
7	2,268	110	-3,257	148	1,311	193	-2,074	228	2,219	302	-4,99	383	2,185	432
8	-0,682	80	-3,302	114	4,374	175	-5,899	335	1,475	400	-0,84	445	7,94	523
9	0,279	83	-1,906	110	5,781	166	0,045	210	2,9	253	-2,212	311	5,765	483
10	-0,081	101	-2,075	132	3,389	172	-0,958	215	-2,855	269	0,799	311	4,666	400
11	-1,569	105	-1,821	114	2,452	148	0,26	210	2,993	231	-3,049	374	1,115	506
12	1,25	143	-4	193	1,08	235	-5,23	307	-1,72	335	-5,58	358	1,01	441
13	-0,561	99	-1,685	136	1,226	183	-1,132	215	1,832	286	-0,714	336	0,932	373
14	1,058	80	-4,025	157	4,337	275	-1,767	342	1,028	403	-3,046	599	2,241	662
15	-0,623	65	-1,607	78	7,53	188	4,51	213	6,57	259	-3,15	338	3,49	456
16	-0,63	110	-2,95	141	1,002	181	-0,39	210	0,97	248	-5,84	298	5,39	479
17	0,64	81	-0,94	130	2,661	213	-1,187	313	0,59	371	-3,078	468	2,415	624
18	-0,387	87	-2,03	108	6,84	192	2,653	226	3,5	239	0,34	349	2,331	378
19	0,08	114	-1,287	141	0,938	174	-0,54	206	1,079	255	-1,72	367	3,958	512
20	1,26	69	-0,15	98	0,62	114	-0,42	137	4,8	271	-4,617	340	1,55	409

PZ:

PZ														
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	1,176	118	-3,311	183	4,594	251	2,952	275	9,719	336	-2,642	477	3,295	658
4	0,555	119	-1,312	137	2,647	174	-0,108	201	6,404	246	-1,327	403	8,594	669
5														
6	-2,02	90	-4,018	112	3,997	183	-1,287	231	2,839	282	0,662	327	6,011	445
7	2,709	101	-2,22	157	1,47	197	-1,774	268	3,927	304	-1,869	344	2,505	448
8	-0,917	81	-3,373	112	5,634	174	-3,29	304	1,24	391	-2,641	447	4,837	514
9	-0,164	83	-2,036	105	9,481	163	-4,925	215	2,072	257	0,03	291	5,455	349
10	-0,238	78	-1,225	125	6,01	168	-0,73	219	3,551	266	2,892	294	6,688	400
11	1,937	148	-0,523	207	1,578	227	-0,04	264	3,352	330	-0,323	374	1,407	429
12	2,15	145	-4,44	193	1,24	239	-3,24	309	-0,89	335	-4,58	358	3,73	427
13	-0,72	71	-1,279	80	1,67	119	-2,359	221	1,173	293	-1,115	333	1,517	382
14	1,47	99	-3,033	172	2,869	291	0,882	344	5,394	418	-4,981	588	-0,828	665
15	-0,38	92	-0,683	108	7,34	186	-0,56	329	1,24	365	0,89	382	4,606	459
16	-0,59	112	1,32	137	2,29	177	-4,98	221	-0,32	268	-4,07	297	3,591	392
17	1,02	78	-1,545	112	0,93	168	-2,437	195	5,187	280	-1,871	468	2,569	624
18	-0,68	92	-1,397	103	5,81	188	0,51	224	3,74	271	0,88	439	2,7	542
19	0,63	80	-0,28	143	0,841	172	-1,75	215	1,75	335	-0,07	425	3,19	544
20	1,14	65	-0,13	96	0,69	116	-0,285	137	3,94	195	-1,467	333	4,27	407

OZ:

OZ														
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	4,842	128	-6,632	181	5,907	255	-3,461	277	6,75	335	-3,712	479	1,277	557
4	-0,366	121	-1,623	137	3,079	233	1,048	268	2,663	423	-1,644	557	1,489	597
5														
6	0,007	63	-1,175	72	2,4116	159	-2,849	206	1,886	293	-2,086	532	2,462	656
7	2,817	123	-4,819	177	0,348	235	-1,081	266	1,653	302	-0,671	409	2,463	452
8														
9	0,795	87	-0,223	98	3,306	141	-6,725	203	0,559	275	-1,099	288	4,374	342
10	0,033	78	-1,284	121	5,227	168	-0,647	219	5,1	262	1,267	300	4,741	347
11	1,874	148	1,249	161	1,614	179	-0,462	208	1,392	230	-0,084	264	3,351	329
12	2,13	168	-0,92	193	0,62	213	0,01	219	2,52	264	0,24	356	4,44	427
13	-0,05	89	-0,775	98	3,288	134	-4,98	186	1,675	322	-1,308	429	2,569	539
14	1,259	101	-0,11	123	1,42	137	-4,192	219	1,369	293	-0,65	354	4,685	420
15	3,05	130	-2	168	2,66	222	0,98	257	2,38	280	-0,29	316	3,69	360
16	-1,078	81	-1,36	94	1,43	132	-7,77	210	1,62	271	-2,42	298	3,64	400
17	0,85	78	-2,171	127	-1,201	145	-8,796	199	8,328	278	-1,611	542	2,669	631
18	0,52	90	0,26	103	3,302	137	-2,82	206	2,374	260	1,623	278	4,78	333
19	0,28	83	-0,03	105	2,51	132	-2,42	179	3,27	282	0,05	416	4,01	622
20	1,881	63	-0,181	92	0,659	105	-0,99	139	3,418	217	-0,353	266	6,145	401

