THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF COMMUNICATION SCIENCES AND DISORDERS

WHAT AFFECTS THE PROCESSING OF ABSTRACT AND CONCRETE WORDS?

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SPRING 2019

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Communication Sciences and Disorders
with honors in Communication Sciences and Disorders

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ABSTRACT

Researchers have found that there is a difference in semantic processing of concrete and abstract words, which has helped to create therapy techniques for individuals who have difficulty with word retrieval. However, individual differences, such as demographic variables, may be important to understand when examining different aspects of language processing. This study examined the demographic variables of participants in relation to the event related potentials (ERPs) in response to abstract and concrete words during a lexical decision task. The demographic variables analyzed were: age, education, and the five domains of the Cognitive Linguistic Quick Test (CLQT). Overall, the regressions were not significant, therefore the demographic variables of the individuals were not predictive of abstract and concrete word processing. However, there were interesting trends. When age is plotted against the difference in latency between abstract and concrete words, as age increases the latency difference in the Pz electrode increases. However, this trend is only seen up to 50 years in age. A significant correlation between age and education were found indicating that the older individuals in the study are well educated. The regression coefficients suggest that independent variables such as language ability, level of education, and attention may play a role in the N400 peaks. Further research needs to be conducted to make any conclusions about the effect of demographic variables on abstract and concrete word processing. More sophisticated statistical models could reveal significant patterns that cannot be captured by the simple regression models used in this study.

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ACKNOWLEDGEMENTS

First, I would like to start by expressing my gratitude to Dr. Chaleece Sandberg. This thesis would not have been possible without the guidance, knowledge and constant support of Dr. Sandberg. I am truly grateful for all of the time she has put into this project. I would also like to thank Dr. Carol Miller for her advice and support throughout this process as well.

Chapter 1

Introduction

Semantic processing is a vital feature of human behavior. It plays an important role in humans' ability to communicate with one another. Semantic processing plays a role in our verbal and visual representation of the word as well as our memory (Warrington, 2017). The semantic system is not only central to language, but also has the ability to access acquired knowledge in reasoning, planning, and problem solving (Binder 2009, pp. 1). Stored knowledge can be found in the semantic memory, which includes knowledge about people, objects, actions, relations, self, and culture that individuals gain through experience. Semantic processing can be referred to as the act of cognitively accessing semantic memory (Binder, 2009). Quillian's Theory of Semantic Memory describes semantic memory as a network where each idea or concept can be represented as a node. Semantic memory is explained in terms of spreading activation from the node of the primed concept to other concept nodes until there is an intersection between the nodes. In this theory, the full meaning of a concept includes all of the attached nodes (Collins, & Loftus, 1975). Semantic memory connects various ideas or facts that have been acquired throughout an individual's life that makes everyday communication possible.

To gain a deeper understanding of how humans process words, researchers have looked at concrete and abstract words. Concrete words are described as objects that can be seen, heard, smelled, touched or otherwise directly experienced through one's senses. An example of a concrete word is *flower*. Abstract words are described as concepts that lack sensory and perceptual grounding. An example of an abstract word is *secret* (Binney, 2016). Researchers have found that there is a difference in the way humans process concrete and abstract words. The concreteness effect is the observation that concrete words are processed faster and more accurately than abstract words in a variety of cognitive tasks (Jessen, Heun, Erb, Granath, & Klose, 2000). When an individual has a brain lesion that affects their ability to process different word types, research has found a double dissociation for abstract and concrete words. For example, if one patient has difficulty identifying concrete words, their ability to identify abstract words may still be intact. A different patient may have difficult identifying abstract words, but their ability to identify concrete words is still intact. Thus, while abstract and concrete words use related processes, they have been found to function independently of one another (Ward, 2015).

However, scientists have not established the exact difference between the processing of abstract and concrete words. There are various different theories that work to describe how individuals understand and process concrete and abstract words. The three theories that will be discussed in this paper are the Dual Coding Theory, the Context Availability Model, and the Grounded Cognition Theory.

The dual coding theory argues that there are two separate processing systems. One that is verbal-based and one that is image-based. Each of the systems operates on its own form of knowledge representation. The processing of abstract words relies on the verbal code representation system, in the left hemisphere only. Concrete word processing is hypothesized to utilize both of these systems. Concrete words access the verbal code representation system in the left hemisphere as well as the image based processing system in the right hemisphere. This allows the concrete words to be processed faster and more accurately than the abstract words, supporting the concreteness effect (Paivio, 1991). There have been various studies that support this theory. Villardita et. al (1988) found that patients with a right hemisphere lesion performed significantly worse when asked to recall previously studied concrete words. A significant difference was not seen when the patients were asked to recall abstract words. Villardita and colleagues hypothesized that concrete words were unable to use the image based processing system, in the right hemisphere, causing a decrease in performance. On the other hand, abstract words only use the verbal code representation system in the left hemisphere, which was not impacted by the lesion, therefore a significant difference in the processing of the abstract words was not observed.

In contrast, the context availability model hypothesizes that there is only one processing system. This model depicts comprehension as heavily reliant on contextual support provided by a stimulus or the individual's own knowledge. This model also supports the concreteness effect by explaining that concrete words automatically activate more associative or contextual information, which results in a faster recognition of concrete than abstract words. However, if abstract words are presented in a meaningful context with sufficient information, the concreteness effect disappears and the abstract words are recognized as quickly as concrete words (Schwanenflugel & Harnishfeger, & Stowe, 1988).

The grounded cognition theory takes a different approach as it rejects the standard view that symbols are represented in knowledge in semantic memory. Grounded cognition focuses mainly on the reenactment of perceptual, motor, and introspective states acquired during one's experience with the world, body and mind. During an experience, the brain will capture different states across modalities and integrate them with a multimodal representation in stored memory (Barasalou, 2008). However, abstract words pose a challenge for this theory. It has been found that individuals often understand concrete words using external sources, such as worldly experiences. However, internal sources can also aid in the understanding of concrete words.

Barasalou (2008) discusses that abstract words are also processed with more ease when background information and experiences help to contextualize the word. In addition, Barasalou believes internal information is also imperative in the understanding of abstract words. Barasalou states that abstract concepts need to be studied at greater depths to understand how humans process the words in respect to the grounded cognition theory.

