Abstract

Donna L. Wolfe THE EFFECTS OF PRESENTATION RATE ON SEMANTIC, SYNTACTIC, AND ORTHOGRAPHIC PROCESSING AND RELATIONSHIP TO READING FLUENCY IN CHILDREN (Under the direction of Marianna Walker, PhD) Department of Communication Sciences and Disorders. May 2011.

Reading fluency is the connection between reading decoding and reading comprehension. A child becomes fluent between second and third grade (Coltheart, 1978). However, it is unknown if fluency is strictly the result of rapid decoding or underlying language skills. It also is unknown how recognition of orthographic word forms, decoding rate, and accuracy independently contribute to the development of reading fluency. Broad relationships have been suggested between reading and oral language skills but studies are limited relative to the relationship between the development of reading fluency and underlying oral language abilities. Several studies have shown that semantic and syntactic abilities of oral language are related to later reading decoding and comprehension skills (Magnusson & Naucler, 1990; Menyuk et al., 1991). While relationships between these oral language abilities and later reading skills have been recognized to some degree, these studies are inconclusive regarding the relationship to reading fluency.

The purpose of the present investigation was to determine if semantic, syntactic, and orthographic processing abilities, as measured by reaction time and accuracy, are differentially affected as a function of stimulus modality (reading and auditory) and stimulus presentation rate. Participants included 50 second and third grade children (7 to 10 years of age) with varying reading and language skills based on a series of pre-experimental tasks. Participants completed a series of semantic, syntactic, and orthographic processing tasks within two controlled stimulus presentation durations for auditory and visual modalities. Relationships to pre-experimental reading and oral language tasks were explored.

Results from the reading tasks did not reveal an overall significant difference in mean reaction time between the semantic and syntactic decision reading tasks as a function of two presentation durations. However, children were more accurate in their ability to make semantic and syntactic decisions in the reading task for the longer presentation duration (1200 ms) than the shorter presentation duration (600 ms). Overall accuracy was higher for the semantic decision task than the syntactic decision task.

Results suggest that making judgments about oral language while using rapid decoding skills requires more information processing for children in this age group than a task that requires answering multiple choice questions. Semantic processing could be the main factor in overall reading efficiency that is not taken into account in current tests that measure reading fluency.

For the auditory linguistic tasks, children were able to make decisions about correctness faster for the syntactic decision than the semantic decision in the normal speech rate condition and the time-compressed speech rate condition. However, reaction time decreased for both tasks with time-compressed speech. Overall, children were more accurate in the normal speech rate condition than the time-compressed speech rate condition for both semantic and syntactic decisions. However, accuracy decreased for the semantic and syntactic decision in the auditory linguistic task when stimuli were presented in the time-compressed speech condition.

The current study suggests that there is a difference in processing content versus form (grammar) in reading tasks but not auditory tasks for children who are beginning fluent readers, suggesting that for beginning fluent readers, decreased accuracy in syntactic processing could be related to reading fluency rather than just language processing or the task itself.

There was no significant difference in reaction time between presentation duration conditions for an orthographic decision in a reading task. Accuracy increased for the orthographic decision in a reading task in general and the phonetic word type in particular for the shorter presentation duration (150 ms).

When making orthographic decisions in an auditory linguistic task, children were able to make decisions about spelling correctness faster for the time-compressed – 100 ms condition in comparison to the normal speech rate – 150 ms condition. Accuracy increased for the orthographic decision in general and the phonetic words in particular for the time-compressed speech condition.

Current results show that children can quickly and accurately determine if a word is spelled correctly between second and third grade when decoding skills are mastered and word recognition automaticity develops suggesting that orthographic verification and decoding skills are highly related skills (Hagiliassis, et al., 2006). For beginning fluent readers with varying reading skills, even the poorer readers may have less difficulty making discriminations for the phonetic word type than the nonphonetic word type.

The current study revealed that there was a strong relationship between oral language and reading fluency. Results suggest that rate of processing and stimulus duration may be factors in the overall assessment of efficient reading fluency. Results from the current study revealed that reading also involves making semantic and syntactic connections. The current study suggests that orthographic processing skills in the reading and auditory modality is an additional predictor of fluency single word identification (Burt, 2006). The current study also shows that for beginning fluent readers, there is more relationship between the rate of decoding and encoding spelling as seen in the orthographic decision or verification task, but semantic processing is still underdeveloped.

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CHAPTER I

Review of the Literature

Introduction

Reading fluency is the ability to accurately decode words quickly and automatically. A child becomes fluent between second and third grade when the visual/lexical strategy of decoding takes over (Coltheart, 1978). As a child becomes a fluent reader, they no longer need to focus on word recognition and can devote all of their attention to reading comprehension (Fox, 2004). Children who do not accurately decode words and struggle to read text comfortably often have difficulty comprehending the information being read (Pinnell, Pikulski, Wixson, et al., 1995). During this period of reading development, children become fluent at different times and the reason is unclear. It is not sufficient to study reading decoding and reading comprehension alone. Reading fluency is an important part of the reading process that must be looked at further because fluency is the connection between intact decoding and comprehension.

As oral language skills develop before reading skills, it would be expected that these skills are needed for the development of reading fluency. However, the relationship between semantic and syntactic processing skills and their contributions to reading fluency is unknown. Recognition of orthographic word forms, decoding rate, and accuracy could also be factors in the development of reading fluency. There have been broad relationships suggested but studies have been limited in their assessment or measurement of oral language abilities and their relationship to the development of reading fluency and subsequent reading comprehension.

In attempts to explain the relationship between reading fluency and oral language skills, researchers have examined several specific areas of oral language including semantics and syntax as well as orthographic processing. Several studies have shown that semantic and syntactic abilities are related to later reading skills (Magnusson & Naucler, 1990; Menyuk et al., 1991) and other studies have shown that children who have problems in reading often have problems in spelling (Bruck 1988; Bruck & Treiman 1990; Dodd, Sprainger, & Oerlemans, 1989; Levinthal & Hornung, 1992). Although it has been suggested that oral language skills contribute to the proficiency of reading fluency (Lombardino, Riccio, Hynd, & Pinheiro, 1997), results are difficult to compare due to differences in methodology. Several studies have examined children based on grade level (Bentin, Deutsch, & Liberman, 1990; Bowey, 1986; Vellutino, Scanlon, & Tanzman, 1991; Velluntino, Scanlon, & Spearing, 1995) and other studies have examined children based on age (Nation, Snowling, & Clarke, 2007). Some studies have used standardized tests (Lombardino, et al., 1997) while others have used nonstandardized tasks to evaluate the relationship between reading skills and other language skills (Velluntino, et al., 1995). Researchers also have defined their populations differentially as children with poor and normal reading skills (Velluntino, et al., 1995) or poor and normal reading comprehension (Nation, et al., 2007) making them difficult to interpret.

Research has revealed that deficiencies in certain areas of oral language are related to reading disorders in both the visual and auditory modality (Booth, Bebko, Burman, & Bitan, 2007). It has been suggested that deficits in reading could be due to an asynchrony between auditory and visual processing (Breznitz, 2002; Breznitz & Meyler, 2003; Breznitz & Misra; 2003; Meyler & Breznitz, 2005). However, the effect of oral language and orthographic processing skills on the proficiency of reading fluency for visual and auditory linguistic tasks has not been clearly specified or delineated.

It has been found that reading automaticity and fluency free up mental capacity for comprehension (Stanovich, 1991). However, speed and accuracy contribute differentially to reading decoding (Breznitz, 2001) specifically in the development of automatic and fluent reading. When children are forced to read and a faster rate, there is an increase in their accuracy of decoding and reading comprehension (Breznitz & Berman, 2003; Breznitz & Share 1992). Research has shown a relationship between semantic and syntactic decision tasks and reading proficiency under time constraints (Tyler & Marslen-Wilson, 1977). A relationship also has been found between orthographic processing skills and lexical decision accuracy and time (Burt & Tate, 2002). However, the effect of oral language and orthographic processing skills on the proficiency of reading fluency for reading and auditory linguistic tasks presented at different reading rates is not clearly understood.

Therefore, the purpose of the current study was to investigate the effects of presentation duration on semantic, syntactic, and orthographic processing and the relationship to reading fluency in the reading and auditory modality. The literature review will initially focus on several models of reading development with emphasis on both reading decoding and reading comprehension. General issues will be discussed regarding the relationship between oral language and reading decoding and comprehension based on a normal model of reading development. A disordered model of language and reading including current theories of reading disorders also will be addressed. Neurolinguistic and neuroanatomical aspects of reading disorders will provide evidence of brain regions activated during reading. Studies involving semantic, syntax, and orthographic aspects of language and their relationship to reading also will be reviewed. The review of the literature will conclude with a summary and rationale, plan of study, and experimental questions for the current investigation.

Reading Development

Many developmental changes occur as a child learns to read. According to Chall (1987), before a child goes through the first stage of learning to read, he passes through a pre-reading/literacy socialization stage that is associated with making connections with print, identifying with pictures, and remembering the story that goes with print. Between 6 and 7 years of age, a child goes through the decoding stage. This is when the fundamentals of reading are learned. The child is learning to decode phonologically or holistically (sight words) and the focus is not on comprehension (Chall, 1987). In stage two, confirmation of fluency, the child can read silently. The child uses the visual- lexical strategy when fluently decoding, thus allowing the child to free up attention for comprehension. This strategy will overtake the phonological strategy and should be established by the third grade for typical development of reading. Stage three, reading to learn, occurs between fourth and eighth grade. Between 9-11 years of age, the child can read adult length text with grade level vocabulary; between 11-13 years of age, the child can read popular magazines, newspapers, and popular fiction (Chall, 1987). At this time, the more the child reads, the better their reading skills will become. Stage four and five are based on the development of cognitive abilities. Stage four, multiple viewpoints, occurs when the child begins to read text presented from multiple viewpoints and begins to understands that there are different ways to interpret things. Stage five, construction and reconstruction, occurs when reasoning skills are used to comprehend and evaluate text (Chall, 1987). Thus, reading changes quantitatively and qualitatively at each stage of development.

The Science of Reading

Several anatomical structures have been identified as being involved in reading. According to Freidman, Ween, and Albert (1993), these include Heschl's gyrus, Wernicke's area, Broca’s area, and the angular gyrus. It has been suggested that primary auditory input goes to Heschl’s gyrus initially since it is connected to the primary auditory association cortex. Heschl’s gyrus is located along the superior temporal gyrus along with Wernicke’s area. Wernickes’s area is responsible for most of language input and comprehension and is located along the angular gyrus with Broca’s area. Wernicke’s area is considered to be the central location for semantic/lexical reading and language processing. Broca’s area is responsible for language input and carrying out information to the primary motor cortex. Broca’s area is considered the central location for syntactic and articulatory processing. The angular gyrus processes information from the auditory, visual, and somatosensory association cortices. The angular gyrus is located posteriorly to Wernicke’s area and is responsible for visual processing of abstract word forms. Both Wernicke’s area and Broca’s area are thought to work together to process language and input and output (Freidman, et al., 1993).

Serial Transfer Model

There are several scientific models of processing that can be used to explain reading including serial transfer, the parallel distributed processing model (a connectionist model), and the dual-route model of reading. According to Freidman et al. (1993), in serial transfer, information is thought to be transferred from one area of the brain to the next. The information processed in one area of the brain must be completed before it is transferred to the next area of the brain. For example, when reading a single word, the visual information is transferred to the orthographic lexicon where the letter strings are matched with corresponding letter strings stored in memory. This process then activates the orthographic word form and information is sent to the phonological and semantic areas of the brain for word recognition.

Parallel Distributed Processing Model

In the parallel distributed processing model, it is speculated that neurons from several anatomical areas of the brain are connected to other areas of the brain through white matter tracts, creating complex neural networks that function together to cause a behavioral function like word recognition (Freidman, et al., 1993). One network may constrain another allowing that network to yield different patterns of activity depending on the information it receives. Learning takes place in these networks as the strength of connections change through experience (Freidman, et al., 1993).

The parallel distributed processing model of reading only provides an explanation for the oral reading of single words. According to Freidman et al. (1993), reading processing takes place through two major networks. In one network, orthographic information travels directly to the phonological system allowing an individual to pronounce a word for which they do not know the meaning. In the other network, orthographic information travels directly to the semantic access regions of the brain allowing an individual to understand the meaning of a word even if it is spelled differently. This model provides a rather simplistic description of the anatomical areas involved in reading including Heschl's gyrus, Wernicke's area, Broca's area, and the angular gyrus. The model merely suggests that these areas work together concurrently for reading to take place.

According to Freidman, et al. (1993), a child begins to read in a slow, serial manner and then as they become more proficient, they will read letter strings fast and in parallel. The parallel distributed processing model does not account for grapheme-phoneme conversions like many models of reading because it suggests that the same connections are used to identify letter strings of nonwords that are in common with real words. These connections can be accomplished more easily with experience. It is important to note that even in this model some serial transfer of information must occur.

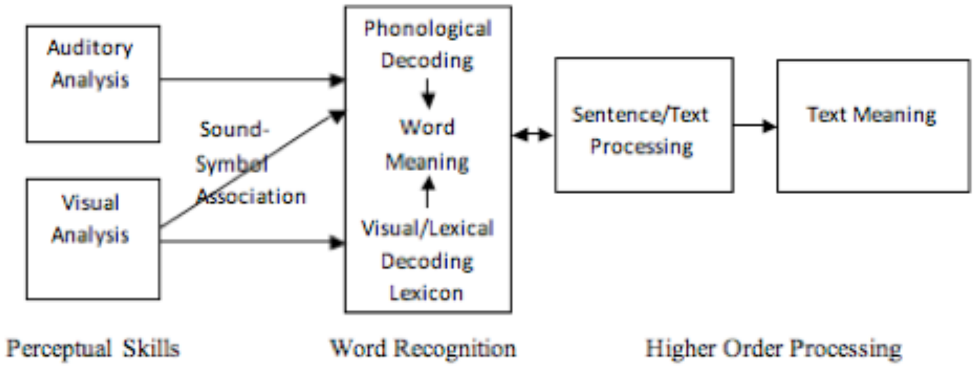
Dual-Route Model of Reading

The dual-route model of reading, proposed by Coltheart (1978), can be used to understand the development of reading. Figure 1 shows the dual-route model of reading. This model emphasizes two distinct strategies of decoding. Before decoding can begin, the child must have intact perceptual analysis. The child also must have intact visual and auditory detection, phonetic and orthographic analysis and discrimination, and identification or sound symbol correspondence skills. The phonological or non-lexical strategy and the visual-lexical strategy must be intact for skilled reading to develop (Castles, Bates, & Coltheart, 2006). The child first learns to read using the phonological decoding strategy. In the phonological strategy, decoding begins with phonemic and phonological processing, and then auditory linguistic processing of more meaningful language when input is auditory. The phonological or nonlexical strategy is considered the indirect access strategy of decoding because the child uses grapheme-phoneme correspondence to access word meaning. This nonlexical strategy is used to read and spell nonwords (ex. “depnonlel”) and regular words that use grapheme-phoneme rules (ex.cat) (Castles, et al., 2006). Nonsense words are a pure measure of phonological decoding ability. Children who only use the phonological strategy to decode have difficulty reading sight words. This is a slow access indirect strategy to word meaning because it requires both visual and auditory skills to process meaning (Castles, et al., 2006).

In the visual-lexical strategy, decoding begins with orthographic discrimination. The lexical level of the visual-lexical strategy provides direct access to the semantic system (Castles, et al., 2006). This strategy allows a reader to read and spell irregular words (ex. “laugh”) and

Figure 1

The Dual-Route Model of Reading



(Catts & Kamhi, 1986)

function words (ex. "and", "the"). A reader can successfully read all words using this strategy except for nonwords because they are not represented in the semantic system. Thus, to read a word, the reader must have the word in their mental lexicon. Phonological processing is not needed when the visual-lexical strategy is activated for sight word recognition and decoding. Readers process a word holistically using letter sequences in a word; they are using orthographic encoding, not phonological encoding. Because the visual-lexical strategy is a direct strategy, it provides fast access to decoding. Thus, the visual-lexical strategy increases the speed of lexical access and word retrieval and is utilized to develop fluency by chunking letters into words. Therefore, the visual-lexical strategy becomes the dominant strategy, used primarily when a child becomes a fluent reader. Once the child is able to decode by using this strategy, they are able to allocate all of their attention to process and comprehend phrases, sentences, and text. Using the visual-lexical strategy to decode enables the child to process text meaning for reading comprehension. If the child does not develop fluency, they will have subsequent deficits in reading comprehension.

Both decoding strategies are important to the process of spelling (Apel & Masterson, 2001). Apel and Masterson (2001) reported that word level decoding skills are necessary for good spelling abilities. They found that a spelling intervention program focusing on phonemic awareness, morphological awareness, and orthographic knowledge helped to increase the spelling ability of a child with decoding and spelling deficits. Based on scores from The Test of Written Spelling – 4 (Larsen, Hammill, & Moats, 1999), a writing sample, and spelling on morphological awareness tasks, Apel and Masterson (2001) concluded that word level decoding skills from both visual-lexical and phonological strategies are necessary for adequate spelling abilities.

Decoding strategies can be viewed from a developmental perspective; however, a particular reading curriculum may alter a beginning reader's primary or initial decoding strategy. When a child first learns to read, decoding is more important than comprehension. A child uses the phonological strategy to decode from six to seven years of age (Chall, 1987). As the child adds words to his or her mental lexicon, the direct access visual-lexical strategy becomes the predominant strategy of decoding, allowing the child to read rapidly, accurately, and effortlessly (Fox, 2004).

A child becomes fluent in decoding sometime between seven to eight years of age or between second and third grade. As a child gets older and decoding becomes more automatic, they can devote all of their attention to reading comprehension (Fox, 2004). Fluent readers use the visual-lexical strategy when they read words they know or common words, such as "sight words". When they come to an unfamiliar word, they break down the word into its syllables by using the phonological decoding strategy. According to Catts and Kamhi (1999), a child uses bottom-up processing when he or she first begins to read but switches to a top-down processing approach to facilitate higher level textual comprehension. Though the dual-route model of reading has been discussed using a bottom-up perspective, a proficient reader modulates both decoding and comprehension using an interactive processing approach.

The dual-route model of decoding (Coltheart, 1978) has been supported by findings based on neuroimaging studies. Jobard, Crivello, and Tzourio-Maoyer (2003) did a study to determine if there are two distinct strategies for decoding. They compared 35 neuroimaging studies using fMRI and PET scans of normal readers as they read nonwords and real words to determine if there are two distinct strategies for decoding in the brain. In doing this, they obtained contrasts between words and nonwords in individuals with normal reading skills. Based on their analysis, they suggested that the dual-route model of reading begins with early processing, thought to be located in the posterior visual brain regions or precentral gyrus. Jobard et al. (2003) proposed that pre-lexical processing occurs in the occipito-temporal junction. The semantic access regions of the brain are thought to be activated by way of the direct visual-lexical strategy. Pre-lexical processing is thought to follow an indirect phonological route. The superior temporal gyrus (dedicated to phonological access), middle temporal gyrus, posterior superior temporal gyrus, supramarginal gyrus, and the inferior frontal gyrus (opercular region thought to be involved in working memory needed to store and maintain grapheme-to-phoneme conversions) are regions activated during grapheme-phoneme conversions (Jobard, et al., 2003). Both the phonological and visual-lexical strategies are thought to activate the semantic access system, suggested to be located in the posterior middle temporal gyrus, the basal temporal area, and the inferior frontal gyrus (triangular gyrus). These regions also are thought to be connected to areas of the brain involved in object perception and oral language abilities (Jobard, et al., 2003). Thus, results suggest that there are two distinct strategies for decoding.

Reading Decoding

Decoding is the ability to recognize and interpret words; this is a skill necessary for reading fluency and reading comprehension. Before a child is able to decode, they must begin to recognize initial word sounds (Chall, 1987). They sound out words and use invented spelling which is the beginning of phonological decoding. Then, the child begins to understand that letters have names but are different than the sounds they represent. Thus, they begin to decode orthographically and use nonphonological spelling patterns (Chall, 1987; Coltheart 1978). As the child learns to read, the orthographic decoding strategy takes over and the child is able to comprehend the information being read. Both strategies of decoding are important for reading fluency because the child uses the direct strategy of decoding to read quickly and accurately and will switch to the phonological decoding strategy to decode words that are not in their lexicon. If a child has a reading disorder with deficits in decoding, they will not be able to establish reading fluency.

Factors Shown to Influence Decoding

Many factors have been shown to have an effect on the process of decoding. These factors include reading rate, background color and text color, word frequency, vocabulary age of word, word type, silent versus oral reading, and single words versus words in context. These variables need to be taken into account when designing and interpreting studies addressing reading decoding.

Reading rate has been found to influence decoding efficiency. Breznitz and Share (1992) found that a fast-paced reading rate, which is the maximum rate of demonstrated reading capability for an individual, was found to increase reading comprehension and decoding accuracy in second graders as measured by multiple-choice questions. The fast-paced reading rate condition also resulted in a decrease in oral reading errors resulting from increased information held in short-term memory. Breznitz and Berman (2003) suggested that a forced accelerated reading rate could influence various cognitive processes such as attention span in both normal and disordered readers. Increasing reading rate allows children with reading disorders to read faster than normal, to reduce decoding errors, and to increase comprehension (Breznitz & Berman, 2003).

Walker (2002) found that background and text color have an influence on decoding. She studied the influence of visual tasks involving vocabulary, color, and hemispheric processing on rapid naming abilities of children with reading disorders, and children and adults with normal reading using a visual half-field tachistoscopic picture naming task. Results revealed that the adults named vocabulary pictures faster when presented to the left hemisphere. Children with reading disorders had slower picture naming reaction times regardless of visual field, color, and vocabulary. There was a significant effect of color on naming speed when stimuli were presented to the left-visual field for the children with normal reading. The author concluded that immature hemispheric processing of rapid naming could be responsible for the differences in naming for normal and disordered reading groups. Thus, text color has an effect on the process of decoding (Walker, 2002).

According to Catts and Kamhi (1999), even novel words usually have familiar syllable structures or orthographic sequences that can facilitate decoding. In a lexical decision task, Verhoeven, Baayen, and Schreuder (2004) found that higher word frequency resulted in faster word identification in adults with normal reading abilities. The authors concluded that the more frequent the word, the greater the chance the reader had to learn the letter family associated with that word due to repetition of the letter-sound rules. The same is true for vocabulary age of a word. The letter family associated with a familiar word will help the child decode the unfamiliar word that is most similar to it (Catts & Kamhi, 1999).

Reading orally facilitates word recognition beyond that of silent reading due to the allocation of attention to decoding. According to Catts and Kamhi (1999), context also facilitates decoding abilities for high frequency function words but not as much for content words. Share and Stanovich (1995), report that phonetic decoding is an essential part of the reading process, because direct instruction and contextual guessing of orthographic words is not adequate for the development of fluent reading. While these variables have been found to affect decoding, they should be taking into account when designing and interpreting research studies involving reading.

Reading Comprehension

While the dual-route model of reading (Coltheart, 1978) provides a detailed explanation of the auditory and visual-lexical decoding strategies, it does not provide a detailed explanation relative to the complex reading comprehension process. In order for reading comprehension to occur, a reader must have intact word recognition (decoding) skills (Catts & Kamhi, 1999). As reading comprehension develops, attentional resources shift from decoding to comprehension. According to Graesser and Briton (1996), "Reading comprehension is a dynamic process of constructing coherent representations and inferences at multiple levels of text and context and storing them within a working memory capacity" (p. 350).

Reading comprehension is a process of using context to gain meaning. It involves assigning meaning to print and using prior knowledge to assist in understanding the text. A text may be comprehended or interpreted in multiple ways by many different readers. The true assessment of reading comprehension is complex and involves more than answering questions but in many situations; reading comprehension relies on the recall of facts, primarily through questions. Reading comprehension, however, involves more than the recall of salient information. The level of comprehension is unique to every reader and is related to type of instruction, type of text, question type, engagement in text, and purpose of the reading action. A reader can attain a deeper level of comprehension while reading, but factual and inferential assessment questions will not assess deeper understanding of the material being read.

Reading comprehension includes deriving a main idea, determining what details support the topic and genre, and the ability to read to learn. Reading comprehension also involves establishing a reciprocal relationship between the author and the reader. The reader accomplishes this by considering the author's perspective and by integrating background information from the text. Reading comprehension can be affected by several factors including the reader's ability to acquire information from text as well as their ability to organize that information, which also can be influenced by familiarity of the topic to the reader. Deficits in reading comprehension may occur because an individual has difficulty understanding that reading is a meaningful act. Decoding deficits can cause decreases in comprehension due to problems in reading rate and accuracy as well as reading fluency (Catts & Kamhi, 1999).

Reading Comprehension Assessment Consideration

There is an assumption that the knowledge gained from a particular subject can be assessed through various forms of reading comprehension. However, it may appear that an individual lacks comprehension of a particular text not because of difficulty understanding the information, but because of how their reading comprehension has been assessed. Different types of assessments can be used to assess reading comprehension in multiple ways and are administered for various purposes. The particular instruments and methods may be used to determine if knowledge was obtained or measure specific reading comprehension abilities through standardized tests or informal assessment, including the effects of executive functioning and information processing constraints on reading comprehension (Wolfe, Walker, & Vos, in process).

Reading comprehension is formally evaluated by answering questions about the text read including cloze format, open-ended questions, and factual and inferential multiple-choice questions. These formants can be found in assessments such as The *Spadafore Diagnostic Reading Test* (Spadafore, 1983), the *Woodcock Reading Mastery Test – Revised* (WRMT-R;

Woodcock, 1998), the *Nelson-Denny Reading Test* (Brown, Fishco, & Hanna, 1993), and the *Gray Oral Reading Test* - Fourth Edition (GORT-4; Wiederholt & Bryant, 2001). The *Spadafore Diagnostic Reading Test* (Spadafore, 1983) measures reading comprehension through the use of short answer questions that are both factual and inferential, following a series of short passages. *The Woodcock Reading Mastery Test – Revised* (Woodcock, 1998) measures reading comprehension via a series of fill-in-the-blank response choices in a cloze format. The *Nelson-Denny Reading Test* (Brown, et al., 1993) is a timed assessment; reading comprehension is assessed using longer reading passages followed by a series of multiple-choice questions. The *Gray Oral Reading Test* - Fourth Edition (GORT-4; Wiederholt & Bryant, 2001) is also a timed assessment; reading comprehension is assessed along with reading rate, accuracy, and fluency using reading passages that increase in length and complexity with grade level followed by a series of multiple-choice questions. With many of these tests, the examinee is not able to look back at the reading passage when answering the multiple-choice questions.

Several variables may be examined to informally assess reading comprehension, including reading rate (Breznitz & Share, 1992), text genre (Best, Floyd, & McNamara, 2008; De Beni, Borella, & Carretti, 2007; Wolfe, 2005), text length (Breznitz 1987; 1990; Breznitz, DeMarco, Shammi, & Hakerem, 1994; Breznitz & Share, 1992; Leikin & Breznitz, 2001; Meyer, Talbot, & Florencio, 1999), and question type (Breznitz 1987; 1990; Breznitz, et al., 1994; Breznitz & Share, 1992; Leikin & Breznitz, 2001; Walczyk, et al., 2007). The reader must use different strategies and skills depending on the information presented (Danks & End, 1987). Thus, the results of reading comprehension research are often difficult to compare due to all of the variables that must be taken into account when assessing comprehension.

Research has shown that an increase in reading rate often improves reading comprehension for adults (Breznitz et al., 1994; Leikin & Breznitz, 2001) and children (Biancarosa, 2005; Breznitz, 1987; 1990; Breznitz & Share, 1992); however, it has been difficult to determine the extent to which reading rate increases affect comprehension. In one study (Breznitz & Share, 1992), a fast-paced reading rate (the maximum rate of demonstrated reading capability for an individual) was found to improve reading comprehension and decoding accuracy in second graders as measured by multiple-choice questions. The fast-paced reading rate condition also resulted in a decrease in oral reading errors, possibly resulting from increased information held in short-term memory (Breznitz & Share, 1992).

Breznitz and Berman (2003) have identified the increase in comprehension with increased reading rate as the acceleration phenomenon. They suggested that a forced accelerated reading rate can influence various cognitive processes such as attention span in typical and disordered readers. They suggest that reading acceleration reduces distractibility and short-term memory limitations, enhances working memory, and increases word retrieval skills in normal and disordered children and adults. They found that in children with reading disorders, a forced increase in reading rate, reduces decoding errors, and improves reading comprehension (Breznitz & Berman, 2003). In a longitudinal study examining reading in children, Breznitz (1997) found that second grade reading rate was the best predictor of reading performance in fourth and fifth grade. Reading rate also was shown to be a determining factor in performance of typical readers by fourth and fifth grade. Furthermore, reading acceleration led to improved reading comprehension and decoding accuracy for all grade levels (Breznitz, 1997). However, in another study designed to investigate the acceleration phenomenon, Meyer et al. (1999) presented expository text to adults at three different presentation rates (90, 130, 300 words per minute) and using free-recall, main idea questions, a cloze task, and a series of standardized tests, found that adults had greater reading comprehension for expository text at the lowest reading rate, 90 wpm, even as the text increased in length suggesting that expository text requires a slower reading rate for increased comprehension to occur.

Text genre also has been found to have an effect on reading retention and comprehension in adults and children (Best, et al., 2008; De Beni, et al., 2007; Wolfe, 2005). Studies comparing narrative and expository text have shown that expository text becomes easier for the reader to comprehend as reading skills develop (Best, et al., 2008). Best et al. (2008) conducted a study comparing differences in reading comprehension of second through fourth grade level narrative and expository texts with third grade children. Using free recall, cued recall, and factual and inference based multiple-choice questions, they found that children comprehended narrative text better than expository text. In another study (Wolfe, 2005), reading comprehension was measured by comparing self-paced reading of narrative and expository text. Using free-recall questions, Wolfe found that undergraduate students were able to recall more elements from narrative text than expository text, suggesting that expository text is more difficult to comprehend and recall, as measured by multiple-choice questions.

Research using varying text lengths has resulted in inconsistent results when comparing findings relative to reading comprehension. Inconsistencies in results may be due to the fact that a clear effect of text length on reading comprehension has not been established. Studies examining reading comprehension have used various text lengths ranging from lengthy sentences (Breznitz, 1987; 1990; Breznitz, et al., 1994; Breznitz & Share, 1992; Leikin & Breznitz, 2001), to short paragraphs (Breznitz & Share, 1992; Meyer, et al., 1999), to longer texts ranging from 26 to 36 sentences in length with 290 to 422 words each (Best, et al., 2008; Biancarosa, 2005;

Wolfe, 2005; Wolfe & Mienko, 2007); thus, the findings from these investigation are difficult to compare.

Reading comprehension has been found to improve under a forced reading rate condition when short declarative sentences are used (Breznitz, 1987; 1990; Breznitz, et al., 1994; Breznitz & Share, 1992; Leikin & Breznitz, 2001). Breznitz and Share (2001) also used six declarative sentences and four passages, two to four sentences in length with 20 to 35 words. They found improved reading comprehension and decoding accuracy and a decrease in oral reading errors in second grade children in a fast-paced reading condition (300 words per minute). Meyer et al. (1999) used three expository texts, consisting of 88 words on a seventh grade level, read under three reading rate conditions (90, 130, and 300 wpm). They found that adult participants had improved reading comprehension under the lowest reading rate condition (90 wpm). When narrative text was 26-29 sentences in length and 295 words on average and expository text was 25 sentences in length with 290 words on average, Wolfe (2005) found that for undergraduate students, semantic associations were influenced by reading comprehension of expository text more than narrative text. The way in which the text was organized was found to affect differences in recall of narrative and expository text, but reading was self-paced. In contrast, Wolfe and Mienko (2007) used narrative text, 27 sentences in length with 378 words, and expository text, 26-29 sentences with 362-366 words in length. They found that undergraduate students showed no difference in recall of the different types of text when reading was self-paced. Best et al. (2008) used expository and narrative text, 304 to 471 words in length, and found that older school-age children comprehended expository text better than younger children when children were given five minutes to read the text.

The acquisition of knowledge gained following the reading of text can be measured in many different ways. During research, testing, and clinical situations, the types of reading comprehension questions asked are usually multiple-choice in nature (Breznitz, 1987; 1990; Breznitz, et al., 1994; Breznitz & Share, 1992; Leikin & Breznitz, 2001; Walczyk, et al., 2007) and do not necessarily take into account what level of reading comprehension the reader has obtained. Multiple-choice questions can be factual or inferential. Factual questions assess the reader's reading comprehension of exactly what has been written, whereas inferential questions require the reader to synthesize the information and make inferences about facts in the text (Breznitz, 1987; 1990; Breznitz, et al., 1994; Breznitz & Share, 1992; Leikin & Breznitz, 2001; Walczyk, et al., 2007).

A study by Wolfe, et al. (in process) was conducted to determine if factual and inferential reading comprehension was affected by text length and reading rate in accelerated reading conditions. College students with normal reading abilities were instructed to read six college-level expository texts, at two different text lengths (8 sentences and 16 sentences), and at three reading rates (self-paced, fast-paced, and faster-paced). The participants answered ten multiple-choice comprehension questions (5 factual and 5 inferential) following the silent reading of expository text on the same general topic. Relative to percentage of accuracy on multiple-choice questions, participants were found to recall more factual questions in the self-paced condition. Inferential reading comprehension was found to improve for shorter text in the fastest reading rate condition as compared to the slower reading rate conditions. Total accuracy scores for each reading rate condition did not influence differences in reading comprehension, but there was a difference approaching significance in reading comprehension accuracy scores for inferential questions from the eight sentence length text. Based on these results, Wolfe et al. (in process) suggested that reading comprehension efficiency should be assessed at multiple levels, including factual and inferential understanding of text. Further research also is needed to examine the effects of working memory capacity in reading impaired individuals relative to performance on accelerated reading comprehension tasks. Thus, it is valuable to take into account underlying factors such as reading rate, text length, and question type when determining comprehension levels.

