2015-01-01

Behavioral And Electrophysiologic Performance In Participants With No Brain Damage Responding To Spoken Sentence Length Messages With Pauses Of Different Durations Inserted Withi The Spoken Message: A Pilot Study

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BEHAVIORAL AND ELECTROPHYSIOLOGIC PERFORMANCE IN PARTICIPANTS WITH NO BRAIN DAMAGE RESPONDING TO SPOKEN SENTENCE LENGTH MESSAGES WITH PAUSES OF DIFFERENT DURATIONS INSERTED WITHI THE SPOKEN MESSAGE: A PILOT STUDY

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THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

Program in Speech Language Pathology

THE UNIVERSITY OF TEXAS AT EL PASO

May 2015

Abstract

Aim: The purpose of this pilot study was to examine the behavioral and electrophysiologic performance in two age groups of individuals with no history of brain damage responding to spoken sentence length messages with pauses of different durations inserted within the message with the use of Event-Related Potentials.

Pilot Study**:** A modified version of the Revised Token Test was used for the experimental task. All participants have not experienced any brain damage. The first group of adult participants consisted of three college age adults; ages 20-30 and the second consisted of three older adults, ages 50-60. Participants were randomly assigned to participate in a modified version of the RTT that contained pauses within the command of one, two, or three-second duration.

Hypothesis: It is hypothesized that:

1) The 2-second pause duration will result in a highest response accuracy rate in young and old participants.

2) There will be no difference in peak latency and amplitude of the N400 ERP component between the young and old participants.

3) The college age participants would demonstrate higher response accuracy compared to the older participants.

4) The college age participants would demonstrate decreased physical reaction time when compared to the older young participants.

Results: The one and two-second pause time groups had comparable rates in percentages of correct responses but overall the one-second-pause time showed a higher percentage of correct responses with a decreased reaction time for both sets of participants. It was hypothesized that the college age participants as a whole would produce a higher percent of correct responses with

a decreased reaction time compared to the older participants. The results showed that this was true for the for the 1 and 2 second conditions but not for the three-second condition. It was hypothesized that there would be no difference between the groups in the electrophysiological measures, since all participants were participants with no brain damage. While individual differences were observed, all but two of the participants showed an N400 ERP component with the peak occurring between 350-650 ms after the onset of the auditory command.

***Discussion*:** The current pilot study shows that individuals are highly variable in the way they process auditory information. The one-second-pause condition resulted in increased correct response rates and shorter reaction times for both college age and old participants. In addition, old participants with no brain damage performed similar to their college age counterparts.

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Chapter 1: Introduction

Trying to understand how individuals that suffer from brain injuries recover continues to be a topic of vigorous study in order to determine the best treatment techniques. The purpose of this pilot study is to compare the behavioral and electrophysiologic activity in healthy adult participants responding to spoken sentence length messages that contained pauses of different durations inserted within the auditory message. The information gained from this study serves as a framework for future research that can be conducted with a larger sample size of participants with no brain damage and broaden, to include individuals that suffer from aphasia.

This chapter will discuss the background and content outlining this study, followed by the statement of the problem, the purpose of the study, the research questions, hypothesis, and significance of the study.

1.1 Background and Content

Auditory comprehension, the brain's ability to perceive and interpret information, is the basis for the development of language (Loraine, 2010). Therefore it is crucial to understand the mechanisms that underlie this process. Auditory comprehension in individuals that have no prior history of brain damage has been studied extensively with the use of neuroimaging techniques, specifically with the use of Functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), and Event-Related Potentials (ERP) to gain a better understanding of the mechanisms that underlie the processes of auditory comprehension (Handy, 2005). Studies on individuals with no history of brain damage are done in order to identify differences in individuals with brain damage.

fMRI measures the oxygen levels in red blood cells that are produced in response to an increase in brain activity. PET measures functional activity produced in the brain in response to a stimulus using radioactive tracer isotopes that are injected directly into the bloodstream (Baily, 2005). As such, fMRI and PET have excellent spatial resolution that allows us to determine the anatomical areas responsible for a cognitive process. ERP measures electrical activity that the brain produces in response to a stimulus using a skullcap with electrodes attached. Therefore it measures electrical activity at the cortical level. As a result, ERP provides information about the area responsible for a cognitive process relative to electrode placement. However, ERP can be time-locked to a specific event providing excellent spatial resolution. As a result, ERP is the logical choice for this study, as it will provide real time information.

The human brain has the capacity for continuously changing its structure and its function throughout a person's lifetime. This is referred to as brain plasticity. It is important to understand how the brain reorganizes its neural pathways after damage occurs, because improved understanding has the potential to assist with the development of improved treatment techniques for individuals with brain damage. However, studies on normal individuals need to be completed first so that we can identify aberrant patterns.

Kolb (1995) discusses how the capacity to change the brain's structure and function in response to experiences, provides the nervous system with the ability to learn and remember information that is presented to the brain. The brain constantly goes through changes. Some experimental changes are "definite, such as when we acquire new knowledge, while some changes are more subtle, such as perceptual learning (Kolb, 1995, p.5)." Regardless, the brain changes its form and function. After the brain is injured it is changed again. The brain must then re-organize neural pathways to allow the production of behaviors that are lost. Further, Kolb (1995) goes on to explain that when there is significant compensation of function there is a

remodeling of cortical circuitry. This research shows that after the brain does suffer damage, the brain is remodeled and reorganized since the damaged areas are no longer able to perform their intended functions. It is of great interest to study then, how auditory comprehension is affected in individuals with brain damage resulting in Aphasia. Studies that will be discussed further show that by inserting pause times of different durations into spoken commands, an individual with Aphasia has more time to process the information thus increasing response accuracy.

However, these early studies were behavioral studies and did not include the use of neuroimaging techniques. The advances and increased availability of neuroimaging techniques allow us to increase our understanding of the spatial and temporal characteristics of cognitive processes such as auditory comprehension. As discussed earlier, fMRI and PET provides valuable information in studies of auditory comprehension due to their excellent spatial resolution. However, since we need to know when in time individual processes auditory information, and ERP can be time locked to a specific event it appears to be a logical choice to study electrophysiologic behavior in individuals with no brain damage responding to spoken sentence length messages with pauses of different durations inserted within the message.

1.2 STATEMENT OF THE PROBLEM

While there has been a plethora of research conducted on auditory comprehension with the use of neuroimaging technology, thus far minimal research has been conducted with the use of ERP in the study of spoken sentence length messages. Furthermore, to date no research has been conducted to study the effects of pauses on the comprehension of spoken sentence length messages. Several limitations currently exist with the current neuroimaging techniques that are used. For example, fMRI can only be used to study short periods of the behavior because it uses radiation. In addition, the participant endures loud noises and the equipment is intolerant of any

movement. PET is more quiet compared to fMRI but does require that the participant be injected with radioactive isotopes; therefore it only allows the researcher to examine speech for an average of 40 seconds. While PET and fMRI are exceptional instruments for examining auditory comprehension due to their excellent spatial resolution, the cost, limited availability and increased invasiveness make their use prohibitive. ERP on the other hand provides real-time information since it can be time-locked to a specific event. It is low in invasiveness, presents with a lower cost, higher availability and exceptional temporal resolution making it a more appropriate choice for the study of cognitive and language processes.

Often, Speech-Language Pathologists counsel families of individuals with aphasia, to decrease rate of speech and insert pauses within the spoken message to increase comprehension on the part of the individual with aphasia. In order to examine whether this compensatory strategy is effective in individuals with aphasia, professionals need to examine this first in individuals that have no apparent brain damage. By examining electrophysiologic and behavioral activity in individuals with no brain damage in response to the given tasks, we can detect abnormal patterns in pathological populations.

1.3 Purpose of the Study

The purpose of this pilot study is to examine the behavioral and electrophysiologic performance in two groups (3-college age adults ages 20-30 and 3 older adults ages 50-60) with no history of brain damage responding to spoken sentence length messages with pauses of different durations inserted within the message. A modified version of the Revised Token Test (RTT) (Lara, 2012; McNeil& Prescott, 1978) was used for the experimental task. Individuals with no brain damage participated in the study. The participant was seated in a sound proof room in front of a touch screen monitor. A spoken sentence length message was presented via

speakers to the participant. The participant was instructed to listen to the spoken sentence length message and respond to their visual display of choices that appeared on the touchscreen monitor. The behavioral measures that were examined include physical reaction time and the percent of correct responses. Physical reaction time is defined as the time from the end of the spoken message to the time the participant touches their visual display of choices. The electrophysiologic measures that were examined in this study include the peak latency and amplitude of the N400 ERP component. Kutas and Hillyard (1980) showed that a semantic reaction elicited a negative going peak occurring at approximately 400 ms post stimulus onset. For the present study, the N400 is defined as the largest negative going peak that occurs between 350-650 ms (Handy, 2005; Luck, 2005).

1.4 RESEARCH QUESTIONS

The research questions addressed included:

1) What pause duration (3-second, 2-second, 1-second) results in increased response accuracy in young and old participants with no brain damage responding to spoken sentence length messages with pauses of different durations (1, 2 and 3 seconds) inserted within the message?

2) What are the electrophysiologic performance differences (latency [ms], amplitude [ms]) between young and old participants responding to spoken sentence length messages with pauses of different durations (1, 2, and 3 seconds) inserted within the spoken message?

3) What are the behavioral performance differences (accuracy, reaction time) between young and old participants responding to spoken sentence length messages with pauses of different durations (1, 2 and 3 seconds) inserted within the auditory messages?

1.5 HYPOTHESES

It was hypothesized that: there would be no difference between the groups in the electrophysiological data, since all participants were participants with no brain damage. More specifically it was hypothesized that;

1) The 2-second pause duration would result in increased response accuracy in young and old participants, responding to spoken sentence length messages with 1, 2 and 3 second pauses inserted within the message. This was determined based on previous studies conducted by Liles and Brookshire (1975) and Salvatore (1976).

2) There was be no difference in peak latency and amplitude of the N400 ERP component between the young and old participants responding to spoken sentence length messages with 1, 2 and 3 second pauses inserted within the message since all the participants are non brain damaged individuals.

3) The younger college age participants would produce higher response accuracy percentages compared to the older participants responding to spoken sentence length messages with 1, 2 and 3 second pauses inserted within the auditory message.

1.6 SIGNIFICANCE OF THE STUDY

This study sought to gain a better understanding of patterns produced by typical individuals with no history of brain damage responding to sentence length messages with pauses of different durations inserted within the message. Studies on normal health individuals are important because knowledge of normal patterns will allow us to detect abnormal patterns in pathological populations. Earlier studies on the effects of pause durations inserted within a spoken message were completed using behavioral methodology. However, since Liles & Brookshire (1974) reported that a pause inserted within commands allows individuals extra

processing time, studies to date have continued to examine the effects of have since examine in the 70's. This pilot study serves, as the initial phase of a larger study by investigating if inserting a pause into a spoken sentence length command would result in a difference in the behavioral and electrophysiologic components of ERP when comparing college age adults and adults ages 50-60.

Chapter 2: Literature Review

The purpose of this pilot study is to compare behavioral and electrophysiologic performance between young and old participants with no history of brain damage responding to spoken sentence length messages with pauses of different durations inserted within the message. This chapter presents a review of the literature as it pertains to A) auditory comprehension B) neuroimaging techniques that have investigated auditory comprehension, C) the basics of ERP, D) auditory comprehension in ERP studies and E) studies that have assessed ERP in the brain damaged population.

2.1 Auditory Comprehension

Auditory comprehension is the process of the brain perceiving and interpreting information. It is the basis for the development of language; therefore it is crucial to understand the mechanisms that underlie this process. For auditory comprehension to occur the individual must access prior knowledge in order to comprehend the meaning of the spoken message. (Friederici, Ruschemeyer, Hahne, & Fiebach, 2003) Lexical models indicate that in normal individuals, auditory comprehension involves multiple processing stages. The phonemic content of the word is determined by auditory analysis, followed by word recognition, which occurs when the lexicon is accessed. Finally, the understanding is achieved when the word is linked to the semantic representation (Whitworth et al. 2014; Wooleff et al. 2014). In individuals that suffer from brain damage, there is a disturbance in this flow.

2.2 Auditory Comprehension and Neuroimaging Techniques

Studies on individuals with no history of brain damage are valuable because they help identify abnormal patterns in individuals with brain damage. As mentioned earlier, auditory

comprehension in individuals with no prior history of brain damage has been studied extensively with the use of neuroimaging techniques, such as Functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), and Event-Related Potentials (ERP). A study by Demonet et al. (1992) used PET to study the functional anatomy of the two main components of auditory comprehension and language, specifically phonological versus lexico-semanctic processing. In this study, brain activation in nine participants with no history of brain damage was assessed. The participants were asked to complete three tasks. The first task required the participants to distinguish rising pitches within a series of pitch tones. In the second task, the participants were requested to judge the sequential phonemic organization of non-words. Finally, the participants were asked to judge concrete nouns according to a semantic criterion. Results of this study showed highly significant and different activation patterns. The authors found phonological processing activated the left superior temporal gyrus (specifically Wernicke's area) with some degree of activation in the right superior temporal gyrus and Broca's area. However, lexico-semantic processing was found to be connected with activity in the left superior prefrontal region and the superior temporal regions. Furthermore, a comparison of the two patterns of activation (lexico-semantic and phonological) was made and no difference was noted in the activation in Broca's area and the superior temporal areas. The authors concluded that these results suggest that these areas are stimulated by the phonological element of both tasks, but activation was found in temporal, parietal, and frontal multi-modal association areas. The authors concluded "these constitute parts of a large network that represent the specific anatomic substrate of the lexico-semantic processing of language (Demonet et al., 1992, p.1)."