There are various regions of the brain that are involved in semantic processing. These regions include: the posterior inferior parietal lobe, the lateral temporal cortex, the ventral temporal cortex, the dorsal medial prefrontal cortex, the inferior frontal gyrus, the ventromedial prefrontal cortex, and the posterior cingulate gyrus. Studies have found that both concrete and abstract words have strong activation in the bilateral angular gyrus, left mid-fusiform gyrus, left dorsomedial prefrontal cortex, and the left posterior cingulate cortex. Differences in activation are seen between the word types as well. Abstract words engage the perisylvian and prefrontal areas to a greater extent than concrete words. Concrete words have been proposed to engage more of the mid fusiform gyrus when retrieving information about the visual characteristics the words. (Binder, 2009).

When studying abstract and concrete words and the primary regions of brain activation involved, fMRIs are often used. An fMRI has good spatial resolution and is a good tool for localizing abstract and concrete word processing. However, it cannot precisely measure the timing of these processes. An EEG has good temporal resolution, and has the ability to measure the timing of abstract and concrete word processing. Latency represents the time between the stimulus and the response. This is an important component for studying the differences in semantic processing of concrete and abstract words because according to the concreteness effect concrete words are processed faster than abstract words. The latency component will show differences in the temporal aspects of semantic processing of the word types. An EEG is defined as a test that detects electrical activity in the brain using small, metal discs (electrodes) attached to an individual's scalp. An individual's brain cells communicate via electrical impulses and are active all the time, even when the individual is asleep. An important measurement, used to interpret EEG data, is the event related potentials (ERPs). ERPs are the stimulus bound portion of the EEG that averages all of the electrical activity of each stimulus event that is equal in nature. (Luck, 2014).

There are specific ERP components that are relevant to language, such as the N400 and P600. The P600 is a positive ERP that occurs around 600 milliseconds after the onset of a word (Ward, 2015). The P600 is elicited by syntactic violations or words that are inconsistent with a sentence's structure. The N400 is important for this study and will be the only ERP component analyzed. The N400 is a negative-going wave that occurs around 400 milliseconds after the onset of a word (Ward, 2015). The N400 is often largest over central and parietal electrode sites with a slightly larger amplitude over the right hemisphere than the left. The amplitude of the N400 correlates with how well a word fits a prior context (Luck, 2014). The amplitude increases to words that are anomalous, and the amplitude is often smaller or nonexistent to probable words. The same effects can be seen when words are presented aurally or visually, and when words are presented in sentences or at the single word level (Kounious, & Holcomb, 1994).

One EEG study that has looked specifically at N400 differences between abstract and concrete word processing is Kounious and Holcomb's study (1994). The researchers conducted an experiment using EEG to look at the contrasting structural implications, of the dual coding and context availability theories, on semantic processing. This study conducted two experiments. The first experiment included twelve native English speaking volunteers ranging from 19 to 30 years of age, from the Tufts University community. The participants were shown a word on the screen and asked to click a ‘yes’ button to indicate that this was an English word or click a ‘no’ button to indicate that this was not an English word. There were two sub-lists of words, 160 words in each list, presented to the participants. Each sub-list consisted of 40 concrete words, 40 abstract words, 40 pseudowords formed from concrete words and 40 pseudowords formed from abstract words. Experiment two was similarly structured with twelve native English speaking volunteers ranging from 21 to 35 years of age, from the Tufts University community. In this experiment only concrete and abstract words were being looked at therefore, the stimulus lists were made up of 40 concrete words and 40 abstract words. The task was the same, where a word would pop up on the screen and the participant would click a button for ‘concrete’ or ‘abstract’ depending on what category they thought the word belonged to.

Overall, the results show that concrete words elicit larger negativities in the N400 than abstract words. The authors suggest that this may be because concrete words activate more semantic information in memory than abstract words. In addition, the N400 effect for concrete words is greater over the right hemisphere than the left, suggesting that the information activated by concrete words is of a different type than abstract words. This suggested that the semantic information activated by the concrete words is different than the semantic information activated by abstract words. These results support the dual coding theory in that both the concrete and abstract words are processed by the left-hemisphere verbal system, but the right-hemisphere imaginal system is also involved in primary processing of concrete words (Kounious, & Holcomb, 1994).

This study and other studies using EEG have helped researchers to gain a foundation to understand how individuals process abstract and concrete words. However, researchers have not looked at how variables that are different for each individual may affect the processing of words on an individual level. Some demographic variables that can be studied are age, sex, education, and cognitive abilities. Examining the effects of age may be especially important because linguistic processes have been shown to changes as we age.

Diaz and colleagues (2014) conducted a study that suggests age differences in linguistic processing. The researchers tested older and younger adults' performance on phonological and semantic tasks. The participants were asked to identify objects in a picture. They were either given a phonological cue, the first letter of the word for the object, or a semantic cue, a one word description or characteristic of the object. During the tasks, the participants received an fMRI scan. The behavioral performance of the older adults was less accurate and slower than the younger adults' performance on the phonological task. However, group performance did not differ on the semantic task. When looking at the fMRI results, the authors did not find a statistically significant interaction between age and condition. However, the correlations examining the relationship between behavior and fMRI activation were stronger for the younger adults than the older adults. It was found that the neural activation of older adults, produced more activation throughout different regions of the brain than the younger adults did. The combined pattern of an increase in functional activation and a slower and more variable behavioral performance, in the phonological task, may represent an overall decline in individual abilities to identify these objects. These findings suggest that the relationship between the behavior and the neural activation declines with age, specifically for the phonological task. It is important to note that a larger difference may not be seen in the semantic tasks because there is more activation among different regions of the brain. This increased activation is believed to compensate for the decrease activation in specific regions of the brain causing little to no difference in performance on the semantic task (Diaz, Johnson, Burke, & Madden, 2014).