Factors That Contribute to Reading Comprehension Success

Several skills need to be intact for successful reading comprehension. These skills include working memory (Breznitz & Share, 1992; De Beni, et al., 2007; Leikin & Breznitz, 2001; Linderholm, et al., 2008), attention (Leikin & Breznitz, 2001), world knowledge (Best, et al., 2008), motivation (Dai & Wang, 2007), level of development and skill (Walczyk, et al., 2007), and purpose of reading (Linderholm, et al., 2008). Working memory or “working memory capacity” serves to enable the ability to discriminate and organize recently read text (Cain, Oakhill, & Bryant, 2004). Information stored in long-term memory will facilitate integration with the current text. Linderholm et al. (2008) found that young adult readers with decreased working memory capacity read slower overall and answered fewer multiple-choice questions correctly than those with high working memory capacity relative to a set of explicit and implicit multiple-choice questions about the text.

Other variables such as prior knowledge (Wolfe & Mienko, 2007) and world knowledge (Best, et al., 2008) have been observed to play an important role in comprehending expository text in older school-age children and adults, possibly due to an increase in text complexity. Motivation also is an important part of text comprehension, especially when taking into account purpose of reading (Dai & Wang, 2007). However, Walczyk et al. (2007) suggested that one of the most important underlying factors contributing to reading comprehension is a child's developmental level and reading skill level. As noted, many variables can have an effect on reading comprehension. All of these variables need to be taken into account when considering an individual's reading comprehension abilities.

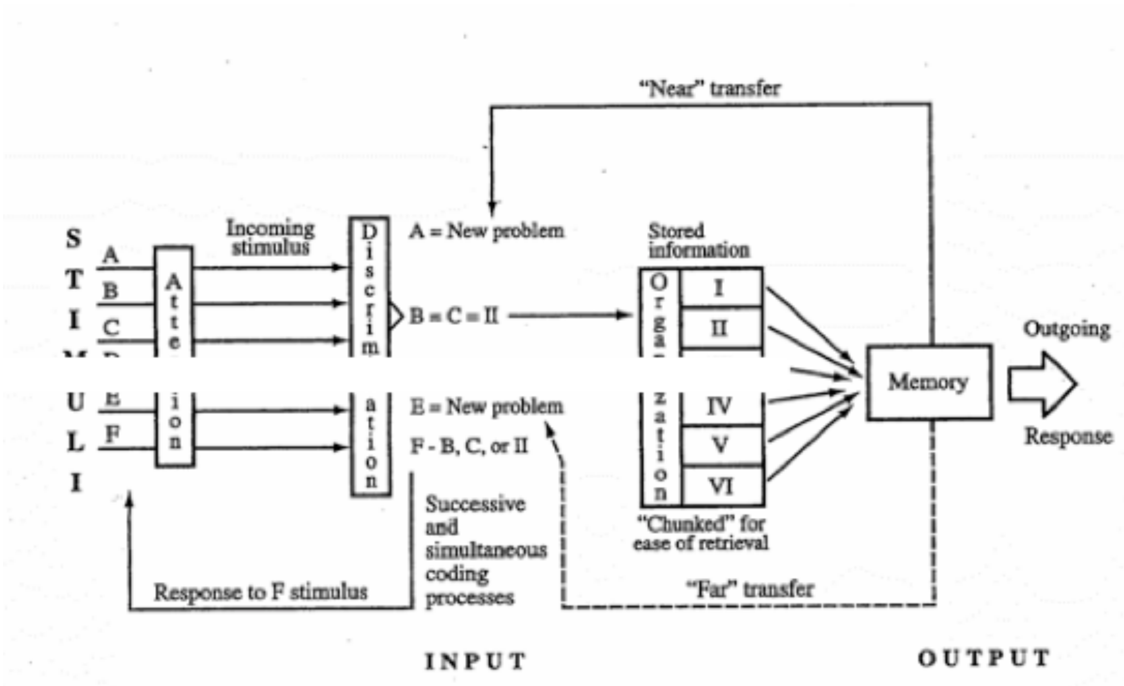
Information Processing Aspects of Reading

Though there are several different views of reading, the most common is the simple perspective (Gough & Tunmer, 1986) that there are two basic processes: decoding and comprehension. Decoding or "ungluing from print" deals with word recognition processes that transform print into words. Comprehension addresses the processes of interpretation of words, sentences, and discourse. In normal readers, intact decoding skills lead to reading comprehension. Gough and Tunmer (1986) indicate that decoding without comprehension is not reading. For example, a child with autism may be able to decode but not comprehend. In addition, comprehension without decoding also is not reading.

It is not enough to think of reading as just the basic processes of decoding and comprehension. Executive functioning and information processing abilities are involved in the reading process. Figure 2 shows a schematic representation of information processing. There are several aspects relative to information processing including memory, attention, and organization that must be intact for the reader to stay on task and remember what has been read. A skilled reader allocates attentional resources to detect incoming stimuli. A reader then discriminates the information being read through a successive and simultaneous coding process. Organization and storage of the information into memory occurs by "chunking it" for ease of retrieval. As reading decoding skills increase, the beginning reader is able to organize and store the information more accurately. This input process allows the reader to display accurate knowledge of read material.

Figure 2

Schematic Representation of Information Processing



Auditory Linguistic Processing and Relationship to Reading

Relationships between reading and auditory processing have been found (Walker, Givens, Cranford, Holbert, & Walker, 2006). Auditory linguistic processing involves several processes and mechanisms necessary for accurate decoding, perception, recognition, and interpretation when input is auditory (Bellis, 2003). Accessing the mental lexicon through the phonological route requires the auditory system to receive and process the acoustic message (i.e. voice onset time, transition and formant structures). Therefore, the auditory system is necessary for the recognition and discrimination of information from the basic acoustic signals to spoken language (Bellis, 2003).

At a basic level, perceptual skills are needed for phonemic and phonological processing of speech sounds. At the highest level, auditory processing involves the auditory linguistic processing of language when input is auditory. That is, the listener is able to access the information stored in the mental lexicon based on an acoustic signal (Frauenfelder & Lahiria, 1996). For phonological decoding to occur, auditory perceptual skills converge with visual perceptual skills for sound-symbol analysis.

Humes, Burk, Coughlin, Busey, and Strauser (2007) did a study to examine age-related differences in auditory speech recognition and visual text recognition for parallel sets of stimuli presented in the auditory and visual modalities at different presentation rates. They presented adults with a sentence in noise task, time-compressed monosyllables, and a speeded spelling test in both the auditory and visual modalities. They found that performance on these parallel measures were closely associated regardless of the presentation rate for the visual text recognition among the age groups. However, the older adults had more difficulty with fast presentation of auditory stimuli (Humes, et al., 2007).

As auditory processing and discrimination are the basic skills required for decoding and recognition of the sounds of a language including phonemic awareness and phonological awareness, auditory temporal processing deficits may underlie difficulties in phonological processing and the subsequent reading disability whereas visual temporal processing deficits may influence reading fluency. Breakdowns in normal reading development, especially in auditory and visual perception, could be linked to more complex and global processing disorders (Breznitz & Meyler, 2003).

There is evidence that many dyslexia readers exhibit a fundamental disturbance in sound perception that is most apparent when processing stimuli presented in rapid sequence (Farmer & Klein, 1993; 1995; Tallal, 1980). This could be due to a lower-level auditory perceptual dysfunction rather than a higher- level language dysfunction specifically in phonological awareness. Research has also suggested that low-level deficits in visual processing may also contribute to dyslexic. Many dyslexic readers also have difficulty when compared to normal readers on rapid, temporal, visual information processing tasks (Farmer & Klein, 1995). It has also been proposed that dyslexic readers have difficulty with the integration of temporal information from both the auditory and visual modalities (Farmer & Klein, 1993) due to impaired speed of processing in the auditory or visual modality or both.

Breznitz and Meyler (2003) did a study to determine if there is a specific pattern of speed of processing among college-level readers, both normal readers and dyslexic readers, when processing visual, auditory, and cross-model information. They used low- level linguistic and nonlinguistic stimuli in oddball and choice reaction tasks to assess speed of processing in the absence of semantic processing requirements while measuring reaction time and ERP latencies. Baseline measures revealed that dyslexic readers produced more oral reading errors, lower comprehension scores, and slower than normal readers when making phonological and orthographic decision but they were not less accurate. However, there was no difference in general ability. Experimentally, dyslexic readers were slower on measures of reaction time when responding to visual and auditory stimuli at the linguistic level and nonlinguistic level. They were also significantly slower and less accurate than normal readers on cross modality tasks. ERP latencies were delayed in dyslexic readers when compared to normal readers and there was a gap between ERP latencies in the visual versus auditory tasks. Results suggest a speed of processing deficit in either the auditory or visual modality in dyslexic readers. Researchers concluded that slower cross modal speed of processing is due to slower information processing in general and an asynchrony in processing between the auditory and visual modalities (Breznitz & Meyler, 2003).

In another study, Breznitz and Misra (2003) examined speed of processing between visual and auditory modalities and how each modality contributes to word recognition in college level students with dyslexia and normal reading using ERP's and reaction time data for nonlinguistic and linguistic low–level stimuli and higher–level orthographic and phonological processing in a lexical decision task. Dyslexic readers had slower reaction times and longer latencies than the normal readers in most of the experimental tasks. They also exhibited a gap in speed of processing between the auditory and visual measures supporting the theory that asynchrony in speed of processing is an underlying factor in dyslexia (Breznitz & Misra, 2003).

Meyler and Breznitz (2005) did a study to determine if dyslexic readers have difficulty with their perception of timing as addressed by sensitivity to rhythm. They examined visual, auditory, and cross-modal temporal pattern processing at the nonlinguistic and sublexical linguistic levels, and their relationship to decoding skills in college level adults with dyslexia and normal reading. Results revealed that dyslexic adults had an impairment in temporal processing. They also had an impairment in processing visual syllables. Temporal pattern processing correlated to decoding in normal readers but not in the dyslexic readers suggesting that dyslexic adults may use an orthographic strategy to decode to compensate for their deficits in temporal processing deficits.

In another study, Breznitz (2002) investigated the asynchrony of speed of processing between the visual and auditory modality in children between 9 and 10 years of age with normal reading and dyslexic readers. Speed of processing was assessed using ERP's and reaction time data for nonlinguistic and linguistic auditory and visual low–level stimuli and higher –level orthographic and phonological processing. She also found that dyslexic readers had slower reaction times and longer latencies in most experimental tasks than the normal readers. They also exhibited a gap in speed of processing between the auditory and visual measures explaining most of the variance in word recognition. Findings also support the theory that asynchrony in speed of processing is an underlying factor in dyslexia (Breznitz, 2002).

Breznitz (2001) suggested that dyslexic readers have slower speed of processing than normal readers in the auditory-phonological system when reading. It is know that word recognition involves information processing in the visual and auditory modalities and the integration of each. Therefore, slow speed of information processing within and between these modalities may be a factor underlying impaired decoding skills (Breznitz, 2001)

Oral Language Relationship to Reading Decoding and Comprehension

The reading process may be explained from a systems-based perspective. Reading is considered a dynamic process involving aspects of information processing, an intact dual-route system of decoding (Coltheart, 1978), and many underlying factors such as reading rate

(Breznitz & Share, 1992) , working memory(Breznitz & Share, 1992; De Beni, et al., 2007; Leikin & Breznitz, 2001; Linderholm, et al., 2008), attention (Leikin & Breznitz, 2001), text genre (Best, et al., 2008; De Beni, et al., 2007; Wolfe, 2005), and text length (Breznitz, 1987; 1990; Breznitz, et al., 1994; Breznitz & Share, 1992; Leikin & Breznitz, 2001; Meyer, et al., 1999) that contribute to reading comprehension. Reading is only one aspect of the overall language system. Language consists of two domains: oral and written language. Oral language is the foundation for reading and written language. The oral language domain consists of input (comprehension, reception, and processing) and output (production) (Catts & Kamhi, 1999). Therefore, it is reasonable to believe that oral language proficiency enhances early literacy knowledge.

The written language domain involves reading and writing or written expression. There is a reciprocal relationship between oral and written language. Specifically, strong oral language skills are needed for strong written language and literacy skills to develop. Within each language domain, five components should be considered including semantics (content), phonology, syntax, morphology (form), and pragmatics (function of language in communication) (Roth & Worthington, 2005).

Reading can be considered from a hierarchical perspective as well as from a systems-based perspective. As the dual-route model demonstrates, children learn to read by developing the phonological and visual-lexical strategies of decoding (Coltheart, 1978). As decoding skills develop, a child becomes a fluent reader and begins to comprehend sentences and text (Fox, 2004). For beginning readers, understanding and use of certain language systems (phonology, semantics, syntax, pragmatics) is necessary for reading skills to develop because language development precedes reading development (Catts & Kamhi, 1999).

Reading and Reading Disorders: Language Systems

Oral and written language impairments may involve weaknesses in any area of language (phonology, semantics, syntax, pragmatics) (Catts & Kamhi, 1999). Therefore, it is important to look for patterns in these areas of language across domains such as deficits in semantics or syntax. All language systems are interconnected, regardless of the modality, which indicates that if there are deficits in oral language, then there are probably deficits in reading and written language. For example, if a child exhibits an oral retrieval impairment, which affects expressive oral language abilities, then the child will be at risk for a written language deficit that is retrieval-based. If a child exhibits basic oral language processing and production deficiencies in semantics and syntax, then the child will be at risk for secondary reading comprehension deficits and written language deficits in processing, storage, and retrieval.

It has been found that children with language impairments are at risk for later reading impairments (Catts, 1993; Scarborough, 2001). Therefore, oral language intervention will affect reading and written language skills; the same is true for reading and written language. This is why oral language, reading, and written language modalities should be remediated in any intervention of language (Roth & Worthington, 2005). Children with reading disabilities tend to have difficulties with inter-modality tasks. Specifically, if a child has difficulty reading, then the child will probably have difficulty with written output. Furthermore, expressive and receptive areas of each language domain should be considered during the evaluation process. Thus, deficits in reading and writing may involve deficiencies in basic language systems.

Current Theories of Reading Disorders

It is difficult to determine the basic underlying causes of reading dysfunction in children identified with reading disorders. This is because reading occurs through the combined efforts of complex neural networks. Consequently, there are several theories addressing the possible underlying basis of reading disorders. These theories propose that reading disorders may be caused by a temporal processing deficit (Tallal, 1980), phonological core deficit (Torgeson, Wagner, & Rashotte, 1994), or problems in both the phonological and visual-lexical systems, referred to as the double-deficit hypothesis (Wolf & Bowers, 1999). These theories with be addressed in the following section.

Temporal Processing Deficit

Temporal processing relates to the underlying relationship between auditory processing and decoding abilities. That is, children with temporal processing deficits have been found to have reading disorders. According to the temporal processing deficit theory (Cestnick & Jerger, 2000; Tallal, 1980), reading disorders are caused by central auditory processing deficits (speed of processing of rapidly changing acoustic symbols). This means that there is a deficit in the ability to discriminate the differences between rapidly occurring acoustic events (Tallal, 1980; Wright, et al., 1997). The impairments make it difficult for the child to hear acoustic changes in speech sounds. For example, they may have difficulty discriminating between a “ba” and “ga” at different rates. The basis for the reading deficiency appears to be related to auditory processing ability. Programs such as Fast ForWard, in which the vowel is lengthened and a child is trained to discriminate and shorten the transitions between the consonant and vowel, have been developed based on the temporal processing deficit theory (Fast ForWord, 1998).

In studies of temporal perception, children with reading disorders have typically performed more poorly than typically developing children (Cestnick & Jerger, 2000; Tallal, 1980). In an early study, Tallal (1980) investigated temporal processing deficits in reading disordered children. She examined the various components of temporal processing individually to determine how each contributed to the ability to discriminate temporal patterns. The overall purpose was to investigate the role that impaired auditory temporal perception plays in reading. Tallal administered The Repetition Test (Tallal & Piercy, 1975), The Metropolitan Reading Test (Spache, 1973), and The Kennedy Institute Phonics Test (Guthrie & Seifert, 1974) to reading disordered children and typically developing children, aged 8-12, as a means of identifying specific auditory perceptual deficits as well as determining levels of reading ability through use of phonics rules in reading. The results revealed that the difficulty that reading disordered children had with temporal pattern perception was due to the rate at which they processed perceptual information. When rate was increased, the reading disordered children began to have difficulty with temporal pattern perception. These findings suggested that rate of presentation of perceptual stimuli may influence performance on higher level perceptual tasks. The number of errors the children made when responding to rapidly presented auditory stimuli correlated significantly with reading rate, particularly with nonsense words.

Cestnick and Jerger (2000) tested auditory processing skills in reading disordered primary school children through the use of lexical (irregular words) and non-lexical (nonwords) reading measures to determine if performance on lexical and non-lexical tasks was unique to particular reading disordered subgroups or was the same for all children with reading disorders. The primary school age children with reading disorders were divided into subgroups based on poorer sight word recognition (lexical reading) and poorer nonlexical reading (phonologically impaired), to the extent they were using one reading route over the other. Poorer lexical readers exhibited deficits in sequential recall of rapidly presented tones. Poorer nonlexical readers had deficits in recall of tone, regardless of presentation speed or mode of recall. The authors found that temporal order and rapid temporal processing skills were related differently to lexical and nonlexical reading. Nonword reading was related to performance on the fast same-different tone task, whereas lexical (irregular word) reading was associated with auditory sequencing abilities. The subgroups differed in auditory temporal processing abilities, but did not differ on learning and memory tasks, suggesting that performance on auditory processing tasks reflects auditory processing abnormalities. These auditory processing deficits lead to poor speech perception, making it difficult to learn grapheme-phoneme relationships when reading nonwords (Cestnick & Jerger, 2000). Thus, deficits in auditory processing skills can lead to reading disorders.

Walker, et al. (2006) examined reading and auditory processing skills in children, aged 9-12, with and without reading disorders. In a series of auditory processing tasks, they administered frequency and duration pattern tests, brief tone frequencies differentiation tests, and psychological tests to determine the relationship between phonological and lexical decoding abilities, and auditory perceptual abilities. Compared to children with typical reading abilities, children with reading disorders had deficits in their ability to recognize patterns of tonal stimuli that differed in frequency and temporal duration. The reading-disordered children were more inconsistent on all temporal processing measures, especially in detecting frequency patterns and discriminating small frequency differences in short duration tonal signals. They had difficulty in both reading and auditory processing skills; however, the group as a whole had poorer sight word decoding compared to phonological decoding (Walker, et al., 2006). It is possible that for some children, reading disorders are caused by a temporal processing deficit. Relative to this possibility, it is important to rule out a temporal processing deficit.

A comprehensive language and reading evaluation should be administered before determining that a temporal processing deficit is a child's only problem because auditory processing deficits can lead to phonological decoding deficits. Walker et al. (2006) found that reading disordered children had difficulty with temporal processing tasks, as well as difficulty with sight word decoding. Based on the dual-route model, this may be due to the hypothesis that reading rate and reading fluency involve the visual-lexical route. Thus, reading disordered children may be more likely as a group to have difficulty with temporal processing tasks than normally developing children (Cestnick & Jerger, 2000; Walker, et al., 2006).

Phonological Core Deficit Theory

In the phonological core deficit theory (Torgeson, et al., 1994) phonological processing deficits are identified as the cause of early reading problems. An intact phonological system is required for phonological processing skills, which includes phonological awareness, phonological memory, and rate of access of phonological information (Torgeson, et al., 1994). These skills have been positively related to differences in the rate of acquisition of beginning reading skills (Fox & Routh, 1984). When considered individually, all phonological abilities have a causal relationship to reading growth and are relatively stable during early reading instruction. Thus, Torgeson et al. (1994) consider phonological awareness to be the most significant basis of growth in reading skills and it is frequently delayed in children with developmental reading disabilities (Torgeson, et al., 1994). Consequently, phonological skills have been shown to influence first and second grade word reading skills. Performance at the beginning of kindergarten has been found to be predictive of oral and written language skills at the end of first grade (Torgeson, et al., 1994). Thus, phonological skill analysis should be included when identifying children at risk for reading disorders.

According to the phonological core deficit theory, reading disabilities are caused by phonological system deficits, which are at a higher level than auditory processing (Torgeson, et al., 1994). It has been proposed that if a child has difficulty learning to read, the deficiency is caused by a breakdown in the phonological system. There appears to be a direct relationship between phonological awareness and the ability to decode in the phonological route (Torgeson, et al., 1994). Phonological awareness skills underlie reading and spelling of phonetic words and nonwords, allowing for sound-symbol association (Stanovich, 1998).

The Double-Deficit Hypothesis

The double-deficit hypothesis (Wolf & Bowers, 1999) is a theory indicating that reading failure may be due to deficits in one or two sources: phonological access (ability to identify and manipulate speech sounds or nonword decoding) and/or lexical access (the ability to process vocabulary rapidly using the visual and auditory modality). Deficits in the visual-lexical system are thought to be due to problems in rapid lexical access of sight words and lexical retrieval deficits. Even with phonological intervention, many at-risk children show no change in their reading skills (Wolf & Bowers, 1999). This theory identifies deficits in phonological processing and the visual-lexical system as two separate sources of reading disorders. Deficits in the phonological and visual-lexical strategy are thought to lead to the most severe type of reading impairments.

The double-deficit model includes phonological processing skills such as naming speed as an essential part of reading ability. According to Wolf and Bowers (1999), naming speed involves the rapid recognition and retrieval of visually presented linguistic stimuli affecting reading rate, reading fluency, and reading comprehension. Therefore, the access and retrieval of phonological processing skills are essential to naming speed abilities. According to the Double-Deficit Hypothesis, phonological awareness predicts nonword reading and visual-lexical ability predicts real word reading, naming speed, and accuracy (Wolf, 1997).

There is increasing evidence that deficits in phonological processing skills and visual-lexical access are the underlying causes of reading disorders (Wolf & Bowers, 1999). Thus, reading disorders may be due to deficits in one of two systems causing deficits in phonological processing, naming speed, or lexical access, or in both phonological processing and the visual-lexical system, creating a more severe reading disorder.

All of the theories mentioned propose that reading disorders are due to internal factors and not external factors. The temporal processing deficit theory is the oldest theory and is used by audiologists to explain deficits in central auditory processing as the source of reading failure. This theory suggests that reading disorders are caused by deficits in perceptual analysis of speech sounds (Tallal, 1980).

The phonological core deficit theory proposes that the disorder is in phonological processing which is at a higher level of functioning than auditory processing. This theory treats all reading disordered individuals as a homogenous group (Torgeson, et al., 1994). This theory also suggests that rapid naming abilities are due to phonological access and retrieval (Torgeson, et al., 1994).

The double-deficit hypothesis is the most contemporary theory and the most inclusive theory. This theory identifies deficits in the phonological strategy of word reading as one possible cause of reading failure. It also delineates deficits in the visual-lexical strategy of decoding as another possible cause of reading failure. Deficits in more than one strategy of reading decoding can account for the possibility of several types of reading disorders (Wolf & Bowers, 1999).

Neurolinguistic/ Neuroanatomical Aspects of Reading Disorders

Investigations exploring neurolinguistic aspects of reading disorders have revealed that there are processing differences between individuals with and without reading disorders (Booth, et al., 2007; Kevan & Pammer, 2008; Walker; 2001; 2002; Walker, Spires, & Rastatter, 2001). In a study examining processing aspects of reading efficiency for phonological and sight word decoding skills, Walker (2001) found different interhemispheric processing patterns for adults with and without reading disorders in a unilateral visual half-field lexical decision task. For reading-disordered adults, reading proficiency was related to rate of lexical processing and interhemispheric transfer time. Reading disordered individuals became more proficient readers as rate of lexical processing increased and interhemispheric transfer time decreased. Interhemispheric transfer time and phonological decoding were not significantly related for either group. In another study, Walker et al. (2001) examined interhemispheric visual processing in typical and reading-disordered adults. They measured vocal reaction times and error rates through a series of lexical decision tasks using concrete, abstract, and nonwords, presented unilaterally. They found that the reading disordered adults used different processing strategies than the adults with typical reading skills when performing lexical decisions (Walker, et al., 2001).

Kevan and Pammer (2008) indicated that individuals with reading disorders not only have language-based impairments, but also have visual deficits due to impairment to the magnocellular or dorsal pathway in the brain. They studied children with and without reading disorders, presenting frequency doubling (performance tasks requiring shifts of attention to locate a target in the visual field) and fixed nonlexical stimuli visually. The authors found that children with reading disorders had deficits in the magnocellular or dorsal stream as they exhibited less sensitivity to frequency doubling stimuli than the typical readers. The normal and disordered reading groups were equally sensitive to fixed stimuli. The children with reading disorders were not as sensitive as the typical group in seeing frequency-doubled stimuli. The authors proposed that the magnocellular pathway is important for reading speed, reading accuracy, and irregular and nonword reading (Kevan & Pammer, 2008).

Walker (2002) studied the influence of visual tasks involving vocabulary, color, and hemispheric processing on rapid naming abilities of children with reading disorders, and children and adults without reading disorders. Results revealed that the adults named vocabulary pictures faster when presented to the left hemisphere. Children with reading disorders had slower picture naming reaction times regardless of visual field, color, and vocabulary. There was a significant effect of color on naming speed when stimuli were presented to the left-visual field for the children with normal reading. The author concluded that immature hemispheric processing of rapid picture naming may have been responsible for the differences in naming for the normal and reading disordered children and adults.

Semantics, Syntax, and Orthography

In attempts to explain the relationship between reading fluency and oral language skills, researchers have taken into account several specific aspects of oral language including semantics, syntax, and spelling. There is a complex relationship between phonological processing, oral language, and reading across disordered populations (Lombardino, et al., 1997). Lombardino et al. (1997) completed a study to determine if children with reading disorders, ADHD, and typical reading skills differ in phonological coding, expressive language, and receptive language skills to determine which of these variables were most predictive of reading skills. Eighty children which a mean age of 9 years, 8 months participated in neuropsychological, neurolinguistic, behavioral, and educational measures including subtests from the *Clinical Evaluation of Language Fundamentals – Revised* (CELF-R; Semel, Wiig, & Secord, 1987), the *Comprehensive Test of Phonological Processing – Experimental Version* (CTOPP; Wagner, Torgesen, & Rashotte), the *WRAT-3*, and the *WRMT-R*. Results revealed that children with reading disorders performed more poorly than the ADHD and typical readers on tasks of phonemic processing and expressive language abilities, especially the elision tasks (Lombardino, et al., 1997). In the area of oral language, only the children with reading disorders showed depressed expressive composite scores. The children with reading disorders and ADHD showed depressed receptive composite scores. The results suggested that oral language skills contribute to reading proficiency. It was suggested that the predictive strength of these relationships depends on the type of reading skills examined, specifically whether it is reading decoding or reading comprehension (Lombardino, et al. 1997).

It has been suggested that there is a relationship between semantic processing and reading disorders. Velluntino et al. (1995) assessed semantic and phonological deficits in second and sixth grade children with poor and normal reading skills. Participants completed tests evaluating semantics, rapid naming, decoding of nonwords, verbal memory, and visual-verbal learning. Results revealed that sixth grade children with reading deficits exhibited poorer semantic skills than the normal readers. Children in both second and sixth grade with poor reading skills exhibited deficits in rapid naming and pseudoword learning tasks. They concluded that semantic deficits may not be the cause of reading difficulties in children with poor reading skills as they begin learning to read but begin to cause deficits due to prolonged reading difficulties in readers as they get older (Velluntino, et al., 1995).

Nation et al. (2007), investigated differences in vocabulary acquisition in children between 8 and 9 years of age with poor and normal reading comprehension. Participants were required to associate new phonological word forms to pictures of novel objects. They were then taught semantic information about the objects. Children classified as poor comprehenders were able to learn to label the objects but had difficulty learning the meaning of the words associated with the objects, suggesting that poor visual comprehenders have difficulty with semantics rather than vocabulary learning (Nation, et al., 2007).

There is neurological evidence that semantic processing deficits are related to reading disorders. It has been suggested that semantic processing in normal children activates the left inferior frontal gyrus, left inferior parietal lobule, and left middle temporal gyrus. Booth et al. (2007) used fMRI to determine if these same regions are related to semantic processing in children with reading disorders. Children 9-15 years of age with reading disorders and their age-matched peers were asked to make judgments about the relationship between word pairs that varied between high association and low association strength presented auditorally and visually. Results revealed that the children with reading disorders showed a reduced correlation between association strength and activation in the areas associated with semantic processing. Furthermore, children with reading disorders have semantic deficits across auditory and visual modalities (Booth, et al., 2007).

Semantic and syntactic abilities are related to later reading skills (Magnusson & Naucler, 1990; Menyuk, et al., 1991). Lombardino et al. (1997) suggested that many poor readers exhibit difficulties in phonological processing, semantics, and syntax. Though all language domains (semantics, syntax, morphology, phonology, pragmatics) play a role in the development of oral and written language, Vellutino et al. (1991) suggest that not all language domains are of equal importance. Based on a longitudinal study of reading development of second, third, sixth, and seventh graders, they reported that word identification is facilitated by phonologically based skills and retrieval skills and text comprehension is facilitated by semantically based skills (Vellutino, et al., 1991). Thus, there is a differential relationship between language domains and reading skills.

Eisenberg and Becker (1982) studied the effects of semantic context on single words in undergraduate students participating in a reading task and a lexical decision task. They found that semantic context strategies may be used in reading short sentences. Chiappe, Chiappe, and Gottardo (2004) conducted a study to determine if semantic skills are related to phonological awareness skills in a group of poor readers and normally developing readers in the first through third grades. They found that expressive and receptive vocabulary knowledge was related to phonological awareness tasks such as blending and phoneme deletion.

Research has revealed that there is a relationship between reading decoding and syntactical processing. Bowey (1986) completed a study examining whether less skilled decoders are more delayed than skilled readers in awareness of well formed syntactic structure to determine if there is a relationship between syntactic abilities and reading comprehension. Fourth and fifth grade children with varying decoding abilities were asked to repeat an incorrect sentence as they heard it and then correct grammatically deviant sentences presented in the auditory modality in an oral language task. Syntactic awareness was more strongly associated with decoding skills than reading comprehension abilities, suggesting that the difference between skilled and less skilled readers/decoders may be a delay in syntactic awareness. Furthermore, because tasks were presented as auditory tasks, it also was suggested that these difficulties are not restricted to written language (Bowey, 1986).

Bentin et al. (1990) conducted another study to examine the relationship between word recognition and syntactic awareness. They tested the effect of syntactic context on the identification of words presented in the auditory modality. They also tested the ability to detect and correct syntactic errors in speech. Good and poor readers in fourth grade were matched on their ability to decode voweled nonwords and IQ scores. The identification of words was less affected by syntactic context in severely disabled readers than good and poor readers. Disabled readers were less able to judge the syntactical integrity of spoken sentences and correct syntactical errors. Poor readers were similar to good readers in their ability to identify and make judgments about syntactic errors. However, they had more difficulty correcting syntactic errors, suggesting that severely disabled readers have greater deficits in syntactic awareness and processing than poor readers (Bentin, et al., 1990). Good and poor readers had syntactic awareness but poor readers could not use their syntactic awareness skills to correct errors (Bentin, et al., 1990).

Research suggests that children who have problems in reading often have problems in spelling (Bruck, 1988; Bruck & Treiman 1990; Dodd, et al. 1989; Levinthal & Hornung, 1992). Learning to read and spell is often difficult for children because English words can be pronounced differently even though they look the same orthographically or pronounced the same even though they are spelled differently (Levinthal & Hornung, 1992). Children often use two strategies to read and spell words; the phonological strategy and orthographic strategy. According to Levinthal and Hornung (1992), it is thought that a deficiency in one of these strategies leads to difficulties in reading and spelling. Levinthal and Hornung (1992) evaluated spelling and reading abilities in the context of the phonological and orthographic coding. Thirty college students between 18 and 22 years of age were directed to determine if word pairs were similar orthographically (visually similar) or phonologically (rhyme). Trials included word pairs similar in orthography and phonology, dissimilar in orthography and similar in phonology, and similar in orthography but not in phonology (Levinthal & Hornung, 1992). These word pairs were also presented in upper and lower case conditions to determine whether an increase in difficulty of making orthographic matches would affect the degree of phonological coding (Levinthal & Hornung, 1992). Results revealed that poorer readers were able to make visual discriminations during phonological interference but poorer readers and spellers were less able to make visual discriminations during orthographic interference when making rhyme matches. These findings suggest that deficits in the phonological strategy and an over reliance on orthographic coding often seen within the reading disordered population can also be seen in poor readers and spellers in the adult population (Levinthal & Hornung, 1992).

Decoding abilities are related to reading and spelling skills in children. In a longitudinal study, Stuart and Masterson (1992) assessed children's prereading phonological abilities and their reading and spelling performance between 9 and 10 years of age. Twenty children were administered phonological tests at age 4, IQ tests at age 6, and standardized reading, spelling, and vocabulary tests as well as assessments of reading and spelling nonwords and regular and irregular real words between 9 and 10 years of age. Test results revealed that children with good early phonological awareness had well-developed lexical and sublexical reading and spelling abilities, showed larger regularity effects in word reading and spelling, and were better at nonword reading and spelling than children with poor early phonological awareness. Thus, these findings suggest that early phonological awareness is significantly related to reading regular but not irregular words (Stuart & Masterson, 1992). Therefore, children at risk for reading and spelling deficits may be identified before they learn to read (Stuart & Masterson, 1992).