Zatorre and Belin (2001) conducted another study on individuals with no history of brain damage with the use of neuroimaging techniques. The authors used PET to inspect the reaction of the human auditory cortex to spectral and temporal variation. There were 12 participants that

attended to two pure tones that were separated by one octave interchanging on a randomized sequence. In one series of five scans, spectral information referred to, as tone spacing was kept continuous, while the speed of alternation was doubled at each level. In the other five scans, speed was kept continuous, but the number of tones tested in each octave was doubled at each level, creating sufficient frequency differences. Results of this study found that "the core auditory cortex in both hemispheres responded to the temporal variation, while the anterior superior temporal areas bilaterally responded to the spectral variation, and the responses to the temporal features were weighted towards the right (Zatorre & Belin, 2001, p.1)". Zatorre and Belin stated that their results verify the concentration of the left-hemisphere auditory cortex for quick temporal processing and reveal that core areas are related in these processes.

Similarly, Belin et al., (1998) used synthesized sounds that contained speech like rapid acoustic changes to explore the function of temporal processing in language lateralization. The authors observed irregularity of cerebral activation in ten participants using PET. The participants were assessed during a passive auditory stimulation with the nonverbal sounds that consisted of either quick (40 msec) or prolonged (200 msec) frequency transitions. Regional cerebral blood flow patterns obtained during participant differentiation of sounds revealed that, both sets of sounds activated both the right and left hemisphere. However, the left hemisphere had larger areas of activation. Additionally, the sounds with the formant transition of 40 milliseconds activated the left dorsolateral prefrontal region, while the group of sounds with the formant transition of 200 milliseconds activated both the right and left superior temporal gyri. The findings reported in this study suggest that temporal processing is localized in the left hemisphere.

Friederici et al. (2003) conducted a study using fMRI on individuals with no brain damage to identify the anatomical brain areas specific to processing of semantic and syntactic

linguistic information. Participants included 15 normal and healthy males between the ages of 23-30 years. In this study, the participants were asked to listen to correct, semantically incorrect, and syntactically incorrect short sentences. Results obtained from fMRI revealed that semantically incorrect sentences resulted in increased activation along in the mid-portion of the superior temporal gyrus bilaterally, and in the insular cortices bilaterally. In addition, sentences that were syntactically incorrect activated the left posterior frontal operculum, the anterior portion of the left superior temporal gyrus, and the putamen of the basal ganglia. Overall, the study revealed differences and similarities for processing sentences that contained semantic or syntactic violations. Both conditions required greater areas of the superior temporal region than the correct sentences, as well as, produced activity ranging to the most posterior part of the superior temporal region. The differences include, the way the brain processed the semantic violations was through the mid-portion of the superior temporal region bilaterally and the insular cortex bilaterally while the brain processed syntactic violations through the anterior portion of the superior temporal gyrus, the left posterior frontal operculum, and the putamen. The authors suggested that these results support the understandings that both semantic and syntactic processes are dependent on a temporo-frontal network, each with different precise areas (Friederici et al., 2003). Research has also examined the processes that underlie auditory comprehension in individuals with brain damage. For example, Friederici and Kilborn (1989) conducted a study that examined aggrammatic comprehension in individuals with Broca's Aphasia. Results showed that individuals with Aphasia have not lost their overall syntactic knowledge; rather, they have lost the ability to process the linguistic information within a given time frame. This is important in the processing of information given that this is thought to occur at a very rapid rate. Therefore, studies on auditory comprehension in individuals with brain

damage show that auditory comprehension is localized to different and variable activation areas of the brain.

2.3 The Basics of ERP

While multiple studies have examined auditory comprehension in normal, healthy individuals and individuals with no brain damage using neuroimaging techniques, only a handful have examined spoken sentence length messages using a paradigm such as the one used in the present study, spoken sentence length messages that require the participant to respond to an auditory command (Liles & Brookshire, 1975; Salvatore, 1975; Lara 2012). To our knowledge even less have examined stimulus manipulation such as insertion of pauses within the spoken message using Event Related Potentials (ERP). ERP is the logical choice for the study of language processes such as comprehension because of its excellent temporal resolution. ERP are minor deviations in the electrical activity produced by the brain that are recorded via the scalp. These deviations in the electrical activity occur in response to internal and external stimulus. This electrical activity changes very rapidly and is therefore recorded with a temporal resolution in the millisecond time range from multiple electrode locations on the scalp. ERP is most often used in the disciplines of psychology, psychiatry, and neuroscience. In addition, ERP is used to assist with the diagnosis of ADHD and schizophrenia, as well as finding answers to how attention typically works and why memory declines with age (Handy, 2005). ERP has also been used in many studies in order to relate specific features or ERP waveforms with certain cognitive processes. Based on previous studies it is now possible to use precise ERP qualities, also known as components, as indicators for the cognitive processes with which they are associated (Handy, 2005; Light et al., 2010). ERP is time-locked to a specific stimulus event thus it provides real-

time information within the millisecond time range, making it an appropriate choice for the study of cognitive processes such as auditory comprehension.

2.4 ERP Studies in Individuals with No Brain Damage

Haggort et al. (2003) used ERP on individuals with no history of brain damage responding to either syntactically or semantically incorrect sentences, to examine the N400 and P300 components. ERP studies have revealed that semantic processing in individuals with no history of brain damage is reflected in the N400 ERP component. The N400 is seen when the brain responds to auditory words. In a typical adult, the N400 component is triggered between 400-600 milliseconds. Kutas and Hillyard (1980) observed this waveform in a study that required participants to read seven sentences in which the last word was 75% congruous and 25% incongruous. A negative waveform that appeared at approximately 400ms after the onset of the stimulus was elicited in response to the anomalous word. Salmon and Pratt (2002) also examined the N400 in response to sentences and stories that were semantically congruous and incongruous in 18 participants with no history of brain damage. The participants exhibited large N400 peaks for congruous sentences and stories than for the incongruous ones. Additionally, Neville et al. (1991) examined 40 normal healthy participants. The participants were asked to read sentences that were semantically and grammatically congruous or incongruous. Results revealed that semantic errors produced an N400 ERP component with cortical distribution over the temporal and parietal regions of the left hemisphere.

Most studies on auditory comprehension in individuals with no-brain damage use tasks that require the participant to make judgments about the semantically and/or grammatically correctness of a sentence. To date only a handful of studies have examined auditory comprehension by asking questions about the material presented (Sommers et al., 2011) and

even fewer used tasks that require the participant to respond after an auditory command. To date, no studies have examined comprehension of spoken sentence length messages with pauses of different durations inserted within the message using ERP in individuals with no brain damage or individuals with aphasia..

2.5 ERP Studies in Brain Damaged Adults

In individuals with aphasia, the process of accessing semantic information is disturbed. Studies have suggested that aphasia is supplemented by discrepancies in the ability to perceive, interpret, and respond to the various kinds of auditory stimuli (Liles & Brookshire, 1975). As a result clinicians will use stimulus manipulation as a treatment strategy in the management of aphasia. However, this treatment strategy has only been examined in studies that use behavioral methodology.

For example, a study by Weidner and Lasky (1976), examined manipulation of the presentation of the spoken commands. Weidner and Lasky (1976) delivered spoken material at a normal rate of 150 wpm and at a slowed rate of 110 wpm to participants with aphasia. The results showed that participants performed better when the material was presented at a slower rate. In another study Parkhurst (1970) investigated how aphasics and nonaphasics responded to spoken commands that varied in length and complexity. Results from this study suggested that some individuals with aphasia might comprehend everyday information better if the speaker slowed down, allowing the individual more time to process the message. Furthermore, studies by Liles and Brookshire (1975) and Salvatore (1975) found that exposure to long pauses inserted within the spoken message resulted in an increase in accurate responses to verbal commands in participants with aphasia. More specifically, Liles and Brookshire (1975) had patients with aphasia perform a modified version of the Token Test and five-second pauses were positioned at

several points in spoken sentence length commands. In this study, Liles and Brookshire (1975) examined whether understanding of spoken commands in individuals with aphasia was supported when given additional processing time within the messages. The results of the study suggested that inserting pauses of long durations within the spoken messages supported the patient's comprehension of the spoken messages. Similarly, Salvatore (1975) examined whether training individuals with aphasia using pause times of different durations within the spoken message was effective. In this study, Salvatore (1975) exposed individuals with aphasia to four different conditions (4, 2, 1 and 0.5 sec); pause durations inserted within spoken commands. A pre and post-test was completed using commands that contained 2 and 0.5 second inserted within the command. The results of this study showed that there was an increase in the correct response rate from pre to post test. Furthermore, the participants in this study made fewer errors in the 2-second pause condition than in the 0.5 second condition. These results support the findings of Liles and Brookshire (1975) and suggest that insertion of long pauses within the auditory message improves accuracy of response. The implications for treatment of aphasia based on these results is that insertion of long pauses inserted within the auditory message will improve the comprehension of information by individuals with aphasia more effectively than shorter pause durations.

Later Salvatore (1976) used shaping technique on pause insertion to examine whether pauses of long durations could be faded and still result in correct responses. Shaping technique was completed with fading of 4, 2, 1 and 0.5 second pause durations. Results showed that the participant was successful in responding to spoken commands that contained a 4 second pause as well as the 2-second pause. Some success in correct response rate was obtained with a with a 1 second pause, but the participant was not able to consistently respond to commands that had a pause time of less than 2 seconds. Even further, Liles and Brookshire (1975) stated that not only

does the length of pause time affect the individuals' ability to recall the command, but also the location of the pause makes a difference to individuals with no brain damage. Studies have shown that recollection of sentences is most accurate when the pause is placed at a major syntactic boundary such as at the phrase of clause boundary, than when they are inserted within syntactic groupings (Martin & Strange, 1968; Martin 1970). Therefore, for this current study the pause will be inserted before the adjective for single commands and after the conjunction in two-step commands.

Chapter 3: Methodology

The purpose of this pilot study is to compare cortical electrophysiologic and behavioral activity in individuals with no history of brain damage responding to spoken sentence length messages that contain one, two and three-second pause times inserted within the message. While fMRI and PET are used to examine language processes such as comprehension of spoken messages, they do not provide the temporal resolution that ERP does. However, ERP studies that examine auditory comprehension have primarily used tasks that require participants to make judgments about semantic incongruencies. Few studies to date use ERP to examine comprehension of sentence length messages that require the participant to respond to that message. In addition, to our knowledge no electrophysiologic studies have examined stimulus manipulation such as rate of speech or pause duration. The following research questions were proposed:

1) What pause duration (3-second, 2-second, 1-second) results in increased response accuracy in young and old participants with no brain damage responding to spoken sentence length messages with 1, 2 and 3 second pauses inserted within the message?

2) What are the electrophysiologic performance differences (latency [ms], amplitude [ms]) between young and old participants responding to spoken sentence length messages with 1, 2, and 3 second pause durations inserted within the spoken message?

3) What are the behavioral performance differences (accuracy, reaction time) between young and old participants responding to spoken sentence length messages with 1, 2 and 3 second pauses inserted within the auditory messages?

This chapter describes the study's research methodology and includes: a) rationale, b) experimental design, c) subjects, d) materials, e) setting/procedures, f) data analysis.

3.1 RATIONALE

In order to provide effective treatment for individuals with brain damage it is important to first examine the target behavior in individuals with no brain damage. Studies on individuals with no brain damage help to identify abnormal patterns or behaviors and can be used for comparison. Previous studies have been conducted by Liles and Brookshire (1975) and Salvatore (1976), who found that a two-second pause time led to an increase in response accuracy. However, few studies have examined ERP and the comprehension of sentence length messages that require the participant to respond to that message. In addition, no electrophysiologic studies have examined stimulus manipulation such as pause duration. Research on stimulus manipulation, specifically with insertion of pause durations into spoken sentence length commands has not been replicated since the 1970's. Therefore, the first step is to create a framework for larger studies that need to be conducted for future treatment purposes. Furthermore, evidence from previous research found that advanced age results in auditory processing decline (Tun, Williams, Small & Hafter, 2012). This would suggest that the old participant would have increased difficulties processing spoken messages. Therefore, it is of interest to compare younger college participants versus older participants in order to compare performance differences based on age.

3.2 EXPERIMENTAL DESIGN

This pilot study compared behavioral and electrophysiologic activity of young and old individuals with no history of brain damage responding to spoken sentence length messages with one, two and three-second pause duration inserted within the message. The independent variable is dichotomous (college level students vs. 50-60 year old individuals) and 3 pause conditions.

The dependent variables are continuous (performance as measured by physical reaction time, response accuracy, amplitude and peak latency of the N400 ERP component).

3.3 Subjects

Participants were recruited from the UTEP and El Paso area community. Face-face meetings and announcements were presented at university classes by the principal investigator and used for recruitment purposes. The participants consisted of three dominant English-speaking college level students (ages 20-30) with no history of brain damage. The second group consisted of three dominant English-speaking individuals with no history of brain damage between the ages of 50-60 years. Two additional participants (0ne college age and one older participant) were recruited however; data was unable to be collected due to equipment malfunction. Inclusion criteria included normal or corrected-to-normal vision and normal or corrected-to normal hearing (Table 3.1. and 3.2). Handedness was established to determine the language–dominant hemisphere. Typically language is housed in the left hemisphere as well as, typical patterns would indicate rand handedness (Manasco, 2014).