This study suggests that as individuals age, they process words differently and at a slower rate than younger individuals. The results of Diaz's study emphasize the importance of examining demographic variables like age when examining different aspects of language processing. Thus, the current study examines the demographic variables of the participants in relation to the ERPs of the EEG data during a lexical decision task. Demographic variables such as age, education, and cognitive and linguistic abilities, assessed through the Cognitive Linguistic Quick Test (CLQT), will be analyzed to see if they have an effect on the semantic processing of different words. This study will examine word type -- abstract words, concrete words and nonwords -- and the differences in processing these words. Given the Diaz et al. (2014) findings that suggested a relationship between behavior and fMRI activation were stronger for the younger adults than the older adults, I hypothesize that the demographic variables of the individuals, specifically age, will have an effect on the event related potentials. I speculate that there will be an increase in the latency of the event related potentials for older participants and participants who have a lower score in their cognitive and linguistic abilities. I also hypothesize that N400 patterns will be larger for concrete words. This will replicate previous work showing a larger N400 for concrete than abstract words because larger parts of the brain are activated for the semantic processing of concrete words (Kounious, & Holcomb, 1994). By understanding the effects that demographic variables can have on semantic processing of different word types, researchers will better understand the semantic system and ultimately be able to create more effective therapy techniques and interventions for individuals who experience semantic processing difficulties.

Chapter 2

Methods

The data were collected during Sandberg's on-going study "Investigation of spatial and temporal aspects of abstract and concrete word processing in neurologically healthy adults and persons with aphasia using ERP and fMRI." The current study is a secondary analysis of that data.

Thirty-four native English-speaking participants (12 males and 21 females) ranging from 18 to 64 years of age (M=34.2, SD= 16.8), who did not have any deficits, participated in Sandberg's study. There were 24 younger adults in the study ranging from 18 to 36 years of age (M=24.5, SD= 4.9) and 10 older adults in the study ranging from 41 to 78 years of age (M=57.5, SD=10.8). In addition, 11 English-speaking participants with aphasia (9 males and 2 females) ranging from 46 to 82 years of age (M=62.3, SD= 11.6) also participated in the experiment. For the current study, only the data of the individuals who did not have any deficits were analyzed. All of the participants attained at least a high school education and many of the participants attained a college degree or higher.

All of the participants were given the Cognitive Linguistic Quick Test (CLQT). This test is given to evaluate neurological impairment. The CLQT is made up of ten tasks and each task assesses various cognitive and language skills. The CLQT encompasses five cognitive domains; attention, memory, executive function, language, and visuospatial skills. After the CLQT is conducted, each of the five domains is scored for severity, according to the participant's age range (Helm-Estabrooks, 2001). All of the participants analyzed in this study scored within normal limits.

Averages and standard deviations of the younger and older participants' demographic information, including the CLQT scores are provided in Table 1 below.

Table 1.
Demographic Variables of Participants

	Age	Education	Attention	Memory	EF	Language	Visuospatial
YA	24.46 (SD=4.89)	14.58 (SD=2.60)	206.42 (SD=6.96)	172.96 (SD=8.72)	35.63 (SD=3.09)	34.13 (SD=1.96)	100.79 (SD=3.61)
OA	57.50 (SD=10.77)	18.30 (SD=1.16)	202.50 (SD=4.22)	174.10 (SD=5.23)	32.30 (SD=1.57)	34.10 (SD=1.79)	96.60 (SD=2.91)

Note. YA = Younger Adults; OA = Older Adults. Attention, memory, EF (Executive Function), language and visuospatial skills are all domains of the CLQT.

Each participant completed a lexical decision task and a semantic association task during an EEG and during an fMRI. Only the EEG data from the lexical decision task were analyzed for this study. The lexical decision task is thought to elicit basic semantic processing. In this study, the lexical decision task included 60 abstract words, 60 concrete words, and 120 nonwords. While connected to the EEG system, the participant sat in front of a screen with a "yes" button and a "no" button. A word would appear on the screen and the participant would select "yes" if they thought the word on the screen was a real word in English or they would select "no" if they thought the word on the screen was not a real word in English.

All of the participants' EEG data were collected and analyzed using Brain Vision. The primary analysis was conducted by re-referencing the electrodes, which creates a new unbiased reference using the mastoid electrodes. Then an artifact rejection was conducted to exclude trials containing artifacts, which allows for better interpretation of the data. An artifact is recorded activity that is not of cerebral origin. Finally, an ocular Independent Component Analysis (ICA) was conducted to remove ocular activity, such as eye blinks, to create an analysis that includes minimal artifacts. Additionally, the N400 peaks were identified for each participant.

The secondary analysis averaged all of the individual data together and created graphs for each electrode for visually comparing the ERP waves for each word type. The peak latency and voltage data for the N400 component for the Fz, Cz, and Pz electrodes were exported to an excel file. This information was combined with the demographic information for each participant, normalized, and then imported into SPSS. For latency, the data were normalized by subtracting 400 ms because this is the expected time point for the N400 response. For voltage, the average of each electrode's voltage was found and then subtracted from each participant's individual voltage for that electrode.

In SPSS, the data were analyzed in two ways. Linear regressions were conducted to understand how the demographic variables will affect the N400 peak latency and peak voltage. Repeated measures ANOVAs were conducted to understand whether there is a difference in N400 peak latency and peak voltage for each word type. For the regressions, the peak latency and voltage at each electrode (Fz, Cz, and Pz), served as the dependent variables in separate regressions. In each regression, the independent variables were the demographic variables: age, level of education, and CLQT scores for attention, memory, executive function, language and visuospatial skills. For the repeated measures ANOVAs, the factor was word type, with three levels: abstract, concrete, and nonword. These were the within-subject variables. As an exploratory analysis, additional repeated measures ANOVAs were performed in which a between-subject variable was added, which split the data into two age groups -- younger and older adults -- with the split set at 40 years of age. In all analyses, a p-value of 0.05 was used for significance.

Chapter 3

Results

Visual inspection of the ERP graphs reveal N400 patterns for each electrode. Illustrated in Figure 1 in the Fz, the N400 peak is the largest for nonwords, then concrete words, then abstract words. Illustrated in Figure 2 in the Cz, the N400 peak is largest for nonwords, then concrete words, then abstract words. Illustrated in Figure 3 in the Pz, the N400 peak is largest for concrete words, then nonwords, then abstract words.