Burt and Tate (2002) have suggested that there is a relationship between spelling and lexical ability. They assessed the relationship between spelling accuracy on a set of words as well as efficiency of visual word recognition on the same words. Performance on the word recognition task was then compared to words spelled incorrectly by each participant. College students with a mean age of 17.8 years of age completed spelling and lexical decision tasks. They spelled low frequency words after hearing them. They were then asked to decide if the word they spelled was a word or nonword as quickly as possible. Next, they were required to determine if the word was spelled correctly within 200 milliseconds. Results revealed that performance on low frequency words in the lexical decision task depended on the accuracy with which words were spelled on the prior spelling task (Burt & Tate, 2002). Lexical decision latencies were longer for incorrectly than correctly spelled words, suggesting that orthographic knowledge underlies visual word recognition and spelling (Burt & Tate, 2002).

As previously mentioned, Humes et al. (2007) did a study to examine age-related differences in auditory speech recognition and visual text recognition stimuli presented in the auditory and visual modalities at different presentation rates. Based on the presentation of a speeded spelling tests in both the auditory and visual modalities, they found that performance on these parallel measures were closely associated regardless of the presentation rate for the visual text recognition among the age groups. (Humes, et al., 2007). As previously mentioned, Meyler and Breznitz (2005) suggested that dyslexic adults may use an orthographic strategy to decode to compensate for deficits in temporal processing.

Studies have shown that semantic (Booth, et al., 2007; Nation, et al., 2007; Velluntino, et al., 1995) and syntactic (Bentin, et al., 1990; Bowey, 1986) abilities are related to later reading skills and other studies have shown that children who have problems in reading often have problems in spelling (Bruck 1988; Bruck & Treiman 1990; Dodd et al. 1989; Levinthal & Hornung, 1992). While it is known that there are relationships between these abilities and later reading skills, differences in methodology make it is difficult to make conclusions based on research finding as to how these skills can account for the variability and establishment of reading fluency. It is still not known what causes a child to transition from learning to read to the ability to read to learn.

Several studies have examined children based on grade level (Bentin, et al., 1990; Bowey, 1986; Vellutino, et al., 1991; Velluntino, et al., 1995), while other studies have examined children based on age (Nation, et al., 2007). As mentioned previously, Velluntino et al. (1995), examined second and sixth grade children while Nation et al. (2007), investigated children between 8 and 9 years of age.

Age of population being studied is another methodological difference that exists in studies examining the relationship between processing skills and reading. As mentioned previously, Stuart and Masterson (1992) assessed prereading skills and later, reading and spelling skills, in children 9 and 10 years of age. Burt and Tate (2002) assessed reading and spelling skills in college students.

Several studies have used standardized tests to examine the relationship between reading skills and other language skills. As mentioned previously, Lombardino et al. (1997) used standardized tests to examine children with reading disorders and children with reading disorders and ADHD. Velluntino et al. (1995) used nonstandardized tasks to assess semantic and phonological deficits in children.

In examining language skills and how they compare to reading skills, many studies define their populations differently. As mentioned, Velluntino et al. (1995) defined their population of children as having poor and normal reading skills. Nation et al. (2007) examined children with poor and normal reading comprehension. Vellutino et al. (1991) examined children without classification.

Though many studies have not considered rate as a factor in the relationship between oral language skills and reading skills, several have examined accuracy and reaction time (Tyler & Marslen-Wilson, 1977). As mentioned previously, Tyler and Marslen-Wilson (1977) presented a timed semantic decision task.

Though many studies present semantic (Lombardino, et al., 1997; Nation, et al., 2007; Velluntino, et al, 1995), syntactic (Lombardino, et al., 1997), and orthographic processing tasks (Levinthal & Hornung, 1992) in the visual modality, other studies present these tasks in the auditory modality (Bentin, et al., 1990; Booth, et al., 2007; Bowey, 1986).

Summary and Rationale

Reading decoding and its effects on reading comprehension have been widely researched. Although there are several reading models suggesting that intact decoding is necessary for reading comprehension to occur, fluency is an important part of the reading process that must be further examined. Speed and accuracy contribute differentially to reading decoding, specifically in the development of automatic and fluent reading. A child typically establishes fluency sometime between second and third grade. However, during this period of reading development, children become fluent at different times.

Fluency is the connection between intact decoding and comprehension. However, it is unknown if fluency is strictly the result of decoding or some underlying language skill such as semantics or syntax. Recognition of orthographic word forms and decoding rate and accuracy may also be factors in the development of reading fluency. There have been broad relationships between reading and oral language skills suggested but studies have been limited in their assessment or measurement/examination of oral language abilities and their relationship to the development of reading fluency and subsequent reading comprehension.

In attempts to explain the relationship between reading and language skills, researchers have taken into account several specific areas of language including semantics and syntax as well as spelling. Several studies have shown that semantic and syntactic abilities are related to later reading skills and other studies have shown that children who have problems in reading often have problems in spelling. While relationships between these abilities and later reading skills have been established to some degree, it is difficult to make conclusions as to how these skills can account for the variability and establishment of reading fluency. Specifically, what affects the ability to read to learn rather than learn to read is unknown.

Although a relationship exists between oral language and reading, the nature of the association is unclear. Research has shown that semantic processing skills are related to reading skills. More specifically, the literature has shown that oral language skills are related to reading skills differentially depending on the age and grade level of the child. In earlier elementary school, children are learning to read whereas, in later elementary school, children are reading to learn. As discussed, longitudinal studies have shown that word identification is facilitated by phonological skills, whereas retrieval and reading comprehension skills are facilitated by semantic skills. It has been suggested that semantic deficits may not be the cause of reading difficulties in children with poor reading skills as they begin learning to read. However, semantic deficits begin to cause reading deficits due to prolonged difficulties in reading, as a child gets older.

Relative to syntax, it has been suggested that the difference between skilled and less skilled readers/decoders may be related to a delay in syntactic awareness. Severely disabled readers have greater deficits in syntactic processing than poor readers as measured by decoding skills. Good and poor readers both appear to have syntactic awareness but poor readers are not able to use their syntactic awareness skills to correct errors.

Children who have problems in reading often have problems in spelling. Accessing mental lexicon via visual/lexical route requires accurate orthographic processing. It has been suggested that the cognitive/perceptual processes involved in learning to distinguish and name letters are similar to those involved in word recognition. Also, letter identification is in part a reflection of literacy experience, which in turn affects reading achievement.

Reading rate and decoding accuracy have been shown to be factors in the relationship between oral language skills and reading skills. As discussed, research has shown that syntactic decisions can be influenced by prior semantic context before an entire sentence has been read. Researchers suggest that semantic processing deficits are related to reading disorders in both the visual and auditory modality though it remains unclear as to what extent these oral language skills affect reading fluency.

Research has suggested that deficiencies in certain areas of oral language are related to reading disorders in both the visual and auditory modality. Research also has shown that there is a relationship between semantic and syntactic decision tasks and reading proficiency under time constraints. However, a clear and well-defined effect of oral language and orthographic processing skills on the proficiency of reading fluency is still unknown.

Although studies indicate a relationship between semantics, syntax, orthographic processing, and reading fluency, results are difficult to compare due to differences in methodology including definition of the population, standardized testing versus non-standardized testing, and age versus grade level of participants. Several studies have examined children based on grade level, while other studies have examined children based on age. Many studies assess the relationship between language skills and reading skills in young children, while other studies assess these skills in college students. Several studies have used standardized tests to examine the relationship between reading skills and other language skills while other studies used non-standardized tasks to assess oral language skills in children with poor and normal reading skills. In examining language skills and how they compare to reading skills, many studies define their populations differently in terms of poor and normal reading skills versus poor and normal reading comprehension, while other studies examine children of different ages without classifying their population. A few studies have examined language profiles as measured by oral language and reading skills when comparing various pathological populations including ADHD, reading disorders, and typical readers

At present, research has shown that oral language skills and orthographic processing skills are related to reading. That is, it has been suggested that many poor readers exhibit weaknesses in semantics, syntax, and orthographic processing. However, the use of varying methodology suggests the need to identify a more standardized way to measure oral language and orthographic processing skills and their effect on reading fluency depending on presentation rate and presentation modality. If a relationship is found between deficits in language skills and reading fluency, it may be possible to target those skills in therapy to increase reading fluency. It is necessary to determine the relationship between semantic, syntactic, and orthographic processing skills and reading fluency in typical reading development as well as in the reading disordered population.

Plan of Study and Experimental Questions

The purpose of the current study was to investigate the effects of presentation duration on semantic, syntactic, and orthographic processing and the relationship to reading fluency in the reading and auditory modality. Participants included second and third grade children between 7 and 10 years of age with varying reading and language skills. Processing skills were assessed using semantic decision tasks, syntactic decision tasks, and orthographic decision tasks. Participants were administered a series of eight pre-experimental standardized tests to determine their baseline reading rate and reading comprehension, receptive vocabulary, and decoding abilities. The following experimental questions were answered, divided into two sections.

Reading

1. Is there a difference in mean reaction time (ms) for a semantic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children?
2. Is there a difference in mean accuracy (proportion) for a semantic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children?
3. Is there a difference in mean reaction time (ms) for a syntactic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children?
4. Is there a difference in mean accuracy (proportion) for a syntactic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children?

5. Is there a difference in mean reaction time (ms) between a semantic decision and a syntactic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children?
6. Is there a difference in mean accuracy (proportion) between a semantic decision and a syntactic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children?
7. Is there a difference in mean reaction time (ms) for an orthographic decision in a reading task presented at two stimulus presentation durations (350 ms and 150 ms) for early elementary school children?
8. Is there a difference in mean accuracy (proportion) between phonetic and nonphonetic word type for an orthographic decision in a reading task presented at two stimulus presentation durations (350 ms and 150 ms) for early elementary school children?

Auditory

1. Is there a difference in mean reaction time (ms) for a semantic decision within an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children?
2. Is there a difference in mean accuracy (proportion) for a semantic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children?
3. Is there a difference in mean reaction time (ms) for a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children?

4. Is there a difference in mean accuracy (proportion) for a syntactic decision in an auditory linguistic task presented at two stimulus presentations (normal speech rate and time-compressed) for early elementary school children?
5. Is there a difference in mean reaction time (ms) between a semantic decision and a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children?
6. Is there a difference in mean accuracy (proportion) between a semantic decision and a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children?
7. Is there a difference in mean reaction time (ms) for an orthographic decision in an auditory linguistic (reading) task presented at two stimulus presentation durations (normal speaking rate – 150 ms and time-compressed – 100 ms) for early elementary school children?
8. Is there a difference in mean accuracy (proportion) between phonetic and nonphonetic word type for an orthographic decision in an auditory linguistic (reading) task presented at two stimulus presentation durations (normal speaking rate – 150 ms and time-compressed – 100 ms) for early elementary school children?

CHAPTER II

METHOD

Participants

For the current study, participants consisted of 50 children (27 male, 23 female) in second and third grade between 7 and 10 years of age (mean age 8 years, 11 months). Participants with typical reading and deficient reading skills were eligible to participate including those diagnosed with dyslexia. Children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) (only if medicated), Learning Disabilities, and Language Impairments were also eligible to participate. Children diagnosed with a speech impairment, autism spectrum disorder (ASD), mental retardation (MR), traumatic brain injury (TBI), or developmental disabilities were not included in the study. Table 1 provides participant diagnoses as reported by caregiver on the parent survey. All participants were native English speakers and reported having no visual, hearing, or cognitive impairments. All participants were required to pass a hearing screening at 20 dB HL at 1000, 2000, & 4000 Hz as indicated by ASHA (2010) and a vision screening based on the Snellen Visual Acuity Chart on the first day of the study, a copy of which is presented in Appendix A.

All participants were second and third grade children from Carteret and Pitt Counties. Participants were recruited on a voluntary basis based on written correspondence provided to the parents, newspaper advertisement, ads placed in local tutoring centers and Boys and Girls Clubs, the ECU List Serve, and through the ECU Speech-Language and Hearing Clinic research participant pool. A copy of the advertisement is presented in Appendix B. Participants were also recruited on a voluntary basis from the second and third grade classrooms at The Oakwood School located in Greenville, NC through a letter sent home to the parents, a copy of which is

Table 1

Participant diagnosis as reported by caregiver on parent survey.

Diagnosis	*Number of Participants* N = 50
ADHD	2
Dyslexia	3
In Process	1
LD	1
NA	42
Repeated	1

N = number of participants; ADHD = Attention Deficit Hyperactivity Disorder; In Process = being evaluated for a language learning disability; LD = Learning Disability; NA = No known diagnoses; Repeated = repeated a grade.

presented in Appendix C. A questionnaire was given to each participant's primary care giver to complete to further determine criteria for participation in the study with questions such as "Has your child ever been diagnosed with ADHD?" and "If so, is your child currently on medication?" A copy of the parent questionnaire is presented in Appendix D. Mean age, grade level, and gender information by grade are presented in Table 2.

Each participant and their parent/guardian gave informed consent and minor assent using approved forms including Health Insurance Portability and Accountability (HIPPA) consent that was reviewed and signed, a copy of which is in Appendix E. Standardized test results were reported to the parents of each participant using a test results form, a copy of which is in Appendix G. All participants were given a $5.00 gift card for their participation in the study.

Pre-experimental Tests

Participants were administered a series of pre-experimental standardized tests to determine their baseline reading rate and reading comprehension, receptive vocabulary, and decoding abilities. Administration of the pre-experimental tests was counterbalanced to account for an order effect. The *Raven's Coloured Progressive Matrices* (CPM; Raven, 2003) was administered to assess nonverbal intelligence to rule out information processing problems due to basic cognitive deficits. The *Peabody Picture Vocabulary Test* (PPVT-4; Dunn & Dunn, 2007) was administered to assess one-word receptive vocabulary. Participants were required to achieve a standard score of 70 or greater to participate in the study. The *Woodcock Reading Mastery Test-Revised* (WRMT-R; Woodcock, 1998) (subtests 3 & 4) was administered to assess decoding abilities. Participants were required to achieve a basic skills cluster of 70 or greater to participate in the study. The *Test of Word Reading Efficiency* (TOWRE; Torgesen, Wagner, & Rashotte,

Table 2

Gender distribution and means, standard deviations, ranges for age, and education by grade.

Demographic		*Group* Second Grade (N = 24)	Third Grade (N = 27)
Gender		Male: 16 Female: 8	Male: 11 Female: 15
Age	Mean	7.6	8.56
	SD	.39	.37
	Range	7.1 – 8.6	8.0 – 9.5

N = number of participants; SD = standard deviation

1999) was administered to assess rapid sight word and phonemic decoding efficiency under time constraints, which was used as a measure of decoding rate. The *Gray Oral Reading Test* - Fourth Edition (GORT-4; Wiederholt & Bryant, 2001) was administered to assess oral reading skills involving reading rate, accuracy, fluency, and comprehension. The *Test of Language Development-Primary* (Fourth Edition) (TOLD-P:4; Hammill & Newcomer, 2005) was administered to assess basic oral language skills in the semantic and syntactic domains in participants 7 years of age. The *Test of Language Development-Intermediate* (Fourth Edition) (TOLD-I:4; Hammill & Newcomer, 2005) was administered to assess basic oral language skills in the semantic and syntactic domains in participants 8 years of age and older. Participants were required to achieve a spoken language quotient of 70 or greater to participate in the study to ensure a more homogeneous sample and to ensure the results were not due to cognitive delays. The *RAN/RAS: Rapid Automatized Naming and Rapid Alternating Stimulus Tests* (Wolf & Denckla, 2005) were administered to assess rapid naming abilities. The *Comprehensive Test of Phonological Processing* (CTOPP; Wagner, Torgesen, and Rashotte, 1999) was administered to assess phonological abilities. Results of the tests were reported as quotients with a mean of 100 and a standard deviation of $\pm$ 15. Means, standard deviations, and range of scores for these subtests are presented in Table 3.

General Procedures

Testing occurred in a quiet environment. Testing was completed in the East Carolina University Language and Reading Lab in The Department of Communication Sciences and Disorders, at The Oakwood School in Greenville, NC, and in the conference room of The Carteret County News-Times in Morehead City, NC. Participants were tested over at least two

Table 3

Means, standard deviations, and range of scaled scores for these subtests are presented by grade.

Standardized Test	*Grade*	*N*	*Scaled Score Range*	*Mean*	*SD*
RAVEN'S CPM	2	24	19 – 35	25.54	4.16
(Raw Score)	3	26	19 – 36	26.92	5.21
RAVEN'S CPM (PR)	2	24	24 – 99	70.17	19.60
	3	26	17 – 99	62.62	26.86
PPVT – 4	2	24	86 – 135	112.79	13.37
	3	26	91 – 140	112.38	12.28
WRMT (ID)	2	24	90 – 133	109.38	12.20
	3	26	88 – 136	111.50	9.56
WRMT (Attack)	2	24	85 – 141	113.12	15.78
	3	26	85 – 140	109.15	14.31
TOWRE (SWE)	2	24	79 – 131	105.25	13.73
	3	26	90 – 126	110.19	10.56
TOWRE (PDE)	2	24	80 – 135	103.21	13.34
	3	26	80 – 136	107	13.26
TOWRE (TWRE)	2	24	78 – 140	105.13	15.93
	3	26	82 – 137	110.23	13.97
GORT – 4 (Rate)	2	24	4 – 16	10.08	3.51
	3	26	4 – 17	12.27	3.32
GORT – 4 (Accuracy)	2	24	4 – 17	9.87	3.81
	3	26	5 – 17	11.65	2.61
GORT – 4 (Fluency)	2	24	4 – 17	9.92	3.75
	3	26	5 – 18	12.15	3.04
GORT – 4	2	24	6 – 19	11.25	3.37
(Comprehension)	3	26	6 – 19	13.15	2.99
GORT – 4 (ORQ)	2	24	73 – 148	103.50	19.36

	3	26	79 – 148	115.81	15.75
TOLD (Listening)	2	24	92 – 131	111.08	9.19
	3	26	84 – 124	111	8.79
TOLD (Organizing)	2	24	81 – 123	105.54	13.57
	3	26	81 – 129	106.88	10.06
TOLD (Speaking)	2	24	85 – 128	105.21	11.49
	3	26	80 – 127	111.73	10.82
TOLD (Grammar)	2	24	78 – 123	106.12	11.44
	3	26	82 - 126	110.31	10.19
TOLD (Semantics)	2	24	88 – 129	108.96	11.54
	3	26	77 - 134	111.42	11.37
TOLD	2	24	86 – 125	107.79	11.32
(Spoken Language)	3	26	77 – 126	111.35	10.23
CTOPP (PA)	2	24	82 – 136	108.13	13.80
	3	26	82 – 124	102.19	10.98
CTOPP (PM)	2	24	79 – 124	100.00	12.29
	3	26	79 - 121	98.73	11.17
RAN (Objects)	2	24	56 - 111	96.63	12.89
	3	26	74 - 138	97.50	15.53
RAN (Colors)	2	24	66 - 117	98.29	13.34
	3	26	64 - 133	100.42	18.86
RAN (Numbers)	2	24	76 - 121	102.92	12.40
	3	26	73 - 132	107	15.37
RAN (Letters)	2	24	77 - 127	103.96	12.13
	3	26	70 - 121	99.77	13.39
RAN (2-Set)	2	24	82 - 123	100.37	11.50
	3	26	69 - 124	105.69	13.82
RAN (3-Set)	2	24	75 - 125	101.21	13.15
	3	26	72 - 121	101.50	12.26

N = number of participants; SD = standard deviations; Raven's CPM (Raw) = The Raven's Coloured Progressive Matrices: Raw Score; (PR) = Percentile Rank; PPVT- 4 = Peabody Picture Vocabulary Test -

4; WRMT-R (ID) = Woodcock Reading Mastery Test-Revised: Word ID; (Attack) = Word Attack; TOWRE (SWE) = Test of Word Reading Efficiency: Sight Word Efficiency; (PDE) = Phonological Decoding Efficiency; (TWRE) = Total Word Reading Efficiency; GORT – 4 = Gray Oral Reading Test – 4; GORT-4 (ORQ) = Oral Reading Quotient; TOLD = Test of Language Development; (Spoken Lang.) = Spoken Language; CTOPP (PA) = Comprehensive Test of Phonological Processing: Phonological Awareness; (PM) = Phonological Memory; RAN = RAN/RAS: Rapid Automatized Naming and Rapid Alternating Stimulus Tests; RAN (2-Set) = 2-Set Letters & Numbers; RAN (3-Set) = 3-Set Letters, Numbers, & Colors.

sessions; pre-experimental testing was completed during one session and the experimental tasks discussed below were completed during at least one session. Total length of testing was approximately three hours. Pre-experimental testing and experimental tasks were counterbalanced to account for an order effect. Before participants were given the experimental tasks, they were given an explanation of each task. Participants participated in three reading and three auditory linguistic tasks at two different presentation rates. Both reading and auditory systems were assessed to examine how fluency is related to semantic, syntactic, and orthographic processing within the reading and auditory modalities. For each participant, all six experimental tasks, with two presentation rates each, were presented in random order to control for an order effect. Data was obtained in terms of accuracy (percentage) and response time (milliseconds).

Stimuli for Experimental Tasks

Stimuli were carefully controlled for all experimental tasks. Measures were taken to insure consistency of stimuli between tasks and across modalities. All sentences consisted of four words. The syntax was kept consistent using a “subject-verb-object” format for each sentence. Vocabulary was taken from second, third, and fourth grade Dolch word lists and from second and third grade Open Court Reading, Spelling, and Vocabulary Skills text books (SRA/McGraw-Hill, 2002). The content vocabulary consisted of pronouns, adjectives, adverbs, prepositions, and verbs. Sentences were balanced with these content words. None of the content words were repeated within tasks and no sentences were repeated between tasks. The orthographic decision task and auditory linguistic (reading) task contained words not used in any other task. Stimuli for the orthographic decision task and auditory linguistic (reading) task consisted of an equal number of phonetic words and nonphonetic words. See Appendix G for list of stimuli. Three practice trials were presented before each task to familiarize the participants with the tasks and were not included in the experimental trials. For all experimental tasks, participants were seated comfortably in front of a Dell Laptop with a 14.2 inch screen.

Reading Stimuli

Words and sentences were presented in Times New Roman, thirty-six point font. Black text was presented on a 14.2 inch computer screen in the center of a white background. Stimuli were presented using the SuperLab Version 4.0.7 stimulus presentation software (Cedrus Corporation, 2008). Accuracy (percentage) and response times (ms) were calculated using the SuperLab software. The participants responded to stimuli by pushing a button on the keyboard placed on the table in front of them. They pressed a white button if the sentence was correct and a black button if the sentence was incorrect. Participants practiced doing this before the experimental portion of the study began.

Auditory Stimuli

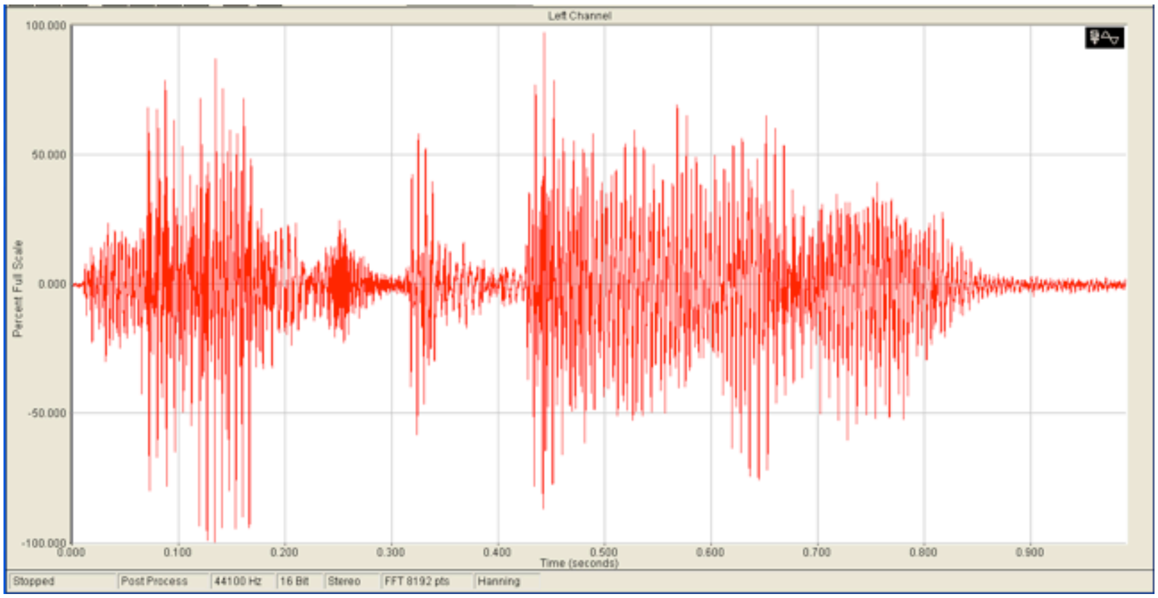
Stimuli were presented auditorally at a normal speaking rate and at a 55% time-compressed speech rate, also known as 55% of the original length. All stimuli were originally recorded by a male voice using a comfortable speaking rate of approximately 175 wpm (Wingfield & Tun, 2001) using the Apple Computers program, Garage Band (2009). Speech was time-compressed using PEAK Pro 6 Software (BIAS, 2010). The PEAK Pro 6 Software program uses a signal processing algorhythm that does not alter the pitch of the signal. It is similar to the approach used by Abrams, Nicol, Zecker, and Kraus (2008). Once the stimuli were time-compressed, the root mean square (RMS) for each sentence and word was individually normalized to 100% using the PEAK Pro 6 Software (BIAS, 2010). Ten percent of the normalized time-compressed sentences and words were then analyzed, using SpectraPRO acoustic software version 3.32.18d (Sound Technology Inc.), to ensure that they were accurately compressed to 55% of the original length. Analysis was completed using post process FFT spectral time series analysis with a sampling rate of 44100 Hz, 16 Bit, Hannen window, left channel only. Figure 3 shows an analysis of a sentence and a word at a normal rate and at 55% of the original length.

Time-compression is a method used to periodically delete small segments at regular intervals with the remaining segments then abutted in time (Wingfield & Tun, 2001). When a word or sentence is played back, it is reproduced in less than its original time but without the distortion in pitch. This method preserves the relative temporal pattern of speech and silences of the original while maintaining the original intonation pattern. According to Wingfield and Tun (2001), the degree of time-compression is controlled by the frequency of the deletions. Speech that is time-compressed sounds normal except for its rate.

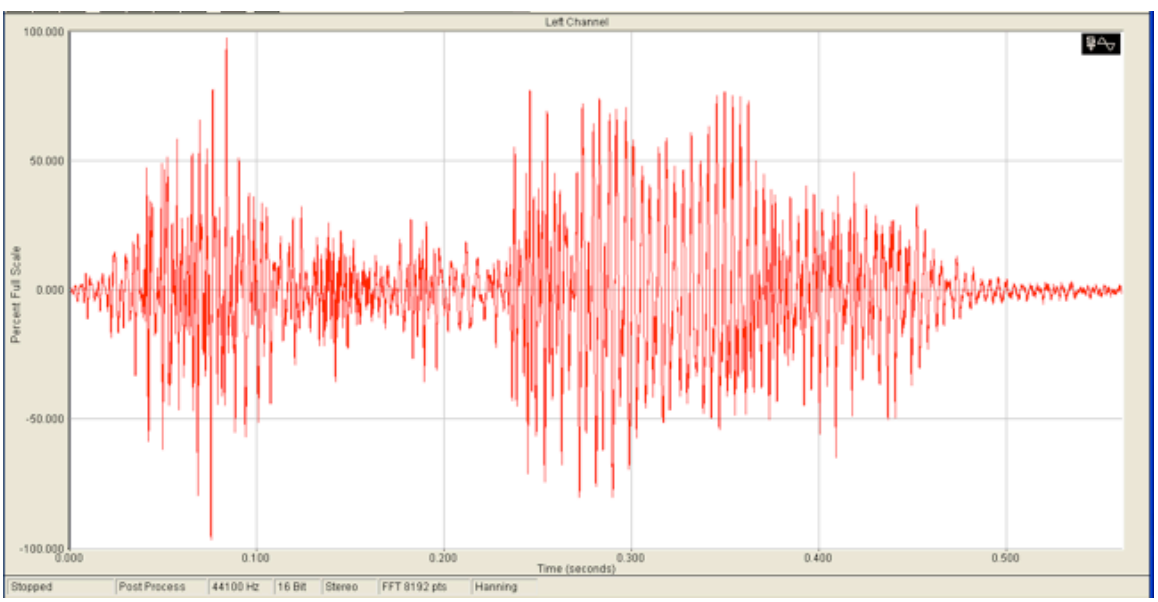
For this study, a time-compression of 55% was used because it is consistent with previous compression rates of 45% -65% (Beasley, Bratt, & Rintelman, 1980; Beasley, Maki, Orchik; 1976; DeMarco, Harbour, Hume, Givens, 1989; Humes, et al., 2007; Gordon-Salant, Fitzgibbons, & Friedman, 2007; Wilson, Preece, Salamon, Sperry, & Bornstein, 1994; Wingfield & Tun, 2001). For example, Wilson et al. (1994) completed a study to document the effects of time-compression on recognition performance on adults with normal hearing. They used 45%, 55%, 65%, 70%, and 75% time-compressed speech and found that recognition ranged from 90% correct at 45% compression, 80% correct between 55-65%, and 25% at 75% compression. Beasley, et al. (1976) used a time-compression of 30% and 60% of original time and found that for groups of children with mean ages of 4, 6, and 8, intelligibility scores increased as a function of increased age and sensation level, and decreased with increasing amounts of time-compression for word lists. Beasley et al. (1980) also found a decrease in intelligibility for words

Figure 3

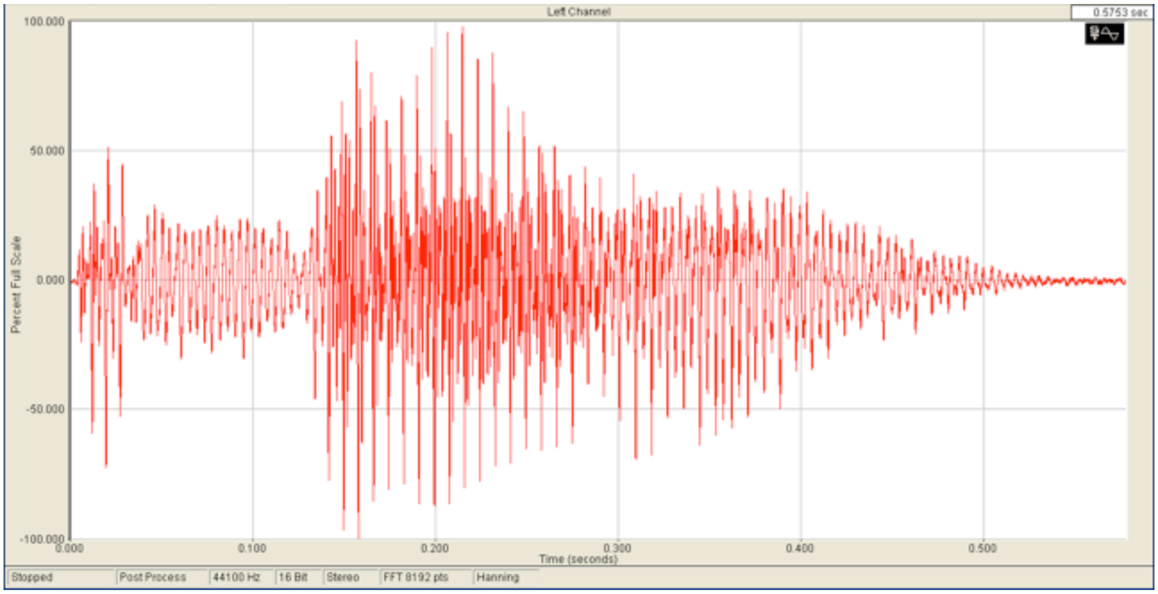
Spectral Analysis of a sentence and a word at a normal rate and at 55% percent of the original length.



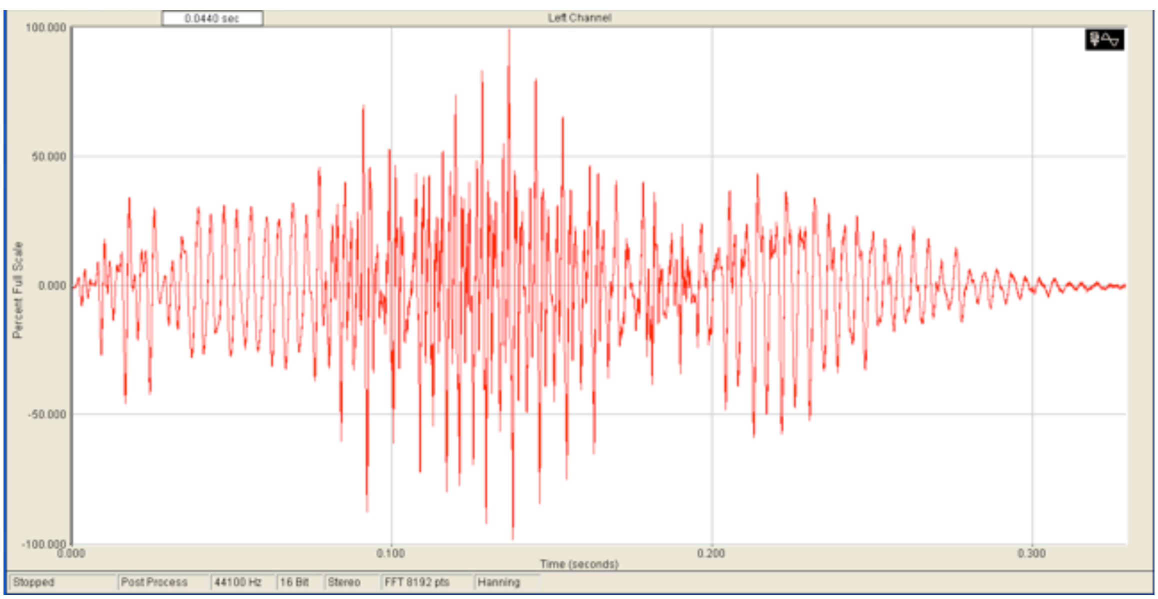
The sentence "I took a nap." was normalized and was .98 seconds in length. The sentence "I took a nap" was used in the Auditory Linguistic Experimental Set for the Semantic Decision Task.