Participants in both groups completed the following tasks:

(1) Self-report medical history questionnaire (*Appendix 1.1*);

(2) Annett Handedness Inventory (*Appendix 1.2*);

(3) Experimental Task

The principal investigator completed the following tasks:

(1) Administer a hearing screening to both groups;

(2) Take head measurements;

(3) Apply electrode cap according to Biosemi procedure of conduction gel and amplified electrodes;

(4) Assessment and analysis of participants' performance

Young and old participants were randomly assigned to one of the 3 conditions (pause durations of 3-seconds, 2-seconds, 1-second).

TABLE 3.1: SUMMARY OF GROUP A PARTICIPANTS (YOUNG, COLLEGE AGE)

	Age	Handedness	Hearing Screening Results	Pause Time Assigned
A1	**30**	**R**	**Pass**	**3-seconds**
A2	**21**	**R**	**Pass**	**1-second**
A3	**24**	**Both (Mostly R)**	**Pass**	**2-seconds**

TABLE 3.2: SUMMARY OF GROUP B PARTICIPANTS (OLDER PARTICIPANTS)

	Age	Handedness	Hearing Screening Results	Pause Time Assigned
B1	**54**	**L**	**Pass**	**2-seconds**
B2	**50**	**R**	**Pass**	**3-second**
B3	**55**	**R**	**Pass**	**1-second**

3.4 MATERIALS

The visual stimuli and auditory commands presented to participants was a modified version of the Revised Token Test (RTT) (Lara, 2012; McNeil & Prescott, 1978). The RTT is a behavioral assessment instrument that is used to identify mild comprehension deficits in individuals with brain damage. The RTT (1978) was selected for this experiment because it is based on the theory that a test of language comprehension should be grounded on language abilities and not on an intellectual level. In addition, the RTT (1978) has been well validated on individuals with no brain damage and individuals with right and left hemisphere damage (Orgass, 1976). Modifications were necessary in order to use this test in an electrophysiologic experiment. Among the modifications made were manipulating the mode of presentation.

The RTT (1978) presents visual stimuli (plastic square and circle token of different colors-red, white, blue, black, and green) on a tabletop using a 4 X 5 matrix. This experiment presented stimuli on a touchscreen using Superlab Stimulus Presentation software (Cedrus, 2008). In this modification, stimulus are presented on a 3x3 matrix on the touch screen monitor. Plastic tokens were therefore not used.

Triggers were added to mark the events of interest within the trial, for example, the point in time where the participant responds to the auditory stimuli. Triggers are markers that are time-locked to each event within the trial and tell the program which specific areas to capture measurements for future analysis.

3.5 SETTING/PROCEDURES

Once selected, participants were provided with a verbal explanation regarding the purpose of the study, all procedures, benefits and/or risks associated with the study. Participants were then given the opportunity to read the informed consent. They were provided with the opportunity to ask questions regarding their participation in the study as well as the research project. In addition, the researcher provided the participants with an explanation as to their right to participate and/or withdraw from the project at any time. Once all questions had been answered to the participant's satisfaction, they signed a letter of informed consent in accordance with the University of Texas at El Paso's IRB committee guidelines.

The researcher asked participants to come to the ERP and Aphasia Laboratory in the Speech Language Pathology Research Facility located at 1101 N. Campbell El Paso, Texas 79902. Participants were asked to come to the lab for one visit. During this visit, participants were provided with a brief explanation regarding the use of ERP. Participants filled out the self-report medical and handedness questionnaires. The principal investigator completed a hearing

screening. Following this, the principal investigator took head measurements and applied the electrode cap according to the Biosemi procedure of conduction gel and amplified electrodes (Brooks & List, 2006). Prior to ERP task administration, investigators randomly assigned participants to one of three tasks via an online randomizer tool (http://www.randomizer.org). This determined the experimental condition (3-second, 2-second, 1-second) the participant completed.

Principal investigator seated participant comfortably in a 6 X 6 soundproof room in front of the EntuitiveTouchmonitor. Principal investigator asked participant to place his/her hand on a mark on the table at the start of the procedure. The participant was instructed to return his/her hand to the mark after touching the visual display appearing on the monitor. The mark was placed at a distance of 34 cm from the touch monitor. Principal investigator instructed participant to move only to touch the screen when either a white sample (Fig. 3.1.) or visual display of the choices (Fig. 3.2.) appeared on the touch monitor. The participant was instructed to look at the observational white sample (Fig. 1.) that appeared on a black screen on the touch monitor. Principal investigator then instructed participant to touch the white sample (Fig. 3.1) to initiate the experimental task. Participant was instructed to listen to the auditory command (examples listed below) presented via speakers and to follow the command by touching the visual choice (Fig. 3.2) that matched the auditory command.

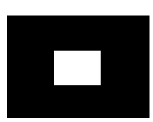


FIG. 3.1 EXAMPLE OF AN OBSERVATIONAL WHITE SAMPLE

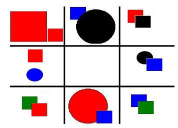


FIG. 3.2 AN EXAMPLE OF A VISUAL CHOICE

Examples of Auditory Commands include "Touch the black circle (pause of either 3, 2, or 1 second duration) and the green square." A complete list of the visual stimuli and spoken sentence length messages are found in Appendix C and D.

3.6 DATA ANALYSIS

Electrical activity was recorded from the scalp via 64 electrodes that were placed according to the International 10-20 system. Two reference electrodes were placed on the left and right mastoids. All electrodes were referenced to the mastoids. Active Two from Bio Semi was used to record the electrical signals in this experiment. Four additional electrodes were placed on the participant's lower outer canthi and the orbital ridge of the right eye, as well as the right and left temple. These electrodes were used to remove artifacts such as vertical and horizontal eye movements during data analysis (Handy, 2005). The notch filter removes noise from electrical power lines and was set at 60 Hz. Electrodes transmitted the electrical signals at a sampling rate of 2048 Hz, with the bandpass set at 0.1 Hz for the low cut off (with a 12 dB slope) and a high cut off at 30Hz (Handy, 2008). Data were corrected for eye movement and noise artifacts off-line with Brain Vision Analyzer from Cortech Solutions (2008), with the sampling rate set at 512 Hz. Brain Vision Analyzer (2008) was used to eliminate artifacts from the signal of interest. ERP data is segmented from trigger to trigger in order to separate the data into epochs (temporal time window). Once data is segmented it is averaged and the result is the

ERP waveform. Spatial analysis was completed in order to generate cortical activation maps in the form of topographic (surface) maps.

Chapter 4: Results

The purpose of this study was to examine the behavioral and electrophysiologic performance with the use of ERP. Participants completed a modified version of the RTT (Lara, 2012; McNeil & Prescott, 1978), that consisted of spoken sentence length messages with pauses of 1, 2, and 3 second duration inserted within the commands. All participants were randomly assigned to one of the three conditions of 1, 2, or 3 second pause durations that were inserted within the spoken commands. Participants were instructed to touch the visual display of choices after spoken sentence length messages were presented via speakers. ERP was used to examine electrophysiologic behavior, as ERP measures electrical activity at the level of the cortex in response to internal or external stimulus. The ERP component of interest in this study is the N400 because it is reflective of a semantic reaction. The N400 was defined as the highest negative peak occurring between 350-650ms. Visual inspection of the ERP waveforms was completed to detect the N400 component. The behavioral measures that were examined include physical reaction time, and the percent of correct responses. Physical reaction time is defined as the time from the end of the spoken message to the time the participant touches their visual display of choices.

4.1 Behavioral Results

Behavioral results were compared across two participants who completed the RTT containing the same pause times (Table 4.1). The first behavioral measure assessed was percent of correct responses followed by reaction time. Reaction time is measured from the offset of the spoken message to the time the participant makes a selection by touching the visual display of choices that matches the spoken message. Participant 1A (young, college age participant) who underwent the RTT with a 3 second pause time achieved 90.63% accuracy with an average

response time of 6,883ms. Participant 2B (older participant) who was also assigned to the 3-second pause time achieved 93.75% accuracy with an average response time of 50,391ms. In the 3-second pause condition the younger college age participant displayed more errors and shorter reaction times compared to the older participant that displayed less errors but took more time to respond to the commands.

Participant 3A (young, college age) participated in the two-second pause condition and obtained 93.13% correct response rate with a physical reaction time of 42,164 ms. Participant 1B (older participant) was assigned to the two-second pause condition and obtained 91.88% correct response rate with a physical reaction time of 56,078 ms. Participant 3A, the college age participant that was assigned to the two-second pause time exhibited a higher percent of correct responses as well as shorter physical reaction time compared to the older participant (1B).

Participant 2A (young, college age participant) assigned to the one second pause condition achieved a 93.13% correct response rate with a physical reaction time of 7,339 ms. The older participant, (3B) achieved 91.93% correct response rate s with a physical reaction time of 8,027 ms. Similar to the two participants that participated in the two-second pause condition, the college age participant in the 1second pause condition also displayed a higher percent correct response rate with a shorter average reaction time compared to the older counterpart.

It was hypothesized that the two-second-pause time would produce a higher percent of correct response with a shorter reaction time for both the college age and older participants. Both the one and two-second pause conditions, participants (young and old) had comparable rates in percentages of correct responses. However, the one-second-pause condition showed a higher percentage of correct responses with shorter reaction times for both sets of participants. The three-second-pause condition resulted in the lowest percent of correct responses compared to the two and one-second pause conditions. The physical reaction time was split across

participants with three individuals (two college age and one older participant) obtaining an average reaction time of less than 10,000 milliseconds and three participants (one college age and two old participants) obtaining an average reaction time between 40,000-60,000 milliseconds. It was also hypothesized that the college age adults as a whole would produce a higher percent of correct responses with a decreased response time compared to the older participants. This was the found to be true for the one and two second conditions but not for the three-second condition, as the college age participant had a less percent of correct responses than the older counterpart. Tables 4.2 and 4.3 display side-by-side comparisons of the participants in each pause condition.

TABLE 4.1: SUMMARY OF BEHAVIORAL RESULTS

PARTICIPANTS A= College Age B=Older Adults	% CORRECT RESPONSE RATE	AVERAGE REACTION TIME
1A (3-SEC)	90.63%	6,883.93 MSEC
2B (3-SEC)	93.75%	50,391.32 MSEC
3A (2-SEC)	93.13%	42,164.32 MSEC
1B (2-SEC)	91.88%	56,078.72 MSEC
2A (1-SEC)	93.13%	7,339.80 MSEC
3B (1-SEC)	91.93%	8,027.37 MSEC

TABLE 4.2: COMPARISON OF PARTICIPANTS' PERCENT'S OF CORRECT RESPONSES

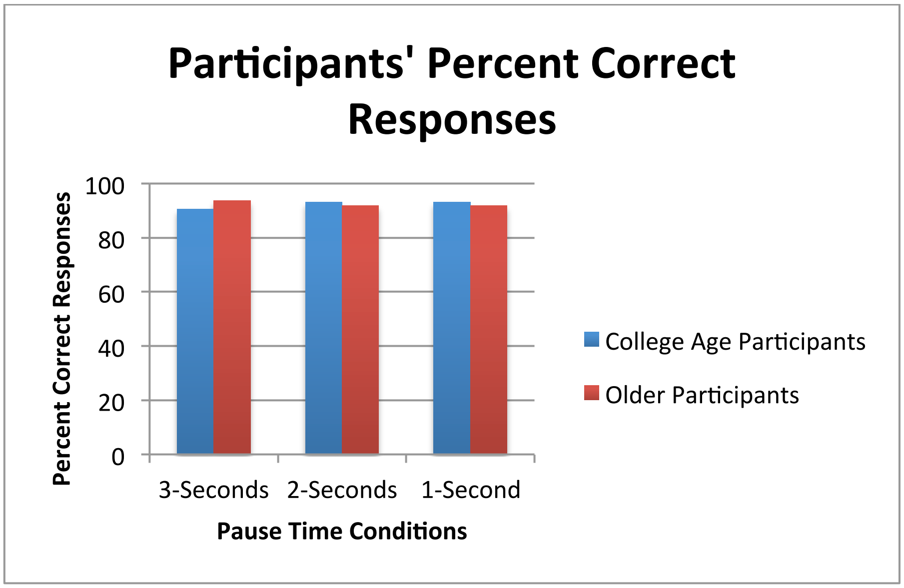
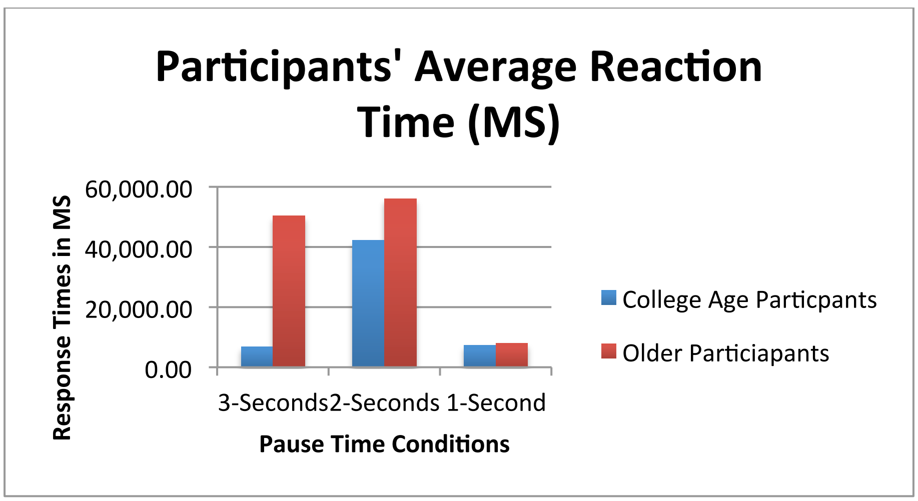


TABLE 4.3. COMPARISON OF PARTICIPANTS 'AVERAGE REACTION TIMES



4.2 ELECTROPHYSIOLOGIC RESULTS

Analysis of the N400 waveform was conducted. The N400 ERP component observed is the largest negative deflecting peak that occurs between 350-650 ms after the onset of the auditory stimulus. This measurement is referred to as the latency and is measured in milliseconds (ms). This was the chosen time frame as the research using ERP operationally

defined the N400 component as occurring during this time frame in individuals with no-brain damage. Amplitude was measured in microvoltages (mv) and is described as the amount of electrical energy the brain produces. The more resources required by the brain will lead to an increase in amplitude. Both amplitude (mv) and latency (ms) were measured from the time after the spoken message was presented to the time the participant touched their visual display of choices. See Table 4.2. Tables 4.5 and 4.6 display side-by-side comparisons of the participants in each pause condition.