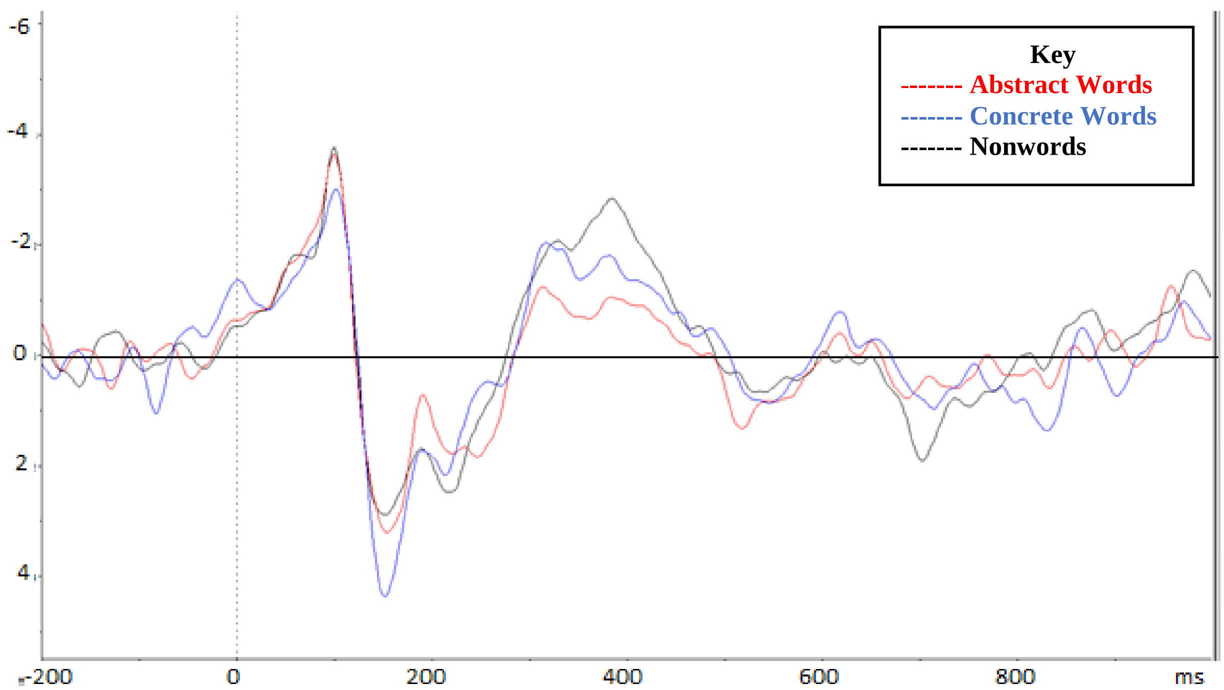

Figure 1: Fz N400 Peaks. This figure illustrates the Fz electrode event related potentials

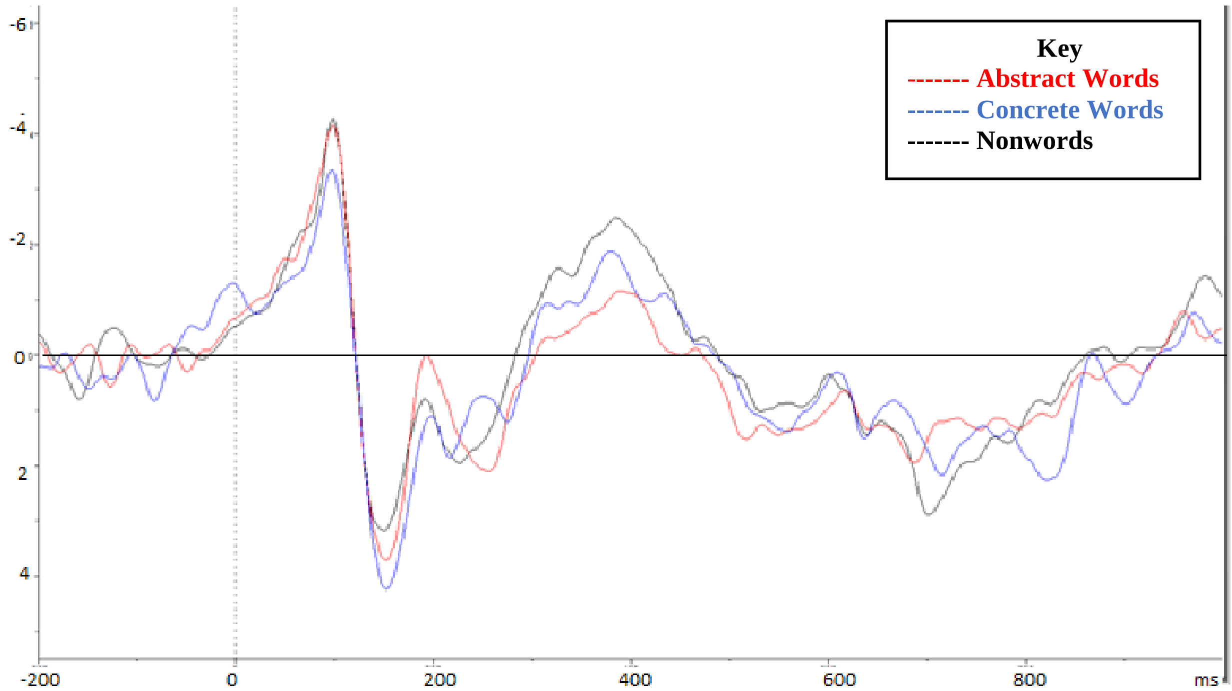

Figure 2: Cz N400 Peaks. This figure illustrates the Cz electrode event related potentials.