FZ:

FZ													
subj no	P100	LatP100	N100	Lat N100	P200	LatP200	N200	Lat N200	P300	Lat P3	N400	LatN4	Late Pos	Lat LP
1														
2														
3	0,41	107	-3,298	139	2,936	224	-4,574	349	1,107	401	-4,46	463	5,109	660
4	-0,73	107	-1,023	116	1,567	163	0,792	192	5,632	271	-6,455	570	7,667	673
5														
6	0,048	89	-1,399	125	1,011	168	-0,705	309	3,201	465	-1,633	582	1,624	759
7	0,908	71	-0,931	137	2,373	172	-1,679	222	0,514	260	-2,972	367	1,254	501
8	-0,034	78	-2,269	143	2,598	237	-6,345	336	4,644	523	-2,081	613	3,513	680
9	-0,202	87	-3,299	136	4,013	235	-3,376	311	2,921	443	-4,276	556	2,089	653
10	0,076	103	-1,284	132	1,967	179	-0,33	210	2,019	273	0,842	313	2,917	537
11														
12	0	143	-2,17	161	-1,53	184	-2,32	193	0	235	-3,89	306	-1,6	336
13	1,03	98	-0,613	137	2,445	183	0,13	213	2,262	284	-1,185	349	1,835	434
14	0,02	72	-2,543	154	2,07	280	-2,225	326	1	479	-0,76	541	1,126	636
15	-0,637	98	-0,913	112	3,6	174	1,42	213	3,85	257	-5,167	342	2,22	439
16	0,51	71	-0,285	98	-0,11	116	-2,453	145	1,468	228	-4,69	304	3,27	476
17	1,112	105	-1,106	143	4,492	217	-1,709	315	-0,92	340	-2,862	392	0,252	490
18	0,136	96	-0,73	121	4,51	193	-1,81	344	0,72	382	-0,7	441	0,04	486
19	0,53	110	-1,01	141	1,22	181	0,459	208	1,35	241	-2,07	363	2,796	519
20	0,55	73	-0,177	99	0,44	116	-0,2	134	4,506	268	-3,413	347	-0,05	410

Rater 2 Measurements for LPC

CZ		
subj no	Late Pos	Lat LP
1		
2		
3	0,055	497
4	4,033	429
5	2,341	473
6	-1,207	657
7	1,053	601
8	8,068	519
9	5,832	482
10	1,726	689
11	2,693	662
12		
13	1,292	539
14	2,242	664
15	3,599	454
16	3,089	672
17	2,21	590
18		
19	3,966	513
20	1,542	410

PZ		
subj no	Late Pos	Lat LP
1	1,368	372
2	5,808	511
3	3,295	658
4		
5	2,847	473
6	6,194	443
7	2,505	447
8	4,84	515
9	1,311	590
10	1,642	569
11	2,617	597
12	3,622	555
13	3,272	559
14	5,424	403
15	4,649	456
16	4,501	473
17	2,602	628
18	2,846	569
19	3,197	544
20	0,987	697

OZ		
subj no	Late Pos	Lat LP
1		
2	4,446	500
3	1,305	553
4	1,569	683
5	3,547	653
6	1,377	569
7	2,463	452
8		
9	1,732	527
10	1,472	574
11	2,684	599
12	2,796	561
13	2,625	536
14		
15	1,13	651
16	2,053	618
17	2,675	630
18	2,262	569
19	4,012	622
20		

FZ		
subj no	Late Pos	Lat LP
1		
2		
3	5,125	659
4		
5	0,388	517
6	1,334	675
7	1,254	501
8	4,696	521
9	2,921	444
10		
11		
12		
13	0,528	513
14	1,355	666
15	2,253	445
16	3,174	479
17		
18	0,643	685
19	2,796	519
20	0,539	529

APPENDIX C: ETHICAL COMMITTEE PERMISSION

ÖĞRENCİ İŞLERİ
DAİRESİ BAŞKANLIĞI
Ev. Arş. Md. Saat :

T.C.
DOKUZ EYLÜL ÜNİVERSİTESİ REKTÖRLÜĞÜ
Öğrenci İşleri Daire Başkanlığı

SAYI: B.30.2.DEÜ.0.72.02/504-
KONU: Seda Nilgün DUMLU

06.03.2012* 00377

ORTA DOĞU TEKNİK ÜNİVERSİTESİ REKTÖRLÜĞÜNE
ANKARA

İLGİ: 27.01.2012 tarih B.30.2.ODT.72.00.00-400-423/1108 sayılı yazınız.