The sentence "I took a nap." was time-compressed to 55% of its original length and normalized and was .54 seconds in length.



The word “above” was normalized and was .58 seconds in length. The word “above” was used in the Auditory Linguistic Experimental Set for the Auditory Linguistic (Reading) Experimental Task.



The word “above” was time-compressed to 55% of its original length .32 seconds in length.

and sentences presented at 24 dB SL and 40 dB SL between 40% and 60% time-compression in adults. A calibration tone of 1KAL was created using SpectraPro software version 3.32.18d. The calibration tone was then normalized by 100% using PeakPro 6 software. The average dB RMS SPL for a sound pressure level was determined for all of the recorded sentences and words. The average dB RMS SPL for each normalized sentence and word was then entered into the Cool Edits 96 software program (Syntrillium Software Corporation, 1996) for the creation of a calibration tone equal to the average dB RMS SPL for sentences and words.

The dBV RMS for the normalized calibration tone (2.19) was then determined. The calibration tone was amplified giving it a peak amplitude of -10.69 dBV RMS which was equal to the average dBV RMS for words (normal and time-compressed) which was -10.6835 dBV RMS. The calibration tone was amplified again giving it a peak amplitude of -13.70 dBV RMS which was equal to the average dBV RMS for sentences (normal and time-compressed) which was -13.6995. Both tones were then inserted into the corresponding SuperLab Pro experiments (the sentence tone into the semantic and syntactic experiments and the word tone in the orthographic experiment). The tones were then routed through the audiometer and set (saved) to the recommended calibration level as described in the manual. Prior to the presentation of all auditory testing material, the calibration tone within the SuperLab program was calibrated through both channels of the audiometer via the VU meter to establish a leveled peak setting of the calibration tone at 0VU.

Stimuli were presented bilaterally over calibrated audiometer headphones at 65 dB HL. This particular decibel level was chosen because it is consistent with previous presentation levels between 60 dB HL (DeMarco, et al., 1989) and 75 dB HL (Breznitz & Meyler, 2003). Presentation level was chosen based on findings that it was a comfortable listening level during pilot testing.

Experiment 1: Reading Experimental Set

Task 1: Reading Semantic Decision Task

This task consisted of sentences that had plausible and nonplausible meanings. For the purposes of this study, plausibility was defined as well reasoned or factual content. For example, “The dog eats food” is a factual statement and “The dog eats water” does not make sense. In presenting the stimuli, a fixation asterisk appeared for 1,000 ms in the center of a computer screen. Immediately after the asterisk appeared, a sentence appeared in the center of the screen. Thirty, four word sentences (15 correct and 15 incorrect) appeared on the computer screen at 1200 ms and thirty appeared on the screen at 600 ms one at a time. The participants were given instructions to read each sentence quickly and determine if the sentence made sense, that is, if it was plausible or not by pushing the appropriate button on the keypad located on the table in front of them. Complete task instructions are presented in Appendix H.

Task 2: Reading Syntactic Decision Task

The participants were asked to make a decision about correct sentence structure and morphological correctness. Sentences contained either problems in syntactic order or morphological errors for example, “The dog food eats.” or “The dogs eats food.” The task was equally balanced with fifteen correct sentences, fifteen sentence containing syntactic order problems, and fifteen sentences containing morphological errors. In presenting the stimuli, a fixation asterisk appeared for 1,000 ms in the center of the computer screen. Immediately after the asterisk appeared, forty-five, four word sentences appeared on the computer screen at 1200 ms and forty-five appeared on the screen at 600 ms one at a time. The participants were given instructions to read each sentence quickly and determine if the sentence was correct or incorrect based on word order or tense by pushing the appropriate button on the keypad located on the table in front of them. Complete task instructions are presented in Appendix H.

Task 3: Reading Orthographic Decision Task

The participants were asked to make an orthographic decision based on the correctness in the spelling of a single word. Targets consisted of phonetic and nonphonetic words spelled correctly or incorrectly. For example, “kan” for “can” and “knife” or nife” The task was equally balanced with phonetic and nonphonetic words. For presentation of the stimuli, a fixation asterisk appeared for 1,000 ms in the center of the computer screen. Immediately after the asterisk appeared, a word appeared in the center of the screen. Thirty words (15 correct and 15 incorrect) appeared on the computer screen at 350 ms and thirty appeared on the screen at 150 ms one at a time. The participants were given instructions to read each word quickly and determine if the word was spelled correctly or incorrectly by pushing the appropriate button on the keypad located on the table in front of them. Full instructions are presented in Appendix H.

Experiment 2: Auditory Linguistic Experimental Set

Task 1: Auditory Semantic Decision Task

This task consisted of sentences that had plausible and nonplausible meanings. For the purposes of this study, plausibility was defined as well reasoned or factual content. For example, “The dog eats food” is a factual statement and “The dog eats water” does not make sense. In presenting the stimuli, a fixation asterisk appeared for 1,000 ms in the center of a computer screen. Immediately after the asterisk appeared, a sentence was presented auditorally. Thirty, four word sentences (15 correct and 15 incorrect) were presented at a normal rate and thirty were presented as 55% time-compressed speech one at a time. The participants were given instructions to listen to each sentence carefully and determine if the sentence made sense, that is, if it was plausible or not by pushing the appropriate button on the keypad located on the table in front of them. Complete task instructions are presented in Appendix H.

Task 2: Auditory Syntactic Decision Task

The participants were asked to make a decision about correct sentence structure and morphological correctness. Sentences contained either problems in syntactic order or morphological errors for example, “The dog food eats.” or “The dogs eats food.” The task was equally balanced with fifteen correct sentences, fifteen sentence containing syntactic order problems, and fifteen sentences containing morphological errors. In presenting the stimuli, a fixation asterisk appeared for 1,000 ms in the center of the computer screen. Immediately after the asterisk appeared, forty-five, four word sentences were presented at a normal rate and forty-five sentences were presented as 55% time-compressed speech one at a time. The participants were given instructions to listen to each sentence carefully and determine if the sentence was correct or incorrect based on word order or tense by pushing the appropriate button on the keypad located on the table in front of them. Complete task instructions are presented in Appendix H.

Task 3: Auditory (Reading) Orthographic Decision Task

The participants were asked to make an orthographic decision based on the auditory presentation of a word and simultaneous presentation of that same word spelled correctly or incorrectly. Targets consisted of phonetic and nonphonetic words spelled correctly or incorrectly. For example, “kan” for “can” and “knife” or nife” The task was equally balanced with phonetic and nonphonetic words. For presentation of the stimuli, a fixation asterisk appeared for 1,000 ms in the center of the computer screen. Immediately after the asterisk appeared, a word appeared in the center of the screen while the same word was presented auditoraly. Thirty words (15 correct and 15 incorrect) appeared on the computer screen at 150 ms while the same word was presented simultaneously at a normal rate and thirty appeared on the screen at 100 ms while the same word was presented simultaneously at 55% time-compressed speech. Each word was presented one at a time. The participants were given instructions to read each word quickly while listening carefully and determine if the word was spelled correctly or incorrectly by pushing the appropriate button on the keypad located on the table in front of them. Complete task instructions are presented in Appendix H.

Analysis

The independent variables for the reading experimental set as well as the auditory linguistic experimental set included presentation duration in the semantic decision tasks, presentation duration in the syntactic decision tasks, and presentation duration and phonetic/nonphonetic word type in the orthographic decision tasks. The dependent variables were accuracy (proportion) and reaction time (ms). Statistical analysis of the results included graphical tools such as scatter plots and normal q-q plots to visualize the data and check assumptions. Paired t-tests and CI's were conducted to estimate differences in mean reaction time and accuracy for each task presented at two presentation durations and mean accuracy for word type for the orthographic decision task presented at two presentation durations. Interaction plots were used to further address presentation duration and task for reaction time and accuracy for the experimental tasks and presentation duration and word type for accuracy for the orthographic decision tasks. Pearson's Correlations were conducted to determine the significance of relationships between the pre-experimental tasks and performance on the experimental tasks.

CHAPTER III

RESULTS

Fifty second and third grade children were administered a series of eight pre-experimental standardized tests to evaluate language and reading abilities. Following completion of these standardized tests, each participant completed two experiments involving a series of reading and auditory processing tasks. Each task required semantic, syntactic, and orthographic decisions. In each of the experimental tasks, written and auditory stimuli were presented at two different presentation duration rates. For the reading tasks, written stimuli were presented under shorter and longer presentation duration conditions. For auditory linguistic tasks, stimuli were presented using normal and time-compressed speech rates.

In each of the experimental tasks, both reaction time (in milliseconds) and accuracy (proportion) were determined for each stimulus. The participant was required to make a decision about whether the stimulus was “correct” or “incorrect”, following the presentation of the written or auditory stimulus relating to its content (semantic), form (syntactic), or spelling. Reaction times were measured using the SuperLab Pro software program. Participants were given 4000 ms to indicate if the sentence or words was correct or incorrect by pushing the appropriate button on the keypad located on the table in front of them. In the event that the participant either pushed a button after the 4000 ms time limit or did not respond, a reaction time was not calculated for that particular word or sentence. Accuracy was determined for each stimulus item and an overall accuracy proportion was determined for each participant for each task.

Experiment 1: Reading Tasks

Descriptive statistics were conducted to visualize the data and check assumptions. Normal qq-plots were conducted on each individual variable and scatter plots were conducted for pairs of values. Overall, raw data for variables did not show serious violations of the normality assumption. Scatter plots showed a linear shape for each pair of values. However, it should be noted that for reading orthographic reaction time there were two high outliers for second grade and one low outlier for auditory semantic accuracy for second grade. Reaction time and accuracy data were not transformed using the arcsine transformation because the number of responses within each condition was large enough to make the data more normal based on statistical assumptions that the data must be normal.

Semantic Decision Task

Reaction time: The first experimental question addressed an examination of the difference in mean reaction time (ms) for a semantic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children.

Mean reaction time data for the semantic decision in a reading task are presented in Table 4. A paired t-test was conducted on these mean reaction time (ms) data. The results on the semantic decision in a reading task were found to approach statistical significance with a *p*-value of .051. *P*-values were not adjusted for multiple comparisons. Mean reaction time for the shorter stimulus presentation duration (600 ms) was slower (1523.51) in comparison to the longer presentation duration (1200 ms) (1412.46) for the written stimuli in making semantic decisions. Individual reaction times for the reading experimental tasks are presented in Appendix J.

Accuracy: The next experimental question addressed an examination of the difference in mean accuracy (proportion) for a semantic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children.

Mean accuracy data for the semantic decision in a reading task are reported in Table 5. A paired t-test was conducted on these mean accuracy (proportion) data at the two stimulus

Table 4

Paired T-Tests to compare differences in mean reaction time for the semantic decision in a reading task presented at two presentation durations.

Pair Names – Reading	Mean Reaction Time (ms)	Std. Deviation	Significance (2-tailed) & 95% CI of Difference
Semantic Decision 1200ms	1412.46	428.47	.051
Semantic Decision 600ms	1523.51	479.09	- 222.74 to .64

Table 5

Paired T-Tests to compare differences in mean accuracy for the semantic decision in a reading task presented at two presentation durations.

Pair Names – Reading	**Mean Accuracy (proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Semantic Decision 1200ms	66.10	18.52	.083
Semantic Decision 600ms	63.47	13.53	- .48 to 7.55

presentation durations (600 ms and 1200 ms). Results revealed no significant difference in mean accuracy between presentation durations. *P*-values were not adjusted for multiple comparisons. Individual accuracy scores for the reading experimental tasks are presented in Appendix K.

Syntactic Decision Task

Reaction Time: The next experimental question addressed an examination of the difference in mean reaction time (ms) for a syntactic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children.

Mean reaction time data for the syntactic decision in a reading task are presented in Table 6. A paired t-test was conducted on these mean reaction time (ms) data. Results revealed no significant difference in mean reaction time between presentation durations. *P*-values were not adjusted for multiple comparisons. Individual reaction times for the reading experimental tasks are presented in Appendix J.

Accuracy: The next experimental question addressed an examination of the difference in mean accuracy (proportion) for a syntactic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children.

Mean accuracy data for the syntactic decision in a reading task are presented in Table 7. A paired t-test was conducted on these mean accuracy (proportion) data. Results revealed a significant difference in mean accuracy between presentation durations with a *p*-value of .038. *P*-values were not adjusted for multiple comparisons. Mean accuracy for the shorter stimulus presentation duration (600 ms) was lower (59.51%) in comparison to a higher mean accuracy (63.24%) for the longer presentation duration (1200 ms) for the written stimuli, in making syntactic decisions. Individual accuracy scores for the reading experimental tasks are presented in Appendix K.

Table 6

Paired T-Tests to compare differences in mean reaction time for the syntactic decision in a reading task presented at two presentation durations.

Pair Names - Reading	**Mean Reaction Time (ms)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of Difference**
Syntactic Decision 1200ms	1524.01	435.20	.769
Syntactic Decision 600ms	1544.33	489.49	- 158.41 to 117.76

Table 7

Paired T-Tests to compare differences in mean accuracy for the syntactic decision in a reading task presented at two presentation durations.

Pair Names - Reading	**Mean Accuracy (Proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of Difference**
Syntactic Decision 1200ms	63.24	18.27	.038 *
Syntactic Decision 600ms	59.51	14.30	.22 to 7.25

Comparison of Semantic and Syntactic Processing

Reaction time: The next experimental question addressed an examination of the difference in mean reaction time (ms) between a semantic decision and a syntactic decision in a reading task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children.

Mean reaction time data for the semantic and syntactic decision in a reading task are presented in Table 8. A series of paired t-tests were conducted on these mean reaction time (ms) data. Results reveal that for the longer presentation duration (1200 ms), the difference in reaction time between the reading semantic decision task and reading syntactic decision task was found to approach statistical significance with a *p-value* of .053. *P*-values were not adjusted for multiple comparisons. For the longer stimulus presentation duration (1200 ms), mean reaction time was faster (1412.46 ms) for the semantic decision task compared to the syntactic decision task (1524.01 ms). For the shorter presentation duration (600 ms), no statistically significant difference was found in mean reaction time between the semantic and syntactic decision in a reading task. Overall, there was no statistically significant difference in mean reaction time between semantic and syntactic decisions in a reading task. Individual reaction times for the reading experimental tasks are presented in Appendix J.

An interaction plot to further address performance in the semantic decision and syntactic decision in a reading task relative to presentation duration for reaction time is presented in Figure 4. The interaction plot does not indicate an interaction between presentation duration and task. Individual reaction times for the experimental tasks are presented in Appendix J.

Accuracy: The next experimental question addressed an examination of the difference in mean accuracy (proportion) between a semantic decision and a syntactic decision in a reading

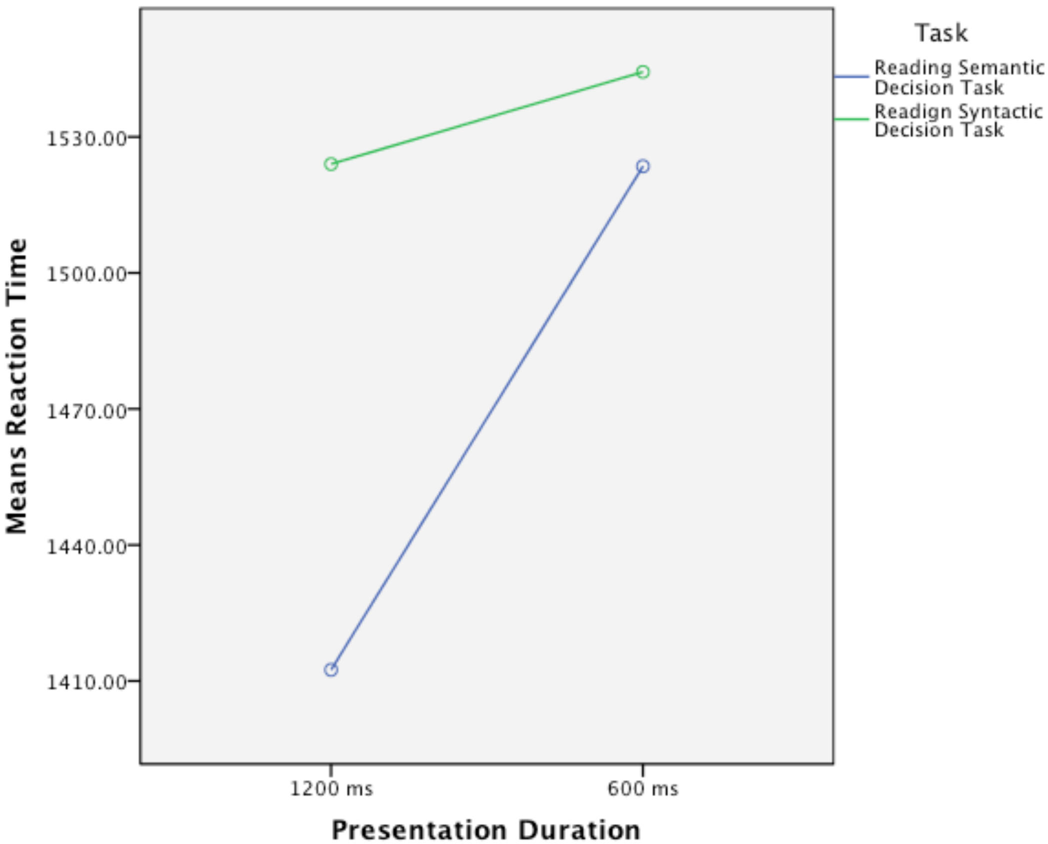
Table 8

Paired T-Tests to compare differences in mean reaction time between the semantic decision and syntactic decision in a reading task presented at two presentation durations.

Pair Names - Reading	**Mean Reaction Time (ms)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of Difference**
Semantic Decision 1200ms	1412.46	428.47	.053
Syntactic Decision 1200ms	1524.01	435.20	-224.36 to 1.26
Semantic Decision 600ms	1523.51	479.09	.730
Syntactic Decision 600ms	1544.33	489.49	-141.49 to 99.84
Semantic Decision Combined	1467.99	409.81	.157
Syntactic Decision Combined	1534.17	394.31	-158.80 to 26.42

Figure 4

Interaction Plot for task (semantic and syntactic) and presentation duration (1200 ms and 600ms) for mean reaction time data – Experiment 1 – Reading Tasks



task presented at two stimulus presentation durations (600 ms and 1200 ms) for early elementary school children.

Mean accuracy data for the semantic and syntactic decision in a reading task are presented in Table 9. A series of paired t-tests were conducted on these mean accuracy (proportion) data. The results do not reveal a statistically significant difference in accuracy between the semantic decision and the syntactic decision in a reading task at the 1200 ms presentation duration. However, there was a statistically significant difference in accuracy between the reading semantic and reading syntactic tasks at 600 ms with a *p*- value of .022. *P*-values were not adjusted for multiple comparisons. Mean accuracy for the semantic decision was higher (63.47%) in comparison to the syntactic decision task (59.51%) when the written stimuli were presented for the shorter presentation duration (600 ms). Overall, there was a significant difference in mean accuracy between a semantic decision and syntactic decision in a reading task with a *p*-value of .024. Accuracy was higher for the semantic decision (65.23%) than the syntactic decision (61.38%). Individual accuracy scores for the reading experimental tasks are presented in Appendix K.

An interaction plot to further address performance in the semantic decision and syntactic decision in a reading task relative to presentation duration for accuracy is presented in Figure 5. The interaction plot indicates that there is little interaction between presentation duration and task. Individual accuracy scores for the reading experimental tasks are presented in Appendix K.

Reading Orthographic Processing

Reaction time: The next experimental question addressed the examination of the difference in mean reaction time (ms) for an orthographic decision in a reading task presented at two stimulus presentation durations (350 ms and 150 ms) for early elementary school children.

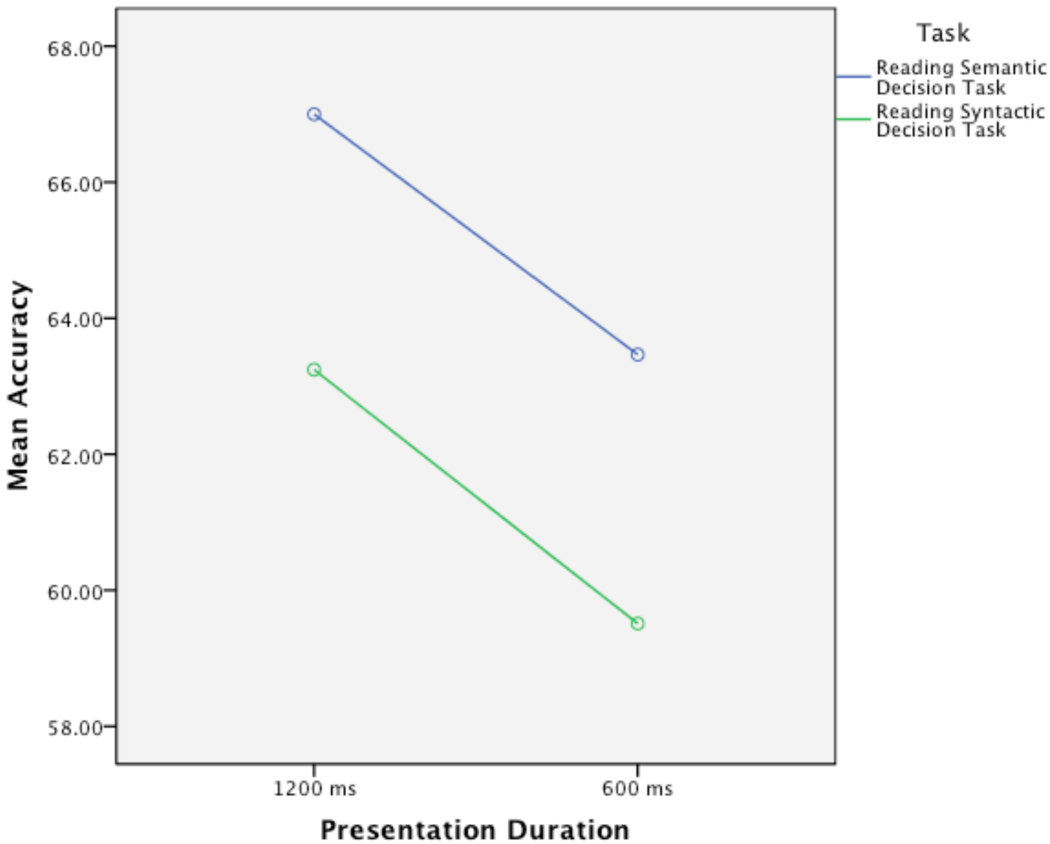
Table 9

Paired T-Tests to compare differences in mean accuracy between the semantic decision and syntactic decision in a reading task presented at two presentation durations.

Pair Names - Reading	**Mean Accuracy (proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of Difference**
Semantic Decision 1200ms	66.10	18.52	.123
Syntactic Decision 1200ms	63.24	18.27	-1.05 to 8.56
Semantic Decision 600ms	63.47	13.53	.022 *
Syntactic Decision 600ms	59.51	14.30	.61 to 7.30
Semantic Decision Combined	65.23	14.60	.024 *
Syntactic Decision Combined	61.38	15.19	.53 to 7.18

Figure 5

Interaction Plot for task (semantic and syntactic) and presentation duration (1200 ms and 600ms) for mean accuracy data – Experiment 1 – Reading Tasks



Mean reaction time data for the orthographic decision in a reading task are presented in Table 10. A paired t-test was conducted on these mean reaction time (ms) data. Results revealed no statistically significant difference in reaction time between presentation durations. *P*-values were not adjusted for multiple comparisons. Individual reaction times for the orthographic decision in a reading task are presented in Appendix J.

Accuracy: The last experimental question addressed an examination of the difference in mean accuracy (proportion) between phonetic and nonphonetic word types for an orthographic decision in a reading task presented at two stimulus presentation durations (350 ms and 150 ms) for early elementary school children.

Mean accuracy data for the phonetic and nonphonetic word type for the orthographic decision in a reading task is reported in Table 11. A series of paired t-tests were conducted on these mean accuracy (proportion) data. Comparisons were made between and across stimulus presentation durations for the phonetic and nonphonetic word types. For phonetic words, there was a significant difference in accuracy between the two stimulus presentation durations (350 ms) and (150 ms) as indicated by a *p*-value of .008. *P*-values were not adjusted for multiple comparisons. Accuracy was higher (79.33%) when the phonetic words were presented at the shorter presentation duration (150 ms) in comparison to a lower accuracy (73.47%) for the longer presentation duration (350 ms) for written stimuli in making orthographic decisions. For the shorter stimulus presentation condition (150 ms), a significant difference in accuracy was found between the phonetic and nonphonetic word types with a *p*-value of .001 where accuracy was higher (79.33%) for the phonetic word type in comparison to lower accuracy (72.27%) for the nonphonetic word type. Individual accuracy scores for the reading orthographic decision in a reading task are presented in Appendix N.

Table 10

Paired T-Tests to compare differences in mean reaction time for the orthographic decision in a reading task presented at two presentation durations.

Pair Names - Reading	Mean Reaction Time (ms)	Std. Deviation	Significance (2-tailed) & 95% CI of Difference
Orthographic Decision 350ms	1047.97	433.66	.137
Orthographic Decision 150ms	1101.86	389.29	- 125.45 to 17.68

Table 11

Paired T-Tests to compare differences in mean accuracy between the phonetic and nonphonetic word type for the orthographic decision in a reading task presented at two presentation durations.

Pair Names - Reading	**Mean Accuracy (proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of Difference**
Orthographic Decision 350ms Orthographic Decision 150ms	72.73 75.80	15.65 15.53	.065 - 6.33 to .20
Orthographic Decision 350ms (phonetic) Orthographic Decision 150ms (phonetic)	73.47 79.33	17.48 17.47	.008 * -10.12 to -1.61
Orthographic Decision 350ms (nonphonetic) Orthographic Decision 150ms (nonphonetic)	72.00 72.27	15.76 16.62	.889 -4.07 to 3.54
Orthographic Decision 350ms (phonetic) Orthographic Decision 350ms (nonphonetic)	73.47 72.00	17.48 15.76	.366 -1.77 to 4.70
Orthographic Decision 150ms (phonetic) Orthographic Decision 150ms (nonphonetic)	79.33 72.27	17.47 16.62	.001 * 3.06 to 11.07

An interaction plot to further address performance between phonetic and nonphonetic word type for the orthographic decision in a reading task relative to presentation duration for accuracy is presented in Figure 6. The interaction plot indicates the presence of an interaction. Mean accuracy was significantly higher for the phonetic word type than the nonphonetic word type. Individual accuracy scores for all participants on the experimental tasks are presented in Appendix N.

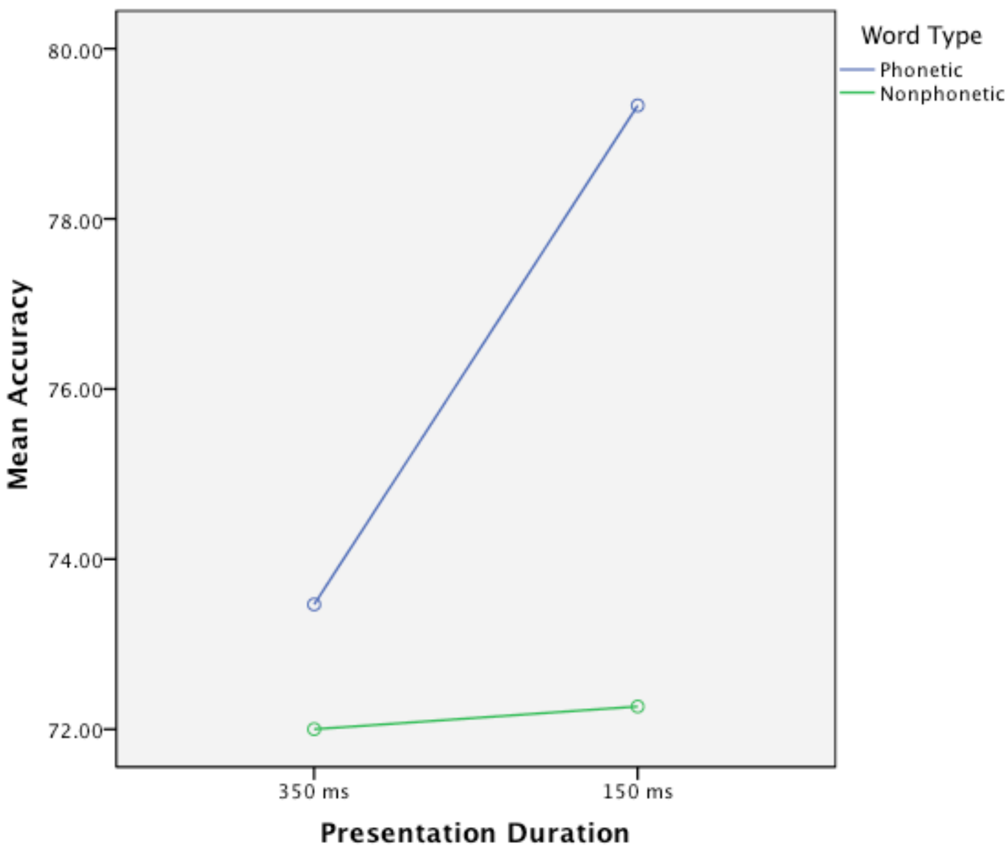
Relationship between Reading Tasks and Reading Fluency

Further analysis was completed to address an examination of which language processing skill, as measured by mean reaction time and accuracy in a reading task (semantic processing, syntactic processing, or orthographic processing) accounts for the majority of the variability in reading fluency for early elementary school children.

A series of Pearson's correlations were conducted on the mean reaction time (ms) and accuracy (proportion) data. Reading decoding was measured by standard scores from pre-experimental tests – *Woodcock Reading Mastery Test-R - Word ID*, *Word Attack, and Comprehensive Test of Phonological Processing - Phonological Awareness, Phonological Memory. R*eading fluency was measured by standard scores from pre-experimental tests – *Test of Word Reading Efficiency – Sight Word Efficiency, Phonological Decoding Efficiency, and Total Word Reading Efficiency, and Gray Oral Reading Test-4 - Rate, Accuracy, Fluency, Oral Reading Quotient*. Reading comprehension was measured by standard scores from the pre-experimental test - *Gray Oral Reading Test-4 – Comprehension and Oral Reading Quotient.* For the semantic decision task, semantic decision accuracy in the longer presentation duration (1200ms) was highly correlated with measures of reading fluency (*Gray Oral Reading Test-4 Oral Reading Quotient* ($r = .657$)). For the syntactic decision task, syntactic decision accuracy in

Figure 6

Interaction Plot for word type (phonetic and nonphonetic) and presentation duration (350 ms and 150ms) for mean accuracy data - Experiment 1 – Reading Tasks



the shorter presentation duration (600 ms) was highly correlated with measures of reading decoding (*Woodcock Reading Mastery Test-R Word ID* (r = .652)) and reading fluency (*Gray Oral Reading Test-4 Rate* (r = .632), *Fluency* (r = .651), and *Oral Reading Quotient* (r = .687). For the orthographic decision task, orthographic decision accuracy in the shorter presentation duration (150 ms) was highly correlated with measures of decoding fluency (*Test of Word Reading Efficiency – Sight Word Efficiency* (r = .627), *Gray Oral Reading Test-4 Rate* (r = .659), *Accurac*y (r = .655), *Fluency* (r = .649), and *Oral Reading Quotient* (r = .624). Scatter plots were conducted for each pairing of variables. Scatter plots reveal a strong positive correlation and the shape was roughly linear with no outliers in each case. A table of correlations between pre-experimental reading tasks and experimental reading tasks is presented in Appendix Q and R.

Experiment 2: Auditory Linguistic Tasks

Semantic Decision Task

Reaction Time: The first experimental question addressed an examination of the difference in mean reaction time (ms) for a semantic decision within an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children.

Mean reaction time data for the semantic decision in an auditory linguistic task are presented in Table 12. A paired t-test was conducted on these mean reaction time (ms) data. Results for the semantic decision in an auditory linguistic task revealed no significant difference in mean reaction time between presentation durations. *P*-values were not adjusted for multiple comparisons. Individual reaction times for the auditory experimental tasks are presented in Appendix L.

Table 12

Paired T-Tests to compare differences in mean reaction time for the semantic decision in an auditory linguistic task presented at two presentation durations.

Pair Names - Auditory	**Mean Reaction Time (ms)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Semantic Decision Normal	1339.43	415.82	.122
Semantic Decision Time-Compressed	1403.57	417.96	-146.14 to 17.86

Accuracy: The next experimental question addressed an examination of the difference in mean accuracy (proportion) for a semantic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children.

