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Speech Modifications for Supporting Auditory Comprehension in Aphasia

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Speech Modifications for Supporting Auditory Comprehension in Aphasia

By

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MASTER'S THESIS

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A Thesis

Presented to

The Faculty of

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ABSTRACT

Speaking “clearly” is a common strategy used to support auditory comprehension for people with hearing loss (Pichney, Durlach, & Braida, 1986). Recent preliminary research has also found that modifying speaking behaviors can facilitate comprehension for all people, not just those with hearing loss. This technique of using “clear speech” was shown to help people with language disorders following neurological impairment (aphasia) as well as the typical control adults. The aim of the present study was to further these findings by analyzing the benefits of using clear speech for people with neurological impairment and typical control peers in less than optimal listening environments (background noise). Although no significant differences were found in participant response accuracy or reaction time regardless of speaking style or listening environment, results of this study were limited by small participant numbers and simple stimuli that lead to observed ceiling effects.

Keywords: Auditory Comprehension, Aphasia, Clear Speech, Background Noise

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Auditory comprehension impairments associated with aphasia (an acquired neurological impairment affecting all aspects of language) are commonly addressed in language therapy to improve an individual's ability to comprehend and maintain oral communication. Language intervention does not ensure that auditory comprehension deficits can be completely resolved however, and intervention practices often include behavioral compensatory strategies to further support communication for people with aphasia. These compensatory strategies can be as simple as having the communication partner draw pictures, write key words, or speak slowly and clearly. Depending on the person's level of functioning, assistive or augmentative communication may be used.

Similar compensatory strategies are helpful for individuals with communication impairments other than aphasia. Many people naturally slow their rate of speech and attempt to over articulate when speaking with people with hearing loss. This phenomena is referred to as "clear speech". Clear speech was originally used to assist communication with people with hearing impairment by providing them with better access to the acoustic signal (Pichney, Durlach, & Braida, 1986). However, the use of clear speech is not confined to communicating with people with hearing loss, as many people use clear speech when attempting to communicate with individuals who have neurological impairments (Musiek, Baran, & Shinn, 2004). This research implies using clear speech is a natural compensatory strategy that many people implement when they experience communication breakdowns due to poor auditory comprehension of the listener. However, the current body of literature provides little experimental research to support such practices with communication impairments beyond hearing loss.

Some researchers have investigated various aspects of clear speech such as rate of speech (Nicholas & Brookshire, 1986; Small, Andersen, & Kempler, 2007), placement, length, frequency of pauses (Brookshire & Nicholas, 1984; Liles & Brookshire, 1975), target word stress (Kimelman, 1991), and prosody (Kimelman, 1999) when communicating with people with aphasia. These researchers found variable results regarding the efficacy of isolated components of clear speech for improving auditory comprehension of people with aphasia. While a reduced speaking rate of 100-130 words per minute (wpm) did not consistently improve auditory comprehension for people with brain injury (Brookshire & Nicholas, 1984; Nicholas & Brookshire, 1986), a rate of 155 wpm did improve auditory comprehension for people with typical working memory capacity (Small et al., 2007). Similarly, 5 second pauses supported auditory comprehension when placed between two descriptors in a single-step command, but a 4 second pause placed in the middle of a sentence was not reliably beneficial (Brookshire & Nicholas, 1984). Finally, Kimelman (1991; 1999) concluded that target word stress was only beneficial when the speaker was allowed to make other acoustic adjustments to the speech signal surrounding the stressed target word. While these variable findings do not provide strong support for the use of isolated aspects of clear speech with people with brain injury, there has been minimal investigation into to compounding effects of using all aspects of clear speech for people with neurological impairment.

Other concerns have more recently been raised regarding cognitive deficits associated with aphasia (e.g., working memory; Small, et al., 2007). These cognitive impairments are also commonly observed among individuals with traumatic brain injury (TBI). While the language centers (e.g., left perisylvian fissure) are thought to be intact in most individuals with TBI, auditory comprehension deficits may still be observed in this population (Musiek et al., 2004). Intervention strategies for cognitive impairment often focus on the cognitive deficits (e.g., attention or memory) which are believed to be the underlying cause of the comprehension impairment. Therefore, there may be a distinction drawn between individuals with auditory comprehension deficits associated with impaired cognitive function (TBI) and those who experience auditory comprehension deficits due to limited language (aphasia).

Another current issue that will be addressed in the present study is the efficacy of using clear speech in background noise. One of the major problems that SLPs face when creating a treatment plan is providing intervention strategies that will be applicable in the client's everyday life. SLPs may implement communication strategies in the therapy room that prove to be effective within the isolated and controlled environment of the therapy room. However, the client may not find these strategies as helpful when placed in real-life situations due to interfering factors in their environment (e.g., noise). The presence of background noise places greater cognitive demands on the listener and can further impede upon linguistic processing or attention. While typical adults can filter distracting stimuli with relatively minimal effort, a person with neurological damage may have difficulty with filtering due to their limited cognitive resources. Therefore, in order to emulate real-world application of the clear speech supported communication technique, the present study will also investigate the effects of background noise on auditory comprehension for individuals with neurological impairment.

Therefore, the present study will aim to address the gap between current research and therapeutic practices regarding the efficacy of using clear speech as a compensatory strategy for people with neurological impairment. By comparing people with varying etiologies, the researchers will attempt to discern patterns of performance that may shed light upon the neurological performance of these individuals. Subsequently, analysis of the results from this experiment may allow the researchers to provide evidence that further supports current theoretical models of auditory comprehension.

CHAPTER 2

LITERATURE REVIEW

Brain Injury

Damage to the brain can occur in multiple ways including cerebral accident (stroke) and physical trauma. Approximately 4.6 million people (1.69%; Health Grades Inc., 2014) in the Unites States currently live with disabilities related to stroke and 5.3 million people (2%; The Brain Trauma Foundation, 2007) in the US live with disabilities related to traumatic brain injury (TBI). Stroke and TBI can have long term effects on physical mobility, language, and cognition.

Traumatic Brain Injury

A person can acquire a TBI from a closed head injury or from an object puncturing the skull and brain. Common causes of brain injury include falls, assaults, motor vehicle accidents, and being struck by objects (Center for Disease Control and Prevention, 2015). Previous researchers have defined a TBI based on loss of consciousness, posttraumatic amnesia, a score of 13 or less on the Glasgow Coma Scale, and observable abnormalities in neurological imaging (Schretlen & Shapiro, 2003).