Üniversiteniz Sağlık Bilişimi Anabilim Dalı Yüksek Lisans öğrencisi Seda Nilgün DUMLU' nun "Odbal Paradigmasındaki Anlamsal ve Duygusal Etkilerin Olay İlişkili Potansiyeller İle İncelenmesi" başlıklı tez çalışması uygulama isteği Üniversitemiz Tıp Fakültesi Dekanlığınca uygun görülmüştür.

Bilgilerini ve gereğini arz ederim.

Prof. Dr. Mehmet FÜZÜN
Rektör

13.03.12*005064

Cumhuriyet Bulvarı No:144 35210 Alsancak-İzmir/TÜRKİYE
Telefon: +90 (232) 464 81 23 Faks : +90 (232) 412 14 03
e-posta : student@deu.edu.tr Elektronik ağ : www.deu.edu.tr

APPENDIX D: INFORMED CONSENT FORM

“SEYREK UYARAN PARADİGMASINDAKİ HARFLİ UYARAN ETKİLERİN OLAY İLİŞKİLİ POTANSİYELLER İLE İNCELENMESİ”
GÖNÜLLÜ UYGULAMA BİLGİLENDİRME FORMU

Bu çalışmada toplam 30 kişiden toplanacak olan olay ilişkili potansiyeli verisi elektroensefalografi (EEG) yöntemi ile ölçülecektir. EEG beyindeki elektriksel aktivitenin kafa derisine yerleştirilen elektrotlar ile fizyolojik olarak ölçülmesi yöntemidir. Bu ölçüm sırasında katılımcıya iki farklı EEG çekimi uygulanacak olup, birinci çekimde duygusal içerikli ile herhangi bir anlamı olmayan kelimeler, ikinci kısımda ise herhangi bir duygu içeriği olmayan (nötr) kelimeler gösterilecektir. Çekim sırasında katılımcının uyarana olan tepkisi sonucu ortaya çıkan EEG sinyallerinin ortalaması alınarak her uyarana özgü olay ilişkili potansiyeller elde edilecektir. Bu çalışmadaki çekimlerde Türkçede Duygusal Anlamsal ve Değersel Normlar (TUDADEN) kelime setinden farklı kelime kategorileri seçilmiştir. Araştırmada amaç anlamsal olarak düzgün olan kelimelerin yani hedef uyaranların katılımcılarda kendi dikkat mekanizmaları tarafından farkındalık yaratıp yaratmadığını ve bu süreçlerde beyin elektriksel aktivitesindeki değişimi göstermektir. Ayrıca katılımcılara uygulanacak olan ikinci EEG çekiminde herhangi bir duygu içeriği olmayan kelimeler yardımı ile katılımcıların dikkat mekanizmalarının temel göstergesi tespit edilecektir. Tüm araştırmaya katılan kişilerde beyin elektrik aktivitesi, hiçbir ağrılı girişim yapılmadan kaydedilecek olup, sinyal analizi bilgisayar programları ile yapılacaktır. Herhangi bir yan etkisi ya da bireye zararı bulunmayan bu işlem için gerekli masraflar size veya güvencesi altında olduğunuz resmi veya özel hiçbir kurum veya kuruluşa ödetilmeyecektir.

Bu çalışma bilimsel bir çalışma olup, size doğrudan bir fayda sağlamamaktadır. Gönüllü, bu çalışmayı ret etme ya da çekim başladıktan sonra devam etmeme hakkına sahiptir. Araştırmacı da gönüllünün kendi rızasına bakmadan, olguyu araştırma dışı bırakabilir.

Bu araştırmada yer aldığınız süre içerisinde kayıtlarınızın yanı sıra ilişkili sağlık kayıtlarınız ve kişisel bilgileriniz kesinlikle gizli kalacaktır. Bununla birlikte kayıtlarınız kurumun yerel etik komitesine ve Sağlık Bakanlığına açık olacaktır. Çalışma verileri herhangi bir yayın ve raporda kullanılırken isminiz kullanılmayacak ve veriler izlenerek size ulaşılmayacaktır.