Mean accuracy scores for the semantic decision in an auditory linguistic task are reported in Table 13. A paired t-test was conducted on the mean accuracy (proportion) data for the two stimulus presentation durations (normal speech rate and time-compressed). Results revealed a significant difference in mean accuracy between presentation durations with a *p*-value of .000. *P*-values were not adjusted for multiple comparisons. Mean accuracy was lower (64.67%) for the shorter stimulus presentation duration (time-compressed speech) in comparison to a higher mean accuracy (77.27%) for the longer presentation duration (normal speech rate) for the auditory stimuli in making semantic decisions. Individual accuracy scores for the auditory linguistic experimental tasks are presented in Appendix M.

Syntactic Decision Task

Reaction Time: The next experimental question addressed an examination of the difference in mean reaction time (ms) for a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children.

Mean reaction time data for the syntactic decision in an auditory linguistic task are presented in Table 14. A paired t-test was conducted on these mean reaction time (ms) data. Results reveal a significant difference in mean reaction time between presentation durations with a *p*-value of .000. *P*-values were not adjusted for multiple comparisons. Mean reaction time was slower (1399.86 ms) for the shorter stimulus presentation duration (time-compressed speech) in

Table 13

Paired T-Tests to compare differences in mean accuracy for the semantic decision in an auditory linguistic task presented at two presentation durations.

Pair Names - Auditory	**Mean Accuracy (proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Semantic Decision Normal	77.27	11.32	.000 *
Semantic Decision Time-Compressed	64.67	12.87	9.27 to 15.93

Table 14

Paired T-Tests to compare differences in mean reaction time for the syntactic decision in an auditory linguistic task presented at two presentation durations.

Pair Names - Auditory	**Mean Reaction Time (ms)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Syntactic Decision Normal	1211.62	344.35	.000 *
Syntactic Decision Time-Compressed	1399.86	410.42	- 262.69 to -113.78

comparison to a faster mean reaction time (1211.62 ms) for the longer presentation duration (normal speech rate) for the auditory stimuli, in making syntactic decisions. Individual reaction times for the auditory linguistic experimental tasks are presented in Appendix L.

Accuracy: The next experimental question addressed an examination of the difference in mean accuracy (proportion) for a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children.

Mean accuracy data for the syntactic decision in an auditory linguistic reading task are presented in Table 15. A paired t-test was conducted on these mean accuracy (proportion) data. Results reveal a significant difference in mean accuracy between presentation durations with a *p*-value of .000. *P*-values were not adjusted for multiple comparisons. The mean accuracy was lower (64.77%) for the shorter stimulus presentation duration (time-compressed speech) in comparison to a higher mean accuracy (77.10%) for the longer presentation duration (normal speech rate) for the auditory stimuli, in making syntactic decisions. Individual accuracy scores for the auditory linguistic experimental tasks are presented in Appendix M.

Comparison of Semantic and Syntactic Processing

Reaction time: The next experimental question addressed an examination of the difference in mean reaction time (ms) between a semantic decision and a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children.

Mean reaction time data for the semantic and syntactic decision in an auditory linguistic task are presented in Table 16. A series of paired t-test were conducted on these mean reaction time (ms) data. Results reveal a statistically significant difference in reaction time between the

Table 15

Paired T-Tests to compare differences in mean accuracy for the syntactic decision in an auditory linguistic task presented at two presentation durations.

Pair Names - Auditory	**Mean Accuracy (proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Syntactic Decision Normal	77.10	11.67	.000 *
Syntactic Decision Time-Compressed	64.71	11.16	10.12 to 16.46

Table 16

Paired T-Tests to compare differences in mean reaction time between the semantic decision and syntactic decision in an auditory linguistic task presented at two presentation durations.

Pair Names - Auditory	**Mean Reaction Time (ms)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Semantic Decision Normal	1339.43	415.82	.017 *
Syntactic Decision Normal	1211.62	344.35	23.82 to 231.79
Semantic Decision Time-Compressed	1403.57	417.96	.936
Syntactic Decision Time-Compressed	1399.86	410.42	-88.14 to 95.56

semantic and syntactic task at the normal speech rate with a *p*-value of .017. *P*-values were not adjusted for multiple comparisons. For the normal speech rate condition, mean reaction time was longer (1339.43 ms) for the semantic decision compared to the syntactic decision (1211.62 ms) when stimuli were presented auditorally. For the time-compressed speech rate conditions, mean reaction time was longer (1403.57 ms) for the semantic decision compared to the syntactic decision (1399.86 ms). Individual reaction times for the auditory linguistic experimental tasks are presented in Appendix L.

An interaction plot to further address performance for a semantic decision and syntactic decision in an auditory linguistic task relative to presentation duration for reaction time is presented in Figure 7. The interaction plot indicates the presence of an interaction between presentation duration and task. Reaction time was significantly lower for the normal speech rate condition than the time-compressed speech rate condition. Individual reaction times for the auditory linguistic experimental tasks are presented in Appendix L.

Accuracy: The next experimental question addressed an examination of the difference in mean accuracy (proportion) between a semantic decision and a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children.

Mean accuracy data for the semantic and syntactic decision in an auditory linguistic task are presented in Table 17. A series of paired t-test were conducted on these mean accuracy (proportion) data. Results reveal no statistically significant difference in accuracy between semantic and syntactic decisions in an auditory linguistic task. *P*-values were not adjusted for multiple comparisons. Individual accuracy scores for the auditory linguistic experimental tasks are presented in Appendix M.

Figure 7

Interaction Plot for task (semantic and syntactic) and presentation duration (normal speech rate and time-compressed speech) for mean reaction time data – Experiment 2 – Auditory Linguistic Tasks

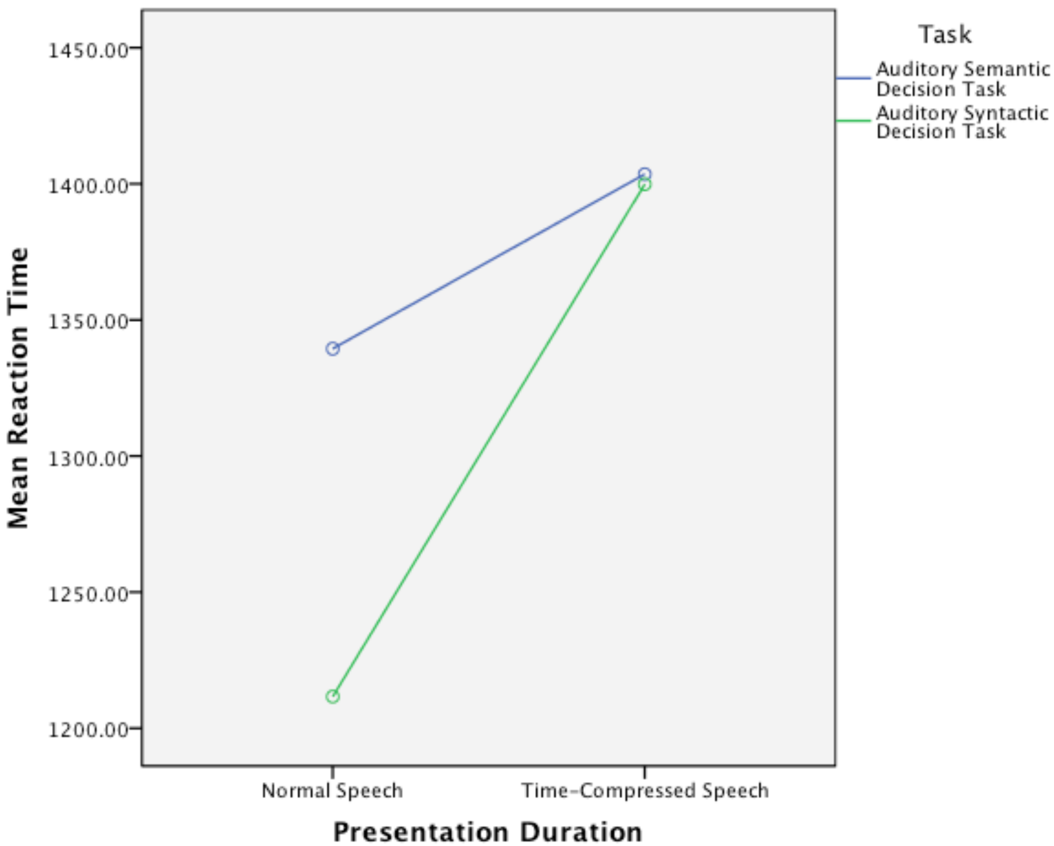


Table 17

Paired T-Tests to compare differences in mean accuracy between the semantic decision and syntactic decision in an auditory linguistic task presented at two presentation durations.

Pair Names – Auditory	**Mean Accuracy (proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Semantic Decision Normal	77.27	11.32	.719
Syntactic Decision Normal	77.10	11.67	-4.80 to 3.34
Semantic Decision Time-Compressed	64.67	12.87	.983
Syntactic Decision Time-Compressed	64.71	11.16	-4.15 to 4.06
Semantic Decision Combined	70.97	10.61	.819
Syntactic Decision Combined	71.36	9.97	-3.79 to 3.02

An interaction plot to further address performance on the semantic decision and syntactic decision in an auditory linguistic task relative to presentation duration for accuracy is presented in Figure 8. The interaction plot indicates that there is little interaction between presentation duration and task. Accuracy decreased for both tasks when stimuli were presented at the shorter presentation duration. Individual accuracy scores for the auditory linguistic experimental tasks are presented in Appendix M.

Auditory Orthographic Processing

Reaction time: The next experimental question addressed the examination of the difference in mean reaction time (ms) for an orthographic decision in an auditory linguistic (reading) task presented at two stimulus presentation durations (normal speech rate – 150 ms and time-compressed – 100 ms) for early elementary school children.

Mean reaction time data for the orthographic decision in an auditory linguistic (reading) task are presented in Table 18. A paired t-test was conducted on these mean reaction time (ms) data. Results revealed a significant difference in reaction time between presentation durations with a *p*-value of .010. *P*-values were not adjusted for multiple comparisons. The mean reaction time was faster (1298.30 ms) for the shorter stimulus presentation duration (time-compressed – 100 ms) in comparison to a slower mean reaction time (1455.93 ms) for the longer presentation duration (normal speech rate – 150 ms) for the auditory stimuli in making orthographic decisions. Individual reaction times for the orthographic decision in an auditory linguistic (reading) task are presented in Appendix L.

Accuracy: The last experimental question addressed an examination of the difference in mean accuracy (proportion) between phonetic and nonphonetic word type for an orthographic

Figure 8

Interaction Plot for task (semantic and syntactic) and presentation duration (normal speech rate and time-compressed speech) for mean accuracy data – Experiment 2 – Auditory Linguistic Tasks

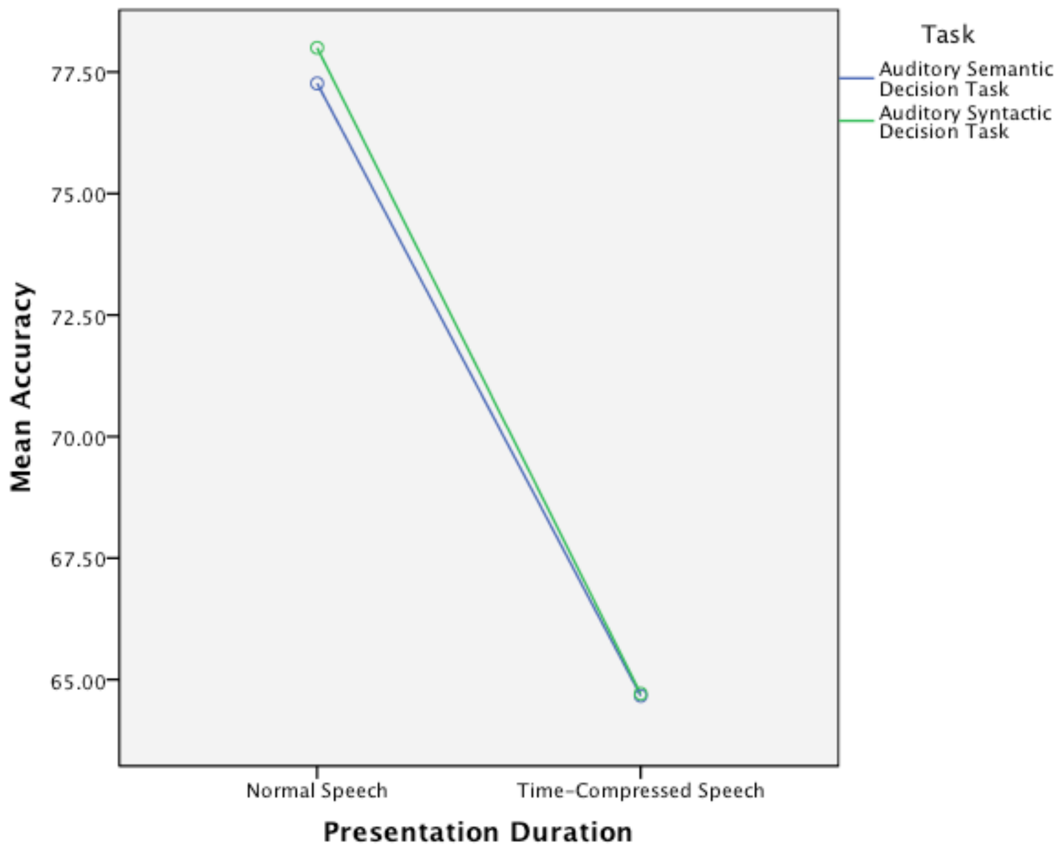


Table 18

Paired T-Tests to compare differences in mean reaction time for the orthographic decision in an auditory linguistic (reading) task presented at two presentation durations.

Pair Names - Auditory	**Mean Reaction Time (ms)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Orthographic Decision Normal/150	1455.93	536.63	.010 *
Orthographic Decision TC/100	1298.30	406.50	39.79 to 275.48

decision in an auditory linguistic (reading) task presented at two stimulus presentation durations (normal speech rate – 150 ms and time-compressed – 100 ms) for early elementary school children.

Mean accuracy data for the phonetic and nonphonetic word type for the orthographic decision in an auditory linguistic (reading) task is reported in Table 19. A series of paired t-tests were conducted on these mean accuracy (proportion) data. There was a significant difference in mean accuracy between presentation durations with a *p*-value of .041. *P*-values were not adjusted for multiple comparisons. Accuracy was higher (67.93%) for words presented at the shorter presentation duration (time-compressed – 100 ms) in comparison to the lower accuracy (64.13%) for the longer presentation duration (normal speech rate – 150 ms) for the auditory stimuli in making orthographic decisions. There was a significant difference in accuracy between the normal and time-compressed speech condition for phonetic word type with a *p*-value of .049. Accuracy was higher (70.27%) for the phonetic word type when words were presented at the shorter presentation duration in comparison to lower accuracy (65.73%) for the phonetic word type presented at the longer presentation duration. There was no statistically significant difference between normal and time-compressed speech for nonphonetic word type. There was no statistically significant difference between phonetic and nonphonetic word type for the normal speech rate. The difference between the phonetic and nonphonetic word type for the time-compressed speech condition was approaching significance with a *p*-value of .054 with higher accuracy (70.27%) for the phonetic word type in comparison to lower accuracy (65.60%) for the nonphomeic word type. Overall, there was a statistically significant difference between the phonetic and nonphonetic word type with a p-value of .041. Accuracy for the phonetic word type was higher (67.10%) than for the nonphonetic word type (64.07%). Individual accuracy scores

Table 19

Paired T-Tests to compare differences in accuracy between the phonetic and nonphonetic word type for orthographic decision in an auditory linguistic (reading) task presented at two presentation durations.

Pair Names - Auditory	**Mean Accuracy (proportion)**	**Std. Deviation**	**Significance (2-tailed) & 95% CI of the Difference**
Orthographic Decision Normal/150 Orthographic Decision Time-Comp/100	64.13 67.93	14.76 17.10	.041 * -7.45 to -.15
Orthographic Decision Normal/150 (phonetic) Orthographic Decision Time-Comp/100 (phonetic)	65.73 70.27	16.27 19.48	.049 * -9.05 to -.01
Orthographic Decision Normal/150 (nonphonetic) Orthographic Decision Time-Comp/100 (nonphonetic)	62.53 65.60	17.86 18.58	.216 -7.99 to 1.85
Orthographic Decision Normal/150 (phonetic) Orthographic Decision Normal/150 (nonphonetic)	65.73 62.53	16.27 17.86	.195 -1.69 to 8.09
Orthographic Decision Time-Comp/100 (phonetic) Orthographic Decision Time-Comp/100 (nonphonetic)	70.27 65.60	19.48 18.58	.054 -.09 to 9.42
Orthographic Decision Phonetic Word Type Combined Orthographic Decision Nonphonetic Word Type Combined	67.10 64.07	16.09 16.04	.041 * .16 to 7.71

for the auditory linguistic (reading) decision task are presented in Appendix O.

An interaction plot to further address performance between phonetic and nonphonetic word type for the orthographic decision in an auditory (reading) task relative to presentation rate for accuracy is presented in Figure 9. The interaction plot indicates that there is little interaction between presentation duration and word type. Individual accuracy scores for auditory linguistic (reading) task are presented in Appendix N.

Relationship between Auditory Tasks and Reading Fluency

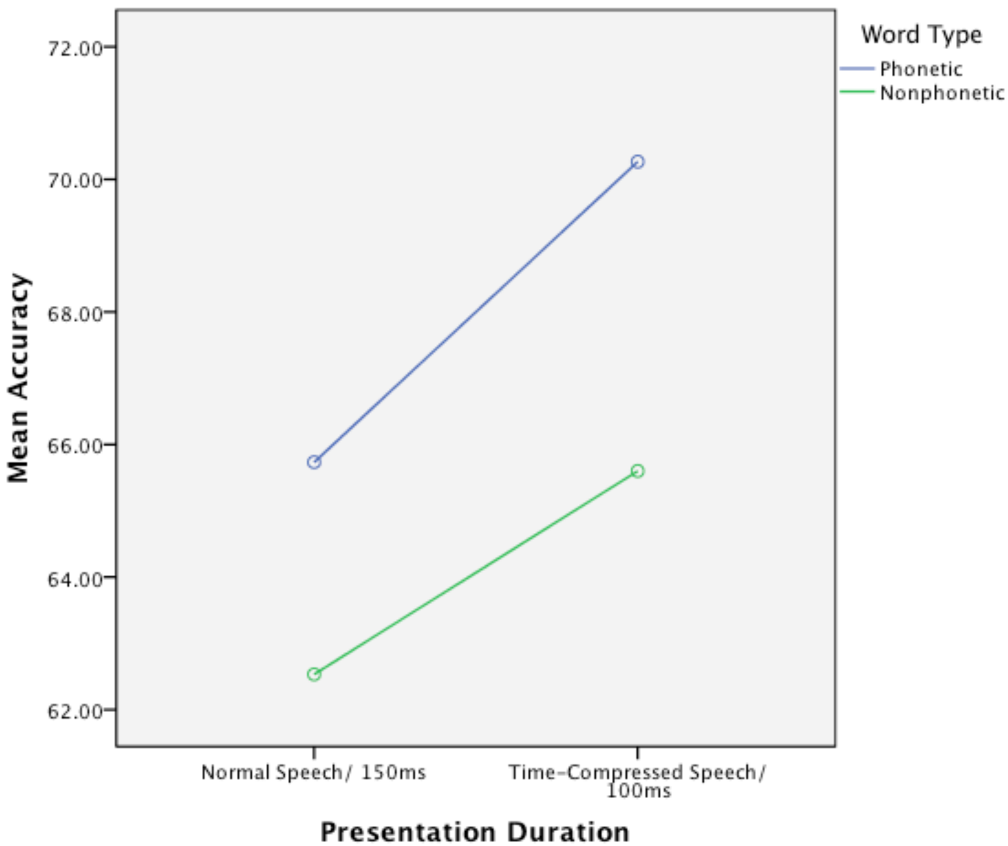
Further analysis was completed to address an examination of which language processing skill, as measured by mean reaction time and accuracy in an auditory linguistic task (semantic processing, syntactic processing, or orthographic processing) accounts for the majority of the variability in reading fluency for early elementary school children.

A series of Pearson's correlations were conducted on the mean reaction time (ms) and accuracy (proportion) data. Reading decoding was measured by standard scores from pre-experimental tests – *Woodcock Reading Mastery Test-R - Word ID*, *Word Attack,* and *Comprehensive Test of Phonological Processing - Phonological Awareness, Phonological Memory. R*eading fluency was measured by standard scores from pre-experimental tests – *Test of Word Reading Efficiency – Sight Word Efficiency, Phonological Decoding Efficiency, and Total Word Reading Efficiency, and Gray Oral Reading Test-4 - Rate, Accuracy, Fluency, Oral Reading Quotient. R*eading comprehension was measured by standard scores from the pre-experimental test – *Gray Oral Reading Test-4 – Comprehension and Oral Reading Quotient.*

Accuracy for the orthographic decision in an auditory reading task (time compressed speech – 100 ms) was significantly correlated with measures of reading decoding (*Woodcock Reading Mastery Test-R Word Identification* (r = .624)), reading fluency (*Test of Word Reading*

Figure 9

Interaction Plot for word type (phonetic and nonphonetic) and presentation duration (normal speech rate and time-compressed speech) for mean accuracy data – Experiment 2 – Auditory Tasks



Efficiency – Sight Word Efficiency (r = .694), *Phonological Decoding Efficiency* (r = .645), *Total Word Reading Efficiency* (r = .686), *Gray Oral Reading Test-4 Rate* (r = .697), *Gray Oral Reading Test-4 Accuracy* (r = .659), and *Gray Oral Reading Test-4 Fluency* (r = .693)). Scatter plots were conducted for each pairing of variables. Scatter plots reveal a strong positive correlation and the shape was roughly linear with no outliers in each case. A table of correlations between pre-experimental reading tasks and experimental auditory tasks is presented in Appendix S and T.

Descriptive Data and Correlation Analyses

Pre-Experimental Test Results

This section provides analyses and tables for additional analyses regarding pre-experimental test results and grade level differences, and relationships between pre-experimental test scores and experimental results.

Mean data for pre-experimental test scores for grade level differences are presented in Table 20. Two Independent Samples T-tests were completed to determine if there were differences in performance on pre-experimental tests as measured by standard scores as a function of grade level. P-values were not adjusted for multiple comparisons. Based on the independent samples t-tests, there were no statistically significant differences between children in second and third grade for one-word receptive vocabulary knowledge as measured by the Peabody Picture *Vocabulary Test*, decoding abilities as measured by the *Woodcock Reading Mastery Test-R*, decoding rate as measured by the Test of Word Reading Efficiency, rapid naming abilities as measured by the *RAN/RAS: Rapid Automatized Naming and Rapid Alternating Stimulus Tests*, or phonological abilities as measured by the *Comprehensive Test of Phonological Processing*.

Table 20

Two Independent Samples T-tests for pre-experimental testing based on grade level.

Standardized Test	*Grade*	*Means*	*Significant p-value (2-tailed)*	*95% Confidence Interval of the Difference*
RAVENS *RAW	2 3	25.54 26.92	.308	-1.313 to 4.076
RAVENS *PR	2 3	70.17 62.62	.265	-21.018 to 5.915
PPVT – 4	2 3	112.79 112.38	.911	-7.70 to 6.89
WRMT (ID)	2 3	109.38 111.50	.495	-4.08 to 8.33
WRMT (Attack)	2 3	113.12 109.15	.355	-12.53 to 4.59
TOWRE (SWE)	2 3	105.25 110.19	.158	-1.99 to 11.88
TOWRE (PDE)	2 3	103.21 107	.319	-3.78 to 11.36
TOWRE (TWRE)	2 3	105.13 110.23	.233	-3.40 to 13.61
GORT – 4 (Rate)	2 3	10.08 12.27	.028 *	0.24 to 4.13
GORT – 4 (Accuracy)	2 3	9.88 11.65	.058	-0.07 to 3.62
GORT – 4 (Fluency)	2 3	9.92 12.15	.024 *	0.30 to 4.17
GORT – 4 (Comp.)	2 3	11.25 13.15	.039 *	.10 to 3.71
GORT – 4 (ORQ)	2 3	103.50 115.81	.017 *	2.31 to 22. 31
TOLD (Listening)	2 3	111.08 111	.974	-5.20 to 5.03
TOLD (Organizing)	2 3	105.54 106.88	.691	-5.41 to 8.10
TOLD (Speaking)	2 3	105.21 111.73	.044 *	.18 to 12.87
TOLD (Grammar)	2 3	106.12 110.31	.178	-1.97 to 10.34
TOLD (Semantics)	2 3	108.96 111.42	.451	-4.05 to 8.98
TOLD (Spoken Lang.)	2 3	107.79 111.35	.249	-2.57 to 9.68

CTOPP (PA)	2 3	108.13 102.19	.098	-12.10 to 1.13
CTOPP (PM)	2 3	100.00 98.73	.704	-7.94 to 5.40
RAN (Objects)	2 3	96.63 97.50	.830	-7.28 to 9.03
RAN (Colors)	2 3	98.29 100.42	.639	-7.23 to 11.49
RAN (Numbers)	2 3	102.92 107	.309	-3.90 to 12.07
RAN (Letters)	2 3	103.96 99.77	.253	-11.47 to 3.10
RAN (2-Set)	2 3	100.37 105.69	.147	-1.94 to 12.58
RAN (3-Set)	2 3	101.21 101.50	.936	-6.93 to 7.52

Raven's CPM (Raw) = The Raven's Coloured Progressive Matrices: Raw Score; (PR) = Percentile Rank; PPVT- 4 = Peabody Picture Vocabulary Test - 4; WRMT-R (ID) = Woodcock Reading Mastery Test-Revised: Word ID; (Attack) = Word Attack; TOWRE (SWE) = Test of Word Reading Efficiency: Sight Word Efficiency; (PDE) = Phonological Decoding Efficiency; (TWRE) = Total Word Reading Efficiency; GORT – 4 = Gray Oral Reading Test – 4; GORT-4 (ORQ) = Oral Reading Quotient; TOLD = Test of Language Development; (Spoken Lang.) = Spoken Language; CTOPP (PA) = Comprehensive Test of Phonological Processing: Phonological Awareness; (PM) = Phonological Memory; RAN = RAN/RAS: Rapid Automatized Naming and Rapid Alternating Stimulus Tests; RAN (2-Set) = 2-Set Letters & Numbers; RAN (3-Set) = 3-Set Letters, Numbers, & Colors.

There was a statistically significant difference between children in second and third grade for oral reading skills as measured by the composite standard scores on the *Gray Oral Reading Test-4 – Rate* (p = .028), Fluency (p = .024), and Comprehension (p = .039) and approaching statistical significance for Accuracy (p = .058). There also was a statistically significant difference between children in second and third grade for basic oral language skills in the semantic and syntactic domains as measured by the composite score of Speaking (p = .044) on the Test of Language Development-P/I:4.

Relationships Between Experimental Tasks

A series of Pearson's correlations were conducted to determine the linear relationship between experimental tasks. For the reading tasks, there was a high correlation between reaction time for the semantic 1200ms and the semantic 600ms tasks (r = .630), the semantic 600ms and the syntactic 600ms tasks (r = .616), and the orthographic 350ms and the orthographic 150ms tasks (r = .818). There was a high correlation between accuracy for the semantic 1200ms and the semantic 600ms (r = .651), the semantic 1200ms and the syntactic 600ms (r = .615), semantic 600ms and syntactic 600ms (r = .643), syntactic 1200ms and syntactic 600ms (r = .737), syntactic 600ms and orthographic 350ms (r = .613), and orthographic 350ms and orthographic 150ms (r = .729). Correlations reveal a strong positive linear relationship between semantic and syntactic tasks regardless of presentation duration. A correlation table is provided in Appendix V.

For the auditory tasks, there was a significant correlation between reaction time for the semantic normal speech with the semantic time-compressed speech (r = .761). There also was a high correlation between the semantic time-compressed speech and the syntactic normal speech (r = .682) and syntactic time-compressed speech (r = .696). A high correlation was found between the syntactic normal speech and syntactic time-compressed speech (*r* = .773), and between the orthographic normal speech 150ms and the orthographic time-compressed speech 100ms (*r* = .645). For accuracy, there was a significant correlation between the orthographic normal speech 150ms and the orthographic time-compressed speech 100ms (*r* = .685). Correlations reveal a strong positive linear relationship between semantic and syntactic tasks regardless of presentation duration or modality. A correlation table is provided in Appendix W.

Relationships Between Pre-experimental Tests

A series of Pearson's correlations were conducted to determine if there were relationships between pre-experimental tests. A significant correlation was found between tests that measure decoding and reading fluency (*WMRT-R Word Identification* and *Word Attack* (*r* = .863), *TOWRE – Sight Word Efficiency* (*r* = .832), *Phonological Decoding Efficiency* (*r* = .833), and *Total Word Reading Efficiency* (*r* = .853)). A significant correlation also was found between the *WRMT-R Word Attack* and the *TOWRE – Sight Word Efficiency* (*r* = .682), *Phonological Decoding Efficiency* (*r* = .731), and *Total Word Reading Efficiency* (*r* = .726). The *TOWRE – Sight Word Efficiency* was significantly correlated with *Phonological Decoding Efficiency* (*r* = .897), and *Total Word Reading Efficiency* (*r* = .971). The *TOWRE – Phonological Decoding Efficiency* was highly correlated with *Total Word Reading Efficiency* (*r* = .976). The *GORT-4 Rate* was significantly correlated with the *WRMT-R Word Identification* (*r* = .795), *TOWRE – Sight Word Efficiency* (*r* = .882), *Phonological Decoding Efficiency* (*r* = .802), *Total Word Reading Efficiency* (*r* = .861), and the *GORT-4 Accuracy* (*r* = .902), *Fluency* (*r* = .791), and *Oral Reading Quotient* (*r* = .888). The *GORT-4 Accuracy* was highly correlated with the *WRMT-R Word Identification* (*r* = .869), *Word Attack* (*r* = .706), *TOWRE – Sight Word Efficiency* (*r* = .875), *Phonological Decoding Efficiency* (*r* = .814), *Total Word Reading Efficiency* (*r* = .866), *GORT-4 Fluency* (*r* = .969), and *Oral Reading Quotient* (*r* = .871). The *GORT-4 Fluency* was correlated with the *WRMT-R Word Identification* (*r* = .847), *Word Attack* (*r* = .659), *TOWRE – Sight Word Efficiency* (*r* = .887), *Phonetic Decoding Efficiency* (*r* = .833), and *Total Word Reading Efficiency* (*r* = .881), and *GORT-4 Oral Reading Quotient* (*r* = .914). The *GORT-4 Comprehension* was highly correlated with *Oral Reading Quotient* (*r* = .898). The *GORT-4 Oral Reading Quotient* was highly correlated with the *WRMT-R Word Identification* (*r* = .770), and the *TOWRE – Sight Word Efficiency* (*r* = .771), *Phonological Decoding Efficiency* (*r* = .749), and *Total Word Reading Efficiency* (*r* = .777). A correlation table is provided in Appendix U. Results reveal strong relationships between and within pre-experimental tests that measure reading decoding, decoding fluency, and reading comprehension.

Correlations for pre-experimental tests that measure oral language skills reveal a significant relationship between the *TOLD – Listening and Spoken Language* (*r* = .813), and the *PPVT-4* (*r* = 672). There was a strong correlation between the *TOLD – Organizing* and *Grammar* (*r* = .751), *Semantics* (*r* = .793), *Spoken Language* (*r* = .876), and the *PPVT-4* (*r* = .777). A significant correlation was found between the *TOLD – Semantics and Spoken Language* (*r* = .876), and *PPVT-4* (*r* = .758). There also was a significant correlation between the *TOLD – Spoken Language* and the *PPVT-4* (*r* = .743).

There was a high correlation between subtests that measure rapid naming skills. *The RAN/RAS – Objects* was highly correlated with *Colors* (*r* = .702). The *Numbers* subtest was highly correlated with *Letters* (*r* = .750), *2-Set* (*r* = .823), and *3-Set* (*r* = .799). The *Letters* subtest was highly correlated with *2-Set* (*r* = .775), and *3-Set* (*r* = .782) and the *2-Set* subtest was highly correlated with the *3-Set* (*r* = .799).

CHAPTER IV

DISCUSSION

Reading fluency is the connection between reading decoding and reading comprehension. Investigations involving reading fluency have been inconclusive regarding the relationship between reading decoding skills, particularly relative to differential measures of decoding rate and accuracy, and the establishment of reading fluency (Breznitz, 2006; 2001; Breznitz & Berman, 2003; Breznitz & Share 1992). While the relationship between reading decoding and spelling abilities is generally acknowledged (Badian, 2001; Bruck 1988; Bruck & Treiman 1990; Dodd, et al., 1989; Hagiliassis, Pratt, & Johnston, 2006; Katzir, et al. 2006; Levinthal & Hornung, 1992), orthographic processing has not been widely investigated. Furthermore, while most researchers and practitioners support the notion that there are relationships between reading and oral language skills, studies have been limited in examining linguistic system relationships to the development of reading fluency (Chiappe, et al., 2004; Magnusson & Naucler, 1990; Menyuk et al., 1991; Nation et al., 2007). Children typically develop fluent reading skills within the second and third grades (Breznitz, 2006; Castles, et al., 2006; Catts & Kamhi, 1999; Chall, 1987; Coltheart, 1978; Fox, 2004). Research has been inconclusive, however, as to the factors that may predict or serve as a foundation for the development of fluent reading. Many factors have been found to have an influence on decoding efficiency (reading rate, background color and text color, word frequency, vocabulary age of word, word type, silent versus oral reading, and single words versus words in context) or reading comprehension (reading rate, text genre, text length, and question type). However, the influence of such factors on reading fluency has not been widely investigation. It has been suggested that when a reader becomes fluent, decoding rate increases. Breznitz & Share (1992) found that when the rate of reading is forced, as in controlled presentation rate of written stimuli, an increase in decoding accuracy and second comprehension occurs in second graders. Other language factors, however, have not been widely explored relative to the relationship between oral language skills and the development of reading fluency development, especially when reading rate is controlled or when reading comprehension is based on language processing measures.