Researchers have also previously examined the cognitive impairments that result from a TBI including deficits in attention, memory, executive functioning, and social skills (Haskins, Cicerone, Dams-O’Connor, Eberle, Langenbahn, Shapiro-Rosenbaum, & Trexler, 2014). Severity of cognitive impairment is highly variable depending on the type of damage (e.g., diffuse axonal or focal) and location of damage. For example, the function of storing memories is thought to reside in the hippocampus, whereas the ability to make executive decisions regarding action initiation/ inhibition is thought to be located in neurological connections of the frontal lobe (Dvorak & Mansfield, 2013). Although language is not explicitly stated as an impaired function associated with a cognitive communication disorder, poor attention, memory, executive functioning, and social skills can limit a person's ability to successfully communicate with people in their daily lives. These cognitive deficits can also have negative impacts on a person's safety, daily functioning, independence, and quality of life in regards to both communication and nonverbal functioning.

Non-Traumatic Brain Injury

The term non-traumatic brain injury is used to refer to an event that causes damage to the brain, but the damage is not caused by outside physical trauma. One example is a cerebrovascualar accident (CVA), more commonly referred to as a stroke. A CVA can be either ischemic (i.e., a constriction/blockage of an artery) or hemorrhagic (i.e., an artery ruptures) and can have varying effects on neurological function depending on the artery/arteries involved and the severity of the insult. For example, the left medial cerebral artery (MCA) is the main blood source to the left hemisphere (e.g., perisylvian area) which, for the majority of people, is the language-dominant hemisphere. Therefore, damage to the MCA often leads to language impairments following the insult (Dvorak & Mansfield, 2013).

The type of language impairment (i.e., receptive or expressive) depends on location of the damaged neurons (Chapey, 2001).

The term aphasia is used to refer to language impairment following injury (either traumatic or vascular) to the language centers of the brain, typically the areas of the brain surrounding the left perisylvian fissure. Impairments in language can include difficulties with speaking, listening, reading, and/or writing. There are seven identified types of aphasia: Broca's, transcortical motor, conduction, anomic, Wernicke's, transcortical sensory, and global aphasia. These seven types fall into two main categories of either expressive (non-fluent) or receptive (fluent) aphasia. For example, a person with receptive aphasia will likely demonstrate the most difficulty with receiving and processing language input (either auditorily or visually) due to neurological damage to Wernicke's area and/or the surrounding tissue (Chapey, 2001). The degree to which auditory comprehension skills can be regained is a question that is still debated among researchers. Some aphasiologists state that once damage has occurred, the neurons in the affected area are dead and their function is forever lost (Locationist Theory; Chapey, 2001). Others however, argue that damage reduces the reactivity of the neurons to excitation and therefore, the lost functions can be regained (to some extent) by strengthening the other connections in the neural network (Resource Allocation Theory; McNeil, Odell, & Tseng, 1991). Therefore, treatment techniques to address auditory comprehension in aphasia often focus on both restorative (e.g., repetition and drill) and compensatory strategies (e.g., using clear speech).

Therapy Approaches to Brain Injury

While traditional therapy approaches of language intervention to address aphasia focus on restoring function of impaired language, more recent therapy approaches integrate the International Classification of Functioning (ICF) model which defines disabilities in part by life participation limitations. Therefore, aphasia therapy now often also involves a compensatory component which aims to teach techniques that will minimize the communication barriers caused by the person's impairment. Compensatory strategies can include behavioral adjustments for both the speaker and the listener.

Supported communication techniques in aphasia therapy include teaching the person with aphasia and their communication partners how to effectively communicate by using multiple modalities, promoting opportunities for social interaction, and supporting expression and auditory comprehension for the person with aphasia (Chapey, 2001). SLPs often teach communication partners behavioral modifications to maximize multimodal communication (e.g., writing, picture drawing, gesturing). Another focus is to provide verbal support through lexical and syntactic adjustments to the partner's language that provides better clarification or support for understanding (Kagan, 1998). However, behavioral speech modifications, like clear speech, are not commonly addressed in the aphasia literature. Although clear speech may not be commonly included in partner training, SLPs commonly use clear speech when communicating with people with aphasia (Evans, et al., 2007). Therefore, the efficacy of this communication technique requires more comprehensive research-based evidence to demonstrate the auditory comprehension benefits of using clear speech.

Cognitive therapy techniques on the other hand, tend to address the underlying areas of cognitive deficit such as problem solving, executive functioning, memory, attention, and social communication. Although the researchers who have designed current cognitive therapy practices acknowledge the need for compensatory strategies (e.g., memory notebooks or pneumonic strategies) (Haskins et al., 2014), there is minimal literature that addresses compensatory communication techniques for communication partners when interacting with people with TBI. This gap in the literature may be partly attributed to the current idea that people with TBI do not present with language deficits and therefore, do not need strategies to facilitate auditory comprehension. Another possible explanation may be that comprehension deficits exhibited by people with TBI are thought to stem from deficits in memory or attention, and therefore, cognitive therapy that focuses on improving those underlying cognitive functions will in turn improve auditory comprehension. However, with the publication of research by the American Speech-Language Hearing Association (ASHA, 2009) that discusses central auditory processing impairments following TBI, more attention toward in depth analysis of auditory comprehension in people with TBI may be warranted.

With the major concepts defined, the remaining topics that will be discussed in this review include specific experiments that investigated the efficacy of clear speech for people with hearing loss, attempted behavioral compensatory strategies for improving auditory comprehension in aphasia and TBI, and the efficacy of using clear speech to compensate for increased signal-to-noise ratio.

Clear Speech

The term “clear speech” was originally coined by Pichney and colleges in 1986 as a supported communication technique for communicating with people with hearing loss. By reducing the rate of speech, inserting more pauses of greater length, and increasing precise articulation (e.g., increasing vowel space and releasing stop consonants) the acoustic signal is more easily accessed by the person with a hearing loss, and thus, improves auditory comprehension. Nejime & Moore (1997) also found that when the signal was altered for only one of the various components of clear speech (i.e., reduced speaking rate), the person with a hearing loss did not experience significant improvement in auditory comprehension. In fact, Nejime & Moore (1997) observed a decrease in auditory comprehension when they presented participants with hearing impairment with an acoustic signal that was expanded by 1.25 and 1.5 times the original signal. These findings by Nejime & Moore (1997) suggest that expanding the signal time alone created distortions or an unnatural signal rather than accentuating the signal within the acoustic parameters of normal English speech. Similarly, Kraus & Braida (2002) investigated the intelligibility of various rates of speech; however, these researchers also utilized the other acoustic properties of clear speech (e.g., more precise articulation of phonemes) and found that clear speech was significantly more intelligible than conversational speech for people with typical hearing. The researchers also found that with more specific training increased intelligibility could also be achieved at faster rates that previously determined rates of clear speech. This finding suggests that for people with typical hearing and with simulated hearing loss, the acoustic properties of clear speech may have a greater impact on speech intelligibility that the amount of pauses or pause length. However, it is unclear whether the same performance could be expected from individuals with slower processing speeds, as with people with neurological impairment.