Size uygulanacak olan ölçümlerde izlenilecek basamaklar aşağıdaki gibidir:

- Randevu tarihinizde size bildirilen saatte laboratuvarımızda bulunmanız gerekmektedir.
- Öncelikle sizi gürültüden arındırılmış özel bir odaya alacağız.
- Bu odada sizi rahat bir koltuğa oturtacağız. Çekim süresince yalnız olacaksınız. Odada bir mikrofon ile iletişimi sağlayacağız.
- Beyin elektriksel aktivitenizi ölçen kayıt için başınıza ucunda kabloları bulunan özel bir kayıt bonesi takılacak. Düzgün bir şekilde kayıt alabilmek için bonenin deliklerine bir miktar jel sıkılacak. Bu jelin cildinize herhangi bir zararı olmayacak ve suyla kolayca yıkanabilecektir.
- Ek olarak göz kırpmalarınızı kayıt altında tutacağımız iki kablo cildinize zarar vermeyecek şekilde kalıcı olmayan özel bir macunla tutturulacaktır.

- İstediğiniz zaman mikrofon aracılığı ile bizimle iletişim kurabileceksiniz.

- **Toplam beyin aktivitesi kayıt süresi yaklaşık 27 dakikadır. Toplam kalış süreniz anketlerle birlikte yaklaşık 1 saattir.**

- Size uygulanacak olan iki çekimden birincisinde duygusal içerikli kelimeler ile herhangi bir anlamı olmayan kelimeler gösterilecek olup, ikinci çekimde ise herhangi bir duygu içeriği olmayan, yüksüz (nötr) kelimeler gösterilerek beyin elektriksel aktivitenizi ölçen bir kayıt yapacağız.

- Kayıt sonrasında biz sizin bonenizi çıkarıp, kolayca temizlenmenizi sağlayacağız.

Yukarıdaki bilgileri okudum.

<u>Gönüllünün</u>
Adı:
Soyadı:
Tarih:
İmza:

GÖNÜLLÜNÜN BEYANI

Araştırmacı .... tarafından "**Seyrek Uyaran Paradigmasındaki Harfli Uyaran Etkilerin Olay İlişkili Potansiyeller İle İncelenmesi**" isimli bir araştırmanın yapılacağı bana belirtildi. Araştırmanın amacı ve uygulanma biçimi ile riskleri ve tıbbi bilgilerimle ilgili gizliliğin sağlanacağı konusunda yeterli açıklama yapıldı. Araştırma sırasında temas kuracağım telefon numaraları verildi. İstediğim zaman kendisi ile temasa geçebilirim. İstediğim zaman araştırmadan çekilebileceğimi biliyorum. "**Yukarıda gönüllüye araştırmadan önce verilmesi gereken bilgileri okudum. Bunlar hakkında bana yazılı ve sözlü açıklamalar yapıldı. Bu koşullarla söz konusu klinik araştırmaya kendi rızamla, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum**".

Gönüllünün	**Tanığın**
Adı:	Adı:
Soyadı:	Soyadı:
Adresi:	Adresi:
Telefonu:	Telefonu:
Tarih:	Tarih:
İmza:	İmza:

Cekimi yapan
Adı:
Soyadı:
Adresi:
Telefonu:
Tarih:
İmza:

Görüşme tarihi ve saati;

APPENDIX E: OTHER FORMS

Dokuz Eylül Üniversitesi
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Biyofizik Anabilim Dalı

Balçova, 35340, İzmir.
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El Kullanımı Testi

Adı Soyadı:

Yaş :

Cinsiyet :Kadın ( ) Erkek ( )

Sağ veya sol elinizi hangi işlemlerde kullandığınızı bilmek istiyoruz. Lütfen her işlemde kullandığınız ele göre 'sol' veya 'sağ' hanesini işaretleyin. Mesela yazı yazarken, genellikle sağ ama ara sıra sol elinizi kullanıyorsanız, 'sağ' hanesine bir X yapın. Daima sağ elinizi kullanıyorsanız, XX yazın. Diğer soruları aynı şekilde cevaplandırın.

		Sol	Sağ
1	Yazmak		
2	Çizmek		
3	Taş Atmak		
4	Makas kullanmak		
5	Diş fırçası kullanmak		
6	Bıçak kullanmak		
7	Kaşık kullanmak		
8	Süpürge kullanmak (üst el)		
9	Kibrit çakmak		
10	Kutunun kapağını açmak		

$$LQ = \frac{\sum R - \sum L}{\sum R + \sum L} \times 100$$

LQ =

KAYIT BİLGİ FORMU **DEU Protokol No:**………… **Tarih:** …./…./20…
BYF Protokol No:………… **Sayı :** 20…./……

Adı Soyadı: …………………………………………………… **Cinsiyet:** ……..**Yaş:** ……..**Başlama Saati:** …… : …..
Tıbbi Geçmiş: **Kullanılan İlaçlar:**
Sigara (Pasif İçici?): **Alkol:** **Kahve/Çay:** **Şimdi:**
Yemek:
Uyku: **(Önceki gece?):**
Son Mens Tarihi?……/…../……….. **[ ]Düzenli [ ]Düzensiz [ ] Menapoz (OKS?**…………………..**)**
Tansiyon:…….mmHg / …….mmHg
Izole Oda Ortalama Sıcaklığı/Nem (kayıt başı):…..^{0}C …….
Diğer Notlar : **İzole Oda Ortalama Sıcaklığı/Nem(kayıt sonu):**…...^{0}C ……