Research has shown that semantic and syntactic abilities are related to later reading skills (Magnusson & Naucler, 1990; Menyuk et al., 1991) that children who have problems in reading often have problems in spelling (Bruck, 1988; Bruck & Treiman, 1990; Dodd, et al., 1989; Levinthal & Hornung, 1992). While relationships between these abilities and later reading skills have been established to some degree, it is difficult to make conclusions as to how oral language and/or orthographic processing skills can account for the variability and establishment of reading fluency due to differences in methodology, particularly in the age and type of population and type of task used to measure the relationship between oral language and orthographic processing skills. The current study investigated the relationship between semantic, syntactic, and orthographic processing skills and reading fluency as a function of stimulus presentation duration as measured by a series of reading and auditory linguistic processing tasks. For the current study, semantic processing refers to the ability to processing meaning or deep structure. Syntactic processing refers to the ability to process the surface structure of a sentence. Orthographic processing refers to the ability to demonstrate knowledge of real word spelling by identifying whether a printed word is spelled correctly (Hagiliassis, 2006).

For the current study, several research questions were asked relative to the extent of the relationship between semantic, syntactic, and orthographic processing skills and reading fluency. Processing rate was controlled in each experiment, for both reading and auditory processing as this variable has been observed to increase decoding accuracy and comprehension in adults (Breznitz et al., 1994; Leikin & Breznitz, 2001) and children (Biancarosa, 2005; Breznitz, 1987; 1990; Breznitz & Share, 1992) and because the rate of word recognition has become a major component in contemporary studies of reading fluency (Breznitz, 2006). Processing, via a series of controlled computer language and orthographic decision tasks, was examined in both reading and auditory modalities since it is known that word recognition involves information processing abilities in the visual and auditory modalities and the integration of each modality (Breznitz, 2001) and reading comprehension has been related to listening comprehension The auditory modality also was examined to determine if children, with developing fluent reading skills, would be able to process information presented in the auditory modality more easily than information they read. Research questions addressed the relationship between semantic, syntactic, and orthographic processing skills and the level of reading fluency in both the reading and auditory modality to determine if these processing modes are similar or if each contributes independently to reading fluency. The investigation was designed to determine if semantic, syntactic, and orthographic processing in reading and auditory linguistic tasks relate to reading fluency. Participants included second and third grade children between 7 and 10 years of age with varying reading and language skills. The skills were based on pre-experimental standardized tests specifically in the areas of receptive vocabulary, phonological and visual/lexical decoding, decoding rate, fluency, accuracy, comprehension, phonological memory, phonological awareness, rapid naming, and basic oral language as measured by. Reaction time and accuracy of semantic, syntactic, and orthographic processing abilities were measured as a function of stimulus modality (reading and auditory) and stimulus presentation rate. Participants completed a series of semantic, syntactic, and orthographic processing decision tasks within two controlled stimulus presentation durations for auditory and visual modalities by determining if the sentence or word they read or heard was semantically, syntactically, or orthographically correct.

Reading Tasks

Semantic Decision Task

The first series of research questions addressed whether or not there was a difference in mean reaction time (ms) and accuracy (proportion) for a semantic decision within a reading task presented in two stimulus presentation durations (1200 and 600 ms) for second and third grade children. Analysis of reaction time data revealed that mean reaction time was slower for the shorter stimulus presentation duration (600 ms) in comparison to a faster mean reaction time for the longer presentation duration (1200 ms) of the written stimuli, in making semantic decisions. Analysis of accuracy data revealed no significant difference in mean accuracy between the two presentation durations. Results suggest that even though participants took longer to make a semantic decision in the shorter stimulus presentation duration condition (600 ms), accuracy did not change.

Results on the semantic processing task are consistent with Doehring (1976) who found a decrease in oral reading rate during the second grade when reading various levels of connected text depending on the importance of the sentence. It is possible that reaction time would become faster for the faster presentation rate with practice. This finding does not support previous studies regarding the acceleration phenomenon (Breznitz, 1987; 1990; Breznitz & Berman, 2003; Breznitz & Share 1992, Breznitz, et al., 1994; Biancarosa, 2005; Leikin & Breznitz, 2001). In this phenomenon, when children are forced to read at a faster rate, there is an increase in their accuracy of decoding and reading comprehension (Breznitz & Berman, 2003; Breznitz & Share

1992). The current study examined the ability to make semantic or syntactic decisions when reading short sentences at two different presentation durations. Breznitz and Share (1992) found that a fast-paced reading rate increases reading comprehension and decoding accuracy in second graders as measured by multiple-choice questions. Breznitz and Berman (2003) found an improvement in reading comprehension under a forced reading rate when reading short declarative sentences. While this phenomenon has been found, previous studies have not focused on making decisions about the plausibility or syntactic correctness of a sentence under a forced reading rate.

Syntactic Decision Task

The next series of research questions addressed whether there was a difference in mean reaction time and accuracy for a syntactic decision in a reading task presented in two stimulus presentation durations (1200 ms and 600 ms) for early elementary school children. Analysis of reaction time data revealed no significant difference in mean reaction time between presentation duration conditions for a syntactic decision. Analysis of accuracy data revealed that mean accuracy was lower for the shorter stimulus presentation duration (600 ms) in comparison to a higher mean accuracy for the longer presentation duration (1200 ms) of the written stimuli, in making syntactic decisions. Results suggest that even through reaction time for syntactic decisions did not change between presentation duration conditions, accuracy decreased when stimuli were presented in the shorter presentation rate condition (600 ms).

Results from the syntactic decision task are not consistent with previous studies that suggest that a fast-paced reading rate increases reading comprehension and decoding accuracy (Breznitz & Share, 1992; Breznitz & Berman, 2003). Previous studies have only focused on reading sentences under time constraints and then answering multiple-choice questions about the content. These studies have not used a task involving making decisions about syntax, which including making decisions about word order and morphological correctness. Although previous studies have investigated reading comprehension in second and third graders, they have not investigated syntactic processing when reading sentences under time constraints such as in the current study. The present study results are consistent with findings regarding adults and comprehension of expository text under several forced reading rate conditions. Meyer et al. (1999) found improved reading comprehension under the lowest reading rate condition (90 wpm). It is possible that as just as adults from the Meyer study (Meyer et al., 1999), second and third grade children require longer presentation duration for increased reading comprehension to occur. Current results suggest that poorer accuracy scores in the shorter stimulus presentation (600 ms) duration may be due to developing reading fluency or syntactic reading processing skills. Children at this age may have difficulty processing syntactic information while forced to read at a faster rate; therefore, causing a decrease in their comprehension of the information being presented.

Comparison of Semantic and Syntactic Processing

The next series of research questions addressed whether or not there was a difference in mean reaction time and accuracy for a semantic decision and a syntactic decision in a reading task presented in two stimulus presentation durations (1200 and 600 ms) for early elementary school children. Analysis of reaction time data revealed that for the longer presentation duration condition (1200 ms), mean reaction time was shorter for the semantic decision task compared to the syntactic decision task. For the shorter presentation duration (600 ms), no significant difference was found between mean reaction time values for the semantic and syntactic decision reading tasks. A semantic decision requires the participant to determine the plausibility of a sentence. A syntactic decision requires the participant to determine if the words in a sentence are in the correct order or if the sentence is morphologically correct. The results do not reveal an overall significant difference in mean reaction time between the semantic and syntactic decisions in a reading task and two presentation durations. Results suggest that reaction time does not vary significantly between processing tasks that focus on content and those that focus on form regardless of stimulus presentation duration.

Analysis of accuracy did not reveal a significant difference in mean accuracy for the semantic decision and the syntactic decision task when stimuli were presented for the longer presentation duration (1200 ms). Mean accuracy was higher for the semantic decision task when compared to the syntactic decision task, however, when the written stimuli were presented for the shorter presentation duration (600 ms). Overall, accuracy for both the semantic and syntactic processing tasks was higher for the longer presentation duration condition (1200 ms) than the shorter presentation duration condition (600 ms). Overall accuracy was higher for the semantic decision than the syntactic decision, suggesting that children were able to process the content of information more effectively than the form. Accuracy decreased for both the semantic and syntactic decision when written stimuli were presented for the shorter presentation duration (600 ms).

Research has suggested that not all language domains are of equal importance in relationship to reading (Vellutino, et al., 1991). Although there was no significant difference in mean reaction time between semantic and syntactic decision tasks, current results suggest that accuracy in making decisions about word order and morphological correctness is more difficult for this age group than determining plausibility. Results are supported by Vellutino et al. (1991) who suggested that for second, third, sixth, and seventh graders, text comprehension is facilitated by semantically based skills; however, their study did not compare semantic and syntactic processing abilities under time constraints. Results from the current study suggest that there is a difference in processing content versus form (grammar) in children who are beginning fluent readers. However, children had difficulty making both semantic and syntactic decisions when stimuli were presented at the shorter presentation duration. It appears to be easier for children in this age group to think about deep structure than surface structure. At this point in their reading development, children may be reading for meaning rather than engaging in proofreading skills, as is often used to detect grammar errors As children shift from focusing on decoding to comprehension and fluency and are exposed to different types of reading materials increase, children may be able to process and make decisions about content and form more quickly and easily. Perhaps engaging in proofreading tasks would also enhance syntactic processing skills for written stimuli.

Current results which show that accuracy decreases for both semantic and syntactic decision tasks at the faster presentation durations are unlike findings in previous studies, suggesting that when children are forced to read at a faster rate, there is an increase in their accuracy of decoding and reading comprehension (Breznitz & Berman, 2003; Breznitz & Share 1992). This could be due to the fact that, in the current study, children had to quickly read and determine the semantic plausibility or syntactic correctness of a sentence rather than just simply read and answer multiple-choice questions about the content. It appears that making judgments about oral language while using rapid decoding skills requires more information processing for children in this age group. Similar to Meyer et al. (1999), who found that adult participants had improved reading comprehension under the lowest reading rate condition (90 wpm), the current study suggests that a slower reading rate is needed to analyze a sentence for semantic or syntactic correctness. Unlike the current study, Meyer et al. (1999) focused on adults and used expository text and varying text lengths. Meyer et al. (1999) also used several types of comprehension questions to measure comprehension rather than using decision tasks like in the current study. As suggested by Stanovich (1986), reading automaticity and fluency free up mental capacity for reading comprehension. It is possible that as children in this age group become more proficient in oral language and reading skills, they will become more accurate and fast in their ability to make semantic and syntactic decisions.

Reading Orthographic Processing

The next series of research questions addressed whether there was a difference in mean reaction time and accuracy between phonetic and nonphonetic word types for an orthographic decision in a reading task presented at two stimulus presentation durations (350 ms and 150 ms) for early elementary school children. Phonetic word type consisted of all phonetically spelled words. Nonphonetic word type consisted of all nonphonetically spelled words. Analysis of reaction time data revealed that there was no significant difference in reaction time between presentation duration conditions for an orthographic decision task suggesting that stimulus presentation duration did not make a difference in the amount of time it took children to make decisions about the correctness of the spelling of single words.

Analysis of accuracy revealed that for phonetic words, there was a significant difference in accuracy between the two stimulus presentation conditions (350 ms) and (150 ms). Accuracy was significantly higher when the words were presented at the shorter presentation duration (150 ms) in comparison to a lower accuracy for the longer presentation duration (350 ms) of the written stimuli, in making orthographic decisions. For the shorter stimulus presentation duration (150 ms), a significant difference in accuracy was found between the phonetic and nonphonetic word types where accuracy was higher for the phonetic word type in comparison to lower accuracy for the nonphonetic word type. Overall accuracy was higher for the phonetic word type than the nonphonetic word type. Results suggest that children are more able to quickly determine correctness of phonetic words than nonphonetic words even when those words are presented at the faster presentation duration (150 ms).

Results support previous studies that suggest that word level decoding skills are necessary for good spelling abilities. Furthermore, word level decoding skills from both phonological and visual-lexical strategies are necessary for adequate spelling abilities (Apel & Masterson, 2001). Current results show that children can quickly and accurately determine if a word is spelled correctly between second and third grade when decoding skills are mastered and word recognition automaticity develops, suggesting that spelling and decoding skills are highly related skills. A child who is able to quickly decode words is able to quickly determine if words are spelled correctly or incorrectly. Results also are consistent with Verhoeven, et al. (2004) who found that higher word frequency resulted in faster word identification in adults with normal reading abilities. Studies that have examined the relationship between spelling and reading fluency (Burt & Tate, 2002; Humes, et al., 2007) have only used adult participants. However, it is possible that children especially in second and third grade with fluent decoding skills will exhibit the orthographic skills under time constraint. For the current study, familiarity with grade level vocabulary words may have played a part in the ability to make faster judgments about spelling. Stimuli for the current study, stimuli were controlled based on second, third, and fourth grade Dolch words within sentences with age appropriate vocabulary.

The difference in accuracy between phonetic and nonphonetic word type is consistent with Levinthal and Hornung (1992). They found that for college students, poorer readers were able to make visual discriminations during phonological interference but poorer readers and spellers were less able to make visual discriminations during orthographic interference. Stuart and Masterson (1992) found that early phonological awareness is significantly related to reading regular but not irregular words. The same could be true for children in this age group with varying reading skills. Even the poorer readers may have had less difficulty making discriminations for the phonetic word type than the nonphonetic word type. Results also are consistent with studies that have suggested that children improved in decoding and comprehension in the fast paced condition. Breznitz (2003) found that children automatically corrected words containing spelling errors in reading materials in a faster pace reading rate. The current study shows that children were able to read phonetic and nonphonetic misspelled words, out of context, holistically and make decisions about correctness in the shorter stimulus presentation duration (150 ms).

Relationship between Reading Tasks and Reading Fluency

Further analysis was conducted to address which language processing skill, as measured by mean reaction time and accuracy in a reading task (semantic processing, syntactic processing, or orthographic processing) accounted for the majority of the variability in reading fluency for early elementary school children as measured by pre-experimental test scores. Results revealed a strong positive correlation between the reading semantic accuracy scores at the slower presentation duration (1200 ms) and reading fluency specifically performance on the *Gray Oral Reading Test-4 Oral Reading Quotient*; a combination of reading fluency and reading comprehension. Results are consistent with previous findings for the same age group that found that retrieval skills and text comprehension is facilitated by semantically based skills (Vellutino, et al., 1991). Eisenberg and Becker (1982) found that semantic context strategies are used in reading short sentences. Results from the current study reveal that beginning fluent readers focus on meaning of what they are reading, showing that semantic processing is a highly important skills for beginning fluent readers.

A strong positive correlation was found between the reading syntactic accuracy scores at the faster presentation duration (600 ms) and measures of reading fluency, specifically the *Woodcock Reading Mastery Test-R Word Identification*, and the *Gray Oral Reading Test-4 Rate, Fluency*, and *Oral Reading Quotient*. The results of the current study are consistent with previous research that revealed that there is a relationship between reading decoding and syntactical processing. Bowey (1986) found that syntactic awareness was more strongly associated with decoding skills than reading comprehension abilities. The current study shows that there is a relationship between syntactic processing under a forced reading rate and various aspects of reading fluency including reading rate, reading fluency, and reading comprehension. This suggests that children with stronger decoding and reading fluency skills are more able to process syntactic information when presented at the shorter presentation duration. Results from the current study support the claim that semantic and syntactic abilities are related to later reading skills (Magnusson & Naucler, 1990; Menyuk et al., 1991).

Strong positive correlations were found between reading orthographic accuracy scores at the faster presentation duration (150 ms) and reading fluency specifically the *Test of Word Reading Efficiency – Sight Word Efficiency* and the *Gray Oral Reading Test-4 Rate*, *Accuracy*, *Fluency*, and *Oral Reading Quotient*. Current finding support the claim that children who have problems in reading often have problems in spelling (Bruck, 1988; Bruck & Treiman, 1990; Dodd et al., 1989; Levinthal & Hornung, 1992). Studies that have suggested this relationship include Apel and Masterson (2001) who concluded that word level decoding skills from both visual-lexical and phonological strategies are necessary for adequate spelling abilities. Stuart and Masterson (1992) also found that between 9 and 10 years of age, children with good early phonological awareness had well-developed lexical and sublexical reading and spelling abilities, showed larger regularity effects in word reading and spelling, and were better at non-word reading and spelling than children with poor early phonological awareness. Burt and Tate (2002) also suggested that there is a relationship between spelling and lexical ability. They found that orthographic knowledge underlies visual word recognition and spelling (Burt & Tate, 2002).

Auditory Linguistic Tasks

Semantic Decision Task

The first series of research questions addressed whether or not there was a difference in mean reaction time and accuracy for a semantic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children. Analysis of reaction time data revealed that there was no significant difference in reaction time between presentation durations. Analysis of accuracy revealed that there was a significant difference in mean accuracy for semantic decisions between presentation durations. Mean accuracy was lower for the time-compressed speech rate in comparison to a higher mean accuracy for the normal speech rate of the auditory stimuli, in making semantic decisions.

Unlike results from the reading semantic decision task, participants' reaction time remained the same for the faster presentation duration. However, they were less accurate when stimuli were presented using time-compressed speech suggesting that even though children did not have to read sentences at the shorter presentation duration, they still had difficulty making semantic decisions about sentences they listened to at the shorter presentation duration. Results are consistent with Doehring (1976) who found a decrease in oral reading rate for children in second grade. It is possible that even though stimuli were presented auditorally, participants needed more time to process the plausibility of a sentence. Although studies have suggested that a fast-paced reading rate increases reading comprehension and decoding accuracy in children (Biancarosa, 2005; Breznitz, 1987; 1990; Breznitz & Share, 1992), the same does not appear to be true for sentences presented auditorally at a shorter presentation duration suggesting that children may have had more difficulty deciphering information they heard than information they read. Beasley et al. (1976) found that for groups of children with mean ages of 4, 6, and 8, intelligibility scores increased as a function of increased age and sensation level, and decreased with increasing amounts of time compression for word lists. Wilson et al. (1994) also found that recognition of time-compressed speech ranged from 90% correct at 45% compression to 80% correct between 55-65% for adults. It is possible that for the current study a decrease in accuracy occurred simply because speech was time-compressed to 55%.

Syntactic Decision Task

The next series of research questions addressed whether there was a difference in mean reaction time and accuracy for a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed) for early elementary school children. Analysis of reaction time data revealed that there was a significant difference in mean reaction time between presentation durations. Mean reaction time was slower for the time-compressed speech rate in comparison to a faster mean reaction time for the normal speech rate of the auditory stimuli, in making syntactic decisions. Analysis of accuracy revealed that there was a significant difference in mean accuracy between presentation durations. The mean accuracy was lower for the time-compressed speech rate conditions in comparison to a higher mean accuracy for the normal speech rate of the auditory stimuli, in making syntactic decisions. Results suggest that overall reaction time and accuracy for making syntactic decision was better under the normal speech rate condition.

Unlike the reading syntactic decision task, participants' reaction time was longer in the time-compressed speech condition. Like the syntactic decision in a reading task, participants were less accurate in the shorter presentation duration condition, which for this study was time-compressed speech. Results are consistent with previous finding that suggest that in fourth and fifth grade children with varying decoding abilities, difficulty with syntactic awareness is not restricted to written language (Bowey, 1986). The current study shows that children have difficulty making syntactic decisions when stimuli were presented auditorally only when stimuli were presented using time-compressed speech. Although Bentin et al. (1990) found that good and poor readers in fourth grade had syntactic awareness, they did not use a faster presentation rate to force the participants to determine syntactic correctness. As mentioned, studies have shown that when children are forced to read at a faster rate, there is an increase in their accuracy of decoding and reading comprehension (Breznitz & Berman, 2003; Breznitz & Share 2002). Taking into consideration the results of the current study, this phenomenon may not apply to listening comprehension or language processing of auditorally presentedn information, which time-compressed stimuli are used. Similar to the current study, Wilson et al. (1994) and Beasley et al. (1980) found that auditory recognition of words decreased with increased time compression in adults. Beasley et al. (1976) found that for groups of children ages 4, 6, and 8, intelligibility scores decreased with increasing amounts of time compression for word lists. It is possible that mean reaction time and accuracy in making syntactic decisions decreased during the time-compressed speech due to difficulty recognizing the information being presented.

Comparison of Semantic and Syntactic Processing

The next series of research questions addressed whether there was a difference in mean reaction time and accuracy for a semantic decision and a syntactic decision in an auditory linguistic task presented at two stimulus presentation durations (normal speech rate and time-compressed speech) for early elementary school children. Analysis of reaction time data revealed that there was a significant difference in reaction time between the auditory semantic and syntactic task for the normal speech rate condition. For the normal speech rate condition, mean reaction time was longer for the semantic decision task compared to the syntactic decision task when stimuli were presented auditorally. For the time-compressed speech rate condition, mean reaction time was longer for the semantic decision task compared to the syntactic decision task. Results revealed that overall reaction time was longer in making decisions about semantic information than syntactic information regardless of the presentation duration.

Analysis of accuracy revealed that there was no significant difference in accuracy between semantic and syntactic decisions in an auditory linguistic task. Overall accuracy was higher in the normal speech rate condition than the time-compressed speech rate condition. Overall, accuracy decreased for both the semantic and syntactic decisions in the auditory linguistic task when stimuli were presented for the shorter presentation duration (time-compressed speech – 100 ms).

Research has shown that text comprehension is facilitated by semantically based skills (Vellutino, et al., 1991). However, it appears that for this study, children were equally as accurate in making semantic or syntactic decisions. The current study suggests that there is a difference in processing content versus form (grammar) in reading tasks, but not for auditory linguistic tasks for children who are beginning fluent readers. In the reading tasks, children were more accurate in making semantic decisions than syntactic decisions. Results of the current study support previous findings that suggest a relationship between semantic and syntactic decision tasks and reading proficiency under time constraints (Tyler & Marslen-Wilson, 1977). As in the present study, when children are forced to make semantic and syntactic decisions about sentences presented auditorally using time-compressed speech, accuracy does not increase. Results are not consistent with Breznitz and Share (1992) who suggest that accuracy increases with a forced reading rate in second grade children. However, Breznitz and Share (1992) did not compare reading and auditory stimuli when making semantic and syntactic decisions.

Auditory Orthographic Processing

The next series of research questions addressed whether there was a difference in mean reaction time and accuracy between the phonetic and nonphonetic word type for an orthographic decision in an auditory linguistic (reading) task presented at two stimulus presentation durations (normal speech rate – 150 ms and time-compressed – 100 ms) for early elementary school children. In this task, children were asked to make decisions about spelling correctness for words they read and heard simultaneously at two different presentation durations. Analysis of reaction time revealed a significant difference in mean reaction time between presentation durations. Mean reaction time was faster for the shorter stimulus presentation duration (time-compressed – 100 ms) in comparison to a slower mean reaction time for the longer presentation duration (normal speech rate – 150 ms) of the auditory stimuli, in making orthographic decisions suggesting that children were able to make decisions about spelling correctness more quickly when they were presented at a shorter presentation duration.

For an orthographic decision in an auditory linguistic (reading) task, accuracy was higher when words were presented at the shorter presentation duration (time-compressed – 100 ms) in comparison to the lower accuracy for the longer presentation duration (normal speech rate – 150 ms) of the auditory stimuli, in making orthographic decisions suggesting that not only did children make decisions faster in the shorter presentation duration, they also were more accurate. There was a significant difference in accuracy between the normal and time-compressed speech for phonological word type. Accuracy was higher for the phonetic word type when words were presented at the shorter presentation duration (time-compressed – 100 ms) in comparison to lower accuracy for the phonetic word type presented at the longer presentation duration (normal speech rate – 150 ms). There was no significant difference between the normal and time-compressed speech for the nonphonetic word type. There was no significant difference between phonetic and nonphonetic word type for the normal speech condition. The difference between the phonetic and nonphonetic word type for the time-compressed speech condition was approaching significance showing that accuracy was higher for the phonetic word type in comparison to lower accuracy for the nonphonetic word type. Overall accuracy was higher in the time-compressed speech condition as compared to the normal speech rate condition. Overall accuracy also was higher for the phonetic word type than the nonphonetic word type.

Studies have suggested that word level decoding skills from both phonological and visual-lexical strategies are necessary for adequate spelling abilities (Apel & Masterson, 2001). The current study suggests that for the orthographic decision in an auditory linguistic (reading) task, higher accuracy scores in the time-compressed speech condition and in the shorter presentation duration (600 ms) for the reading task may be attributed to the fact that decoding and encoding skills are mastered and word recognition automaticity is developed between second and third grades.

Current findings for the orthographic decision in the auditory linguistic (reading) task support other studies that have found that performance on speeded spelling tests in both the auditory and visual modalities were closely associated regardless of the presentation rate for the visual text recognition among different age groups (Humes, Burk, Coughlin, et al., 2007). This study also supports the finding that children automatically corrected words containing the spelling errors though not in connected text. However, their accuracy improved in the shorter presentation duration condition. Results suggest that for phonological decoding to occur, auditory perceptual skills converge with visual perceptual skills for sound-symbol analysis. It has been found that word recognition involves processing and integration of information in the visual and auditory modalities (Breznitz, 2001). As this study suggests, synchrony in speed of processing between the visual and auditory system in necessary for rapid decoding and spelling to occur (Breznitz, 1992). Results reveal that accuracy is more related to speed of processing of information rather than just the effect of time-compressed speech.

Relationship between Auditory Linguistic Tasks and Reading Fluency

Further analysis was conducted to address which language processing skill, as measured by mean reaction time and accuracy in auditory linguistic tasks (semantic processing, syntactic processing, or orthographic processing) accounts for the majority of the variability in reading fluency in early elementary school children as measured by pre-experimental test scores. Strong positive correlations were found between the auditory linguistic (reading) accuracy scores (100 ms & time compressed speech) and reading fluency specifically the *Test of Word Reading Efficiency – Sight Word Efficiency*, *Phonological Decoding Efficiency*, *Total Word Reading Efficiency*, *Woodcock Reading Mastery Test-R Word Identification*, and *Gray Oral Reading Test-4 Rate*, *Accuracy*, and *Fluency*. It has been suggested that word recognition (decoding) is the basic skill on which other dimensions of reading skills depend (Ehri & Wilce, 1983). It appears that this is true whether words are presented in the reading or auditory modality or both. It has been found that word level decoding skills from both phonological and visual-lexical strategies are necessary for adequate spelling abilities (Apel & Masterson, 2001). Stuart and Masterson (1992) found that for children between 9 and 10 years of age early phonological awareness is significantly related to reading phonetic but not nonphonetic words (Stuart & Masterson, 1992). However, Burt and Tate (2002), found that orthographic knowledge underlies visual word recognition and spelling. This study shows that for phonological decoding to occur, auditory perceptual skills converge with visual perceptual skills for sound-symbol analysis. Breznitz (1997, 2001) suggest that word recognition involves speed of information processing in the visual and auditory modalities and the integration of each. Results from the current study reveal that in the auditory modality, orthographic processing skills are more related to measures of reading decoding and fluency than semantic and syntactic processing skills.

Descriptive and Correlation Analyses

Additional analyses were conducted to determine if there was a difference in pre-experimental test scores between second and third grade children. This additional analysis was completed to determine if reading decoding and fluency skills, as measured by pre-experimental test scores, increase between second and third grade as children develop their reading fluency skills. A significant difference was found between grades for the *Gray Oral Reading Test-4 Rate*, *Accuracy*, *Fluency*, *Comprehension*, and *Oral Reading Quotient*. There was also a significant difference between grades for the *Test of Language Development – Speaking*. All of these pre-experimental test scores increased for third grade children suggesting that reading skills, more than any other language skill, increases between second and third grade when children grasp rapid and accuracy decoding skills and develop reading fluency.

Additional analyses were conducted to determine if there were relationships between experimental tasks (semantic decision task, syntactic decision task, and orthographic decision task presented in the reading and auditory modalities). There were high correlations between semantic and syntactic tasks for reaction time and accuracy regardless of presentation duration. A high correlation was found between presentation duration conditions for the orthographic decision task for reaction time and accuracy for both the reading and auditory tasks. Overall, correlations revealed a relationship between semantic and syntactic tasks regardless of presentation duration. Correlations also reveal a relationship between semantic and syntactic tasks regardless of presentation duration or modality.

Analyses also were conducted to determine if there were relationships between oral and reading fluency skills, as measured by pre-experimental tests (*Peabody Picture Vocabulary Test-4, Test of Word Reading Efficiency, Comprehensive Test of Phonological Processing, Rapid Automatized Naming Test, Gray Oral Reading Test-4, Test of Language Development, and Woodcock Reading Mastery Test-R*). High correlations were found between pre-experimental tests that measure decoding and decoding rate (i.e. *Woodcock Reading Mastery Test-R* and *Test of Word Reading Efficiency*). There also were high correlations between the *Gray Oral Reading Test-4* which is a measure of reading rate, accuracy, fluency, and comprehension and other measures of reading decoding and decoding rate (i.e. *Woodcock Reading Mastery Test-R* and *Test of Word Reading Efficiency*). Correlations are consistent with previous research that suggests that oral reading fluency is a valid and reliable measure for reading skills in general and comprehension in particular (Deno, Mirkin, & Chiang, 1982; Fuchs, Fuchs, & Maxwell, 1988).

There were high correlations within and between oral language tests specifically the *Test of Language Development* and the *Peabody Picture Vocabulary Test-4*. There were strong correlations between subtests on the *Rapid Automatized Naming Test* but this test was not highly correlated with any other pre-experimental test. Results reveal strong relationships between and within pre-experimental tests that measure reading decoding, decoding fluency, and reading comprehension and strong correlations for pre-experimental tests that measure oral language skills.

General Discussion

Results from the reading tasks did not reveal an overall significant difference in mean reaction time between the semantic and syntactic decision reading tasks as a function of two presentation durations. These second and third graders, however, were more accurate in their ability to make semantic and syntactic decisions in the reading task for the longer presentation duration (1200 ms) than the shorter presentation duration (600 ms). Overall accuracy was higher for the semantic decision task than the syntactic decision task.

Though there was no significant difference in mean reaction time between semantic and syntactic decisions in a reading task, current results suggest that making decisions about word order and morphological correctness is more difficult for children who are beginning fluent readers than determining plausibility. Also, increased or forced reading times may reduce semantic or syntactic processing for beginning fluent readers. Perhaps current results can be explained by the fact that early fluent readers need more time to semantically and syntactically process the information, which could be an indication that there is a developmental phase of reading fluency.

Current results show that the acceleration phenomenon, associated with an increase with reading under forced rates as proposed by Breznitz does not hold true for the present study. Breznitz found that when children are forced to read at a faster rate, there is an increase in their accuracy of decoding and reading comprehension (Breznitz & Berman, 2003; Breznitz & Share 1992). Though she examined children within this same age range, her tasks required children to simply read a short sentence or passage and recall the information using multiple-choice questions rather than make semantic and syntactic decisions. It appears that making judgments about oral language while using rapid decoding skills requires more information processing for children in this age group than a task that requires answering multiple choice questions.

Current results suggest that there is a developmental aspect of reading fluency with semantic processing rate and efficiency as a primary component. While some researchers suggest that the rate of decoding single words is the key to reading fluency (i.e. Breznitz), perhaps that relationship is attributed to overall reading rate issues. Semantic processing could be the main factor in overall reading efficiency that is not taken into account in current tests that measure reading fluency. For example, tests such as the Gray Oral Reading Test-4 only truly measure decoding rate and accuracy within context and the ability to answer and recall facts following oral reading, which does not accurately reflect true reading fluency efficiency. It is possible that children who never reach grade-level expectations of their fluency may continue to have underlying semantic processing deficiencies and not just decoding rate and/or accuracy issues. Current results show that semantic and syntactic processing should be considered in diagnostic testing and in the identification of a language or a reading disorder.

For the auditory tasks, children were able to make decisions about correctness faster for the syntactic decision task than the semantic decision task in the normal speech rate condition and the time-compressed speech rate condition. However, reaction time decreased for both tasks with time-compressed speech. Overall, children were more accurate in the normal speech rate condition than the time-compressed speech rate condition for both semantic and syntactic decisions in an auditory task. However, accuracy decreased for semantic and syntactic decision in an auditory task when stimuli were presented in time-compressed speech.

The current study suggests that there is a difference in processing content versus form (grammar) in reading tasks but not auditory tasks for children who are beginning fluent readers. Children exhibited equal accuracy in making semantic and syntactic decisions when listening suggesting that for beginning fluent readers, decreased accuracy in syntactic processing could be related to reading fluency rather than just language processing or the task itself.

As this study has shown, when children are forced to make semantic and syntactic decisions about sentences presented auditorally using time-compressed speech, accuracy decreases. Results concur with previous results that show that for children and adults, intelligibility decreased with increasing amounts of time-compression (Beasley, et al., 1976; 1980).