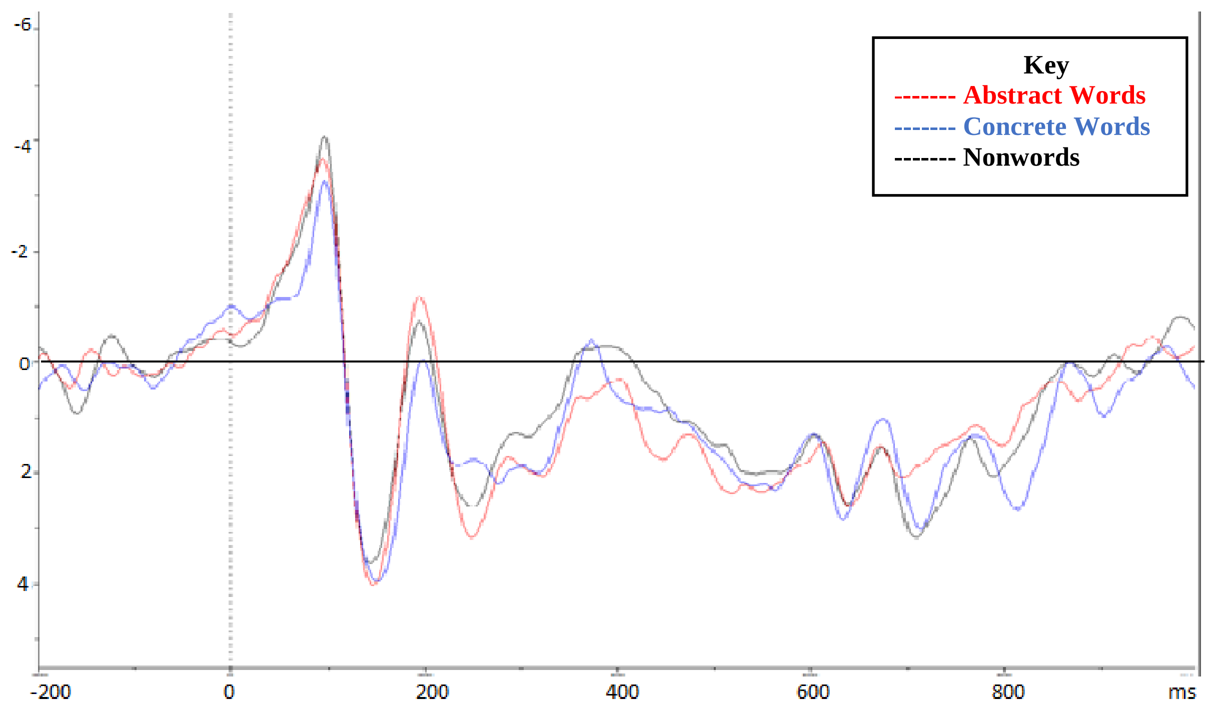

Figure 3: Pz N400 Peaks. This figure illustrates the Pz electrode event related potentials.

Although the ERPs for abstract, concrete, and nonwords are visually separate in the graph, none of the ANOVAs testing these differences in word type for each electrode resulted in any significant effects. The main effects were also non-significant when group was added as a between-subjects factor and no word type x group interactions were found.

None of the regressions testing the effect of demographic variables on peak latency or voltage were statistically significant. However, fifteen significant correlations from the regression were found. Eleven significant correlations among independent variables were found: 1) age and education; 2) age and executive function; 3) age and visuospatial skills; 4) education and visuospatial skills; 5) attention and memory; 6) attention and executive function; 7) attention and language; 8) attention and visuospatial skills; 9) memory and language; 10) executive function and language; 11) executive function and visuospatial skills. Four significant correlations between the independent variables and dependent variables were found: 1) Pz abstract latency and executive function; 2) Pz concrete latency and education; 3) Fz nonword latency and attention; 4) Fz nonword latency and visuospatial.

Table 2:
Demographic Correlations

	Age	Education	Attention	Memory	EF	Language
Age						
Education	*** 0.717					
Attention	-0.25	-0.264				
Memory	0.067	0.018	*** 0.657			
EF	** -0.414	-0.271	*** 0.631	0.194		
Language	0.045	-0.027	*** 0.639	*** 0.814	** 0.451	
visuospatial	** -0.439	* -0.312	*** 0.715	0.168	*** 0.847	0.213

Note. A p-value less than or equal to 0.001 is indicated by ***. A p-value less than or equal to 0.01 is indicated by **. A p-value less than or equal to 0.05 is indicated by *. Attention, memory, EF, language and visuospatial are all domains of the CLQT.

Table 3:

Peak Voltage Correlations

	Pz Nonword	Cz Nonword	Fz Nonword	Pz Concrete	Cz Concrete	Fz Concrete	Pz Abstract	Cz Abstract	Fz Abstract
Age	0.123	0.071	0.067	0.129	0.135	0.044	0.008	0.051	-0.008
Education	-0.063	-0.142	-0.15	-0.016	-0.085	-0.184	-0.105	-0.002	-0.095
Attention	-0.162	-0.067	-0.036	-0.219	-0.156	0.061	-0.148	-0.065	0.128
Memory	-0.153	-0.087	-0.115	-0.182	-0.154	-0.075	-0.164	-0.109	-0.003
EF	-0.152	-0.04	0.021	-0.214	-0.152	0.141	-0.205	-0.203	-0.046
Language	-0.019	0.059	0.066	-0.083	-0.001	0.174	-0.135	-0.104	0.102
Visuospatial	-0.204	-0.115	-0.059	-0.252	-0.234	0.016	-0.188	-0.206	-0.087

Note. A p-value less than or equal to 0.001 is indicated by ***. A p-value less than or equal to 0.01 is indicated by **. A p-value less than or equal to 0.05 is indicated by *. Attention, memory, EF, language and visuospatial are all domains of the CLQT.

Table 4.

Peak Latency Correlations

	Pz Nonword	Cz Nonword	Fz Nonword	Pz Concrete	Cz Concrete	Fz Concrete	Pz Abstract	Cz Abstract	Fz Abstract
Age	0.133	0.001	0.032	-0.146	0.045	0.136	0.144	0.153	-0.116
Education	0.038	-0.021	0.113	* -0.374	-0.003	0.117	0.179	0.157	0.005
Attention	0.172	-0.151	* -0.28	0.078	-0.13	-0.012	-0.073	-0.232	-0.17
Memory	0.191	-0.015	-0.103	-0.007	-0.014	0.076	0.21	-0.146	-0.093
EF	-0.105	-0.117	-0.142	0.143	-0.195	-0.153	** -0.4	-0.17	-0.078
Language	0.161	-0.08	-0.108	-0.055	-0.182	-0.148	-0.071	-0.214	-0.227
visuospatial	-0.113	-0.202	* -0.282	0.243	-0.199	-0.007	-0.219	-0.167	-0.012

Note. A p-value less than or equal to 0.001 is indicated by ***. A p-value less than or equal to 0.01 is indicated by **. A p-value less than or equal to 0.05 is indicated by *. Attention, memory, EF, language and visuospatial are all domains of the CLQT.

Although the regressions themselves were not significant, it is interesting to note that three coefficients from the regressions had significant p-values: 1) language on Cz concrete peak latency ($t = -2.16$, $p < 0.05$); 2) education on Pz concrete latency ($t = -2.61$, $p < 0.05$); 3) attention on Fz abstract voltage ($t = 2.63$, $p = 0.01$).