At a sentence level, clear speech is defined as having a reduced overall rate, increased insertion of pauses at phrase boundaries, increased length of pauses, higher fundamental frequency, and higher contrast in prosody. Maniwa, Jongman, & Wade (2009) also investigated the acoustic characteristics of clear speech fricatives in single words across multiple speakers by using computer analysis of spectral energy distributions and peaks, formant transitions, amplitude, and duration. The researchers concluded that clear speech fricatives are more intelligible for all of these parameters due to longer durations and higher frequency energy shifts. In a similar study, Ferguson & Kewley-Port (2007) investigated the acoustic characteristics of clear speech vowels in single words across multiple speakers. When the researchers performed computer analysis of the formant frequency, formant movement, and duration, they discovered that clear speech vowels had a higher formant frequency for F1 and F2, expanded vowel space, and longer duration. Pichney et al. (1986) determined that, along with the previously mentioned acoustic features of clear speech phonemes, stop consonants were also released more in clear speech than in conversational speech, thus leading to increased intelligibility for phoneme discrimination. Interestingly, the majority of researchers who have studied clear speech, including Bradlow & Bent (2002), Braida (2002), Ferguson & Kewley-Port (2007), and Maniwa et al. (2009) elicited clear speech with measurable intelligibility differences for people with hearing loss by simply instructing the speakers to speak more clearly. Thus, clear speech is a simple and natural compensatory strategy to employ for enhancing communication that requires minimal speaker training.

Auditory Comprehension Techniques for Aphasia

Initial research investigating the auditory comprehension in people with aphasia began by isolating various components of clear speech (e.g., slower rate, pausing, and target word stress). Liles & Brookshire (1975) conducted an investigation to determine the effects of pausing, pause time, and placement of pauses on auditory comprehension of spoken commands in adults with aphasia. The researchers concluded that pausing for 5 seconds between the first object and descriptor of a two-step command provided the most improvement. Since the subjects demonstrated adequate knowledge of the experimental vocabulary in isolation, the researchers concluded that insertion of additional pause time allowed the participants to more accurately process the linguistic information (rather than acoustic information) of the sentences. The researchers also suggested that placing a pause such that separated the pertinent information into units of two rather than three also lead to greater accuracy for recalling the tasks as it complied with the working memory capacity of individuals with aphasia (which the researchers hypothesized to be units of two). However, Liles & Brookshire (1975) were not confident in this assumption as the same pattern of performance was not observed across all participants and in all experimental conditions. Therefore, another study conducted by Brookshire & Nicholas (1984) again looked at the effects of pausing (4 seconds) in addition to reduced speaking rate (100 wpm) on comprehension in adults with aphasia. In this study, Brookshire & Nicholas (1984) investigated individual performances of the participants in regards to severity, time post onset, type of aphasia, and complexity of stimuli sentences. The researchers were unable to establish a reliable correlation between any of the experimental variables and consistent improvement in auditory comprehension. Furthermore, the researchers found inconsistent improvement from increased pausing and reduced rate of speech for each individual between test occasions, which suggested that a person’s increase in auditory comprehension with pauses and reducing rate was dependent upon more than personal variables related to aphasia.

Blumstein, Katz, Goodglass, Shrier, & Dworetsky (1985) conducted a similar study to investigate the relation between slow speaking rate through prolonged vowels, increased pauses between words, or increased pauses between syntactic boundaries and type and severity of aphasia for sentence comprehension of various syntactic structures. Similar to Brookshire & Nicholas (1984), these researchers also discovered variable results regarding the effectiveness of reduced rate and pause time on auditory comprehension. Overall, their results demonstrated limited interaction between syntactic complexity or semantic reversibility and slower speaking rate with greatest benefit from reduced rate for people with Wernicke’s aphasia. Therefore, Blumstein et al. (1985) concluded that the interaction between syntactic processing skills and processing time rather than increased time alone facilitated the most improvement for auditory comprehension for people with aphasia.

Kimelman (1991) isolated another component of clear speech in order to identify the effects of target word stress on auditory comprehension for people with aphasia. Kimelman (1991) presented listeners with aphasia with two paragraphs that differed only in individual target word stress. Other prosodic variability surrounding the stressed target word remained identical between conditions. Because previous research suggested that improvements in auditory comprehension for stressed target words within paragraphs was dependent upon the acoustic changes made prior to the stressed words, Kimelman (1991) correctly hypothesized that by eliminating the preceding acoustic changes, no measurable difference would occur in auditory comprehension for people with aphasia. Kimelman (1991) further explained these findings by stating that “when a speaker stresses a word in context, that word is acoustically modified. However, at a minimum, the duration and fundamental frequency of the preceding context are also modified” (p. 337). To further investigate these findings, Kimelman (1999) conducted another study to identify the effects of prosodic variations on auditory comprehension for people with aphasia. He found a significant improvement in auditory comprehension for the aphasia group when naturally occurring prosodic intonation was provided to emphasize target words. However, Kimelman also observed limitations to prosodic benefits for increasingly complex syntactic structures. Although Kimelman (1999) did not acoustically measure the “naturally occurring” prosodic intonation, descriptions of his elicitation techniques for this type of speech suggest that it may have resembled clear speech. Thus, these findings by Blumstein (1985), Brookshire & Nicholas (1984), Kimelman (1991, 1999), and Liles & Brookshire (1975) in conjunction with the previously discussed findings by Nejime & Moore (2007), suggest that behavioral acoustic changes to the speech signal beyond isolated modifications to speaking rate, pause time, and target word stress are required to improve auditory comprehension for people with aphasia or hearing loss.