There was no significant difference in reaction time between presentation duration conditions for an orthographic decision in a reading task. For both presentation durations, accuracy for the phonetic word type was higher than accuracy for the nonphonetic word type. Accuracy for the nonphonetic word type remained the same for the longer and shorter presentation duration. Results from the reading tasks revealed that accuracy increased for the orthographic decision task in general and the phonetic words in particular. This task is considered an “orthographic verification task” where the child sees a word and has to determine if the word is spelled correctly or not (Hagiliassis, Pratt, & Johnston, 2006). Current results show that children can quickly and accurately determine if a word is spelled correctly between second and third grade when decoding skills are mastered and word recognition automaticity develops suggesting that orthographic verification and decoding skills are highly related skills (Hagiliassis, et al., 2006). It also is possible that familiarity with grade level vocabulary words may have played a part in the ability to make faster judgments about spelling. The written and auditory stimuli for the current study were carefully selected second, third, and fourth grade Dolch words in sentence with age appropriate vocabulary

The difference in accuracy between phonetic and nonphonetic word type is consistent with Levinthal and Hornung (1992). They found that for college students, poorer readers were able to make visual discriminations during phonological interference but poorer readers and spellers were less able to make visual discriminations during orthographic interference. Stuart and Masterson (1992) found that early phonological awareness is significantly related to reading phonetic but not nonphonetic words. The same could be true for beginning fluent readers in this age group with varying reading skills. Even the poorer readers may have had less difficulty making discriminations for the phonetic word type than the nonphonetic word type.

When making orthographic decisions in an auditory linguistic task, children were able to make decisions about spelling correctness faster for the time-compressed – 100 ms condition in comparison to the normal speech rate – 150 ms condition. Overall accuracy was higher in the time-compressed speech condition as compared to the normal speech rate condition. Overall accuracy was higher for the phonetic word type than the nonphonetic word type. Results from the auditory tasks revealed that accuracy increased for the orthographic decision task in general and the phonetic words in particular.

The current study suggests that for the orthographic decision task in the auditory modality, higher accuracy scores in the time-compressed speech combined with shorter presentation duration for both reading and auditory stimuli are due to the fact that decoding skills are mastered and word recognition automaticity has developed between second and third grade. Results also are consistent with studies that have suggested that children improved in decoding and comprehension in the fast paced condition. Breznitz (2003) found that children automatically corrected words containing spelling errors in reading materials in a faster pace reading rate. Again, the faster presentation rate resulted in an increase in accuracy in the reading and auditory modality. Perhaps this is due to skills needed to complete the orthographic verification (or decision) task. Perhaps "synthesis" is needed to process a word holistically and judge its spelling. The faster the presentation, the child was forced into using a holistic or visual gestalt strategy to determine spelling correctness.

Current findings for the orthographic decision task support other studies that have found that performance on speeded spelling tests in both the auditory and visual modalities were closely associated regardless of the presentation rate for the visual text recognition among different age groups. (Humes, Burk, Coughlin, et al., 2007). It has been found that word recognition involves processing and integration of information in the visual and auditory modalities (Breznitz, 2001). As this study suggests, synchrony in speed of processing between the visual and auditory system in necessary for rapid decoding and spelling to occur (Breznitz, 1992). As the current study shows, when children in this age group are reading to decode or determine spelling correctness, they are using a holistic decoding strategy to decode words even when misspelled.

The current study revealed that there was a strong relationship between oral language and reading fluency. For the reading tasks, the longer stimulus presentation duration condition for the semantic processing task resulted in a strong correlation between semantic processing accuracy and overall reading fluency. In addition, the shorter stimulus presentation duration for the syntactic processing task resulted in a strong correlation between syntactic processing accuracy and overall reading efficiency.

Results from the current study also support the claim that semantic and syntactic abilities are related to later reading skills (Magnusson & Naucler, 1990; Menyuk et al., 1991). Results suggest that rate of processing and stimulus duration may be factors in the overall assessment of efficient reading decoding. Results revealed a strong correlation for the shorter stimulus duration between the accuracy of the orthographic processing task in the auditory and reading modalities and reading fluency. Orthographic processing skills were correlated with pre-experimental tests including the *Woodcock Reading Mastery Test-R* and the *Test of Word Reading Efficiency* as well as the *Gray Oral Reading Test-4*. This suggests that orthographic knowledge may be more tied into the rate of decoding or fluency, as evidenced by this orthographic verification task and its relationship to sight word and rapid decoding skills in the reading and auditory modality.

Burt and Tate (2002) suggested orthographic knowledge underlies visual word recognition and spelling (Burt & Tate, 2002). Studies also have suggested that orthographic processing is an additional predictor of single word identification (Burt, 2006). More importantly, it has been suggested that the formation and fluent access of orthographic representations, is a fundamental process of word identification. It appears that phonological skills play a role in orthographic learning (Burt, 2006). Van Der Mark, et al. (2011) found a disconnection of the left occipitotemporal system in dyslexic children limited to the small brain region known as the visual word form area crucial for automatic visual word processing. They found that this disconnection emerges early during reading acquisition in children with dyslexia, along with deficits in orthographic and phonological processing of visual word forms. It has been suggested that orthographic processing is not a skill independent of other language skills associated with fluent reading. Orthographic processing is associated with reading experience, reading achievement, oral vocabulary, motivation, and instruction (Burt, 2006).

Research has shown that reading fluency is related to a combination of variables at the word level, semantic level, and syntactic level (Meyer & Felton, 1999). Results from the current study revealed that reading fluency is more than just decoding. Reading involves making semantic and syntactic connections. Though all language domains (semantics, syntax, morphology, phonology, pragmatics) play a role in the development of oral and written language (Vellutino, et al., 1991), the current study revealed that orthographic processing skills in the reading and auditory modality is an additional predictor of fluency single word identification (Burt, 2006).

The current study also shows that at this level, there is more relationship between the rate of decoding and encoding spelling as seen in the orthographic decision or verification task, but semantic processing is still underdevelopment, as supported by Schulz et al. (2009). Schulz et al. (2009) compared normal reading second and third grade children to older dyslexic children in fifth grade. They found that both groups had similar semantic processing neural patterns in the inferior left parietal region, which may represent the reduced semantic processing skills of beginning fluent readers. Landi and Perfetti (2007) found semantic processing differences between good and poor adult comprehenders, suggesting that deficits in semantic processing may be linked to poor comprehenders' difficulties. Blumenfeld, Booth, and Burman (2006) also suggest that the children with high accuracy in semantic judgment tasks had a semantic system located in temporal areas of the brain that allowed them to efficiently and accurately make meaning based judgments. They suggest that children with low accuracy may have a weakly interconnected semantic system. It is possible that children with reading disorders would continue to have slow and less accurate semantic processing in both reading and auditory processing tasks, even though their peers and ability matched peers do not as they age.

The current study shows that children in this age group who are developing fluent readers are beginning to read fluently for meaning, suggesting that their reading focus is shifting from decoding to comprehension. Children in this age group have not yet developed or not yet been exposed to proof reading skills, such as detecting correct word order or morphological correctness. Although orthographic processing is a different skill, it is related to proof reading. It is possible that as fluency increases and children in this age group become more experienced readers, they will be more able to make decisions about form as well as content more rapidly and more accurately.

Although it is not clear how reading fluency can be trained or remediated, it is clear that fluency is more than just single word decoding. If a child has weak reading fluency, training can begin with phonological and visual/lexical decoding of single words and then increase rate. However, it is not enough to train single words. The importance of semantic and syntactic context must be trained as well. Developing tasks such as proof reading can help a child learn how to receptively identify plausibility and syntactic correctness as well as orthographic correctness before expressively reading for content. Developing tasks that involve language processing skills and reading fluency can help to remediate those areas of language that are deficient.

Limitations

One limitation to this study was that in a population of children with varying reading skills, the number of children who fit the criteria for having a reading disorder was not large enough to subgroup, although the focus of the study was to examine children who are developing reading fluency skills. Comparing children with normal reading skills to those with reading disorders may help to determine if there is a difference in the relationship between language processing skills and reading fluency between groups.

Another limitation to this study was that children were asked to read sentences silently before making a decision about correctness. At this level, oral reading may have facilitated semantic, syntactic, or orthographic processing, although fluent readers are able to read and comprehend material read silently. Reading orally may facilitates word recognition beyond that of silent reading due to the allocation of attention to decoding (Kamhi & Catts, 1999).

Implications for Future Research

Implications from this research suggest the need to further investigate the relationship between semantic, syntactic, and orthographic processing skills and reading fluency within a reading disordered population and for older children at various stages of reading fluency. The current study examined beginning fluent readers but the relationship between language processing and reading fluency in readers that have already established reading fluency is of interest. Further research is warranted to investigate factors that have been shown to have an effect on the process of decoding include reading rate, background color and text color, word frequency, vocabulary age of word, word type, and single words versus words in context and their influence on the relationship between language processing and reading fluency. Further research also is warranted to investigate the relationship between language processing skills and reading sentences and text of various lengths. Future research can involve oral reading of sentences and text to determine oral reading accuracy and prosody. Rate and experience could be factors in reading fluency development. Measuring tasks silently could affect how fluency is measured. Additional studies of orthographic recognition (verification) and reading fluency also are warranted.

Summary

The purpose of the present investigation was to determine if semantic, syntactic, and orthographic processing abilities, as measured by reaction time and accuracy, are differentially affected as a function of stimulus modality (reading and auditory) and stimulus presentation rate. Fifty second and third grade children (7 to 10 years of age) completed a series of semantic, syntactic, and orthographic processing tasks within two controlled stimulus presentation durations for auditory and visual modalities. Relationships to pre-experimental reading and oral language tasks were explored.

Results from the reading tasks did not reveal an overall significant difference in mean reaction time between the semantic and syntactic decision reading tasks as a function of two presentation durations. However, children were more accurate in their ability to make semantic and syntactic decisions in the reading task for the longer presentation duration (1200 ms) than the shorter presentation duration (600 ms). Overall accuracy was higher for the semantic decision task than the syntactic decision task.

Results suggest that making judgments about oral language while using rapid decoding skills requires more information processing for children in this age group than a task that requires answering multiple choice questions. Semantic processing could be the main factor in overall reading efficiency that is not taken into account in current tests that measure reading fluency.

For the auditory linguistic tasks, children were able to make decisions about correctness faster for the syntactic decision than the semantic decision in the normal speech rate condition and the time-compressed speech rate condition. However, reaction time decreased for both tasks with time-compressed speech. Overall, children were more accurate in the normal speech rate condition than the time-compressed speech rate condition for both semantic and syntactic decisions. However, accuracy decreased for the semantic and syntactic decision in the auditory linguistic task when stimuli were presented in the time-compressed speech condition.

The current study suggests that there is a difference in processing content versus form (grammar) in reading tasks but not auditory tasks for children who are beginning fluent readers, suggesting that for beginning fluent readers, decreased accuracy in syntactic processing could be related to reading fluency rather than just language processing or the task itself.

There was no significant difference in reaction time between presentation duration conditions for an orthographic decision in a reading task. Accuracy increased for the orthographic decision in a reading task in general and the phonetic word type in particular for the shorter presentation duration (150 ms).

When making orthographic decisions in an auditory linguistic task, children were able to make decisions about spelling correctness faster for the time-compressed – 100 ms condition in comparison to the normal speech rate – 150 ms condition. Accuracy increased for the orthographic decision in general and the phonetic words in particular for the time-compressed speech condition.

Current results show that children can quickly and accurately determine if a word is spelled correctly between second and third grade when decoding skills are mastered and word recognition automaticity develops suggesting that orthographic verification and decoding skills are highly related skills (Hagiliassis, et al., 2006). For beginning fluent readers with varying reading skills, even the poorer readers may have less difficulty making discriminations for the phonetic word type than the nonphonetic word type.

The current study revealed that there was a strong relationship between oral language and reading fluency. Results suggest that rate of processing and stimulus duration may be factors in the overall assessment of efficient reading fluency. Results from the current study revealed that reading also involves making semantic and syntactic connections. The current study suggests that orthographic processing skills in the reading and auditory modality is an additional predictor of fluency single word identification (Burt, 2006). The current study also shows that for beginning fluent readers, there is more relationship between the rate of decoding and encoding spelling as seen in the orthographic decision or verification task, but semantic processing is still underdeveloped.

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APPENDIX A: SNELLEN VISUAL ACUITY CHART

APPENDIX B: ADVERTISEMENT

Free Evaluation of Reading Skills

A research study will be conducted through the Department of Communication Sciences and Disorders at East Carolina University. Involvement in the study will consist of pre-experimental testing to determine current reading skills (decoding, reading rate and reading comprehension), and receptive vocabulary. In addition, the child will participate in six experimental decision tasks assessing reading and oral language processing abilities in an effort to determine their relationship to reading fluency. Participation will take approximately 3 hours and will be completed in Morehead City, NC or Greenville, NC.

- Children in second and third grade between 7 and 10 years of age are needed to participate.
- Participants with typical reading skills and those reported as having been diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) but are taking medication, Learning Disabilities, and Reading Disorders will be included in the study.
- Children that have been diagnosed with language impairments, speech impairments, or a developmental disability will not be included in the study.
- All participants must be native English speakers and reported as having no visual, hearing, or cognitive impairments.

The purpose of the current study is to assess the extent of the relationship between language processing skills such as semantic processing, syntactic processing, and orthographic processing and how each of these areas of language effect reading fluency.
* For participation in this study, research participants will receive a $5.00 Target gift card.
If interested, please contact Donna Wolfe, MA., CCC-SLP, Doctoral Candidate in Communication Sciences and Disorders at (252) 725-9231 or wolfed06@students.ecu.edu.

This study has been approved by the UMCIRB (#10-0373).

APPENDIX C: THE OAKWOOD SCHOOL PARENT LETTER

Dear Parents,

My name is Donna Wolfe and I am a licensed Speech-Language Pathologist and Doctoral Candidate in the Department of Communication Sciences and Disorders at East Carolina University. Thanks to the wonderful teachers at The Oakwood School, your child will have the opportunity with your permission to participate in my research study. This study will allow us to obtain valuable information about the extent of the relationship between language processing skills and how each of these areas of language effect reading fluency.

This research dissertation study is being conducted through the Department of Communication Sciences and Disorders at East Carolina University. Involvement in the study will consist of pre-experimental testing to determine current reading skills (decoding, reading rate and reading comprehension), and receptive vocabulary. In addition, your child will participate in six experimental decision tasks assessing reading and oral language processing abilities in an effort to determine their relationship to reading fluency. Participation will take approximately 3 hours and will be completed at your school in a minimum of 2 sessions.

For participation in this study, your child will receive a $5.00 gift card to Target. To allow your child to participate in this study, please initial and sign in the highlighted spaces in the attached consent forms.

Thank you for your consideration in having your child participate in our study. Please call me at (252) 725-9231 with any questions or concerns regarding this study.

Sincerely,

Donna L. Wolfe, MA., CCC-SLP
Doctoral Candidate
Department of Communication
Sciences and Disorder
East Carolina University
252-725-9231

Marianna Walker, Ph.D., CCC-SLP
Associate Professor
Department of Communication
Sciences and Disorders
East Carolina University
252-744-6096

APPENDIX D: PARENT QUESTIONNAIRE

Parent Questionnaire

1. What is your child's age? _________ Current Grade level? _____________.

2. Has your child been diagnosed with ADHD, a Learning Disability, or Reading Disorder? YES NO

   If yes, please specify specific diagnosis ______________________.

3. If your child has been diagnosed with ADHD, are they currently taking medication?
   YES NO

   If yes, please specify specific medication ______________________.

4. Has your child been diagnosed with a language impairment, speech impairment, or developmental disability? YES NO

   If yes, please specify specific diagnosis ___________________________.

5. Does your child have a visual or hearing impairment that has not been corrected?
   YES NO

6. Is English your child's first language? YES NO

7. How would you describe your child's current reading skills?
   ____
   ____

APPENDIX E: IRB INFORMED CONCENT AND MINOR ASSENT FORMS

CONSENT DOCUMENT

Title of Research Study: The effect of presentation rate on semantic, syntactic, and orthographic processing on reading fluency in children

Principal Investigators: Donna Wolfe, M.A., Doctoral Candidate, Department of Communication Sciences and Disorders (CSDI)

Subinvestigator: Marianna M. Walker, Ph.D., Associate Professor, Department of Communication Sciences and Disorders (CSDI)

Institution: East Carolina University
Address: 3310Y Health Sciences Building
Telephone #: (252) 744-6096

PURPOSE AND PROCEDURES

The purpose of the current study is to determine the extent of the relationship between semantic, syntactic, and orthographic processing skills and each skill's contribution to reading fluency under different presentation rates. The investigation will seek to determine if semantic, syntactic, and orthographic processing in reading and auditory linguistic tasks relate to reading fluency. Processing skills will be assessed using semantic decision tasks, syntactic decision tasks, and orthographic decision tasks.

In participating in this research, your child will complete a series of standardized language tests and experimental tasks during several sessions. Your child will be given an explanation of the experimental tasks. He/she will then participate in three reading and three auditory linguistic tasks at two different presentation rates. Both auditory and visual systems will be assesses to see how fluency is related to semantic, syntactic, and orthographic processing within reading and auditory linguistic tasks. Data will be obtained in terms of accuracy (percentage) and response time (milliseconds).

POTENTIAL RISKS AND DISCOMFORTS

You may find that there is no more than minimal risk associated with your child's participation in this study.

POTENTIAL BENEFITS

There may be no personal benefit from your participation but the knowledge received may be of value to humanity. Results of this study will provide valuable information relative to the relationship between semantic, syntactic, and orthographic processing and their effect on reading fluency.

SUBJECT PRIVACY AND CONFIDENTIALITY OF RECORDS

Version date:

Participant's initials

Your privacy and confidentiality will be maintained. All data will be housed in a locked filing cabinet in the primary investigator's research laboratory and will only be available to investigators.

All information from pre-experimental testing and experimental tasks will remain confidential and will not be accessible to anyone without your consent. HIPPA standards will be followed if you request information for an outside agency.

You will be identified by a numerical coding system. Only the investigators will be able to link individual subjects to their data. You will be able to access your child's test scores from the pre-experimental testing if requested. If your child attends The Oakwood School, test scores will be shared with the school. These scores will not be released to any other agency unless you complete a request from investigators and sign necessary forms according to HIPPA standards.

COSTS OF PARTICIPATION & COMPENSATION

By participating in this research study, you will not incur any costs.

For participation in this study, your child will receive a $5.00 Target gift card. You may obtain reading and language scores if requested. If your child attends The Oakwood School, reading and language scores will be shared with your child's school.

VOLUNTARY PARTICIPATION

Participating in this study is voluntary. You and your child may stop at any time you choose without penalty.

PERSONS TO CONTACT WITH QUESTIONS

The investigators will be available to answer any questions concerning this research, now or in the future. You may contact the investigators, Donna L. Wolfe at phone number (252) 725-9231 or Dr. Marianna Walker, at (252)744-6096. If you have questions about your rights as a research subject, you may call the Chair of the University and Medical Center Institutional Review Board at phone number 252-744-2914 (days). If you would like to report objections to this research study, you may call the ECU Director of Research Compliance at phone number 252-328-9473.

CONFLICTS OF INTEREST

This study is not funded. Neither the research site, nor Marianna M. Walker, Ph.D., Associate Professor will receive any financial benefit based on the results of this study.

CONSENT TO PARTICIPATE

Title of research study: The effect of presentation rate on semantic, syntactic, and orthographic processing on reading fluency in children

Participant's initials

I have read all of the above information, asked questions and have received satisfactory answers in areas I did not understand. (A copy of this signed and dated consent form will be given to the person signing this form as the participant or as the participant's authorized representative.)

Participant's Name **(PRINT)** **Signature** **Date** **Time**

If applicable:

Guardian's Name **(PRINT)** **Signature** **Date** **Time**

PERSON ADMINISTERING CONSENT: I have conducted the consent process and orally reviewed the contents of the consent document. I believe the participant understands the research.

Donna L. Wolfe, MA., Doctoral Candidate
Person Obtaining Consent **(PRINT)** **Signature** **Date**

Marianna M. Walker, Ph.D
Responsible Faculty **(PRINT)** **Signature** **Date**

UMCIRB
APPROVED
FROM 10.1.10
TO 7.6.11

Participant's initials

MINOR ASSENT DOCUMENT

Title of Proposal: The effect of presentation rate on semantic, syntactic, and orthographic processing on reading fluency in children

Principal Investigator: Donna L. Wolfe, M.A., Doctoral Candidate

Subinvestigator: Marianna M. Walker, Ph.D., Associate Professor

School: East Carolina University
Address: Department of Communication Sciences and Disorders
Office 3310 Y, Health Sciences Building
Telephone number: (252) 744-6096

This assent form may have words that I do not understand. I need to ask the study doctor or the study helper to explain any words or information that I do not understand.

Where will the research study take place?
The study will take place at The Oakwood School, in the Reading and Language Sciences Labs in the East Carolina University Communication Sciences and Disorders Department at the Health Sciences Building and/or in the Carteret Publishing Company conference room in Morehead City, NC.

Who is in charge of the study?
The doctor in charge of this research study is Dr. Marianna Walker. I will see Donna Wolfe, Dr. Walker's student, during the time of the study activity. These people will make sure that the study activity is going as planned. They will also collect information and watch over me during the study activity. If I ever have any questions about what I am doing or the research project, I should call them at (252) 744-6096.

What is the purpose of this research study?
I have been asked to be in a research study. This research study is being done to look at how quickly I can listen to and read different types of words and sentences shown on a computer screen and determine if they are correct or incorrect.

What will I have to do to participate in this study?
I will have a minimum of two study activity sessions. During these sessions, I will do some reading of word lists, naming pictures and reading short passages with questions. I also will sit in front of a computer and read words and sentences (4 word sentences) that are flashed quickly on the screen or listen to words and sentences using headphones. The person in charge of the study will give me directions that will explain what I should do. I will complete some practice activities before the study starts. This will help me understand what I should do.

What are some good things or benefits that may happen because of my participation in this research study?

My participation will help the doctors, researchers, and teachers understand how to better help other 2nd and 3rd graders who may have trouble reading.

What are some bad things or risks that may happen to me because of participating in this research study?
The study doctors do not know of any risks from the study.

What are some things I might receive for being in the study?
I may receive knowledge about my own reading levels. For my participation in this study, I will receive a $5.00 Target gift card.

Can I stop being in the research study anytime I want?
It should be my decision to be in this research study. It will not matter to my school or the researchers if I choose not to be in the study. No one will be angry or upset with me if I do not want to be in the study at any time.

Because I am less than 18 years old, my parent or legal guardian will also have to give me permission to be in the research study. My parent or guardian will have to sign a separate informed consent document that has more information.

Who can answer my questions about being a research participant?
If I have any questions about being a research participant, I should call the person in charge of all research studies being done, the Chairman of the University and Medical Center Institutional Review Board at East Carolina University at (252) 744-2914.

Please ask any questions you may have about the study information.

Minor's Name (PRINT) Age

Minor's Signature Date

Auditor Witness: I confirm that the contents of this assent form were orally presented and that I witnessed the subject's signature.

Auditor's Name | Auditor's Signature date

Person conducting assent discussion | Person conducting assent discussion date

Principal Investigator (Print) | Principal Investigator's signature date

UMCIRB APPROVED FROM 10.1.10 TO 7.6.11

APPENDIX F: INSTITIUTIONAL REVIEW BOARD APPROVAL FORMS

UMCIRB #:

UMCIRB

SEP 24 2010

RECEIVED

UNIVERSITY AND MEDICAL CENTER INSTITUTIONAL REVIEW BOARD
REVISION FORM

UMCIRB #: 10-0373 **Date this form was completed:** September 24, 2010

Title of research: The effect of presentation rate on semantic, syntactic, and orthographic processing on reading fluency in children

Principal Investigator: Donna L. Wolfe, Doctoral Candidate, Dept. of CSDI, East Carolina University

Subinvestigator: Marianna M. Walker, Ph.D., Associate Professor, Department of Communication Sciences and Disorders (CSDI), East Carolina University

Fund number for IRB fee collection (applies to all for-profit, private industry or pharmaceutical company sponsored project revisions requiring review by the convened UMCIRB committee):

Fund	Organization	Account	Program	Activity (optional)
		73059		

Version of the most currently approved protocol: 7-7-10
Version of the most currently approved consent document: 7-7-10

CHECK ALL INSTITUTIONS OR SITES WHERE THIS RESEARCH STUDY WILL BE CONDUCTED:

- ☒ East Carolina University
- ☐ Pitt County Memorial Hospital, Inc
- ☐ Heritage Hospital
- ☒ Other: Carteret County News-Times Conference Room, The Oakwood School
- ☐ Beaufort County Hospital
- ☐ Carteret General Hospital
- ☐ Boice-Willis Clinic

The following items are being submitted for review and approval:

KK ☒ **Protocol: version or date** ~~7-7-10~~ ☒ **Consent: version or date** ~~7-7-10~~ (received 9-24-10).
KK ☒ **Additional material: version or date** • Minor Assent (received 9-24-10)
• Letter of Support (9-24-10)
- Parent Letter - Free Evaluation of Reading Skills

Complete the following:

1. **Level of IRB review required by sponsor:** ☐ full ☒ expedited
2. **Revision effects on risk analysis:** ☐ increased ☒ no change ☐ decreased
3. **Provide an explanation if there has been a greater than 60 day delay in the submission of this revision to the UMCIRB.**

The principal investigator received permission to test participants, with informed consent from parents and minor assent from participants, in the 2nd and 3rd grade classrooms at The Oakwood School. Also, the principal investigator was unable to attain funds to purchase gift cards from the previously mentioned establishments.

4. **Does this revision add any procedures, tests or medications?** ☒ yes ☐ no **If yes, describe the additional information:**

The principal investigator will be testing participants during a minimum of 2 sessions rather than just 2 sessions.

5. **Have participants been locally enrolled in this research study?** ☒ yes ☐ no
6. **Will the revision require previously enrolled participants to sign a new consent document?** ☐ yes ☒ no

Briefly describe and provide a rationale for this revision The principal investigator received permission to test participants, with informed consent from parents and minor assent from participants, in the 2nd and 3rd grade classrooms at The Oakwood School. Testing in a school setting will require testing to be completed in a minimum of 2 sessions. Also, the principal investigator was unable to attain funds to purchase gift cards from the previously mentioned establishments.

Donna L. Wolfe | Donna L. Wolfe, MA, CCC-SLP | 9-24-10
Principal Investigator Signature | **Print** | **Date**

UMCIRB Version 2/21/08 **Page 1 of 2**

UMCIRB #:

Box for Office Use Only

The above revision has been reviewed by:
☐ Full committee review on ________ ☑ Expedited review on 10/1/10

The following action has been taken:
☑ Approval for period of 10/1/10 to 7/6/11
☑ Approval by expedited review according to category 45CFR46.110
☑ See separate correspondence for further required action.

Susan McCammon Susan McCammon 10/1/10
Signature Print Date

APPENDIX G: RESULTS HANDOUT

Test Results for Participant: __________

Hearing Screening ***Pass*** **___*____*****Fail*** **_________**
Vision Screening ***Pass*** **___*____*****Fail*** **_________**

The **Peabody Picture Vocabulary Test-4** assesses one word receptive vocabulary. The participant achieved a standard score (average range 85-115) of _______ yielding a percentile rank of ______.

The **Test of Word Reading Efficiency** assesses sight word and phonemic decoding skills at the one word level when timed. Results are as follows:

Subtest	**Standard Score (Average range = 85 to 115)**	**Percentile Rank**
Sight Word Efficiency		
Phonemic Decoding Efficiency		
Total Word Reading Efficiency		

The **RAN/RAS: Rapid Automatized Naming and Rapid Alternating Stimulus Tests** assess the ability to recognize a visual symbol such as a letter or color and name it accurately and rapidly. The tests consist of rapid automatized naming tests (Letters, Numbers, Colors, Objects) and two rapid alternating stimulus tests (2-Set Letters and Numbers, and 3-Set Letters, Numbers and Colors). Results are as follows:

Subtests	**Standard Score (Average Range = 85-115)**	**Percentile Rank**
Objects		
Colors		
Numbers		
Letters		
2-Set Letters and Numbers		
3-Set Letters, Numbers, and Colors		

The **Test of Language Development- Intermediate** assesses various receptive and expressive oral language skills. The following subtests were administered: Sentence Combining (assesses how well the child can form one compound or complex sentence from two or more simple sentences spoken by the examiner), Picture Vocabulary (assesses receptive vocabulary/listening vocabulary skills), Word Ordering (assesses the ability to form a complete, correct sentence from a randomly ordered string of words), Relational Vocabulary (assesses the ability to tell how three words, spoken by the examiner, are alike), Morphological Comprehension (assesses the ability to distinguish between grammatically correct and incorrect sentences), and Multiple Meanings (assesses the ability to determine different meanings for a given word). Results are as follows:

Subtest	**Scaled Score (Average Range = 7 to 13)**	**Percentile Rank**
Sentence Combining		
Picture Vocabulary		
Word Ordering		
Relational Vocabulary		
Morphological Comprehension		
Multiple Meanings		
Composite	**Index Score (Average Range = 85 to 115)**	**Percentile Rank**
Listening		
Organizing		
Speaking		
Grammar		
Semantics		
Spoken Language		

The **Test of Language Development-Primary: Fourth Edition (TOLD-P:4)** assesses spoken language in young children. The following subtests were administered: Picture Vocabulary (the understanding of the meaning of spoken English words), Relational Vocabulary (the ability to orally express the relationships between two spoken stimulus words), Oral Vocabulary (the ability to give oral directions to common English words that are spoken by the examiner), Syntactic Understanding (the ability to comprehend the meaning of sentences), Sentence Imitation (the ability to imitate English sentences), and Morphological Completion (the ability to recognize, understand, and use common English morphological forms). Results are as follows:

Subtest	**Scaled Score (Average range= 7 to 13)**	**Percentile Rank**
Picture Vocabulary		
Relational Vocabulary		
Oral Vocabulary		
Syntactic Understanding		
Sentence Imitation		
Morphological Completion		
Composite	**Index Score (Average range = 85 to 115)**	**Percentile Rank**
Listening		
Organizing		
Speaking		
Grammar		
Semantics		

Spoken Language		

The **Woodcock Reading Mastery Test-Revised** assesses basic reading skills at the single word and passage levels. The following subtests were administered: Word Identification (assesses sight-word vocabulary) and Word Attack (uses nonsense words that can all be sounded out phonetically to assess phonemic decoding skills). Results are as follows:

Subtest	**Standard Score (Average Range = 85 to 115)**	**Percentile Rank**
Word Identification		
Word Attack		

The **Comprehensive Test of Phonological Processing** assesses phonological awareness and phonological memory. The following core subtests were administered: Elision (measures the ability to remove phonological segments from spoken words to form other words); Blending Words (measures the ability to synthesize sounds to form words); Memory for Digits (measures the ability to repeat numbers accurately); and Nonword Repetition (measures the ability to repeat nonwords accurately). Results are as follows:

Subtests	**Standard Scores (Average Range = 7 to13)**	**Percentile**
Elision		
Blending Words		
Memory for Digits		
Nonword Repetition		
Sum of Subtests	**Composite Score (Average Range = 85 to 115)**	**Percentile**
Phonological Awareness		
Phonological Memory		

The **Gray Oral Reading Test-4** measures oral reading rate, reading accuracy, reading fluency, and reading comprehension abilities while reading passages of increasing complexity. Rate is determined by measuring the amount of time it takes to finish the passage. Accuracy is determined by calculating how many deviations from print occurred when reading. Reading fluency is established by the sum of the rate and accuracy scores. The number of correct answers to multiple choice questions asked after the story is completed determines the comprehension score. Results are as follows:

Measures	**Standard Scores (Average Range = 7 to13)**	**Percentile**
Rate		
Accuracy		
Fluency		
Comprehension		
Oral Reading Quotient	**Composite Score**	**Percentile**

	(Average Range = 85 to 115)	
Fluency + Comprehension		

The Raven's Coloured Progressive Matrices measures clear-thinking ability. The test consists of three sets of 12 items that are arranged to assess cognitive development up to the stage when a person is sufficiently able to reason by analogy and adopt this way of thinking as a consistent method of inference. Based on test results, the participant received a percentile rank of _______, which is ____average___ based on age norms.

If you have any questions or concerns, please feel free to contact me at (252) 725-9231. Thank you for allowing your child to participate in this dissertation research study!!!

Donna L. Wolfe, MA, CCC-SLP
Doctoral Candidate
Department of Communication Sciences and Disorders
East Carolina University

APPENDIX H: LIST OF STIMULI

Reading Experimental Set

Reading Semantic Decision Task

3 Practice Trials
pen (n) The pen is clear.
quick (adj) The snail is quick.
stood (verb) She stood straight up.

Numbers 1-30 were presented at 1200 ms and questions 31-60 were presented at 600 ms.