DENEYSEL KURULUM

EEG Bonesi: Model: [ ] Elektrot No: [ ] Boyut:
Inion-Nasion Mesafesi:……..cm **Kafatası Çevresi:**…….cm
Ölçümler: [ ]BIS [ ] Termal kayıt [ ] Micro EEG [ ]PSG [ ]fNIR [ ] Diğer
(……………………………………….)
Kamera: [ ]Termal Kamera [ ]Standart Kamera

Onemli Notlar: Kişi Görüşü:

Bitiş Saati: …… : ……

Operatör(ler): ………………………………………………………………………………………………………

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Biyofizik Anabilim Dalı
Balçova, 35340, İzmir.
Telefon: 0- 232 412 4481 Faks: 0- 232 412 4489

KİŞİSEL BİLGİ FORMU **Tarih:** ..../......./..........

Adı-Soyadı: ....

1. Doğum Tarihiniz: ....../....../............
2. Cinsiyetiniz ☐ Bayan ☐ Bay
3. Medeni haliniz ☐ Evli ☐ Bekar ☐ Boşanmış
4. Adres : ....
   İlçe .... /İl .... Tel (Ev/İş):......................... Tel (Cep):.........................
   E-mail:..............................
6. Eğitim durumunuz:
   ☐ Okur-yazar değil ☐ İlköğretim ☐ Lise ☐ Üniversite ☐ Lisansüstü
7. En son mezun olduğunuz veya okumakta olduğunuz bölümünüz? (*Lise veya fakülte branşınızı yazınız.*)
   ....
8. Mesleğiniz:
   ☐ Memur ☐ İşçi ☐ Serbest meslek ☐ Öğrenci ☐ Diğer..................
9. Boyunuz:.................... 10. Vücut ağırlığınız:...............

Hastalık öyküsü

11. Geçirmiş olduğunuz önemli hastalık, kaza ve ameliyatlar *(Özellikle ruhsal, nörolojik veya kronik; Hangi tarihte)*:
    1. ....
    2. ....
    3. ....
12. Tedavisini görmekte olduğunuz hastalıklar:

Hastalık Adı:	İlaç Adı:	Doz Miktarı:
....	....	....
....	....	....
....	....	....

13. Soygeçmiş (*Aile üyelerinin geçirmiş olduğu ruhsal, nörolojik ve kronik hastalıklar*):
    ....
    ....

Alışkanlıklar (*sigara/alkol/ madde kullanımı/keyif verici ilaç*):

14. Sigara içiyor musunuz?
    ☐ Evet ☐ Bıraktım ☐ Hayır *(18. soruya geçiniz)*
15. Düzenli olarak sigara içmeye kaç yaşında başladınız?/başlamıştınız? ....
16. Kaç adet sigara içiyorsunuz?/içiyordunuz? Günde............../Haftada................/Ayda.........................

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17. Sigara içmeyi ne kadar zaman önce bıraktınız? ....

18. Düzenli olarak alkol kullanıyor musunuz (Haftada 3 gün ve üstü =Düzenli kullanım)?

□ Evet □ Bıraktım □ Hayır *(22. soruya geçiniz)*

19. Düzenli olarak alkol içmeye kaç yaşında başladınız?/başlamıştınız? ....

20. Alkol kullanım miktarınız nedir? Günde................/Haftada......................./Ayda......................

21. Alkol kullanmayı ne zaman bıraktınız? ....

22. Keyif verici madde kullanıyor musunuz?

□ Evet □ Bıraktım □ Hayır *(26. soruya geçiniz)*

23. Düzenli olarak bu maddeyi içmeye kaç yaşında başladınız?/başlamıştınız? ....

24. Madde kullanım miktarınız nedir? Günde................/Haftada......................./Ayda......................

25. Bu maddeyi içmeyi ne zaman bıraktınız? ....

26. Görme sorununuz var mıdır? □ Evet*(varsa açıklayınız)*:.............................. □ Hayır

27. İşitme sorununuz var mıdır? □ Evet*(varsa açıklayınız)*:.............................. □ Hayır

28. Aşağıda farklı duygusal durumları niteleyen sözcükler bulunmaktadır. Lütfen, her bir sözcüğü okuyarak, aşağıdaki ölçekte anlamları tanımlanmış sayılardan uygun gördüğünüz birini yanındaki boş kutuya yazınız. Şu anda kendinizi nasıl hissettiğinizi, diğer bir deyişle, her bir duyguyu ne ölçüde yaşadığınızı düşünün ve değerlendirmenizi buna göre yapın.