Chapter 4

Discussion

I hypothesized that the demographic variables of the individuals, specifically age, will have an effect on the latency of the ERPs and that the N400 patterns will be larger for concrete words than abstract words. Overall the regressions were not significant, therefore the demographic variables were not predictive of the event relate potentials. Although these hypotheses were not supported statistically, there were patterns in the data that are worth noting. First, the Fz, Cz, and Pz electrode ERP graphs all showed a larger N400 peak for concrete words than abstract words. This supports the findings of Kounious and Holcomb (1994) that concrete words elicit a larger N400 response than abstract words. Figure 4 below illustrates the average N400 peak voltage for each word type in each electrode. Previous research has suggested that a larger N400 peak is more evident over the central (Cz) and parietal (Pz) electrodes (Luck, 2014). However, the opposite is seen in this study, with larger N400 peak averages over the frontal electrode (Fz) than the Cz and Pz electrodes. As seen in Diaz et al. (2014) study, the neural activity of older adults produced more activation throughout different regions of the brain then the younger adults. A similar trend may be occurring in this study. If the older adults are activating different regions of the brain, such as areas where the Fz electrode lies, this may be affecting the overall average peak voltage.

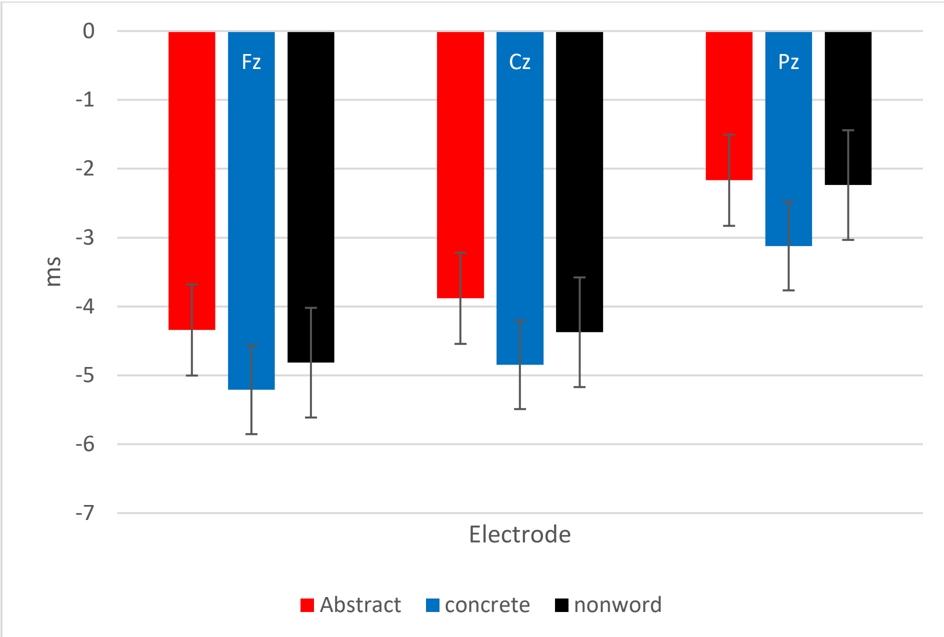

Figure 4: N400 Average Peak Voltage. This figure illustrates the average peak voltages for each word type (abstract, concrete, and nonword) at each electrode.

Figure 5 below illustrates the average N400 peak latency for each word type in the three electrodes. Latency is not often addressed; however, it is being addressed in the current study because one of the ways the concreteness effect is measured is through reaction time. Researchers have found that there is a difference in the semantic processing of abstract and concrete words. In this study, the peak latency was longer for abstract words in the Fz and Pz electrodes. However concrete words had the longest peak latency in the Cz electrode. This suggests that there is a difference in semantic processing of abstract and concrete words because abstract and concrete words have different latency patterns for the different electrodes. With more data or more sophisticated analyses, these interesting patterns may end up being significant.

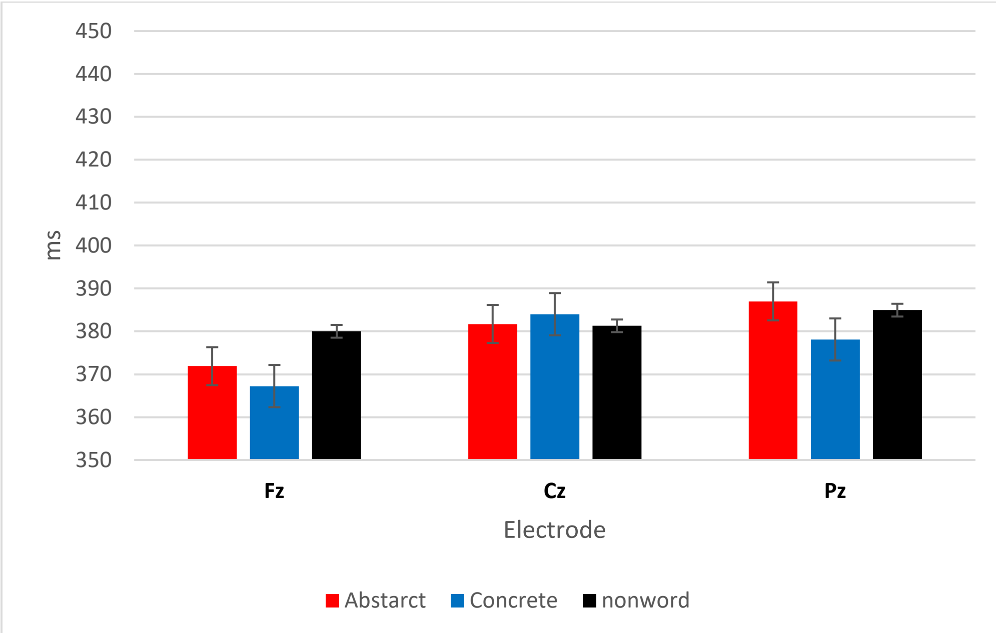

Figure 5: N400 Average Peak Latency. This figure illustrates the average peak latencies for each word type (abstract, concrete, and nonword) at each electrode

When age group was entered as a between-subjects factor into the repeated measures ANOVAs, the results were still not significant for either group, nor were there group x word type interactions. However, when age is plotted against the difference in latency between abstract and concrete words, an interesting pattern emerges. Figure 6, below shows as age increases, the latency difference in electrode Pz increases. This trend is seen until around 50 years of age. The trend is showing a difference between younger and older adults in the processing of abstract and concrete words. For the older adults, larger peak latencies are seen for abstract words than concrete words, making the overall difference closer to zero or greater than zero. The younger adults seemed to have the opposite trend. The concrete peak latencies are larger than the abstract peak latencies making the latency difference further from zero or more negative. Kounious and Holcomb's (1994) findings stated that concrete words activate more semantic information, throughout the brain regions, than abstract words. Therefore, they may have more support during semantic processing which allows them to be identified quicker with more accuracy. As a result, it may be possible that as individuals age and begin to experience a slight neural decline, it may take longer to process abstract words than concrete words. However, this trend was only apparent up until the age of 50.