TABLE 4.4: SUMMARY OF ELECTROPHYSIOLOGIC RESULTS

Participants A=College Age B=Older Participant	N400 Amplitude (Microvolts)	N400 Latency (Milliseconds)
1A (3-SEC)	-1.577	0.501ms
2B (3-SEC)	-0.128	0.709ms
3A (2-SEC)	-0.685	0.580ms
1B (2-SEC)	-0.713	0.582ms
2A (1-SEC)	-4.873	0.452ms
3B (1-SEC)	-0.722	0.389ms

Participant 1A (young, college age participant) in the three-second trial displayed an N400 at 0.501 ms with an amplitude of -1.577 microvolts. Participant 2B (older participant) in the three-second trial did not display a negative peak until .709 ms. Therefore; this participant did not display a negative peak within the time frame of the operational definition of 350-650ms. Results revealed the college age participant that completed the three-second-pause condition produced higher amplitude as well as a shorter latency as compared to the older counterpart.

Figure 4.1 shows a comparison of the N400 ERP component of both participants in the three-second-pause condition. Overall, the college age participant displayed increased amplitude and had shorter latencies than the old participant. This suggests that at least for this condition, the college age participant was more efficient in processing the spoken sentence length message

Participant 3A (young, college participant) of the two-second trial attained an N400 at .580ms with an amplitude of -0.685 microvolts. Participant 1B (older participant) attained an N400 at 0.582 ms with amplitude of -0.713 microvolts. The college age participant in the two-second pause condition displayed decreased amplitude and shorter latency compared to the older adult (Figure 4.2).

Participant 2A (young, college age participant) also did not display the typical N400 criteria as they did not follow the typical pattern of the initial positive peak followed by negative activity. Participant 3B (older participant) obtained an N400 at 0.389 ms with amplitude of -0.722 microvolts. Participant 3B in the one-second-pause condition produced the highest amplitude when compared to the other two participants of similar ages for the 2 and 3-second-pause conditions, meaning he or she required more resources to process the commands (Figure 4.3). However, this participant established a peak latency that was comparable to all other participants. This data suggests that at the one-second-pause condition, this participants at least required more resources to process the spoken message. It was hypothesized that there would be no difference between the young and old groups, since all participants had no history of brain damage. Individual differences were noted disproving the hypothesis, even though, all met the criteria of the N400 peak occurring within 350-650 ms after the onset of the auditory command with the exception of participants 2A and 2B. All of the participants except participants 2A and 2B (older and younger participants) displayed an N400 suggesting that they had a semantic

reaction in response to the spoken command at all three conditions (3, 2 and 1 second pause duration).

TABLE 4.5. COMPARISON OF PARTICIPANTS 'N400 AMPLITUDES

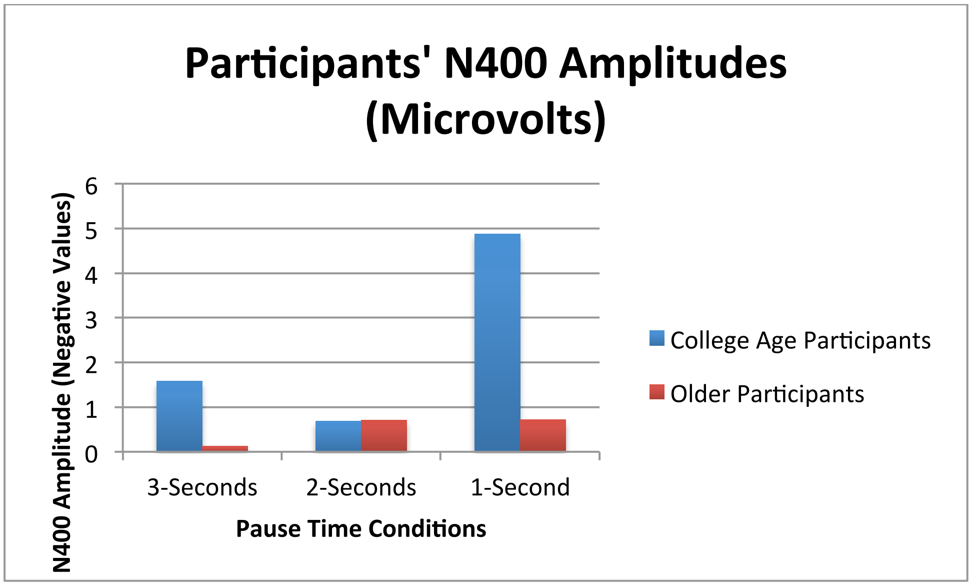
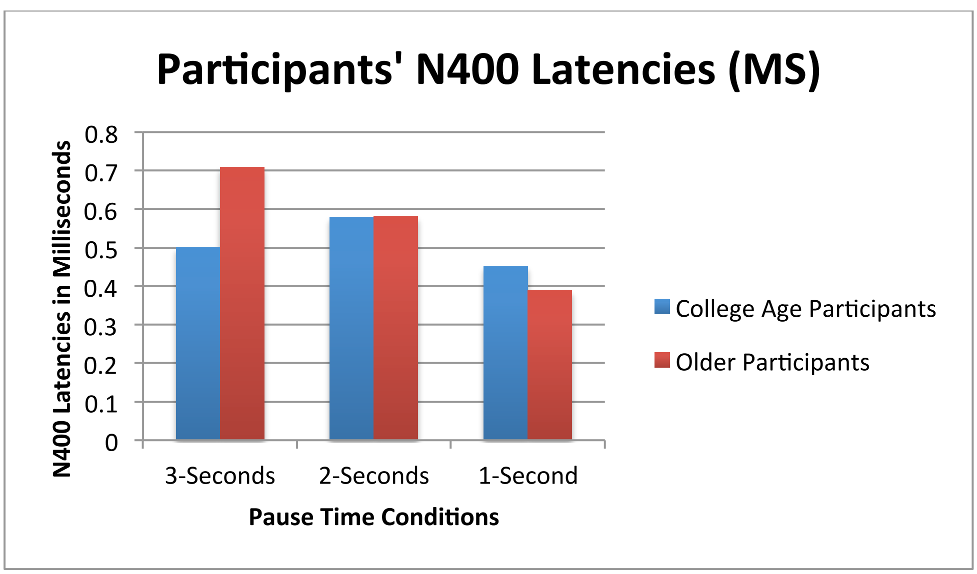


TABLE 4.6. COMPARISON OF PARTICIPANTS 'N400 LATENCIES



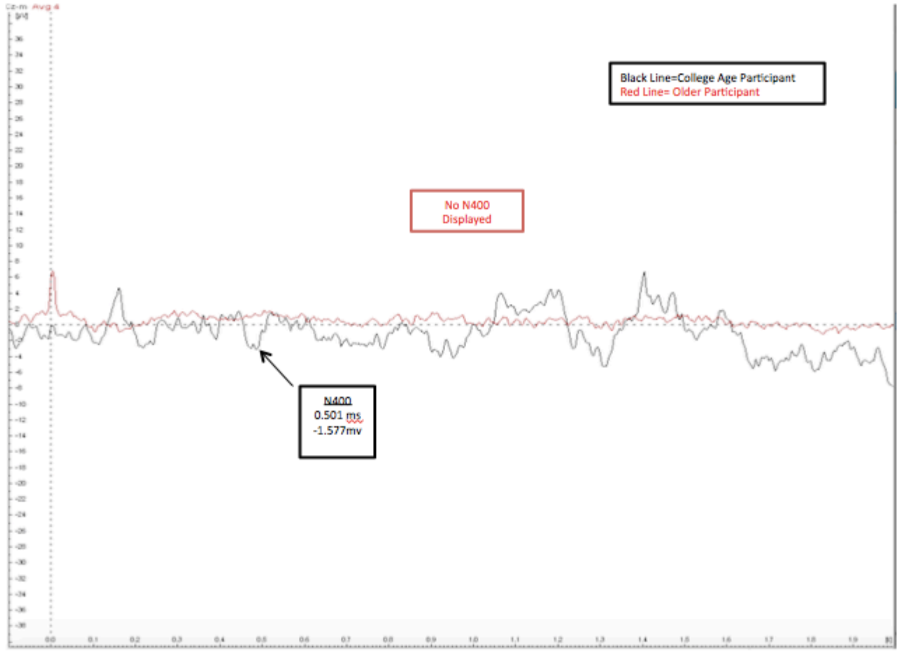


FIGURE 4.1. COMPARISON OF ELECTROPHYSIOLOGIC WAVEFORM 3-SECOND PAUSE TIME

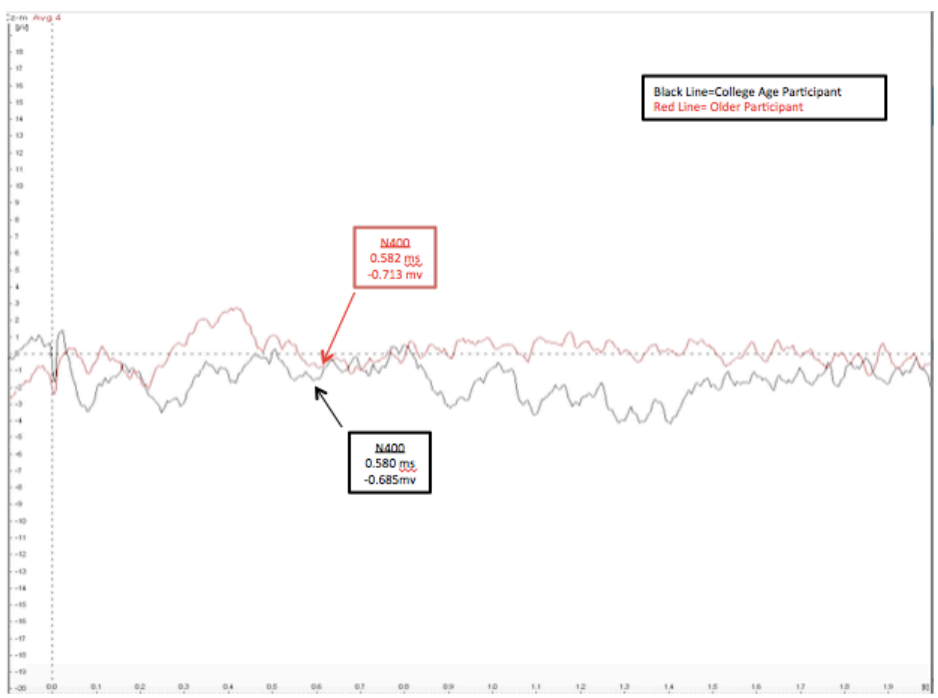


FIGURE 4.2. COMPARISON OF ELECTROPHYSIOLOGIC WAVEFORM 2-SECOND PAUSE TIME

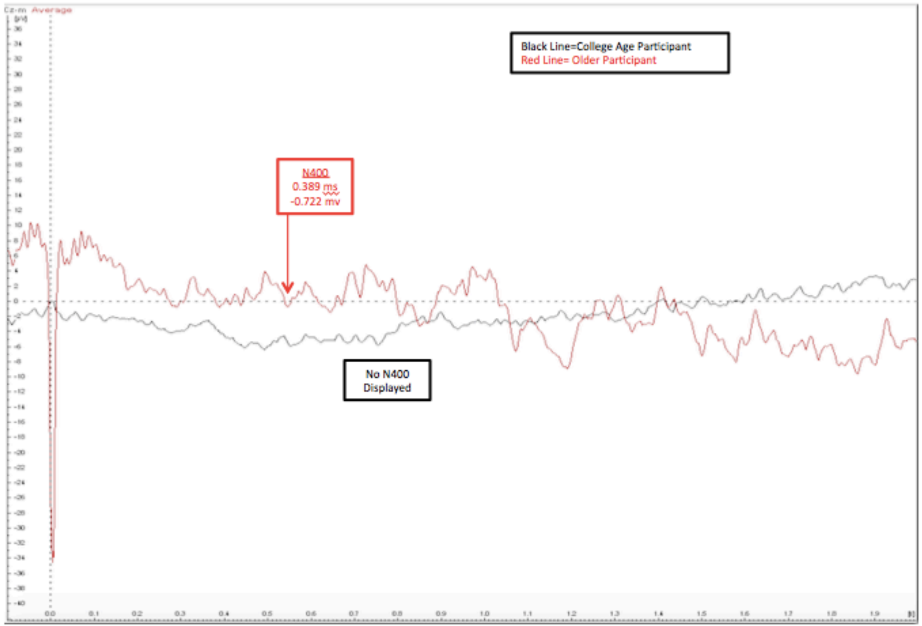


FIGURE 4.3. COMPARISON OF ELECTROPHYSIOLOGIC WAVEFORM 1-SECOND PAUSE TIME

4.3 SPATIAL ANALYSIS

Spatial analysis in the form of topographic maps was performed to produce patterns of cortical activity. This allows for analysis of a specific ERP signal produced from an electrode on the scalp. For this study electrode Cz was used for the spatial analysis since it is centrally located and produces the best illustration to visualize the overall cortical activation that is occurring during specific points in time. Figures 4.4, 4.5, 4.6, 4.7, 4.8 and 4.9 illustrate each participant's individual topographic map, with blue areas indicating negative activation, yellow indicating moderate levels of activation, red indicating high areas of activation, and areas of green indicating neutral activation. It was interesting to observe that all participants except for one (college age participant 3A in the 2 second condition) displayed higher activation on the right frontal electrodes sites. In addition, participant 3A (young, college age participant)

displayed average reaction times that were similar to two of the older participants (2B and 1B) in her and the three-second pause conditions. Participant 3B (older participant in the 1 second condition) also showed variability on the cortical activation maps. The cortical activation map for participant 3B showed higher levels of activation on the right frontal lobe. It should be noted that participant 3B (old or young) had average reaction times similar to those seen in the college age participants. Overall, all of the older participants did require more resources to process the commands but they did achieve response rates that were comparable to the college age participants.