Findings by Bradlow & Bent (2002) are of particular interest in regards to this study because these researchers investigated the efficacy of using clear speech for individuals who experienced communication breakdowns due to limited knowledge of the target language rather than limited access to the acoustic signal. People with aphasia could also be viewed as having limited knowledge of the target language and thus might be expected to have similar performance outcomes when listening to clear speech. Bradlow & Bent (2002) found listeners who were not native to English demonstrated a smaller clear speech effect than listeners that were native to English. The researchers also observed variable clear speech effects among the non-native listeners. After analyzing the variables that may have contributed to this variability, the researchers concluded that clear speech was most beneficial for non-native listeners with the most room for improvement (i.e., lowest proficiency of English), but with enough knowledge of the language to benefit from acoustic enhancement of the phonological and syntactic features. Similarly, the non-native listeners' auditory comprehension regardless of type of speech provided was positively correlated to their ability to produce the sentences accurately (i.e., phonological knowledge). Therefore, the degree to which a listener benefited from clear speech partially related to their stage of target language development. In a similar study by Bradlow & Alexander (2007), both native and non-native participants benefited from listening to clear speech in the presence of background noise, but the non-native listeners performed worse than native listeners when the target words were less predictable (i.e., minimal contextual cues). While the previous study by Bradlow & Bent (2002) was limited by the uncontrolled predictability of the stimuli sentences, the study by Bradlow & Alexander (2007) controlled for target predictability and therefore, were able to accurately assess the non-native listeners' ability to use contextual cues when responding. Again, the findings of this study supported the findings of Bradlow & Bent (2002) in that non-native listeners demonstrated relatively smaller clear speech effects due to their limited knowledge of the sound structures in English. Assuming that people with aphasia also demonstrate limited language knowledge, either due to functional loss of neurological structures (Chapey, 2001) or due to reduced efficiency of function (McNeil, et al., 1991), similar results may be expected when using clear speech with people with aphasia as compared to neurologically typical peers or peers with limited acoustic access (i.e., hearing loss). However, in both studies by Bradlow & Alexander (2007) and Bradlow & Bent (2002), the researchers still achieved significant clear speech benefits from the non-native listeners as compared to conversational speech. Therefore, although the benefits of clear speech may be less than those of typical comparison peers, significant clear speech effects may still be expected for people with aphasia in the present study.

Cognitive Impairment Associated with Aphasia

As Brookshire & Nicholas (1984) suggested, other cognitive factors beyond language impairment may impact auditory comprehension of clear speech in people with aphasia. From a theoretical perspective of the Resource Allocation Model (McNeil et al., 1991), a person with aphasia may also demonstrate cognitive deficits beyond language impairment due to reduced cognitive resources that could be allocated and utilized for various mental functions. Therefore, a person with aphasia may also encounter cognitive impairments such as working memory capacity or attention that would limit their ability to benefit from the increased processing time provided by rate-reduced speech and clear speech. Similarly, according to the psycholinguistic framework, aphasia is defined as an "acquired impairment in language content, form and use and the cognitive processes that underlie language, such as memory and thinking" (Chapey, 2001, p.9). To address these concerns regarding cognitive impairment and auditory comprehension, Small, Andersen, & Kempler (1997) investigated the interaction between working memory capacity and auditory comprehension of rate altered speech for individuals with Alzheimer's Disease. Since the results yielded from previous investigations regarding impaired auditory comprehension in aphasia and rate-altered speech were inconsistent, Small et al. (1997) hypothesized that the inconsistency was a result of variable working memory capacities of the participants which was previously uncontrolled and therefore, confounded the results. Thus, their study was conducted on people with dementia in order to isolate memory impairment from general cognitive impairment. From their results, Small et al. (1997) concluded that working memory capacity directly correlated to rate-altered speech benefits in that participants with the greatest working memory capacity were able to attend to and rehearse the information presented at a slower rate whereas the participants with smaller working memory capacity did not benefit from rate-reduced speech because they could not attend and maintain the information for extended periods of time. These findings do not support the use of rate-reduced speech for people with neurological impairment without first assessing working memory capacity.

Cognitive and Language Impairment Associated with TBI

Cognitive deficits including memory, attention, executive functioning, and sensory processing are typically associated with people who have experienced traumatic brain injury. Although language skills are commonly thought to remain relatively intact after the initial stages of recovery from TBI (i.e., no diagnosis of aphasia), this population also reportedly demonstrates communication impairments (e.g., inappropriate language or confusion of complex language) that interfere with daily living and activity participation. As Groher (1977) stated, "It is the discrepancy between the seemingly 'normal' ability to communicate and a poor performance in organizational and retention skills which becomes such a devastating liability for the patient who suffers closed head trauma with resultant language or memory disorders" (p. 20). This discrepancy in auditory comprehension to which Groher (1977) refers has been hypothesized to be related to lack of attention or memory which limits the person's ability to encode, rehearse, or retrieve information for further processing (Ferstl, Walther, Guthke, & Yves Von Cramon, 2005). Furthermore, working memory span is not directly correlated to comprehension of complex verbal information for conversational speech at a discourse level. In a German study conducted by Ferstl et al. (2005) which compared explicit and implicit comprehension of narrative discourse in individuals with aphasia or TBI and a group of typical comparison peers, the researchers found that the participants with aphasia and TBI performed significantly worse on comprehension tasks when presented with a lengthy narrative. These findings are contradictory to the previously mentioned findings by Small and colleagues (1997). Between the two groups of communication impaired individuals, the group with aphasia performed significantly worse on explicit comprehension questions (while maintaining the overall narrative macrostructure), whereas the group with TBI performed significantly worse on the implicit comprehension questions. Because the people with aphasia performed worse on explicitly stated material, using clear speech could remediate this breakdown in auditory comprehension, as Kimelman (1999) discovered. However, these findings also suggest that, at least for narrative discourse, clear speech may not be as beneficial for individuals with communication impairment due to memory or attention deficits following TBI since they comprehended more of the explicit material but failed to integrate information together to draw inferences.

Another consideration for individuals with TBI is the presence of poor auditory comprehension due to central processing deficits following insult. According to the American Speech-Language-Hearing Association (ASHA, 2015), manifestation of audiologic impairment following TBI is commonly reported in the absence of peripheral auditory processing impairment. While the manifestation of central auditory processing disorder ((C)APD) is still controversial within the literature, the term “slower processing” is commonly accepted in reference to auditory and mental processing following TBI. It is possible that some cases of central auditory processing disorder are lumped together within the overarching slower processing capabilities of the individual with TBI and thus, is not addressed directly in assessment or therapy.