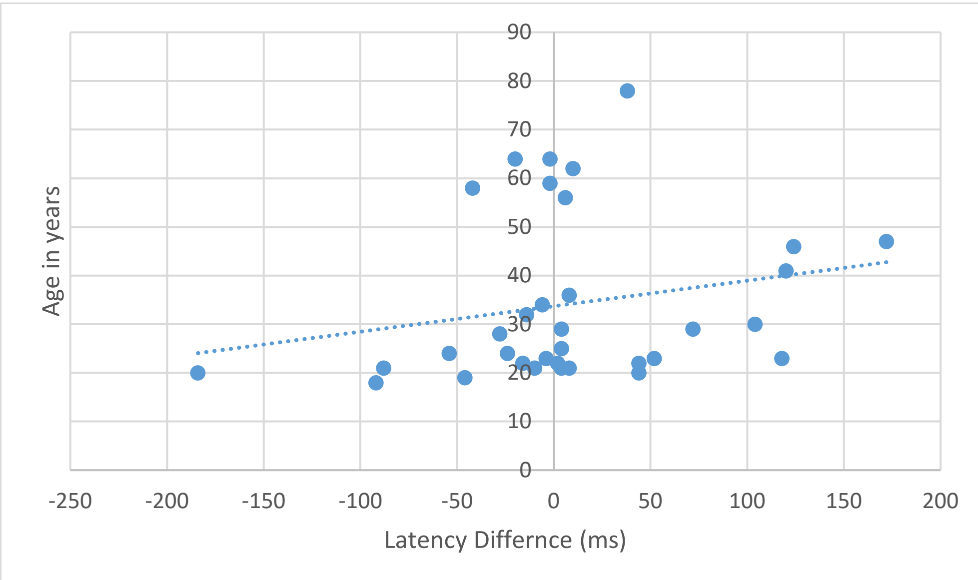

Figure 6: Age vs. Latency Difference of Pz. This figure illustrates as age increases the latency difference in electrode Pz increases. The trend is showing a difference between younger and older adults in the processing of concrete and abstract words.

Additionally Figure 6 above illustrates the older individuals (56 to 78 years in age) being outliers. These individuals' N400 peak latency differences show little to no difference between the abstract and concrete word peak latencies. Cabeza (2002) conducted a study titled "Hemispheric Asymmetry Reduction in Older adults: The HAROLD Model," that could help explain the trend seen among the older adults in Figure 6. The study looked at the effects of aging on brain activity during cognitive performance. The HAROLD model states that during cognitive performance, prefrontal activity tends to be less lateralized in older adults than in younger adults. It is hypothesized that the age-related bilateral activity may result from a global reorganization of the neurocognitive networks. This may reflect a compensatory process for older individuals' neural decline. Cabeza found that the age-related symmetry reductions are typically observed in groups of individuals who are 60 to 80 years of age (Cabeza, 2002). If this model is applicable to the semantic processing of abstract and concrete words, these individuals may be activating bilateral regions of the brain, which in turn is increasing their accuracy and speed identifying abstract words. This could be a factor as to why these individuals have little to no latency difference, while the individuals 50 years in age and younger do have a latency difference. A similar trend was also found in Diaz et al.'s (2014) study when looking at the neural activation of older adults. It was found that older adults produced more activation throughout different regions of the brain than younger adults. Additionally, differences are not seen in the semantic tasks because there is more activation in different regions of the brain to compensate for the decreased activation in the specific regions of the brain (Diaz et al., 2014)

Finally, although the regressions were not significant, there were some interesting patterns in the correlations and in the regression coefficients that may provide some insight into the effect of demographics on abstract and concrete word processing. Regarding regression coefficients, it seems that an individual's language ability may be influencing Cz concrete N400 latency, an individual's level of education may be influencing Pz concrete N400 latency and an individual's attention may be influencing Fz abstract N400 voltage peaks. This suggests that these independent variables may be playing a role in the N400 peaks; however, the lack of a significance in the overall regression makes it difficult to make any firm conclusions. A more sophisticated analysis is needed to fully understand the effects the independent variables may have on the N400 peaks.

Additionally, many of the CLQT measures are correlated, which is not surprising but also indicates that a more advanced statistical test may be needed to understand the exact contribution of each domain on one another and on the other independent variables. The multicollinearity among many of the predictors may be influencing the data and a mixed model statistical analysis may be better suited to find the exact effects of these different demographic factors on the ERPs.

One of the most interesting correlations among the demographic variables was the correlation between age and education, which is illustrated in Figure 7. This indicates that our older population is well-educated and thus, their level of education may be affecting the influence that age may normally exert. A study conducted by Ross and Wu (1996) asked the question of “Do health advantages of high income educational attainment and disadvantages of low educational attainment diverge or converge with age?” The researchers found that the health advantage of the well-educated is larger in older age groups than in younger. They continue to explain education may be a vital factor in successful healthy aging. Cabeza (2002) found that education level is an important variable to consider as well. There is also a hypothesis titled the reserve hypothesis which states that education level contributes to the brains developments of a reserve capacity, which reduces the effect of age related neural decline of cognitive abilities (Katzman, 1993). With a well-educated older population, education may play a role in the lack of differences between the ERPs of younger and older adults.