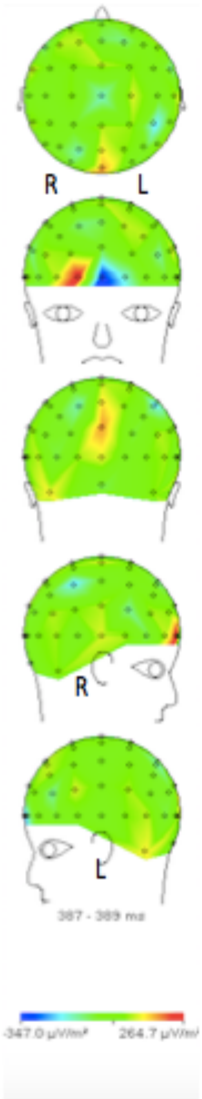


FIGURE 4.4. TOPOGRAPHIC MAP PARTICIPANT 1A (YOUNG, COLLEGE AGE PARTICIPANT)

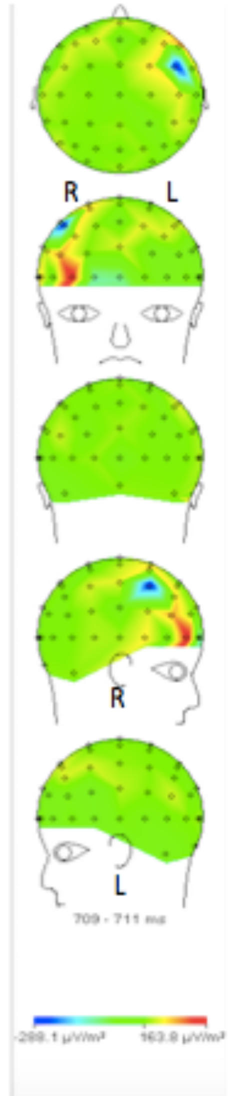
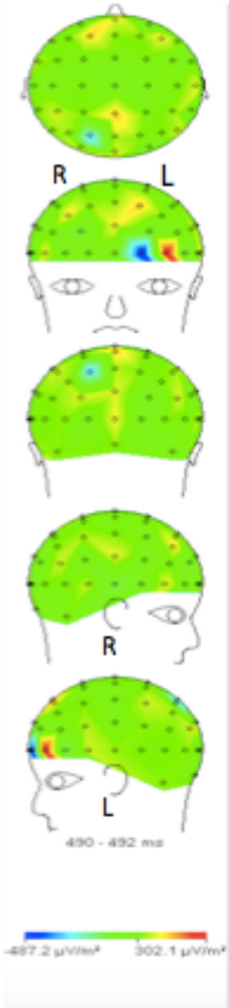


FIGURE 4.5. TOPOGRAPHIC MAP PARTICIPANT 2B (OLDER PARTICIPANT)



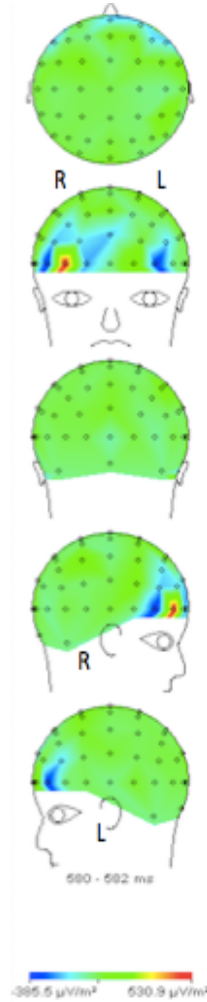


FIGURE 4.6. TOPOGRAPHIC MAP PARTICIPANT 3A (YOUNG, COLLEGE AGE PARTICIPANT)

FIGURE 4.7. TOPOGRAPHIC MAP PARTICIPANT 1B (OLDER PARTICIPANT)

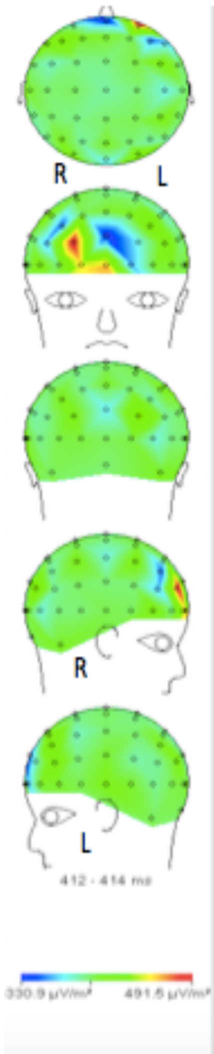


FIGURE 4.8. TOPOGRAPHIC MAP PARTICIPANT 2A (YOUNG, COLLEGE AGE PARTICIPANT)

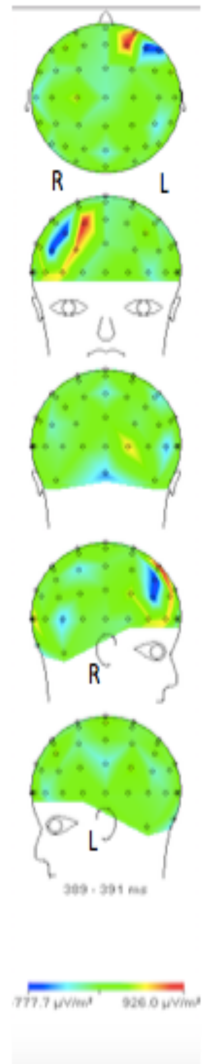


FIGURE 4.9. TOPOGRAPHIC MAP PARTICIPANT 3B (OLDER PARTICIPANT)

Chapter 5: Discussion

The purpose of this study was to examine behavioral and electrophysiologic performance in individuals with no brain damage responding to spoken sentence length messages when 3, 2 or 1-second pause duration was inserted within the message. Two groups of participants were included in the study. Group 1 consisted of college age participants with no history of brain damage. Group 2 consisted older participants between the ages of 50-60 years with no history of brain damage. Participants were randomly assigned to one of 3 conditions (3, 2, 1 second pause duration) using an online randomizer. Participants engaged in a modified version of the RTT (Lara, 2012, McNeil & Prescott, 1978) that required the participant to listen to an auditory command and respond by touching the display of choices that matched the auditory command. Overall, the results of this study show that all individuals in this study are highly variable in the way they process auditory information. While it can be assumed that individuals with no history of brain damage process information in the same area (left hemisphere) within a specific time frame, the data suggests that at least for the participants in this study, the assumption does not hold true. As mentioned, evidence from previous research has suggested that advanced age results in auditory processing decline. With this assumption we would have expected to observe the older participants presenting with increased difficulties in processing the spoken commands. However, this was not found to be the case in the present study. For example, one of college age participant's percent of correct responses was lower than the older counterpart. Young and old participants showed higher correct response rate in the one and two second pause conditions compared to the young and old participants in the 3 second pause condition. This might be attributed to the three-second pause duration being too long and rather than allowing for extra processing time it resulted in the participant forgetting the spoken message. The results at the

three-second-pause condition might also be attributed to distractibility due to the increased length of the pause duration.

As mentioned above, there was variability on the amount of time the individuals required in terms of responding and performing the commands but it is highlighted that the participants in the one-second pause times demonstrated the fastest response time. The findings by Salvatore (1976) where he concluded that a two-second pause duration inserted within commands to be the most effective for individuals with Aphasia. In this study, we hypothesized that the two-second condition would result in less errors and shorter reaction times based on the findings of Salvatore (1975, 1976). However, when looking at three conditions for the participants in this study, the one-second-pause condition resulted in less errors and shorter reaction times. This reveals that while a two second pause time is sufficient time for a brain damaged individual to process a spoken command, for a non brain damaged individual a one second pause time leads to an increase in comprehension as it led to the best overall results in the measures assessed.

In terms of the electrophysiologic behavior all of the participants with the exception of Participants 2A and 2B (younger and older participants) displayed similar patterns of cortical activity. Participant 2A and 2B did not display s negative peak within the time frame of the operational definition. All of the college age participants displayed shorter N400 latencies and greater amplitudes than their older participant counterpart. Furthermore, visual inspection of the ERP waveforms shows increased amplitudes for both participants in the 1-second pause condition. This suggests that there is an increased demand required to complete the task, therefore increasing all possible resources to complete the task.

Finally, visual inspection of the cortical activation showed that all participants except for one regardless of the condition assigned displayed higher areas of activation in the right frontal electrodes rather than the left as would be expected. This is surprising given that the left

hemisphere is the hemisphere responsible for language. In particular the left partial area also known as Wernicke's area is considered to be responsible for semantic processing. While participants did not demonstrate typical patterns of activation in the expected hemisphere, all of the cortical activation was localized to specific areas. This is unlike patterns we would expect to see in the brain damaged population. Observations of cortical activation maps in brain damaged participants has revealed activation in multiple areas throughout the brain, suggesting that the brain is allocating all undamaged areas in order to respond to tasks. It is difficult to speculate about possible explanations for right hemisphere given that there was only one college age and one old participant per condition.

5.1 IMPLICATIONS

As previously stated studies on normal healthy individuals are important because they assist in establishing normal patterns thus helping to identify abnormal patterns in individuals that suffer from brain damage and/or aphasia. By examining, auditory processing in individuals with no brain damage, we can determine the patterns that are expected. This study is the first step in a examining auditory processing in individuals that suffer from aphasia. In order to examine auditory processing with the manipulation of spoken commands, it is first important to examine it in with a larger group of normal healthy individuals in order to establish typical patterns. By collecting data on the temporal characteristics and electrophysiologic behaviors that underline processing of spoken messages with pauses of different durations, clinicians may be able to target behaviors that are receptive to use of pauses. In addition, counseling of families and caregivers may improve thus improving communication between the patient, family and caregivers resulting in improved outcomes. Future implications include improved counseling and treatment strategies in the management of aphasia.

5.2 LIMITATIONS

Several limitations were found during the execution of this study. To begin with, equipment malfunction that occurred throughout the testing phase, made it difficult to obtain a larger sample size. Secondly, the small sample size did not allow for performance of statistical analysis. As a result visual inspection of individual ERP waveforms was the only analysis that was conducted on electrophysiologic data. Bigger sample sizes and randomization of participants into the different pause conditions may result in increasing the level of evidence necessary for rigorous research. Finally, because of the small number of participants used in this study, generalization to the general population cannot be made. Therefore, future research focuses on increasing sample size and extending the study to individuals with aphasia.

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Appendix

A

Self-Report Medical History Questionnaire
UTEP
Brain, Voice and Language Laboratory

The following information is required by the Institutional Review Board to screen for possible participation in EEG studies. We must know if you have had any medical problems that might keep you form participating in this research project. It is important that you be as honest as you can. Information provided will be kept confidential.