1	2	3	4	5
Çok az yada hiç	Biraz	Orta Düzeyde	Oldukça fazla	Aşırı Derecede

1. Hevesli	
2. Sıkıntılı	
3. Heyecan dolu	
4. Üzgün	
5. Güçlü	
6. Suçlu	
7. Ürkek	
8. Kızgın	
9. Coşkulu	

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10. Onurlu	
11. Huzursuz-Tetikte	
12. Canlı	
13. Kendinden utanan	
14. Şevkli	
15. Gergin	
16. Kararlı-azimli	
17. Ilgi	
18. Sinirli	
19. Aktif	
20. Korkmuş	

Anketimize katıldığınız için teşekkür ederiz.

KAYITLARA GELİRKEN:

- Denemeye katılacağınız günün akşamında alkol veya herhangi bir ilaç kullanmamanız gerekmektedir.
- Saçınızın temiz olması ve yanınızda tarağınızın veya fırçanızın bulunması önemlidir.
- Denemeye geleceğiniz gün karnınızın aç veya aşırı tok olmaması ve en az 2 saat öncesinden çay-kahve-sigara içiminin durdurulması gerekmektedir.
- Herhangi bir endişeniz veya sorunuz olursa bölüm çalışanlarından bilgi edininiz.

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Ad ve Soyad:

Tarih:…../……/200…
Saat:…..:…..

SCL-90-R

Aşağıda zaman zaman herkeste olabilecek yakınma ve sorunların bir listesi vardır. Lütfen her birini dikkatlice okuyunuz. Sonra her bir durumun, bugün de dahil olmak üzere son on beş gün içinde sizi ne ölçüde huzursuz ve tedirgin ettiğini göz önüne alarak, cevap kağıdında belirtilen tanımlamalardan (Hiç / Çok az / Orta derecede / Oldukça fazla / Ileri derecede) uygun olanının (yalnızca bir seçeneğin) altındaki parantez arasına bir (x) işareti koyunuz. Düşüncenizi değiştirirseniz ilk yaptığınızı tamamen silmeyi unutmayınız. Lütfen anlamadığınız bir cümleyle karşılaştığınızda uygulamacıya danışınız.

	Hiç	Çok az	Orta derecede	Oldukça Fazla	İleri derecede
1. Baş ağrısı	( )	( )	( )	( )	( )
2. Sinirlilik ya da içinin titremesi	( )	( )	( )	( )	( )
3. Zihinden atamadığınız, yineleyici, hoşa gitmeyen düşünceler	( )	( )	( )	( )	( )
4. Baygınlık veya baş dönmesi	( )	( )	( )	( )	( )
5. Cinsel arzu ve ilginin kaybı	( )	( )	( )	( )	( )
6. Başkaları tarafından eleştirilme duygusu	( )	( )	( )	( )	( )
7. Herhangi bir kimsenin düşüncelerimizi kontrol edebilecegi fikri	( )	( )	( )	( )	( )
8. Sorunlarınızdan pek çoğu için başkalarının suçlanması gerektiği duygusu	( )	( )	( )	( )	( )
9. Olayları anımsamada güçlük	( )	( )	( )	( )	( )
10. Dikkatsizlik veya sakarlıkla ilgili endişeler	( )	( )	( )	( )	( )
11. Kolayca gücenme, rahatsız olma hissi	( )	( )	( )	( )	( )
12. Göğüs veya kalp bölgesinde ağrılar	( )	( )	( )	( )	( )
13. Caddelerde veya açık alanlarda korku hissi	( )	( )	( )	( )	( )
14. Enerjinizde azalma veya yavaşlama hali	( )	( )	( )	( )	( )
15. Yaşamınızın sonlanması düşünceleri	( )	( )	( )	( )	( )
16. Başka kişilerin duymadıkları sesleri duyma	( )	( )	( )	( )	( )
17. Titreme	( )	( )	( )	( )	( )
18. Çoğu kişiye güvenilmemesi gerektiği hissi	( )	( )	( )	( )	( )
19. İştah azalması	( )	( )	( )	( )	( )
20. Kolayca ağlama	( )	( )	( )	( )	( )
21. Karşı cinsten kişilerle utangaçlık ve rahatsızlık hissi	( )	( )	( )	( )	( )
22. Tuzaga düşürülmüş veya yakalanmış olma hissi	( )	( )	( )	( )	( )
23. Bir neden olmaksızın aniden korkuya kapılma	( )	( )	( )	( )	( )
24. Kontrol edilemeyen öfke patlamaları	( )	( )	( )	( )	( )
25. Evden dışarı yalnız çıkma korkusu	( )	( )	( )	( )	( )
26. Olanlar için kendisini suçlama	( )	( )	( )	( )	( )