In a case study by Musiek et al. (2004), the authors described a participant that demonstrated poor central auditory processing as evidenced by below average performance on dichotic digits and compressed speech tests but peripheral auditory processing within normal limits as measured by pure-tone thresholds and speech recognition. This person also presented with deficits in complex auditory comprehension, processing speed, and mental endurance during a complete cognitive neuropsychological evaluation. As such, this participant had not made significant gains in auditory comprehension for complex language or selective attention tasks for auditory stimuli (i.e., dichotic listening) through traditional cognitive therapy approaches. Therefore, the authors developed a therapy plan that would address the participants auditory processing from an audiologic perspective. Since one of the participant’s main complaints was difficulty understanding fast speech, one of the compensatory strategies taught to the participant was to advocate that her communication partners speak 10% slower and louder, while the therapists cautioned that speech that was too slow would distort the acoustic signal (i.e., recommending use of clear speech). Other restorative therapy techniques including reauditorization, dichotic inter-aural intensity difference training, auditory memory enhancement, auditory speech discrimination training, and temporal sequence training which successfully addressed the patient’s auditory processing deficits. After implementing these therapy techniques, the researchers observed a quantitative and qualitative improvement in the participant’s ability to listen in noise, understand compressed speech, listen equally with both ears (as she has previously reported less functioning of her left ear), and improved comprehension of typically paced speech. Whether directly referred to as (C)APD or generally referred to as processing speed, clear speech may be a beneficial compensatory strategy for people with TBI as it presents the acoustic signal at a speed that may be more closely matched to the person’s processing speed, but without the distorting effects of the acoustic information as has been encountered in previously discussed research experiments (e.g., Nejime & Moore, 1997).

Auditory Comprehension in Background Noise

Finally, while none of the previously discussed research experiments investigated the use of clear speech in background noise, many of the experiments addressed components of clear speech (e.g., rate-reduction) in the presence of background noise with varying observed improvement in auditory comprehension. Skowronski & Harris (2006) investigated the efficacy of clear speech/ Lombard speech (a term referring to natural speech modifications made when speaking in a noisy environment) for improving auditory comprehension of participants with hearing and neurological functioning within normal limits. Clear speech and Lombard speech are similar in regards to many acoustic features, with Lombard speech having a greater emphasis on increased sound intensity to overcome the increase in signal-noise ratio. These researchers found that clear/Lombard speech had varying effects on auditory comprehension of non-native English listeners in background noise. 9/16 participants benefited from either clear or Lombard speech while the remaining participants were neither benefited nor hindered by the use of clear/ Lombard speech.

Comprehending language begins by comprehending the speech cues provided in the acoustic signal such as fundamental frequency. In a study conducted by Song, Skoe, Banai, & Kraus (2011), the researchers measured brainstem responses to speech in quiet and noisy environments for neurologically healthy adults. The researchers concluded that the presence of background noise (+5 signal to noise) significantly degraded the amplitude of the fundamental frequency for all listeners, meaning the listeners had less access to fundamental frequency cues (e.g., formant transitions) for the acoustic signal. Furthermore, the six-talker babble noise had a greater negative impact on listening comprehension than the two-talker babble noise. Since neurologically typical adults demonstrated poorer auditory comprehension on speech perception in noise tasks, it can also be concluded that neurologically impaired adults would also perform poorly on these tasks due to limited cognitive resources for filtering extraneous noise.

Previous published research investigating compensatory techniques to support auditory comprehension of individuals with aphasia and TBI has been limited to studies which isolated components of clear speech or provided vague definitions of "naturally slow speaking rate" (Blumstein et al., 1985) which have proved to be highly variable in outcome reliability and of little practical use for guiding therapy practice for training communication partners in the use of clear speech. Previous research has also provided limited information regarding speech perception in noise for individuals with communication impairments, which is unfortunate given that the many communication interactions in daily life may take place in noisy environments (e.g., coffee shops, grocery stores, etc.).

The present study was designed based on the previous findings by Evans, Derby, Hux, & Carrell (2007) who determined the natural acoustic changes (i.e., speaking rate, pause insertion and length, consonant-to-vowel ratio, vowel space, use of alveolar flaps, and releasing of stop consonants) in an SLP's speech varied depending on the population to whom the SLP was directing communication. Evans et al. (2007) concluded that SLPs over-articulate with increased pausing when directing speech toward people with aphasia more so than they do when speaking to people with hearing loss. Therefore, SLPs use a more dramatic form of clear speech when communicating with people with aphasia. Furthermore, in an unpublished thesis by Ansley White at the University of South Alabama (2012), White used auditory stimuli that encompassed this “super clear speech” created by Evans et al. (2007) to determine if this form of speech benefits people with aphasia. In White’s experiment, two participant groups consisting of people with aphasia and typical comparison peers were auditorily presented sentences using either clear or conversational speech. The participants where then given a cloze set of pictures and instructed to identify the picture that represented the final word in the sentence. The target words also varied in predictability, therefore, allowing for varying levels of contextual information to be utilized. This task was conducted in a quiet environment. White (2012) concluded that clear speech benefited all participants. Therefore, the aim of this current study is to replicate the findings by White (2012) and to further investigate the effects of clear speech on auditory comprehension for individuals with brain injury (i.e., aphasia and TBI) as compared to a control group of typical comparison peers. This study will also investigate any benefits that clear speech may provide in noisy environments in an attempt to provide outcomes that can be easily applied to real life situations. Therefore, the following research questions will be addressed:

1) To what extent does group membership (aphasia vs. typical comparison peers) change response accuracy and reaction time on an auditory comprehension task? Hypothesis: Individuals with aphasia will perform with less accuracy and slower reaction time than typical comparison peers on a task of auditory comprehension. This question is designed to replicate well known findings that people with

aphasia have impaired auditory comprehension when compared to typical comparison peers.

2) To what extent does speaking environment (clear speech, conversational speech, clear speech in background noise, conversational speech in background noise) change response accuracy and reaction time on an auditory comprehension task for all participants?

   Hypothesis: Participants will perform with highest accuracy in the clear speech task, and with lowest accuracy in the conversational speech plus background noise task. Clear speech is expected to facilitate auditory comprehension by offering the clearest auditory signal, and conversational speech with background noise is expected to impact auditory comprehension because the auditory signal is degraded. As previously reported by Skoe, et al. (2011), neurologically typical adults demonstrated reduced auditory comprehension of the acoustic features of speech when listening in background noise.

3) How do group membership and speaking situation interact to change response accuracy and reaction time on an auditory comprehension task?

   Hypothesis: Participants with aphasia will perform with the same pattern (best performance on clear speech, followed by conversational speech, followed by clear speech plus background noise, followed by conversational speech plus background noise) as typical comparison peers; however, participants with aphasia will perform with lower accuracy and slower reaction time. Participants with aphasia will benefit more from clear speech than typical comparison peers, because typical comparison peers are expected to perform near ceiling on the clear speech condition.