Participant ID# ___________________________Age_________Gender__________

1. **Since birth have you ever had any medical problems? If yes, please explain.**

2. **Since birth have you ever been hospitalized? If yes, please explain.**

3. **Have you ever hit your head and experienced a concussion? If yes, please explain.**

4. **Did you ever have problems where you saw a counselor, psychologist or psychiatrist? If yes, please explain.**

5. **Have you ever suffered from seizures? If yes, please explain.**

6. **Do you use tobacco (smoke, chew)? If yes, please explain.**

7. **Have you had any hearing problems? If yes, please explain.**

8. **Have you had any vision problems? If yes, please explain.**

9. What is your current weight and height?

10. Do you currently have or have you ever had any of the following? (circle yes or no) Please explain any yes answers.

Yes	**No**	**strong reaction to cold weather**
Yes	**No**	**circulation problems**
Yes	**No**	**tissue disease**
Yes	**No**	**skin disorders (other than facial acne)**
Yes	**No**	**arthritis**
Yes	**No**	**asthma**
Yes	**No**	**lung problems**
Yes	**No**	**heart problems/disease**
Yes	**No**	**diabetes**
Yes	**No**	**hypoglycemia**
Yes	**No**	**hypertension**
Yes	**No**	**low blood pressure**
Yes	**No**	**hepatitis**
Yes	**No**	**neurological problems**
Yes	**No**	**epilepsy or seizures**
Yes	**No**	**brain disorder**
Yes	**No**	**stroke**

11. Have you ever been diagnosed formally to have had?

Yes	**No**	**learning deficiency or disorder**
Yes	**No**	**reading deficiency or disorder**
Yes	**No**	**attention deficit disorder**
Yes	**No**	**attention deficit hyperactivity disorder**

12. Do you have

Yes	**No**	**claustrophobia (high fear of small closed rooms)**
Yes	**No**	**high fear of needles**

13. List any over the counter prescription medications you are presently taking.

14. Do you have or have you ever had any other medical conditions that you can think of? If yes, please note them below.

Appendix

B

Annett Hand Preference Questionnaire

Name________________________Age____________Sex______________

Were you one of twins, triplets at birth or were you single born?_________________

Please indicate which hand you habitually use for each of the following activities by writing R (for right), L (for left), or E (for either).

(1) to write a letter legibly?____

(2) to throw a ball to hit a target?____

(3) to hold a racket in tennis, squash or badminton?__________________________

(4) to hold a match whilst striking it?____
(5) to cut with scissors?____
(6) to guide a thread through the eye of a needle (or guide needle on to thread)?____
(7) at the top of a broom while sweeping?_____________________________________
(8) at the top of a shovel when moving sand?__________________________________
(9) to deal playing cards?____
(10) to hammer a nail into wood?____
(11) to hold a toothbrush while cleaning your teeth?____________________________
(12) to unscrew the lid of a jar**?**____

If you use the right hand for all of these actions, are there any one-handed actions for which you use the left hand? Please record them here.__________________________
____

If you use the left hand for all of these actions, are there any one-handed actions for which you use the right hand? Please record them here.__________________________
____

Annett (1970)

Appendix

C

LIST OF AUDITORY COMMANDS

SUBTEST 1

1. Touch the Green {Pause} Square

2. Touch the Blue {Pause} Circle

3. Touch the White {Pause} Square

4. Touch the Red {Pause} Circle

5. Touch the Blue {Pause} Square

6. Touch the White {Pause} Circle

7. Touch the Black {Pause} Square

8. Touch the Green {Pause} Circle

9. Touch the Red {Pause} Square

10. Touch the Red {Pause} Circle

SUBTEST 2

1. Touch the Big {Pause} Green Circle

2. Touch the Big {Pause} Black Circle

3. Touch the Little {Pause} Blue Square

4. Touch the Big {Pause} Red square

5. Touch the Little {Pause} Red Circle

6. Touch the Little {Pause} Green Square

7. Touch the Little {Pause} White Square

8. Touch the Big {Pause} White Circle

9. Touch the Big {Pause} Blue Circle

10. Touch the Little {Pause} Black Square

SUBTEST 3

1. Touch the Green Square {Pause} and the Black Square

2. Touch the Blue Circle {Pause} and the Green Square

3. Touch the White Circle {Pause} and the Blue Square

4. Touch the Black Circle {Pause} and the White Square

5. Touch the Green Circle {Pause} and the Red Square

6. Touch the Red Square {Pause} and the White Circle

7. Touch the White Square {Pause} and the Green Circle

8. Touch the Black Square {Pause} and the Red Circle

9. Touch the Red Circle {Pause} and the White Circle

10. Touch the Blue Square {Pause} and the Black Circle

SUBTEST 4

1. Touch the Big Green Square {Pause} and the Little Black Square

2. Touch the Big Black Square {Pause} and the Little Red Circle

3. Touch the Big Blue Circle {Pause} and the Little Green Square

4. Touch the Big White Circle {Pause} and the Little Blue Square

5. Touch the Little Blue Square {Pause} and the Big Black Circle

6. Touch the Little Green Circle {Pause} and the Big Red Square

7. Touch the Little Black Circle {Pause} and the Little White Square

8. Touch the Little White Square {Pause} and the Big Green Circle

9. Touch the Little Red Circle {Pause} and the Big Blue Circle

10. Touch the Big Red Square {Pause} and the Big White Circle

SUBTEST 5

1. Put the Black Square {Pause} By the Red Circle

2. Put the Black Circle {Pause} Above the White Square

3. Put the Blue Square {Pause} Before the Black Circle

4. Put the Red Circle {Pause} On the Blue Circle

5. Put the Blue Circle {Pause} Behind the Green Square

6. Put the Green Square {Pause} Under the Black Square

7. Put the White Circle {Pause} Below the Blue Square

8. Put the White Square {Pause} Next to the Green Circle

9. Put the Red Square {Pause} in Front of the White Circle

10. Put the Green Circle {Pause} Beside the Red Square

SUBTEST 6

1. Put the Big Red Square {Pause} In Front of the Big White Circle

2. Put the Big Blue Circle {Pause} Before the Little Green Square

3. Put the Little Green Circle {Pause} Under the Big Red Square

4. Put the Big Black Square {Pause} Above the Little Red Circle

5. Put the Little Black Circle {Pause} Below the Little White Square

6. Put the Little Blue Square {Pause} Behind the Big Black Circle

7. Put the Big Green Square {Pause} By the Little Black Square

8. Put the Big White Circle {Pause} Next to the Little Blue Square

9. Put the Little Red Circle {Pause} Beside the Big Blue Circle

10. Put the Little White Square {Pause} On the Big Green Circle

SUBTEST 7

1.Put the Black Circle {Pause} to the left of the White Square

2.Put the Red Square {Pause} to the left of the White Circle

3.Put the Black Square {Pause} to the Right of the Red Circle

4.Put the Blue Circle {Pause} to the Left of the Green Square

5. Put the Green Circle {Pause} to the Left of the Red Square

6. Put the White Square {Pause} to the Right of the Green Circle

7. Put the Red Circle {Pause} to the Right of the Blue Circle

8.Put the White Circle {Pause} to the Right of the Blue Square

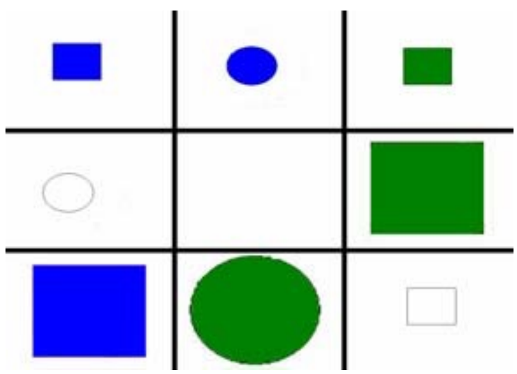
9.Put the Blue Square {Pause} to the Left of the Black Circle

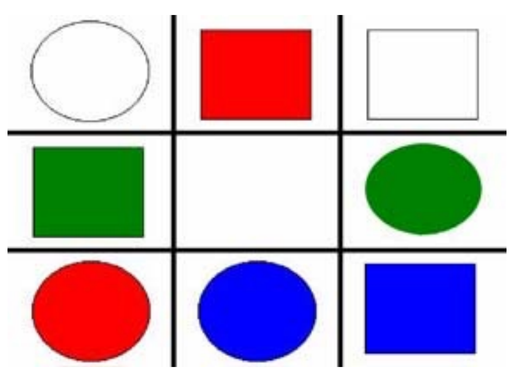
10.Put the Green Square {Pause} to the Right of the Black Square