	Hiç	Çok az	Orta derecede	Oldukça Fazla	İleri derecede
27. Belin alt kısmında ağrılar	( )	( )	( )	( )	( )
28. İşlerin yapılmasında erteleme duygusu	( )	( )	( )	( )	( )
29. Yalnızlık hissi	( )	( )	( )	( )	( )
30. Karamsarlık hissi	( )	( )	( )	( )	( )
31. Her şey için çok fazla endişe duyma	( )	( )	( )	( )	( )
32. Her şeye karşı ilgisizlik hali	( )	( )	( )	( )	( )
33. Korku hissi	( )	( )	( )	( )	( )
34. Duygularınızın kolayca incitilebilmesi hali	( )	( )	( )	( )	( )
35. Diğer insanların sizin özel düşüncelerinizi bilmesi	( )	( )	( )	( )	( )
36. Başkalarının sizi anlamadığı veya hissedemeyecegi duygusu	( )	( )	( )	( )	( )
37. Başkalarının sizi sevmediği ya da dostça olmayan davranışlar gösterdiği hissi	( )	( )	( )	( )	( )
38. İşlerin doğru yapıldığından emin olabilmek için çok yavaş yapma	( )	( )	( )	( )	( )
39. Kalbin çok hızlı çarpması	( )	( )	( )	( )	( )
40. Bulantı veya midede rahatsızlık hissi	( )	( )	( )	( )	( )
41. Kendini başkalarından aşağı görme	( )	( )	( )	( )	( )
42. Adale (kas) ağrıları	( )	( )	( )	( )	( )
43. Başkalarının sizi gözlediği veya hakkınızda konuştuğu hissi	( )	( )	( )	( )	( )
44. Uykuya dalmada güçlük	( )	( )	( )	( )	( )
45. Yaptığınız işleri bir ya da birkaç kez kontrol etme	( )	( )	( )	( )	( )
46. Karar vermede güçlük	( )	( )	( )	( )	( )
47. Otobüs, tren, metro gibi araçlarla yolculuk etme korkusu	( )	( )	( )	( )	( )
48. Nefes almada güçlük	( )	( )	( )	( )	( )
49. Soğuk veya sıcak basması	( )	( )	( )	( )	( )
50. Sizi korkutan belirli uğraş, yer ve nesnelerden kaçınma durumu	( )	( )	( )	( )	( )
51. Hiçbir şey düşünmeme hali	( )	( )	( )	( )	( )
52. Bedeninizin bazı kısımlarında uyuşma, karıncalanma olması	( )	( )	( )	( )	( )
53. Boğazınıza bir yumru tıkanmış olma hissi	( )	( )	( )	( )	( )
54. Gelecek konusunda ümitsizlik	( )	( )	( )	( )	( )
55. Düşüncelerinizi bir konuya yoğunlaştırmada güçlük	( )	( )	( )	( )	( )
56. Bedeninizin çeşitli kısımlarında zayıflık hissi	( )	( )	( )	( )	( )
57. Gerginlik veya coşku hissi	( )	( )	( )	( )	( )
58. Kol ve bacaklarda ağırlık hissi	( )	( )	( )	( )	( )
59. Ölüm ya da ölme düşünceleri	( )	( )	( )	( )	( )
60. Aşırı yemek yeme	( )	( )	( )	( )	( )