CHAPTER 3

METHODOLOGY

Participants

Approval of this study was obtained from the Institutional Review Board at Western Washington University prior to recruitment of the participants. Participants were recruited from the Western Washington University Speech-Language Clinic, Whatcom County stroke support groups, and local rehabilitation facilities. All participants completed a demographic information intake form that provided the following information: gender, age, race, highest level of education, primary language, handedness, and current use of medications. Where applicable, the following was also recorded: amount of time post- injury (stroke or TBI), severity of injury, length of coma or post-traumatic amnesia, previous/ current therapy provided, type of aphasia, severity of aphasia, and any known cognitive deficits. All recruited participants were native speakers of American English, with typical hearing and vision (as determined by a hearing and vision screening), and of typical mental health status. The formal hearing screening was conducted at 25dB, at 500, 1000, 1500, and 2000 Hz. An informal vision screening was conducted during the presentation of 8 trial items to ensure that the participant could visually attend to and process the stimuli pictures in all quadrants of the presented grid. Mental health history and current status were determined by self-report. All neurologically impaired participants were given the Western Aphasia Battery-Revised (WAB-R; Kerstez, 2006), the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, Tierney, Mohr, & Chase, 1998), and the Test of Nonverbal

Intelligence (TONI-2; Brown, Sherbenou, & Johnsen, 1990) to establish participant group membership. All participants in the neurologically typical control group were given the RBANS (Randolph, et al., 1998) and the TONI-2 (Brown, et al., 1990) to ensure typical neurological and language functioning.

A total of 30 participants were recruited to fulfill the required membership groups (i.e., participants with aphasia, participants with TBI, and typical comparison peers). Due to unsuccessful recruitment of participants with TBI and participant attrition, data was not collected for the TBI experimental group. The final data set consisted of data collected from a total of 16 participants; half with a diagnosis of aphasia and half typical comparison peers. Participants in the aphasia group consisted of 6 males and 2 females whose average age was 69.63 years old (SD=7.07). Education level for this participant group was fairly distributed, with 1 participant who earned a high school diploma, 3 who earned Associate's degrees, 1 who earned a Bachelor's degree, and 3 who earned Master's degrees. The typical comparison group also consisted of 6 male and 2 female participants with an average age of 63.75 years (SD = 10.55). Education level for the typical comparison group was similar to the group of participants with aphasia. Groups did not differ by age (M = [$F(1,14) = 1.711$, $p = .212$], gender [$X^2(1) = 1.000$, $p = .715$), or education [$X^2(4) = 4.333$, $p = .363$].

Experimental groups

The first experimental group consisted of 8 individuals with a diagnosis of aphasia which was confirmed by an Aphasia Quotient score below 93.8 on the WAB-R (Kerstez, 2006). Aphasia Quotient scores ranged from 51.8-92.6 (mean=77.9, SD=20.04) which descriptively correlates to a severity rating of mild-moderate aphasia. Participants in the aphasia experimental group also presented with an aphasia classification indicative of relatively intact auditory comprehension. Because auditory comprehension is required in order for the participants to understand the task instructions, recruits with more than mild-moderate auditory comprehension deficits (i.e., Wernicke's, transcortical sensory, or global aphasia) were excluded from this experiment. Participants in this group scored from 77.0-99.0 (mean=89.6, SD 7.4) on a cognitive assessment (TONI-2; Brown, et al., 1990).

The primary investigator originally proposed a second experimental group for this study consisting of participants with TBI. Active recruitment of participants for this group was unsuccessful, and the small number of participants who demonstrated interest in study participation did not follow through with appointments for data collection. Therefore, this group did not generate useable data.

Control group

The control group consisted of 8 adult individuals with no previously reported neurological impairment or severe psychiatric conditions. Participants representing the neurologically typical population scored within average limits on the TONI (Brown, et al., 1990), and the RBANS (Randolph, et al., 1998). TONI (Brown, et al., 1990) scores ranged between 78.0-128.0 (mean=103.4, SD=16.9) and RBANS (Randolph, et al., 1998) scores ranged from 89.0-117.0 (mean=99.9, SD=11.7)

Stimuli

Auditory stimuli for this experiment consisted of 34 highly predictable test and training sentences (28 test sentences and 8 training sentences). These sentences were composed of a lead-in phase that provided linguistic cues for the final word in the sentence (e.g., "Let's decide by tossing a coin."). In the study conducted by White (2012), the participants with aphasia performed significantly worse on auditory comprehension tasks in a quiet environment with low predictability targets than with high predictability targets. Therefore, the researchers chose to use highly predictable targets in the present study in order to avoid a possible flooring effect by participants with neurological impairment due to further increased complexity of the comprehension task with background noise added.

The 34 auditory stimuli and training sentences were previously created by Evans et al. (2007) and adapted from the Revised-Speech Perception in Noise Test (R-SPIN; Bilger, 1984). The original stimuli (Evans et al., 2007) were recorded by a female speaker using either conversational or clear speech using a head-mounted crown microphone (CV-311a) that was positioned 2 cm from the mouth. Sampling rate was 44100 samples/s using a Marantz Professional Solid-State Digital Recorder (PMD670). Each digital file consisting of a single stimuli sentence was normalized to ensure consistent amplitude. Following stimuli creation, perceptual and acoustic features were compared with those of clear or conversational speech to ensure each group of stimuli reflected the features of clear or conversational speech. Analysis included the following characteristics of clear speech as defined by Evans et al., (2007), Ferguson & Kewley-Port (2007), and Maniwa & Johnson, 2008) include: slower speaking rate, increased number of pauses, increased pause duration, pause-to-sentence duration ratio, lower consonant-to-vowel ratio, increased vowel space, increased release of final consonants, and reduced use of alveolar flaps. Conversational speech analysis included increased speaking rate, fewer and shorter pauses, reduced vowel space, and less precise articulation of consonants (e.g., increased usage of alveolar flaps) (Pichney, et al., 1986). Please refer to Evans et al. (2007) for specific details.

For the current study, half of the existing high predictability stimuli were modified to include background noise using a 12-person babble track at a +8 signal-noise ratio (SNR). Stimuli sentences were also presented using either conversational speech or clear speech and in a quiet environment or in background noise. Therefore, the breakdown of stimuli sentences is as follows: 7 sentences using conversational speech in a quiet environment, 7 sentences using clear speech in a quiet environment, 7 sentences using conversational speech in background noise, and 7 sentences using clear speech in background noise (all sentences contain a monosyllabic, highly predictable target). 2 practice sentences for each condition were presented prior to the 7 test sentences.