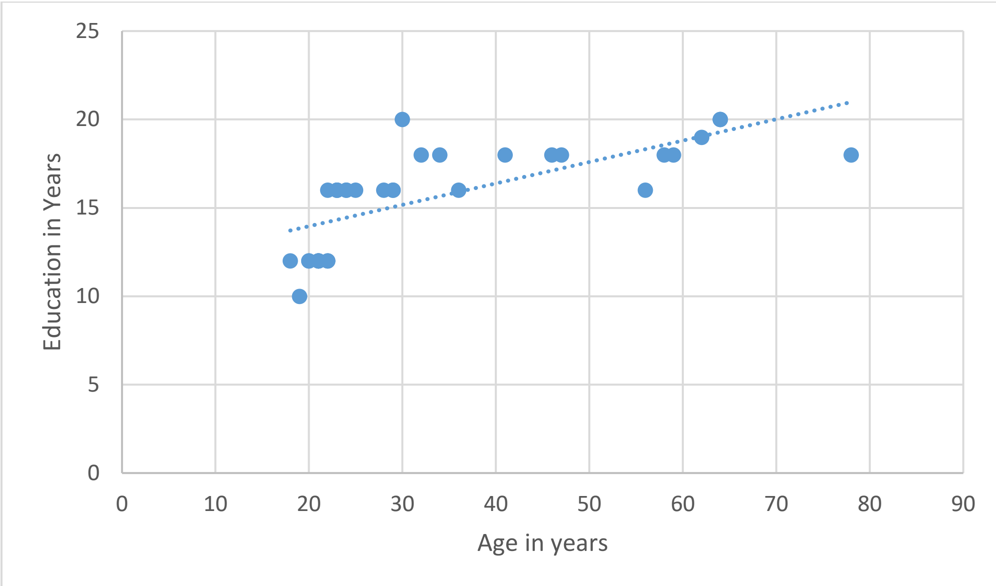

Figure 7: Education Vs. Age. This figure illustrates that age and education are correlated.

One of the limitations of this study is the uneven distribution of younger and older adults. An improvement of this study would be to include a larger number of older adults so that there can be a more even age distribution. In addition, education may be a factor that influences an individual's ability to process different words. Future research may include looking at years of education in a population separately from age to see how this factor may play a role in semantic processing. A sample of participants who are all within a certain age range could be gathered and grouped based on the number of years they have been in school. The results can help suggest the role that education may play in semantic processing, independent from age. When conducting research on education-level effects it is important to keep in mind the individuals who have higher educational degrees often have higher socioeconomic status, better health behaviors, and access to resources that affect their overall health (Ross & Wu, 1996). Better overall health may also include better brain health, and therefore increased neural processing abilities. It may also be interesting for future researchers to consider the HAROLD model when studying older individuals. Including fMRI scans, so that one can look at the areas of activation in the brain, to observe if there is a difference between the younger and older adults, supporting the HAROLD model, may suggest interesting trends as well. Finally, as stated earlier, a more sophisticated statistical analysis, such as a mixed model analysis, could reveal significant patterns that cannot be captured by the simple regression models used in the current study.

Chapter 5

Conclusion

In conclusion, no significant differences were found between word types and demographic variables were not predictive of the event related potentials. However, a few interesting patterns did emerge. First, the scatter plot suggested that as age increases the N400 latency difference in electrode Pz increases. However, this trend is only seen until around 50 years of age. Secondly there were interesting patterns in the regression coefficients that suggests that the independent variables such as CLQT domain language ability, CLQT domain attention and level of education may be playing a role in the N400 peaks. More research will need to be conducted to make any firm conclusions due to the lack of significance in the overall regression. Finally, another interesting pattern that should be taken into consideration when looking at the semantic processing of concrete and abstract words in future studies, is the correlation between age and level of education. In this study, the correlation between age and education illustrated that the older adults are very educated. Education may be playing a role in an individual's semantic processing of abstract and concrete words. These findings suggest that it is worthwhile to further explore if the HAROLD model is applicable to semantic processing of abstract and concrete words. Additionally, it is worthwhile to explore if the health advantage of well-educated older adults has an effect on their neural activity associated with semantic processing of abstract and concrete words.

BIBLIOGRAPHY

Barsalou, L. W. (2008). Grounded cognition. *Annu. Rev. Psychol.*, *59*, 617-645.

Binder, J. R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. *Cerebral cortex*, *19*(12), 2767-2796.

Binney, R. J., Zuckerman, B., & Reilly, J. (2016). A Neuropsychological Perspective on Abstract Word Representation: From Theory to Treatment of Acquired Language Disorders. *Current neurology and neuroscience reports*, *16*(9), 79.

Cabeza, R. (2002). Hemispheric asymmetry reduction in older adults: the HAROLD model. *Psychology and aging*, *17*(1), 85.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological review*, *82*(6), 407.

Diaz, M. T., Johnson, M. A., Burke, D. M., & Madden, D. J. (2014). Age-related differences in the neural bases of phonological and semantic processes. *Journal of cognitive neuroscience*, *26*(12), 2798-2811.

Helm-Estabrooks, N. (2001). *Cognitive linguistic quick test: CLQT*. Psychological Corporation.

Jessen, F., Heun, R., Erb, M., Granath, D. O., Klose, U., Papassotiropoulos, A., & Grodd, W. (2000). The concreteness effect: Evidence for dual coding and context availability. *Brain and language*, *74*(1), 103-112.

Katzman, R. (1993). Education and the prevalence of dementia and Alz- heimer’s disease. *Neurology, 43*, 13–20

Kounios, J., & Holcomb, P. J. (1994). Concreteness effects in semantic processing: ERP evidence supporting dual- coding theory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20(4), 804.*

Luck, S. J. (2014). *An introduction to the event-related potential technique*. MIT press.

Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology/Revue canadienne de pschologie*, 45(3), 255.

Reuter-Lorenz, P. A. (2002). New visions of the aging mind and brain. *Trends in cognitive sciences*, *6*(9), 394-400.

Ross, C. E., & Wu, C. L. (1996). Education, age, and the cumulative advantage in health. *Journal of health and social behavior*, 104-120.

Schwanenflugel, P. J., Harnishfeger, K. K., & Stowe, R. W. (1988). Context availability and lexical decisions for abstract and concrete words. *Journal of Memory and Language*, *27*(5), 499-520.

Villardita, C., Grioli, S., & Quattropani, M. C. (1988). Concreteness/abstractness of stimulus-words and semantic clustering in right brain-damaged patients. *Cortex*, *24*(4), 563-571.

Ward, J. (2015). *The student's guide to cognitive neuroscience*. Psychology Press

Warrington, E. K. (2017). *Neuroscience and Behavioral Psychology*. Elsevier Inc.

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