	Hiç	Çok az	Orta derecede	Oldukça Fazla	İleri derecede
61. İnsanlar size baktığı veya hakkınızda konuştuğu zaman rahatsızlık duyma	( )	( )	( )	( )	( )
62. Size ait olmayan düşüncelere sahip olma	( )	( )	( )	( )	( )
63. Bir başkasına vurmak, zarar vermek, yaralamak dürtülerinin olması	( )	( )	( )	( )	( )
64. Sabahın erken saatlerindeuyanma	( )	( )	( )	( )	( )
65. Yıkanma,sayma,dokunma gibi bazı hareketleri yineleme hali	( )	( )	( )	( )	( )
66. Uykuda huzursuzluk rahat uyuyamama	( )	( )	( )	( )	( )
67. Bazı şeyleri kırıp dökme isteği	( )	( )	( )	( )	( )
68. Başkalarının paylaşıp Kabul etmediği inanç ve düşüncelerin olması	( )	( )	( )	( )	( )
69. Başkalarının yanında kendini çok sıkılgan hissetme	( )	( )	( )	( )	( )
70. Çarşı, sinema gibi kalabalık yerlerde rahatsızlık hissi	( )	( )	( )	( )	( )
71. Her şeyin bir yük gibi görünmesi	( )	( )	( )	( )	( )
72. Dehşet ve panik nöbetleri	( )	( )	( )	( )	( )
73. Toplum içinde yiyip-içerken huzursuzluk hissi	( )	( )	( )	( )	( )
74. Sık sık tartışmaya girme	( )	( )	( )	( )	( )
75. Yalnız bırakıldığında sinirlilik hali	( )	( )	( )	( )	( )
76. Başkalarının sizi başarılarınız için yeterince takdir etmediği duygusu	( )	( )	( )	( )	( )
77. Başkalarıyla birlikte olunan durumlarda bile yalnızlık hissetme	( )	( )	( )	( )	( )
78. Yerinizde duramayacak ölçüde huzursuzluk duyma	( )	( )	( )	( )	( )
79. Değersizlik duygusu	( )	( )	( )	( )	( )
80. Size kötü bir şey olacakmış duygusu	( )	( )	( )	( )	( )
81. Bağırma ya da eşyaları fırlatma	( )	( )	( )	( )	( )
82. Topluluk içinde bayılacağınız korkusu	( )	( )	( )	( )	( )
83. Eğer izin verirseniz insanların sizi sömürecegi duygusu	( )	( )	( )	( )	( )
84. Cinsiyet konusunda sizi çok rahatsız eden düşüncelerin olması	( )	( )	( )	( )	( )
85. Günahlarınızdan dolayı cezalandırılmanız gerektiği düşüncesi	( )	( )	( )	( )	( )
86. Korkutucu türden düşünce ve hayaller	( )	( )	( )	( )	( )
87. Bedeninizin ciddi bir rahatsızlık olduğu düşüncesi	( )	( )	( )	( )	( )
88. Başka bir kişiye asla yakınlık duyamama	( )	( )	( )	( )	( )
89. Suçluluk duygusu	( )	( )	( )	( )	( )
90. Aklınızda bir bozukluğun olduğu düşüncesi	( )	( )	( )	( )	( )

Not:

APPENDIX F: DEFINITIONS OF TERMS

Event Related Potentials(ERP): An ERP is a pattern of brain electrical activity that occurs in response to a particular stimulus event (such as speech) and can be time-locked to that stimulus event (Fabiani, Gratton & Coles, 2000).

Electroencephalography (EEG): Electroencephalography comprises as a result of placing electrodes to the scalp and connecting these electrodes to the amplifier. As an output of the amplifier there is the pattern of voltage variation over time. This is called as electroencephalogram (EEG) (Purves, 2004).

EOG: It is a technique for measuring the resting potential of the retina,namely the eye movements. The resulting signal is called the electrooculogram ("Electrooculography," 2011).

N400: It is the negative peak occurs 400 millisecond (ms) after the stimulus onset.

P300: It is the positive peak occurs 300 millisecond (ms) after the stimulus onset.

Sensory Stimuli: It is a kind of stimuli which is given by sensory information such as pressure, touch, and pain.

Motor Stimuli: Stimuli that is related to motor functions such as regulating movements.

Cognitive Stimuli: A stimulus is related to mental information processing such as counting numbers.

Semantic Incongruity: Sentences which do not have meaningfully appropriate words, in other words, if the semantically correct sentence is 'I like sugar and cream with coffee', the semantically incongruent version of this sentence is 'I like sugar and cream with shoes' (Kutas & Hillyard, 1980).

Syntactic Incongruity: it is based on the appearance of the word structures, for instance while syntactically congruent word is 'shoes', syntactically incongruent 'shoes' with a bigger font.

Oddball Paradigm: In oddball paradigm, a series of events are presented of which one class is rarer than the other. Subjects are asked to count the number of rarer stimuli and keep its number in mind or react the stimulus by a button press response (Polich & Margala, 1997).

Verbal Oddball Paradigm: Oddball paradigm whose stimulus are words.

TUDADEN: TÜDADEN is constructed for creating affective word norm database whose function equals to Affective Norms for English Words (ANEW) (Gökçay & Smith, 2008). It is based on arousal and valence dimensions. It is created by participant's feelings towards Turkish emotional words and each participant voted words between 1 to 9 point scales.

Neurons : They are cells that transfers electrical and chemical information by signals ("Neuron," 2011).

Scalp: The most outer layer of the brain.

Words: orthographically correct and phonologically regular, meaningful items of lexicon.

Pseudo words: pronounceable non-words;letter of strings which resembles words, but not word (for example, 'blick' but not 'lbikc'). (Lau, Phillips & Poeppel,2008).

Non-words: consonant strings (e.g. 'kjjhj' or 'klkluk')

TEZ FOTOKOPİ İZİN FORMU

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YAZARIN

Soyadı : DUMLU

Adı : SEDA NİLGÜN

Bölümü : SAĞLIK BİLİŞİMİ

TEZİN ADI (İngilizce) : **INVESTIGATION OF SEMANTIC EFFECTS IN ODDBALL PARADIGM THROUGH EVENT RELATED POTENTIALS**

TEZİN TÜRÜ : Yüksek Lisans [X] Doktora [ ]

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. [ ]

2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) [X]

3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐

Yazarın imzası .... Tarih ....