All sentences were presented with visual stimuli, also developed by Evans et al. (2007). The visual stimuli for each sentence consisted of 4 black and white drawings to represent the target word (i.e., final word in each sentence) and three foils: a phonemic rhyming foil, a semantic foil, and an unrelated foil. Stimuli were piloted to ensure the picture of the target word accurately symbolized the auditorily presented target word.

Procedures

Following approval of the Institutional Review Board at Western Washington University, data collection took place over two sessions each lasting no longer than 1.5 hours. During the first session, the researcher presented the consent form, collected background information, and collected pre-experimental data to determine each participant met the inclusionary criteria of the study. This session included administration of the WAB-R (Kerstez, 2006), TONI-2 (Brown, et al., 1990), RBANS (Randolph, et al., 1998) and hearing screening. Vision screening and experimental data were collected during the second session. Some participants had completed preliminary testing measures for other studies or evaluations. For these participants, consent was obtained in order to use relevant test results that had been collected in the past year.

Data collection began by presenting the participants with instructions and stimuli materials using a Dell laptop and supra aural headphones. Auditory output for stimuli sentences was calibrated prior to data collection for each participant using a sound level meter with headphone coupler to ensure auditory presentation was between 60-70 dB. Participants were seated in a quiet room either at the WWU Speech-Language Clinic, rehabilitation facility, or house in which the participant resided. First, the researcher read the prepared instructions to the participant and ensured comprehension (e.g., by asking them to restate or ask questions) before the participant began the task. The participants were given 2 practice stimuli prior to each experimental set to ensure adequate orientation to the task and proper functioning of the equipment prior to data collection. Presentation of each stimuli set was counterbalanced among members of each group with stimuli sentences within each set presented randomly through supra-aural headphones.

The stimuli sentences were presented using Direct RT. First, the word “listen” appeared on the screen and was auditorily presented through the headphones. Next, the stimuli sentence was auditorily presented. After the entire sentence was stated, a grid containing 4 black and white drawings appeared on the screen depicting the correct answer, a semantic foil, a phonemic foil, and a remote foil in random array. The participant selected the picture that represented the target word they believed to complete the sentence by clicking on the picture with the cursor. The stimuli pictures were presented in random quadrants of the screen for each sentence. This process was repeated for each of the 28 stimuli. The presentation software, Direct RT, recorded the participant’s response accuracy as well as response time. The researcher also recorded the response accuracy as well as any verbal or gestural information provided by the participant.

CHAPTER 4

RESULTS

Data (response accuracy and response time) was collected using the Direct RT software and exported to an excel sheet. Data was imported into statistical analysis software for calculation of descriptive and inferential statistics. Independent variables included group membership (participants with aphasia vs. typical comparison peers) and speaking environment (conversational speech, clear speech, conversational speech with +8dB background noise, and clear speech with +8dB background noise). Data will be reported according to dependent variable.

Response Accuracy

Measures of central tendency and variability include means and standard deviations for response accuracy as presented in Table 1. Descriptively, participants with aphasia consistently performed with less accuracy than typical comparison peers across all conditions. Mean scores for participants with aphasia ranged from 5.25 (out of 7) to 6.00, and scores for typical comparison peers ranged from 6.75 to 7.00. Typical comparison peers reached a ceiling for the two clear speech conditions, averaging a perfect score of 7.

Table 1

Means and Standard Deviations for Both Participant Groups for Response Accuracy for Each Experimental Condition

Accuracy	Conv. M (SD)	Clear M (SD)	Conv. +8dB M (SD)	Clear +8 dB M (SD)
Participants with Aphasia	6.00 (1.60)	5.63 (1.06)	5.25 (1.75)	6.00 (.756)
Typical Comparison Peers	6.86 (.354)	7.00 (.00)	6.75 (.463)	7.00 (.00)

A mixed groups factorial ANOVA was performed to examine the effects of group membership and speaking environment upon response accuracy during an auditory comprehension task. The Greenhouse-Geisser Test of within subject effects was used to interpret F values because Mauchly's Test of Sphericity was significant ($p=0.024$).

Contrary to the hypothesis, there were no interaction effects of group membership and speaking environment on task performance [$F(1.920, 26.875) = .512$, $p = .598$, partial Eta squared = .035], indicating no significant patterns among the independent variables and response accuracy.

Also contrary to the hypothesis, there was no main effect of speaking environment [$F(1.92,26.875) = 1.144$, $p = .332$, partial eta squared = .076], indicating no significant differences in participant performance across conditions (clear speech, conversational speech, clear speech plus background noise, conversational speech plus background noise).

There was a main effect of group membership [$F(1,14) =12.795$, $p = 0.003$, Partial Eta Squared = 0.478] such that as hypothesized, participants with aphasia performed with less accuracy than typical comparison peers. This finding essentially confirms accuracy of group membership.

Response Time

Measures of central tendency and variability include means and standard deviations for response time as presented in Table 2. Descriptively, participants with aphasia consistently performed with longer response times than typical comparison peers across all conditions. Mean response time for participants with aphasia ranged from 4306.27 ms to 8046.39 ms, and response time for typical comparison peers ranged from 3142.34 ms to 3281.30 ms. Upon visual inspection, response times for participants with aphasia appear more variable across conditions than response times for typical comparison peers.

Table 2

Means and Standard Deviations for Both Participant Groups for Reaction Time (ms) for Each Experimental Condition

Reaction Time (ms)				
	Conv. M (SD)	Clear M (SD)	Conv. +8dB M (SD)	Clear +8 dB M (SD)
Participants with Aphasia	8046.39 (9633.21)	6507.57 (6455.81)	5638.25 (2549.70)	4306.27 (801.17)
Typical Comparison Peers	3281.30 (1636.41)	3142. 34 (1312.63)	3209.13 (1529.36)	3194.88 (1719.51)

A mixed groups factorial ANOVA was performed to examine the effects of group membership and speaking environment upon response time during an auditory comprehension task. Mauchly's Test of Sphericity was significant ($p=0.000$), therefore, the Greenhouse-Geisser Test of within subject effects was used to interpret F values.

Contrary to the hypothesis, there were no interaction effects of group membership and speaking environment on task performance [$F(1.112,15.566) = 1.033$, $p = .334$, partial eta squared = .069], indicating no significant patterns among the independent variables and response time.