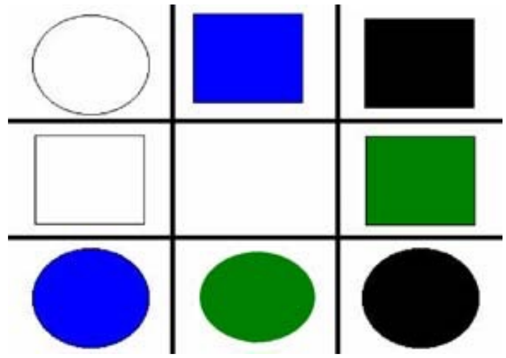
Appendix

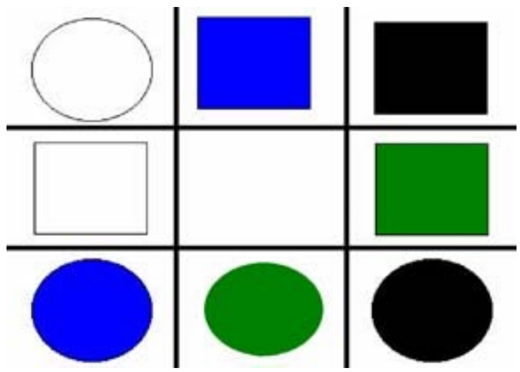
D

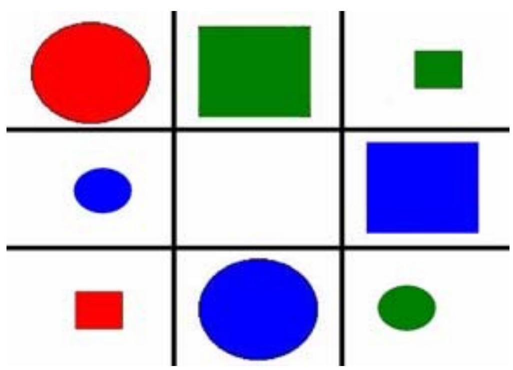
Visual Stimuli

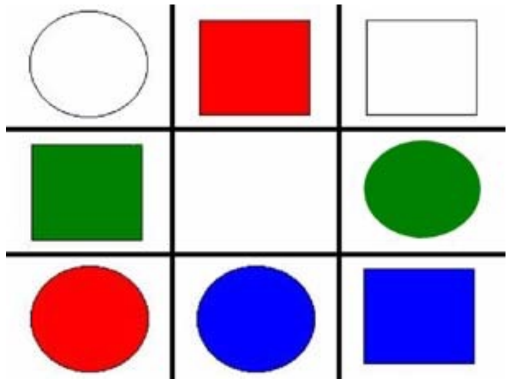


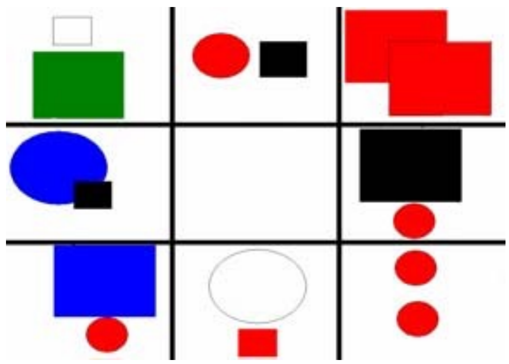


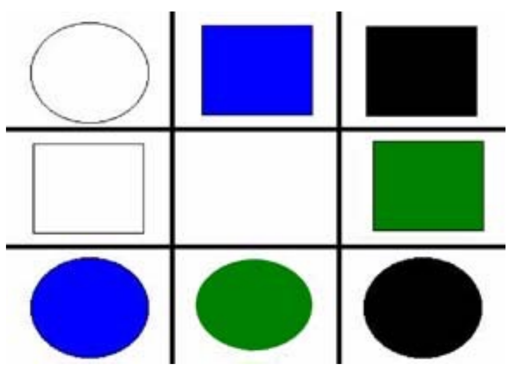


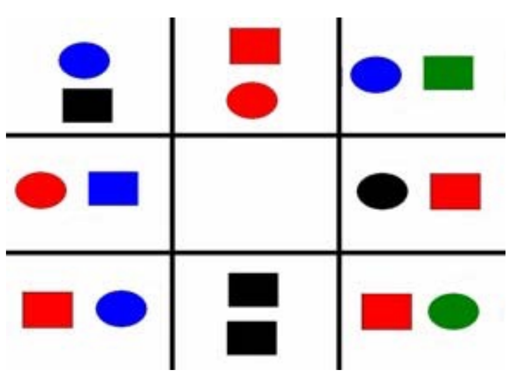


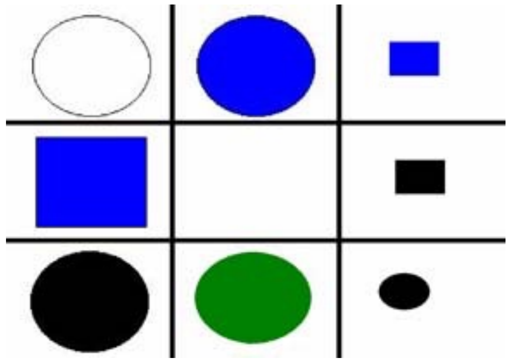


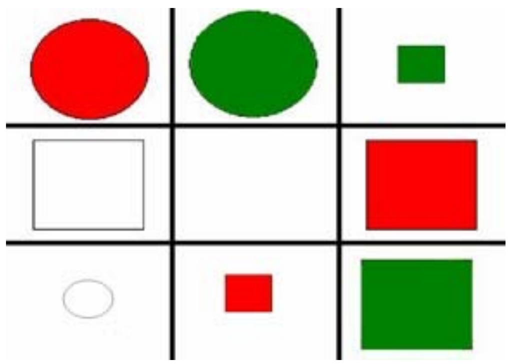


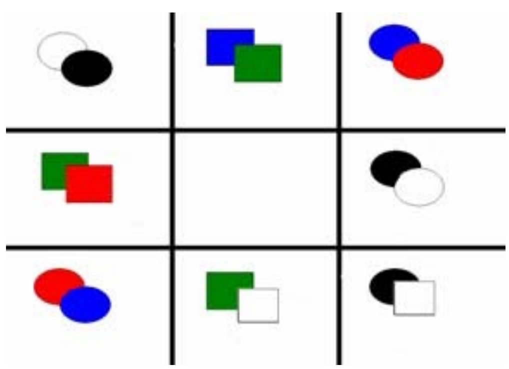


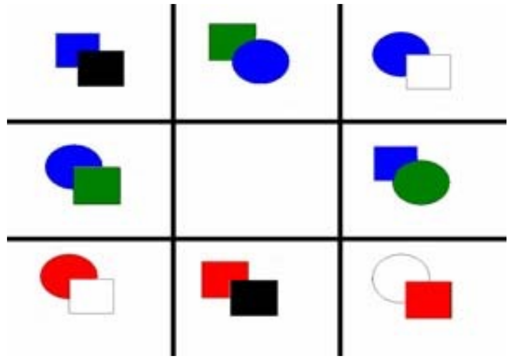


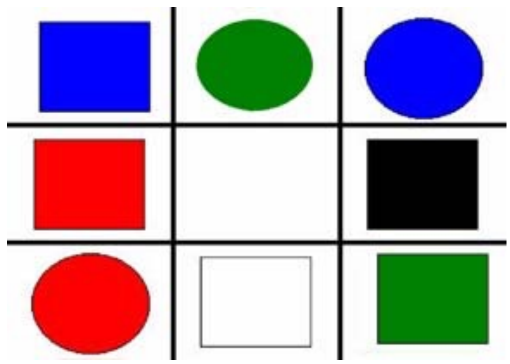


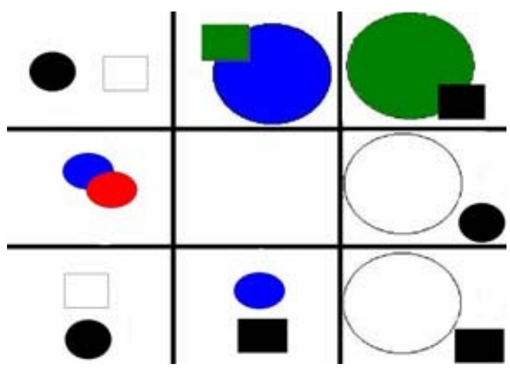


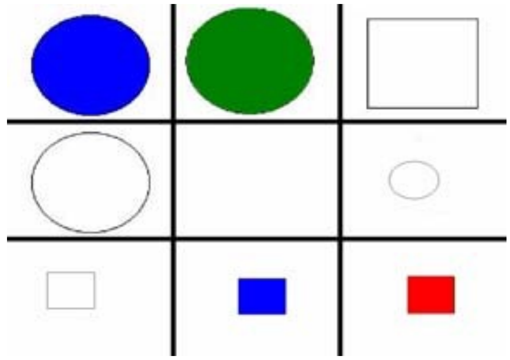


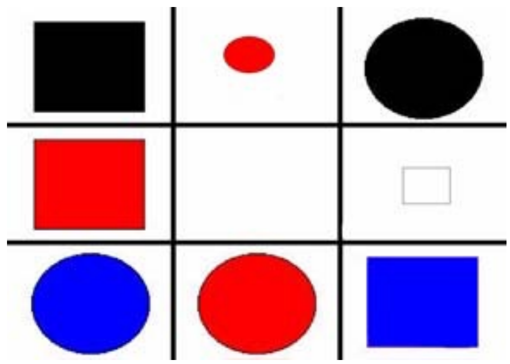


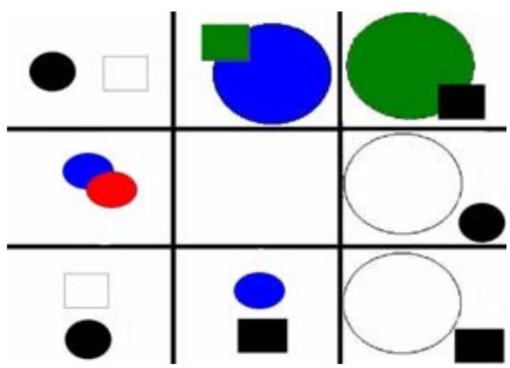


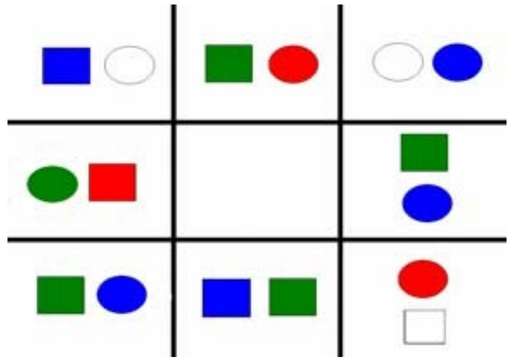


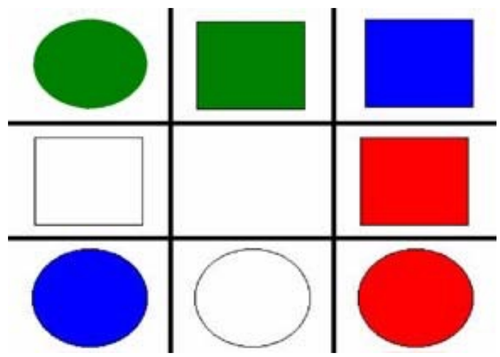


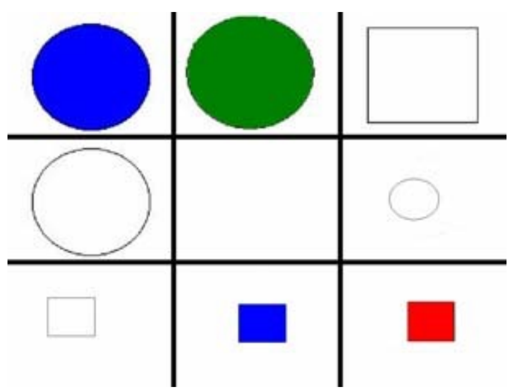


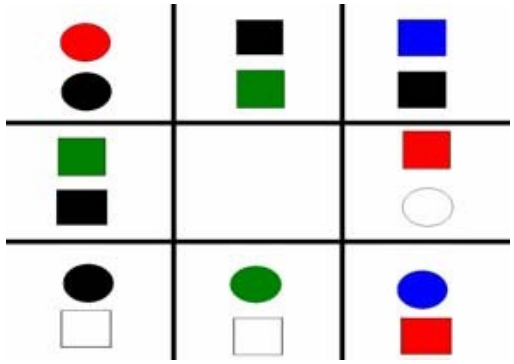


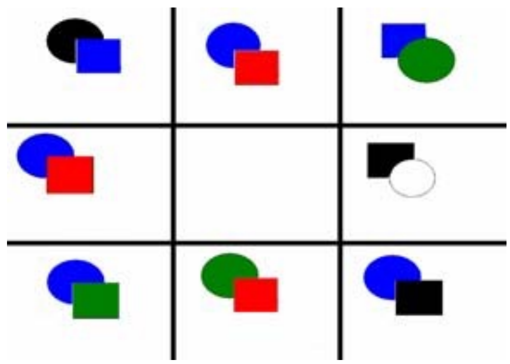


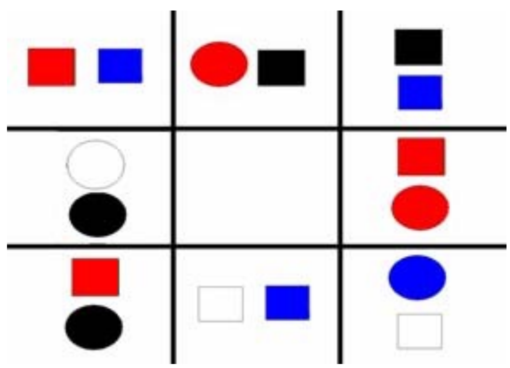












Appendix

E

IRB Research Proposal

I. **Title:** Behavioral and Electrophysiologic Performance in Participants with No Brain Damage Responding to Spoken Sentence Length Messages with Pauses Inserted Within the Spoken Message

II. **Investigators (co-investigators):** Alexandrea Burciaga, B.S.
Supervisor: Patricia Lara, PhD., CCC-SLP, Speech Language Pathology Program
Thesis Committee Members:

III. **Hypothesis, Research Questions, or Goals of the Project**

The purpose of this study is to determine if the amplitude and peak latency of the N400 ERP component are significantly different in two groups of individuals responding to spoken sentence length messages with pauses of different durations inserted within the spoken message. Performance of two different aged groups of participants will be compared. One group of participants will consist of college level students with no history of brain damage. The second group will consist of individuals aged 50-60 years with no history of brain damage. The following questions will be addressed:

1. What pause duration (4sec, 2sec, 1sec, no pause) results in increased accuracy and decreased reaction time in two different aged groups of individuals with no brain damage responding to spoken sentence length messages with pauses of different durations inserted within the message?
2. What are the peak amplitude and latency differences of the N400 ERP components between two different aged groups of participants responding to spoken sentence length messages that increase in length and complexity when additional processing time in the form of pauses inserted within the auditory messages is provided?
3. What are the behavioral performance differences (accuracy, reaction time) between two different aged groups of participants responding to spoken sentence length messages responding to spoken sentence length messages when provided with additional processing time in the form of pauses inserted within the auditory messages?

Study Hypothesis:

There will be no statistically significant difference between the two groups when responding to spoken sentence length messages with pauses of different durations inserted within the spoken message.

IV. **Background and Significance**:

Auditory comprehension is the foundation for the development of language therefore, it is important to understand the mechanisms that underlie this process. Auditory comprehension in individuals with no brain damage has been studied extensively using neuroimaging techniques such as PET, fMRI and ERP. For example, Demonet, Chollet, Ramsay, Cardebat, Nespoulous, Wise, Rascol and Frackowiak (1992) used PET (positron emission tomography) to investigate the functional anatomy of language comprehension. Results show that phonological processing activated the left superior temporal gyrus with some degree of activation in the right superior temporal gyrus. Other studies that examined processing of language have found activation of the left temporal hemispheric area.

However, processing of auditory speech signals requires that the brain access prior knowledge such as words and meanings in the millisecond time range. In order to do this the individual must access the semantic meanings at a very high rate of speed (Friederici&Kilborn, 1989; Hagoort, Wassenaar& Brown, 2003). Event Related Potentials (ERP) can examine this process because of its excellent temporal resolution. ERP examine the electrical activity produced in the brain in response to internal and external stimulus. It is time-locked to a specific stimulus event thus it provides real-time information within the millisecond range making it a logical tool for the study of cognitive processes.

ERP studies have demonstrated that semantic processing in individuals with no brain damage may be reflected in the N400 ERP component. Kutas and Hillyard (1980) observed this waveform in a study that asked participants to read seven word sentences in which the last word was 75% congruous and 25% incongruous. A negative going waveform that appeared at approximately 400ms after the onset of the stimulus was elicited in response to the anomalous word. In another study that used ERP, Salmon and Pratt (2002) examined the N400 in response to sentences and stories that were semantically congruous and incongruous in eighteen participants with no brain damage. The participants exhibited large N400 peaks for congruous sentences and stories than for the incongruous ones. Neville, Nicol, Barass, Forster, and Garret (1991) examined forty adults with no brain damage. The participants were instructed to read sentences that were semantically and grammatically congruous or incongruous. Result show that semantic violations elicited an N400 ERP component with cortical distribution over the temporal and parietal regions of the left hemisphere.

Most studies on auditory comprehension in non-brain damaged individuals have used tasks that ask the participant to make judgments about the semantically and/or grammatically correctness of a sentence. To date only a handful of studies have examined auditory comprehension by asking questions about the material presented (Sommers, Hale, Myerson, Rose, Tye-Murray & Spehar, 2011). To our knowledge, no studies have examined comprehension of spoken sentence length messages with pauses of different durations inserted within the message using ERP. Studies of auditory comprehension in individuals with no brain damage are valuable because the information they provide can be used to recognize abnormal patterns in populations with brain damage.

a. ***Test Description***

The visual stimuli and auditory commands that will be created for this experiment will be a modification of the stimuli used in The Revised Token Test (RTT) (McNeil & Prescott, 1978). The RTT (1978) is a behavioral assessment instrument that detects mild comprehension deficits in brain-injured individuals. The RTT (1978) framework was selected for this experiment because it is based on the theory that a test of language comprehension should be based on a language and not on an intellectual level. In addition, the RTT (1978) has been well validated. Modifications are necessary in order to use this test in an electrophysiologic experiment. The modifications will include mode of presentation. The RTT (1978) presents visual stimuli (plastic tokens-squares and circles of different colors-blue, red, white, black and green) on a tabletop using a 4 X 5 matrix. This experiment will present stimuli on a touch monitor using a 3 X 3 matrix. Plastic tokens will not be used in this EEG experiment since they will be presented on a computer screen. Electrophysiologic procedures require that the visual stimuli and auditory commands used in the RTT (1978) be modified so that triggers can be added and presented using an EEG stimulus presentation software. Triggers are markers that are time-locked to each event within the trial and tell the program

b. ***Experimental Task***

The patient will be seated comfortably in a 6 X 6 soundproof room in front of the Entuitive Touchmonitor. The participant will be asked to place his/her hand on a mark on the table at the start of the procedure. The participant will be instructed to return his/her hand to the mark after touching the visual display appearing on the monitor. The mark will be placed at a distance of 34 cm from the touch monitor. Participants will be instructed to move only to touch the screen when either a white sample (Fig. 1.) or visual display of the choices (Fig. 2.) appears on the touch monitor.