Also contrary to the hypothesis, there was no main effect of speaking environment [$F(1.112,15.566) = 1.114, p = .315$, partial eta squared = .074], indicating no significant differences in participant performance across conditions (clear speech, conversational speech, clear speech plus background noise, conversational speech plus background noise).

Again, contrary to the hypothesis, there was no main effect of group membership [$F(1,14) = 2.823$, $p = .115$, partial eta squared = .168], indicating no significant differences in reaction time between participant groups.

CHAPTER 5

DISCUSSION

Results of this experiment are not in agreement with previous findings that clear speech improves auditory comprehension for people with aphasia and typical control participants (White, 2012). However, multiple factors addressed below may further explain the variable findings in this study.

In addition, the results of the present experiment are also not in agreement with literature reviewed regarding use of clear speech in background noise. While previous researchers identified benefits of using clear speech in background noise, the present study did not conclude any such effects. This disagreement with the findings of the present study may also be a result of factors such as high accuracy performance on predicable stimuli sentences which led to limited improvement among speaking situations for both participant groups.

Speaking Style

In regards to speaking style, no significant differences were observed within or between subject groups for response accuracy or response time, indicating that clear speech was no more beneficial for auditory comprehension than conversation speech for people with aphasia or control participants. These findings do not support previous findings by White (2012) or the hypotheses of the present study. Factors of the present experimental design that may have impacted significance of findings include predictability of the sentence targets and wide ranges of variability within subject response times that were not adjusted for based on small N size. First, in order to avoid flooring effects based on the previous study by White (2012), only sentences with highly predictable targets were used in the present study. However, these sentences may have been too easy for participants as typical controls performed with average 97% accuracy in both conversational speech conditions and 100% accuracy in both clear speech conditions. Participants with aphasia performed mildly worse in all speaking conditions with average 80% accuracy across conversational speech conditions and average 83% accuracy across clear speech conditions; however this level of performance is arguably still within range of functional limits. Therefore, the high levels of accuracy achieved with conversational speech conditions left limited room for participants to improve accuracy significantly within clear speech conditions. Interestingly, both groups demonstrated a 3% improvement in response accuracy, suggesting a consistent, although minimal, clear speech benefit for both participant groups. Next, while participant accuracy was relatively stable across speaking style, participant reaction time was notably more variable. Interestingly, reaction time within the control group only varied between 3.14-3.28 ms across all speaking styles. This lack of variability may be explained by factors mentioned above in regards to participant accuracy (i.e., ceiling effect and SNR). However, reaction time for participants within the aphasia group ranged from 4.31-8.05 ms (see table 2), indicating possible influences by other factors beyond those explained above. First, due to difficulty with participant recruitment and high levels of attrition, sample sizes for each participant group were relatively small. Second, single participants in both groups performed with a wide range of variability in reaction time within single experimental conditions. The trend of improvement across experimental conditions is not likely to be the result of increasing participant familiarity with the task as stimuli sets (quiet and background noise) were counterbalanced across participants in each group in order to eliminate such effects in reaction time. Therefore, it is likely that this wide range of variability across experimental groups is the result of this study not having enough power to account for variability and accurately capture performance trends.

Background Noise

In looking at accuracy and reaction time across listening conditions, participants also performed similarly regardless of the presence of background noise. While researchers hypothesized that participants in both groups would perform worse when listening in background noise, no such trend was observed. One possible explanation for this outcome is that the SNR of +8 dB did not provide enough interference for participants' accuracy to be significantly disrupted. To further support this explanation, the researchers observed at least one participant from each participant group report that they did not noticeably hear any background noise during the noisy conditions. Therefore, a lower SNR may have provided more variable participant accuracy between listening environments.

Since no significant difference was observed in participant response accuracy or reaction time for varying speaking styles or listening environments, interaction effects between the two IVs were null.

CONCLUSION

The results of the present study did not provide further support for the current body of literature due to insignificant findings. However, factors mentioned above in the discussion may have interfered with significance of results collected in this study. Therefore, future experiments regarding use of clear speech in background noise with people with aphasia should focus on using low predictability targets, lower SNR, and greater participant numbers. In regards to background noise, one avenue that may be of interest for further investigation may be the use of adaptive background noise (setting background noise to each individual's level of tolerance) for people with neurological impairment. It is possible that people with aphasia would have a lower level of tolerance as compared to typical comparison peers. Use of adaptive SNR may also provide a greater representation of clear speech effects in background noise. Furthermore, since the TBI participant group was not tested in the present study, future experiments focused on using clear speech with people with brain injury may provide further insight into auditory processing and comprehension impairments associated with cognitive impairment.

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APPENDICES

Appendix A: Spin Sentences

SPIN SENTENCES	Correct Answer	Phonemic Foil	Semantic Foil	Remote Foil
Set 1 - Clear Speech				
The doctor prescribed the	drug	bug	medicine	plane
Stir your coffee with a	spoon	moon	fork	table
Let's decide by tossing a	coin	join	dollar	chair
The dog chewed on a	bone	stone	toy	scissors
The judge is sitting on the	bench	wrench	chair	frame
The ship's captain summoned his	crew	screw	team	pencil
Hold the baby on your	lap	cap	knee	flower
Set 2- Clear + Background				
Paul hit the water with a	splash	flash	pour	carrot
They drank a whole bottle of	gin	fin	milk	frog
The fireman heard a frightened	scream	stream	whisper	baseball
My son has a dog for a	pet	jet	pal	phone
The car drove off a steep	cliff	clip	hill	bell
The policemen captured the	crook	cook	robber	paper
My TV has a twelve inch	screen	bean	moniter	phone
Set 3 - Conversational Speech				
She hated to vacuum the	rug	bug	tile	bear
Watermelons have lots of	seeds	beads	plants	book
The doctor x-rayed his	chest	vest	head	dog
The natives built a wooden	hut	nut	house	can
The king wore a golden	crown	gown	ring	bug
Please wipe your feet on the	mat	cat	floor	fan
The boy took shelter in a	cave	wave	shack	mug
set 4- Conversational + Background				
Bruce poured the water down the	drain	train	faucet	knee
The detectives searched for a	clue	crew	sign	lamp
The doctor charged a low	fee	tree	bill	bathtub
Tighten the belt by a	notch	watch	lace	shell
The rude remark made her	blush	flush	angry	apple
She wore a feather in her	cap	map	pocket	sofa
Her entry should win first	prize	eyes	place	plant

Appendix B: Visual Stimuli