Participant will be instructed to look at the observational white sample (Fig. 1.) that will appear on a black screen on the touch monitor. Participant will be instructed to touch the white sample (Fig. 1.) to initiate an experimental trial. Participant will be instructed to listen to the auditory command (examples listed below) and carry out the command by touching the visual choice (Fig. 2.) that matches the auditory command.

Fig. 1. Example of an observational white sample

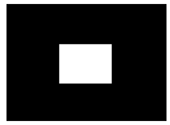
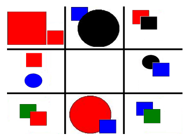


Fig. 2. An example of a visual choice



Examples of Auditory Commands include "Touch (pause) the black circle" and "Touch the green square and (pause) the black square".

c. *Information to be Derived from Test*

Comprehension of spoken commands requires combination of the meaning of individual content words that must be incorporated into the overall meaning of that command. Event related potentials provide information as to the neural processes and networks that are involved in comprehension on a real-time basis. Therefore, this study seeks to determine what the differences are between the neural processes and networks in two groups of individuals that differ in age when processing spoken sentence length messages with pauses inserted within the message.

d. *Summary*

The ability to use and comprehend language is one of the most valuable tools that human beings possess and it is this ability that sets us apart from other living organisms. Studies on non-brain damaged individuals will provide information about abnormal patterns seen in individuals with brain damage.

V. Research Method, Design, and Proposed Statistical Analysis:

a. Experimental Design:

This study compares two groups of individuals responding to spoken sentence length messages with pauses of different durations (4 sec, 2 sec, 1 sec, no pause) inserted within the message. Therefore, this study is a 2X4 factorial experimental design. The independent variable is dichotomous (college level students vs. 50-60 year old individuals). The dependent variable is continuous (performance as measured by reaction time, accuracy, selected ERP components, and amplitude and peak latency of the N400 ERP component).

b. Participants:

Participants will be 10 English-speaking college level students with no history of brain damage. The second group will consist of 10 English-speaking individuals with no history of brain damage between the ages of 50-60 years. Inclusion criteria will also include normal or corrected-to-normal vision and normal or corrected-to normal hearing.

Participants in both groups will complete the following tasks:

(4) Self-report medical history questionnaire;
(5) Annett Handedness Inventory;
(6) Experimental Task

Principal investigator will complete the following tasks:

(5) Administer a hearing screening to both groups;
(6) Take head measurements;
(7) Apply electrode cap according to Biosemi procedure of conduction gel and amplified electrodes;

(8) Performance between groups will be assessed and analyzed.

Participants in both groups will be randomly assigned to one of the 4 conditions (pause durations of 4 sec, 2 sec, 1 sec, no pause).

c. *Proposed Statistical Analysis*:
Comparison ANOVAs will be used to determine if a statistically significant difference in N400 peak latency, amplitude, correct response rate (CRR) and reaction time is found between the two groups of participants. Spatial analysis will also be completed using Vision Analyzer (Cortech Solutions, Inc., 2008) in order to generate cortical activation maps in the form of topographic (surface) maps.

VI. Human Subject Interactions

A. This sample consists of two groups with 10 participants in each group. One group of participants will consist of college level individuals with no history of brain damage. The other group of participants will consist of 50-60 year old individuals with no history of brain damage.

B. Participants will be recruited from the UTEP and El Paso area community. Face-face meetings and announcements presented at the university classes will be used for recruitment purposes. The principal investigator will maintain contact with participants via telephone or mail.

C. Once selected, participants will be provided with verbal explanation as to the purpose of the investigation, all procedures, benefits and/or risks associated with the experiment. Participants will be given an opportunity to read the informed consent. They will also be given opportunity to ask questions regarding their participation in the study as well as the research project itself. Participants will be provided with an explanation as to their right to participate and/or withdraw from the project at any time. Once all questions have been answered to the participant's satisfaction, they will be asked to sign a letter of informed consent.

D. Participants will be asked to come to the ERP and Aphasia Laboratory in the Speech Language Pathology Research Facility located at 1101 N. Campbell El Paso, Tx. 79902. Participants will be asked to come to the lab for one visit. During this visit, participants will be provided with a brief explanation regarding the use of ERP. Participants will fill out the self-report medical and handedness questionnaires. In addition, a hearing screening will be completed by the PI. Following this, the principal investigator will take head measurements and apply the electrode cap according to the Biosemi procedure of conduction gel and amplified electrodes. The patient will then be seated comfortably in a 6 X 6 soundproof room in front of a computer touch monitor to complete the experimental task. The experimental task requires that the participant listen to an auditory command and follow the command by touching the visual choice that matches the auditory command using the touch monitor.

E. Data collection, data entry and data analysis will be the responsibility of the principal investigator. All data, including identifying information in both paper and computer format will be kept in a locked cabinet in the ERP and Aphasia Laboratory in the Speech Language Pathology Department. Only the principal investigator and her thesis advisor will have access to the data and the ERP and Aphasia Laboratory (1101 N. Campbell, El Paso, Tx. 709902). For added protection, electronic data will be stored in a computer that may only be accessed by a password known only to the principal investigator and her thesis advisor. Data collected and used for this experiment will be stored five years after the termination of the study. Data will be destroyed after this five-year time-period.

F. Any information obtained from any participant will be shared only between the principal investigator and her thesis advisor. This information will be used only for the purposes of this research project. All participants will be tested in the ERP and Aphasia Laboratory in the Speech Language Pathology Research Facility located at 1101 N. Campbell El Paso, Texas. 79902. The laboratory is equipped with a table and chairs for the participants to sit and fill out their self-report forms. In addition, this area can be closed off from others in the area for privacy purposes. The principal investigator will be responsible for collecting and analyzing the data during the length of this study. Participants will be identified by a number code that will also be used to identify participant data. Data collected during this study will be stored for a period of five years, after

which, the data will be destroyed. No video and/or auditory recordings will be completed during this study.

G. All participants will be interviewed and tested in the ERP and Aphasia Laboratory of the UTEP Speech Language Pathology Research Facility. Tables and chairs are available for the comfort of the participants. This area is equipped with a door that locks for confidentiality and privacy. The stimuli presentation and ERP recording equipment available for this project includes the software program Superlab (2008) from Cedrus Corporation, custom software program ActiveTwo from Bio Semi (Cortech, 2008), two computers, a printer and a touchmonitor. Additionally, electrode caps in three different sizes, amplified electrodes, conduction gel, gloves, measuring tape and locking cabinet are available for use by the principal investigator during this study.

H. Testing will take place from July 2014 to December 2014. Two days during the week will be designated as testing days. Additional days will be added if needed.

VII. There are no known risks associated with this research. Testing procedures are non-invasive. However, participants may experience mild fatigue during the testing situation. Participants will be provided opportunities to rest should they voice complaints of fatigue.

VIII. Participants may benefit from this study by knowing the outcome of their performance using event related potentials. This study may provide baseline date in case of future neurological damage suffered by these participants.

IX. There are no other specific sites or agencies, other than The University of Texas at El Paso involved in this research project.

X. There are no other IRB approvals, other than The University of Texas at El Paso IRB requested for this project.

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Appendix F

Informed Consent

University of Texas at El Paso (UTEP) Institutional Review Board
Informed Consent Form for Research Involving Human Subjects

Title of Study: Behavioral and Electrophysiologic Performance in Participants with No Brain Damage Responding to Spoken Sentence Length Messages with Pauses Inserted Within the Spoken Message

Principal Investigator: Alexandrea Burciaga, B.S.

Supervisor: Patricia Lara PhD., CCC-SLP

Thesis Members:

UTEP College of Health Sciences: Speech Language Pathology Department

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In this consent form "you" always means the study subject. If you are a legally authorized representative (such as a parent or guardian), please remember that "you" refers to the study subject.

1. **Introduction**
You are being asked to take part voluntarily in the research project described below. Please take your time making a decision and feel free to discuss it with your friends and family. Before agreeing to take part in this research study, it is important that you read the consent form that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

2. Purpose of the Study

You have been asked to take part in a research study that uses event related potentials to compare behavioral and electrophysiologic activity in a individuals with no brain damage responding to spoken messages that contain pauses of different durations. This study examines brain activity in response to spoken messages when additional processing time is provided in the form of pauses inserted within the auditory message.

The rationale:
Auditory comprehension is the foundation for the development of language therefore, it is important to understand the mechanisms that underlie this process. Studies of auditory comprehension in individuals with no brain damage are valuable because the information they provide can be used to recognize abnormal patterns in populations with brain damage.

Approximately, 20 subjects (10 college level individuals with no history of brain damage and 10 individuals between the ages of 50-60 years with no history of brain damage) will be enrolled in this study. You are being asked to be in the study because you are a college level subject with no history brain-damage or a 50-65 year old with no history of brain damage. If you decide to enroll in this study, your involvement will last about approximately one hour.

3. Procedure

If you agree to take part in this study, you will be provided with an explanation regarding the use of event related potentials. Also during your first visit, you will be asked to fill out the self-report medical questionnaire and a handedness inventory. The principal investigator will administer a hearing screening and measure your head to find a cap that best fits the circumference of your head. The principal investigator will fit you with the electrode cap, apply the conduction gel and attach the electrodes. You will then be seated in a soundproof room in front of a computer touch monitor to complete the experimental task. The experimental task requires that you listen to commands presented through speakers and then follow the command by touching the appropriate visual picture that is shown on the touch screen monitor. Examples of commands that you will hear are "touch the black square", "put the little red circle below the big black square".

4. Risks, Discomforts and Benefits

There are no known risks associated with this research. However, you may experience slight fatigue during the testing conditions. If you feel fatigued, you will be given the opportunity to rest.

5. What will happen if I am injured in this study?

The University of Texas at El Paso and its affiliates do not offer to pay for or cover the cost of medical treatment for research related illness or injury. No funds have been set aside to pay or reimburse you in the event of such injury or illness. You will not give up any of your legal rights by signing this consent form. You should report any such injury to the PI, Alexandrea Burciaga (915) 474-6230, her supervisor Dr. Patricia Lara at (915) 747-7271, and/or to the UTEP Institutional Review Board (IRB) at (915-747-8841) or rb.orsp@utep.edu.

6. Benefits

You will not be paid for participating in this study. There will be no other direct benefits to you for taking part in this study. However, you may benefit from this study by knowing the outcome of your performance using event related potentials. This research may lead to better understanding of what is involved in the processes that mediate auditory comprehension of spoken sentence length messages.

7. Options

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study.

8. Funding

No funding has been provided, as this is a Thesis Project.

9. Costs

There are no direct costs to you. However, you will be responsible for travel to and from the research site and any other incidental expenses.

10. Compensation

You will not be paid for participating in this study.

11. Refusal or Withdrawal

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty. If you choose to take part, you have the right to stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them. The researcher may decide to stop your participation without your permission, if he or she thinks that being in the study may cause you harm, and/or there is not sufficient effort on your part to complete the testing.

12. Contact Information

You may ask any questions you have now. If you have questions later, you may call Alexandrea Burciaga at (915) 474-6230 or via email at aearras@miners.utep.edu or Dr. Patricia Lara at (915) 747-7271, or via email at *plara2@utep.edu*. If you have questions or concerns about your participation as a research participant, please contact the UTEP Institutional Review Board (IRB) at (915-747-8841) or irb.orsp@utep.edu.

13. Confidentiality

Your part in this study is confidential therefore; all information collected in this study will remain confidential. Only the principal investigator (Alexandrea Burciaga) and her Thesis Advisor (Dr. Patricia Lara) will have access to this information. In addition, none of the information will identify you by name. Instead, identification numbers will be used. All records will be stored in a locked cabinet in the ERP and Aphasia Laboratory at the UTEP Speech Language Pathology Research Facility located at (1101 N. Campbell, El Paso, Tx. 79902). For further protection, only the principal investigator and her thesis

advisor will have access to the locked cabinet. Computer information will be stored in the laboratory computers and password secured. Only the principal investigator and her thesis advisor will have access to the password. The results of this research study may be presented at meetings or in publications; however, your identity will not be disclosed in those presentations.

14. Mandatory Reporting
If information is revealed about abuse or neglect to the elderly or disabled, the law requires that this information be reported to the proper authorities.

15. Authorization Statement
I have read each page of this paper about the study (or it was read to me). I know that being in this study is voluntary and I choose to be in this study. I know I can stop being in this study without penalty. I will get a copy of this consent form now and can get information on results of the study later if I wish.

Participant Name: ______________________________ Date: ____________

Participant Signature: ______________________________ Time: ____________

Consent form explained/witnessed by: ________________________

Signature

Printed name: ______________________________

Date: ____________ Time: ____________

Vita

Alexandrea Burciaga was born in El Paso, Texas. She received her Bachelor in Hotel and Restaurant Management from The University of Houston in 2010. She began a career with Darden Inc. before deciding to move back to El Paso, Texas to further her education. She enrolled at The University of Texas at El Paso in 2012 to pursue her Masters in Speech Language Pathology. Alexandrea and a colleague had the opportunity to submit a poster presentation at the Texas Speech Hearing Association Convention held in Houston, Texas in 2014.

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This thesis/dissertation was typed by Alexandrea Burciaga