Stimulus Word and Sentence	Stimulus Type
1. 2nd before (prep) She stood before me.	Stim1 (Correct)
2. 2nd cold (adj) The ice is cold.	Stim2 (Correct)
3. 2nd us (pro) She took us home.	Stim3 (Correct)
4. 2nd buy (verb) She will buy lunch.	Stim4 (Correct)
5. 2nd made (verb) She made a cake.	Stim5 (Correct)
6. 2nd sing (verb) The songs will sing.	Stim6 (Incorrect)
7. 2nd your (pro) I'm driving your skates.	Stim7 (Incorrect)
8. 2nd call (verb) The phone will call.	Stim8 (Incorrect)
9. 2nd green (adj) The cat is green.	Stim9 (Incorrect)
10. 2nd read (verb) The book can read.	Stim10 (Incorrect)
11. 3rd about (prep) She cares about birds.	Stim11 (Correct)
12. 3rd try (verb) I will try again.	Stim12 (Correct)
13. 3rd never (adv/adj) You are never forgotten.	Stim13 (Correct)
14. 3rd fall (verb) I sometimes fall down.	Stim14 (Correct)
15. 3rd keep (verb) You keep asking me.	Stim15 (Correct)
16. 3rd full (adj) The water is full.	Stim16 (Incorrect)
17. 3rd carry (verb) My pockets carry gum.	Stim17 (Incorrect)
18. 3rd seven (adj) Eight is before seven.	Stim18 (Incorrect)
19. 3rd grow (verb) The plants grow legs.	Stim19 (Incorrect)
20. 3rd pick (verb) The apples pick worms.	Stim20 (Incorrect)
21. 4th air (noun) The air is cold.	Stim21 (Correct)
22. 4th knew (verb) I knew the answer.	Stim22 (Correct)
23. 4th slow (adj) You should slow down.	Stim23 (Correct)
24. 4th almost (adv) I am almost there.	Stim24 (Correct)
25. 4th beside (prep) He sat beside me.	Stim25 (Correct)
26. 4th lake (n) The lake is square.	Stim26 (Incorrect)
27. 4th feel (verb) The rock feels soft.	Stim27 (Incorrect)
28. 4th large (adj) The ant is large.	Stim28 (Incorrect)
29. 4th outside (adv) My room is outside.	Stim29 (Incorrect)
30. 4th yard (n) The yard has carpet.	Stim30 (Incorrect)
31. 2nd very (adv) She is very nice.	Stim31 (Correct)

32. 2nd its (pro) Its not too late.	Stim32 (Correct)
33. 2nd pull (verb) She can pull weeds.	Stim33 (Correct)
34. 2nd these (adj) I like these shoes.	Stim34 (Correct)
35. 2nd tell (verb) You can tell me.	Stim35 (Correct)
36. 2nd those (adj) Those apples are black.	Stim36 (Incorrect)
37. 2nd use (verb) Boats use the road.	Stim37 (Incorrect)
38. 2nd wash (verb) I washed the soap.	Stim38 (Incorrect)
39. 2nd off (prep) The sun is off.	Stim39 (Incorrect)
40. 2nd goes (verb) The snail goes fast.	Stim40 (Incorrect)
41. 3rd got (verb) I've got to study.	Stim41 (Correct)
42. 3rd hot (adj) The sun is hot.	Stim42 (Correct)
43. 3rd show (verb) You can show me.	Stim43 (Correct)
44. 3rd myself (pro) I taught myself lessons.	Stim44 (Correct)
45. 3rd bring (verb) You can bring friends.	Stim45 (Correct)
46. 3rd hurt (verb) My leg hurt me.	Stim46 (Incorrect)
47. 3rd together (adv) We left together separately.	Stim47 (Incorrect)
48. 3rd today (n) Today is after tomorrow.	Stim48 (Incorrect)
49. 3rd clean (verb) My house cleaned itself.	Stim49 (Incorrect)
50. 3rd drink (verb) I drink my lunch.	Stim50 (Incorrect)
51. 4th clock (n) The clock has stopped.	Stim51 (Correct)
52. 4th half (adj) The girl ate half.	Stim52 (Correct)
53. 4th till (prep) She slept till noon.	Stim53 (Correct)
54. 4th number (n) I forgot the number.	Stim54 (Correct)
55. 4th led (verb) She led the way.	Stim55 (Correct)
56. 4th dirty (verb) The shampoo is dirty.	Stim56 (Incorrect)
57. 4th even (adj) Three apples are even.	Stim57 (Incorrect)
58. 4th teeth (n) The teeth brushed me.	Stim58 (Incorrect)
59. 4th sweep (verb) I sweep the broom.	Stim59 (Incorrect)
60. 4th brave (adj) The coward is brave.	Stim60 (Incorrect)

Reading Syntactic Decision Task

3 Practice Trials
before (prep) I started before you.
dime (noun) I counted my dime.
fresh (adj) The fresh is fruit.

Numbers 1-30, 66-70, 76-80, 86-90 were presented at 1200ms and numbers 31-65, 71-75, 81-85 were presented at 600ms.

Error Type	Stimulus Word and Sentence	Stimulus Type
C	1. 2nd your (pro) That is your toy.	Stim1 (Correct)
C	2. 2nd goes (verb) He goes to school.	Stim2 (Correct)

C	3. 2nd green (adj) The grass is green.	Stim3 (Correct)
C	4. 2nd call (verb) She called me today.	Stim4 (Correct)
C	5. 2nd use (verb) She can use mine.	Stim5 (Correct)
M	6. 2nd made (verb) She made a sweaters. (morph)	Stim6 (Incorrect)
O	7. 2nd its (pro) Not that easy its. (order)	Stim7 (Incorrect)
M	8. 2nd these (adj) These are my parent. (morph)	Stim8 (Incorrect)
O	9. 2nd pull (verb) You the rope pull. (order)	Stim9 (Incorrect)
M	10. 2nd us (pro) She ask us why. (morph)	Stim10 (Incorrect)
C	11. 3rd drink (verb) I drink milk often.	Stim11 (Correct)
C	12. 3rd myself (pro) I drew it myself.	Stim12 (Correct)
C	13. 3rd bring (verb) I can bring snacks.	Stim13 (Correct)
C	14. 3rd together (adv) We will come together.	Stim14 (Correct)
C	15. 3rd clean (verb) The window is clean.	Stim15 (Correct)
M	16. 3rd carry (verb) She carry the groceries. (morph)	Stim16 (Incorrect)
O	17. 3rd hurt (verb) I hurt am not. (order)	Stim17 (Incorrect)
M	18. 3rd today (n) She come home today. (morph)	Stim18 (Incorrect)
O	19. 3rd keep (verb) You guessing me keep. (order)	Stim19 (Incorrect)
M	20. 3rd grow (verb) I can grows flowers. (morph)	Stim20 (Incorrect)
C	21. 4th creek (n) The creek is high.	Stim21 (Correct)
C	22. 4th kick (v) I kicked the ball.	Stim22 (Correct)
C	23. 4th sweet (adj) The candy is sweet.	Stim23 (Correct)
C	24. 4th win (verb) He will win money.	Stim24 (Correct)
C	25. 4th field (n) The field is dry.	Stim25 (Correct)
M	26. 4th airplane (n) The airplane land safely.(morph)	Stim26 (Incorrect)
O	27. 4th felt (verb) She better felt today. (order)	Stim27 (Incorrect)
M	28. 4th few (adj) She use a few. (morph)	Stim28 (Incorrect)
O	29. 4th teach (verb) He will math teach. (order)	Stim29 (Incorrect)
M	30. 4th eye (n) My eye are blue. (morph)	Stim30 (Incorrect)
C	31. 2nd read (verb) He can read Spanish.	Stim31 (Correct)
C	32. 2nd off (prep) The lights went off.	Stim32 (Correct)
C	33. 2nd buy (verb) I buy used books.	Stim33 (Correct)
C	34. 2nd those (adj) I also like those.	Stim34 (Correct)
C	35. 2nd wash (verb) I will wash dishes.	Stim35 (Correct)
O	36. 2nd cold (adj) Cold is the icy. (order)	Stim36 (Incorrect)
M	37. 2nd tell (verb) She tell me often. (morph)	Stim37 (Incorrect)
O	38. 2nd very (adv) They very are happy. (order)	Stim38 (Incorrect)
M	39. 2nd sing (verb) The soloist sing well. (morph)	Stim39 (Incorrect)
O	40. 2nd wish (verb) I a wish made. (order)	Stim40 (Incorrect)
C	41. 3rd pick (verb) They will pick apples.	Stim41 (Correct)
C	42. 3rd got (verb) I got a card.	Stim42 (Correct)
C	43. 3rd seven (adj) She missed seven calls.	Stim43 (Correct)
C	44. 3rd show (verb) You can show me.	Stim44 (Correct)
C	45. 3rd full (adj) The jar is full.	Stim45 (Correct)
O	46. 3rd hot (adj) The hot is soup. (order)	Stim46 (Incorrect)
M	47. 3rd fall (verb) I saw star fall. (morph)	Stim47 (Incorrect)

O	48. 3rd never (adv/adj) Never I will fly. (order)	Stim48 (Incorrect)
M	49. 3rd try (verb) They will tried again. (morph)	Stim49 (Incorrect)
O	50. 3rd about (prep) About me she cares. (order)	Stim50 (Incorrect)
C	51. 4th stand (verb) She will stand up.	Stim51 (Correct)
C	52. 4th nice (adj) They were very nice.	Stim52 (Correct)
C	53. 4th himself (pro) He has surprised himself.	Stim53 (Correct)
C	54. 4th lift (verb) I can lift weights.	Stim54 (Correct)
C	55. 4th true (adj) The story is true.	Stim55 (Correct)
O	56. 4th shut (verb) She the door shut. (order)	Stim56 (Incorrect)
M	57. 4th gray (adj) The cats is gray. (morph)	Stim57 (Incorrect)
O	58. 4th mouth (n) My open is mouth. (order)	Stim58 (Incorrect)
M	59. 4th learn (verb) She learn a lesson. (morph)	Stim59 (Incorrect)
O	60. 4th nine (adj) They nine stayed hours. (order)	Stim60 (Incorrect)
M	61. 2nd block (n) The blocks was blue. (morph)	Stim61 (Incorrect)
O	62. 2nd glad (adj.) He glad is very. (order)	Stim62 (Incorrect)
M	63. 2nd blend (verb) I blends the juice. (morph)	Stim63 (Incorrect)
O	64. 2nd glue (n) She glue the used. (order)	Stim64 (Incorrect)
M	65. 2nd lost (adj) He losts his wallet. (morph)	Stim65 (Incorrect)
O	66. 2nd blink (verb) I my eyes blink. (order)	Stim66 (Incorrect)
M	67. 2nd pond (n) The pond are empty. (morph)	Stim67 (Incorrect)
O	68. 2nd shy (adj) Shy the girl is. (order)	Stim68 (Incorrect)
M	69. 2nd hide (verb) Mom hide the cookies. (morph)	Stim69 (Incorrect)
O	70. 2nd blast (n) The blast loud was. (order)	Stim70 (Incorrect)
M	71. 3rd path (n) The paths is long. (morph)	Stim71 (Incorrect)
O	72. 3rd damp (adj) The damp is road. (order)	Stim72 (Incorrect)
M	73. 3rd join (verb) I joins the team. (morph)	Stim73 (Incorrect)
O	74. 3rd bread (n)The good was bread. (order)	Stim74 (Incorrect)
M	75. 3rd awake (adj) They is awake now. (morph)	Stim75 (Incorrect)
O	76. 3rd spent (verb) I my money spent. (order)	Stim76 (Incorrect)
M	77. 3rd plate (n) I had two plate. (morph)	Stim77 (Incorrect)
O	78. 3rd last (adj) She in came last. (order)	Stim78 (Incorrect)
M	79. 3rd visit (verb) He went to visits. (morph)	Stim79 (Incorrect)
O	80. 3rd street (n) I the street crossed. (order)	Stim80 (Incorrect)
M	81. 4th address (n) I knowed her address. (morph)	Stim81 (Incorrect)
O	82. 4th loud (adj) The loud is baby. (order)	Stim82 (Incorrect)
M	83. 4th remember (verb) She remember my name. (morph)	Stim83 (Incorrect)
O	84. 4th radio (n) Radio is on the. (order)	Stim84 (Incorrect)
M	85. 4th thin (adj) The girls is thin. (morph)	Stim85 (Incorrect)
O	86. 4th throw (verb) He far can throw. (order)	Stim86 (Incorrect)
M	87. 4th stairs (n) She climb the stairs. (morph)	Stim87 (Incorrect)
O	88. 4th different (adj) That dress different is. (order)	Stim88 (Incorrect)
M	89. 4th drop (verb) She drop the glass. (morph)	Stim89 (Incorrect)
O	90. 4th winter (n) the cold is winter. (order)	Stim90 (Incorrect)

Reading Orthographic Decision Task

3 Practice Trials
2nd green – grean *(adj)*
3rd pick – pick *(verb)*
4th suit – sute *(noun)*

Numbers 1-30 were presented at 350ms and numbers 31- 60 were presented at150ms.

Error Type	Stimulus Word and Sentence	Stimulus Type
P	1. 2nd fast – fast *(adv) P*	Stim01 (Correct)
P	2. 2nd sleep – sleep *(verb) P*	Stim02 (Correct)
P	3. 2nd found – faund *(verb) P*	Stim03 (Incorrect)
P	4. 2nd best – bist *(adj) P*	Stim04 (Incorrect)
P	5. 2nd which – wich *(adj) P*	Stim05 (Incorrect)
V	6. 2nd many – many *(adj) V/L*	Stim06 (Correct)
V	7. 2nd their – their *(pro) V/L*	Stim07 (Correct)
V	8. 2nd been – been *(verb) V/L*	Stim08 (Correct)
V	9. 2nd right – rite *(adj) V/L*	Stim09 (Incorrect)
V	10. 2nd does – dose *(verb) V/L*	Stim10 (Incorrect)
P	11. 3rd long – long *(adj) P*	Stim11 (Correct)
P	12. 3rd start – start *(verb) P*	Stim12 (Correct)
P	13. 3rd far – far *(adj) P*	Stim13 (Correct)
P	14. 3rd cut – kut *(verb) P*	Stim14 (Incorrect)
P	15. 3rd six – siks *(adj) P*	Stim15 (Incorrect)
V	16. 3rd warm – warm *(verb) V/L*	Stim16 (Correct)
V	17. 3rd own – own *(verb) V/L*	Stim17 (Correct)
V	18. 3rd small – smoll *(adj) V/L*	Stim18 (Incorrect)
V	19. 3rd eight – eite *(adj) V/L*	Stim19 (Incorrect)
V	20. 3rd laugh – laff *(verb) V/L*	Stim20 (Incorrect)
P	21. 4th ant – ant *(n) P*	Stim21 (Correct)
P	22. 4th matter – matter *(verb) P*	Stim22 (Correct)
P	23. 4th while – wile *(n) P*	Stim23 (Incorrect)
P	24. 4th slip – slipp *(verb) P*	Stim24 (Incorrect)
P	25. 4th late – lait *(adj) P*	Stim25 (Incorrect)
V	26. 4th above – above *(prep) V/L*	Stim26 (Correct)
V	27. 4th building –building *(verb) V/L*	Stim27 (Correct)
V	28. 4th thought – thought *(verb) V/L*	Stim28 (Correct)
V	29. 4th enough – enoff *(adj) V/L*	Stim29 (Incorrect)
V	30. 4th knife – nife *(n) V/L*	Stim30 (Incorrect)
P	31. 2nd five – five *(adj) P*	Stim31 (Correct)
P	32. 2nd us – us *(pro) P*	Stim32 (Correct)
P	33. 2nd sit – sit *(verb) P*	Stim33 (Correct)
P	34. 2nd gave – gaive *(verb) P*	Stim34 (Incorrect)
P	35. 2nd first – ferst *(adj) P*	Stim35 (Incorrect)

V	36. 2nd work – work *(n) V/L*	Stim36 (Correct)
V	37. 2nd would – would*(verb) V/L*	Stim37 (Correct)
V	38. 2nd both – bothe *(adj) V/L*	Stim38 (Incorrect)
V	39. 2nd always – alwaze*(adv) V/L*	Stim39 (Incorrect)
V	40. 2nd write – wright *(verb) V/L*	Stim40 (Incorrect)
P	41. 3rd ten – ten *(adj) P*	Stim41 (Correct)
P	42. 3rd much – much *(adv) P*	Stim42 (Correct)
P	43. 3rd draw – draugh *(verb) P*	Stim43 (Incorrect)
P	44. 3rd better – beter *(adj) P*	Stim44 (Incorrect)
P	45. 3rd shall – shale *(verb) P*	Stim45 (Incorrect)
V	46. 3rd only – only *(adv) V/L*	Stim46 (Correct)
V	47. 3rd done – done *(verb) V/L*	Stim47 (Correct)
V	48. 3rd hold – hold *(verb) V/L*	Stim48 (Correct)
V	49. 3rd light – leight *(n) V/L*	Stim49 (Incorrect)
V	50. 3rd kind – kinde *(adj) V/L*	Stim50 (Incorrect)
P	51. 4th hundred – hundred *(adj) P*	Stim51 (Correct)
P	52. 4th bath – bath *(verb) P*	Stim52 (Correct)
P	53. 4th kiss – kiss *(verb) P*	Stim53 (Correct)
P	54. 4th cause – cuz *(verb) P*	Stim54 (Incorrect)
P	55. 4th bone – boan (n) *P*	Stim55 (Incorrect)
V	56. 4th bought – bought *(verb) V/L*	Stim56 (Correct)
V	57. 4th breakfast-breakfast *(n) V/L*	Stim57 (Correct)
V	58. 4th through- thrugh *(prep) V/L*	Stim58 (Incorrect)
V	59. 4th country- kuntry *(n) V/L*	Stim59 (Incorrect)
V	60. 4th feather – fether *(n) V/L*	Stim60 (Incorrect)

Auditory Linguistic Experimental Set

Auditory Semantic Decision Task

3 Practice Trials
Rich (adj) The king is rich.
sea (n) The sea is dry.
Lead (verb) She will lead from behind.

Numbers 1-30 were presented at a normal rate and numbers 31-60 were time compressed.

Stimulus Word and Sentence	Stimulus Type
1. 2nd wish (verb) She made a wish.	Stim1 (Correct)
2. 2nd wash (verb) I wash my clothes.	Stim2 (Correct)
3. 2nd sing (verb) I sing at church.	Stim3 (Correct)
4. 2nd use (verb) I use my phone.	Stim4 (Correct)
5. 2nd very (adv) You are very nice.	Stim5 (Correct)
6. 2nd us (pro) The cake ate us.	Stim6 (Incorrect)
7. 2nd those (adj) Those chairs are desks.	Stim7 (Incorrect)

8. 2^{nd} pull (verb) Ants can pull cars.	Stim8 (Incorrect)
9. 2^{nd} call (verb) You call the house.	Stim9 (Incorrect)
10. 2^{nd} these (adj) These people are animals.	Stim10 (Incorrect)
11. 3^{rd} myself (pro) I feel like myself.	Stim11 (Correct)
12. 3^{rd} try (verb) I can try again.	Stim12 (Correct)
13. 3^{rd} together (adv) They are together again.	Stim13 (Correct)
14. 3^{rd} show (verb) She will show pictures.	Stim14 (Correct)
15. 3^{rd} about (prep) He cares about her.	Stim15 (Correct)
16. 3^{rd} today (n) Today is before yesterday.	Stim16 (Incorrect)
17. 3^{rd} fall (verb) She will fall up.	Stim17 (Incorrect)
18. 3^{rd} keep (verb) I keep her elephant.	Stim18 (Incorrect)
19. 3^{rd} got (verb)She's got the moon.	Stim19 (Incorrect)
20. 3^{rd} hot (adj) The ice is hot.	Stim20 (Incorrect)
21. 4^{th} edge (n) The edge is sharp.	Stim21 (Correct)
22. 4^{th} cook (verb) She will cook supper.	Stim22 (Correct)
23. 4^{th} silver (adj) The ring is silver.	Stim23 (Correct)
24. 4^{th} beans (n) The beans	Stim24 (Correct)
25. 4^{th} hair (n) His hair is long.	Stim25 (Correct)
26. 4^{th} finger (n) She has twenty fingers.	Stim26 (Incorrect)
27. 4^{th} hungry (verb) The food is hungry.	Stim27 (Incorrect)
28. 4^{th} dry (adj) The water is dry.	Stim28 (Incorrect)
29. 4^{th} soap (n) The soap is dirty.	Stim29 (Incorrect)
30. 4^{th} wear (verb) The cow wears pants.	Stim30 (Incorrect)
31. 2^{nd} buy (verb) I can buy gum.	Stim31 (Correct)
32. 2^{nd} tell (verb) She can tell stories.	Stim32 (Correct)
33. 2^{nd} off (prep) His hat fell off.	Stim33 (Correct)
34. 2^{nd} cold (adj) The floor is cold.	Stim34 (Correct)
35. 2^{nd} read (verb) I can read books.	Stim35 (Correct)
36. 2^{nd} green (adj) The sky is green.	Stim36 (Incorrect)
37. 2^{nd} its (pro) Its raining sun shine.	Stim37 (Incorrect)
38. 2^{nd} goes (verb) The turtle goes fast.	Stim38 (Incorrect)
39. 2^{nd} made (verb) Cake made the boy.	Stim39 (Incorrect)
40. 2^{nd} your (pro) Your car has feet.	Stim40 (Incorrect)
41. 3^{rd} grow (verb) I can grow flowers.	Stim41 (Correct)
42. 3^{rd} seven (adj) I am seven now.	Stim42 (Correct)
43. 3^{rd} carry (verb) I carry my books.	Stim43 (Correct)
44. 3^{rd} full (adj) The basket is full.	Stim44 (Correct)
45. 3^{rd} hurt (verb) My feelings are hurt.	Stim45 (Correct)
46. 3^{rd} clean (verb) The dirt is clean.	Stim46 (Incorrect)
47. 3^{rd} never (adv/adj) It never rains early.	Stim47 (Incorrect)
48. 3^{rd} bring (verb) Chips can bring dip.	Stim48 (Incorrect)
49. 3^{rd} pick (verb) Grapes will pick her.	Stim49 (Incorrect)
50. 3^{rd} drink (verb) You should drink meat.	Stim50 (Incorrect)
51. 4^{th} knock (verb) I will knock twice.	Stim51 (Correct)
52. 4^{th} bad (adj) The fruit is bad.	Stim52 (Correct)

53. 4th early (adv) He got up early.	Stim53 (Correct)
54. 4th side (n) I'm on her side.	Stim54 (Correct)
55. 4th nap (verb) I took a nap.	Stim55 (Correct)
56. 4th heavy (adj) The feather is heavy.	Stim56 (Incorrect)
57. 4th pie (n) The pie is cake.	Stim57 (Incorrect)
58. 4th twelve (adj) He has twelve feet.	Stim58 (Incorrect)
59. 4th sound (n.) The sound is silent.	Stim59 (Incorrect)
60. 4th built (verb) The house built steps.	Stim60 (Incorrect)

Auditory Syntactic Decision Task

3 Practice Trials

foot (n)	My foot dirty is.
broken (adj)	The vase is broken.
listen (verb)	She listen to music.

Numbers 1-30 and 61-75 were presented at a normal rate and numbers 31-60 and 76-90 were time compressed.

Error Type	Stimulus Word and Sentence	Stimulus Type
C	1. 2nd goes (verb) He goes to school.	Stim1 (Correct)
C	2. 2nd its (pro) Its time to go.	Stim2 (Correct)
C	3. 2nd call (verb) I made the call.	Stim3 (Correct)
C	4. 2nd these (adj) I can take these.	Stim4 (Correct)
C	5. 2nd read (verb) I can read fast.	Stim5 (Correct)
O	6. 2nd your (pro) I your hat like. (order error)	Stim6 (Incorrect)
M	7. 2nd made (verb) The girl made cookie. (morph error)	Stim7 (Incorrect)
O	8. 2nd green (adj) The green is grass. (order error)	Stim8 (Incorrect)
M	9. 2nd pull (verb) She pull the rope. (morph error)	Stim9 (Incorrect)
O	10. 2nd cold (adj) Cold is the snow. (order error)	Stim10 (Incorrect)
C	11. 3rd full (adj) The jar is full.	Stim11 (Correct)
C	12. 3rd drink (verb) I will drink juice.	Stim12 (Correct)
C	13. 3rd pick (verb) I can pick strawberries.	Stim13 (Correct)
C	14. 3rd bring (verb) She will bring chips.	Stim14 (Correct)
C	15. 3 rd myself (pro) I took myself shopping.	Stim15 (Correct)
O	16. 3rd keep (verb) You it can keep. (order error)	Stim16 (Incorrect)
M	17. 3rd hurt (verb) My back still hurt. (morph error)	Stim17 (Incorrect)
O	18. 3rd today (n) She came today home. (order error)	Stim18 (Incorrect)
M	19. 3rd carry (verb) He carry the mail. (morph error)	Stim19 (Incorrect)
O	20. 3rd hot (adj) Hot is the sun. (order error)	Stim20 (Incorrect)
C	21. 4th gift (n) The gift was nice.	Stim21 (Correct)
C	22. 4th count (verb) She counted her money.	Stim22 (Correct)
C	23. 4th soft (adj) The pillow is soft.	Stim23 (Correct)
C	24. 4th herself (pro) She can help herself.	Stim24 (Correct)

C	25. 4th pay (verb) I will pay extra.	Stim25 (Correct)
O	26. 4th kitten (n) She the kittens held. (order error)	Stim26 (Incorrect)
M	27. 4th plant (verb) She plant the tomatoes. (morph er)	Stim27 (Incorrect)
O	28. 4th ready (adj) I ready am now. (order error)	Stim28 (Incorrect)
M	29. 4th without (prep) She walk without shoe. (morph er)	Stim29 (Incorrect)
O	30. 4th bake (verb) I cake the bake. (order error)	Stim30 (Incorrect)
C	31. 2nd us (pro) You can seat us.	Stim31 (Correct)
C	32. 2nd buy (verb) You can buy lunch.	Stim32 (Correct)
C	33. 2nd tell (verb) I tell the truth.	Stim33 (Correct)
C	34. 2nd wash (verb) I wash the dishes.	Stim34 (Correct)
C	35. 2nd sing (verb) I sing to music.	Stim35 (Correct)
M	36. 2nd wish (verb) She wish for snow. (morph error)	Stim36 (Incorrect)
O	37. 2nd off (prep) Off light is the. (order error)	Stim37 (Incorrect)
M	38. 2nd very (adv) She run very fast. (morph error)	Stim38 (Incorrect)
O	39. 2nd use (verb) I use soap hand. (order error)	Stim39 (Incorrect)
M	40. 2nd those (adj) Those key are mine. (morph error)	Stim40 (Incorrect)
C	41. 3rd clean (verb) My room is clean.	Stim41 (Correct)
C	42. 3rd together (adv) We are still together.	Stim42 (Correct)
C	43. 3rd got (verb) I got the mail.	Stim43 (Correct)
C	44. 3rd seven (adj) He ate seven cookies.	Stim44 (Correct)
C	45. 3rd show (verb) I will show you.	Stim45 (Correct)
M	46. 3rd grow (verb) The tree grow tall. (morph error)	Stim46 (Incorrect)
O	47. 3rd never (adv/adj) I will leave never. (order error)	Stim47 (Incorrect)
M	48. 3rd fall (verb) The baby fall asleep. (morph error)	Stim48 (Incorrect)
O	49. 3rd about (prep) You about care me. (order error)	Stim49 (Incorrect)
M	50. 3rd try (verb) He try the soup. (morph error)	Stim50 (Incorrect)
C	51. 4th socks (n) My socks are dirty.	Stim51 (Correct)
C	52. 4th should (verb) You should go soon.	Stim52 (Correct)
C	53. 4th plain (adj) I eat plain pizza.	Stim53 (Correct)
C	54. 4th page (n) I turned the page.	Stim54 (Correct)
C	55. 4th need (verb) I need a job.	Stim55 (Correct)
M	56. 4th strong (adj) He has strong muscle. (morph error)	Stim56 (Incorrect)
O	57. 4th river (n) The river deep is. (order error)	Stim57 (Incorrect)
M	58. 4th wave (verb) He saw wave crash. (morph error)	Stim58 (Incorrect)
O	59. 4th cool (adj) The air cool is. (order error)	Stim59 (Incorrect)
M	60. 4th bit (verb) I added bacon bit. (morph error)	Stim60 (Incorrect)
M	61. 2nd hatch(verb)The chickens will hatched.(morph er)	Stim61 (Incorrect)
O	62. 2nd track (n) The new is track. (order error)	Stim62 (Incorrect)
M	63. 2nd stack (verb) I stacks my clothes. (morph error)	Stim63 (Incorrect)
O	64. 2nd silly (adj) You silly are so. (order error)	Stim64 (Incorrect)
M	65. 2nd truck (n) The trucks is dirty. (morph error)	Stim65 (Incorrect)
M	66. 3nd dump (verb) I dumps the trash. (morph error)	Stim66 (Incorrect)
O	67. 3rd storm (n) The near is storm. (order error)	Stim67 (Incorrect)
M	68. 3rd dark (adj) The skys is dark. (morph error)	Stim68 (Incorrect)
O	69. 3rd hurry (verb) I home will hurry. (order error)	Stim69 (Incorrect)

M	70. 3rd candle (n) She light the candle. (morph error)	Stim70 (Incorrect)
M	71. 4th kept (verb) I kepted the money. (morph error)	Stim71 (Incorrect)
O	72. 4th cloud (n) The moving is cloud. (order error)	Stim72 (Incorrect)
M	73. 4th trade (verb) She trade her lunch. (morph error)	Stim73 (Incorrect)
O	74. 4th sure (adj) I am sure not. (order error)	Stim74 (Incorrect)
M	75. 4th pencil (n) My pencils is sharp. (morph error)	Stim75 (Incorrect)
O	76. 2nd stick (n) A stick he threw. (order error)	Stim76 (Incorrect)
M	77. 2nd rude (adj) He are very rude. (morph error)	Stim77 (Incorrect)
O	78. 2nd sat (verb) She sat me on. (order error)	Stim78 (Incorrect)
M	79. 2nd drum (n) I plays the drum. (morph error)	Stim79 (Incorrect)
O	80. 2nd safe (adj) You safe are here. (order error)	Stim80 (Incorrect)
O	81. 3rd cone (n) Orange is the cone. (order error)	Stim81 (Incorrect)
M	82. 3rd top (adj) Cherrie are on top. (morph error)	Stim82 (Incorrect)
O	83. 3rd scrub (verb) I scrub hands my. (order error)	Stim83 (Incorrect)
M	84. 3rd flute (n) I plays the flute. (morph error)	Stim84 (Incorrect)
O	85. 3rd easy (adj) Easy was the test. (order error)	Stim85 (Incorrect)
O	86. 4th family (n) My family large is. (order error)	Stim86 (Incorrect)
M	87. 4th poor (adj) The mans is poor. (morph error)	Stim87 (Incorrect)
O	88. 4th began (verb) To read I began. (order error)	Stim88 (Incorrect)
M	89. 4th fur (n) Her furs is soft. (morph error)	Stim89 (Incorrect)
O	90. 4th real (adj) The is flower real. (order error)	Stim90 (Incorrect)

Auditory Orthographic Decision Task

3 Practice Trials
2nd green – grean *(adj)*
3rd pick – pike *(verb)*
4th suit – sute *(noun)*

Numbers 1-30 were presented at 150ms (normal rate) and numbers 31-60 were presented at 100 ms (time compressed).

Error Type	Stimulus Word and Sentence	Stimulus Type
P	1. 2nd found – found *(verb) P*	Stim1 (Correct)
P	2. 2nd best – best *(adj) P*	Stim2 (Correct)
P	3. 2nd gave – gave *(verb) P*	Stim3 (Correct)
P	4. 2nd which – wish *(adj) P*	Stim4 (Incorrect)
P	5. 2nd fast – fats *(adv) P*	Stim5 (Incorrect)
V	6. 2nd right – right *(adj) V/L*	Stim6 (Correct)
V	7. 2nd work – work *(noun) V/L*	Stim7 (Correct)
V	8. 2nd many – meny *(adj) V/L*	Stim8 (Incorrect)
V	9. 2nd their – thair *(pro) V/L*	Stim9 (Incorrect)
V	10. 2nd always – always*(adv) V/L*	Stim10 (Incorrect)
P	11. 3rd cut – cut *(verb) P*	Stim11 (Correct)

P	12. 3rd shall – shall *(verb) P*	Stim12 (Correct)
P	13. 3rd long – longue *(adj) P*	Stim13 (Incorrect)
P	14. 3rd draw – drow *(verb) P*	Stim14 (Incorrect)
P	15. 3rd six – sicks *(adj) P*	Stim15 (Incorrect)
V	16. 3rd small – small *(adj) V/L*	Stim16 (Correct)
V	17. 3rd laugh – laugh *(verb) V/L*	Stim17 (Correct)
V	18. 3rd light – light *(n) V/L*	Stim18 (Correct)
V	19. 3rd own – one *(verb) V/L*	Stim19 (Incorrect)
V	20. 3rd eight – aight *(adj) V/L*	Stim20 (Incorrect)
P	21. 4th slip – slip *(verb) P*	Stim21 (Correct)
P	22. 4th while – while *(n) P*	Stim22 (Correct)
P	23. 4th bone – bone *(n) P*	Stim23 (Correct)
P	24. 4th ant – ante *(n) P*	Stim24 (Incorrect)
P	25. 4th late – leight *(adj) P*	Stim25 (Incorrect)
V	26. 4th enough – enough *(adj) V/L*	Stim26 (Correct)
V	27. 4th knife – knife *(n) V/L*	Stim27 (Correct)
V	28. 4th building –bilding*(verb) V/L*	Stim28 (Incorrect)
V	29. 4th breakfast –brakefast*(n) V/L*	Stim29 (Incorrect)
V	30. 4th brought – braut *(verb) V/L*	Stim30 (Incorrect)
P	31. 2nd sit – sit *(verb) P*	Stim31 (Correct)
P	32. 2nd first – first *(adj) P*	Stim32 (Correct)
P	33. 2nd sleep – sleap *(verb) P*	Stim33 (Incorrect)
P	34. 2nd five – faive *(adj) P*	Stim34 (Incorrect)
P	35. 2nd us – uss *(pro) P*	Stim35 (Incorrect)
V	36. 2nd does – does *(verb) V/L*	Stim36 (Correct)
V	37. 2nd both – both *(adj) V/L*	Stim37 (Correct)
V	38. 2nd write – write *(verb) V/L*	Stim38 (Correct)
V	39. 2nd been – bin *(verb) V/L*	Stim39 (Incorrect)
V	40. 2nd would – woad *(verb) V/L*	Stim40 (Incorrect)
P	41. 3rd far – far *(adj) P*	Stim41 (Correct)
P	42. 3rd start – start *(verb) P*	Stim42 (Correct)
P	43. 3rd better – better *(adj) P*	Stim43 (Correct)
P	44. 3rd ten – tin *(adj) P*	Stim44 (Incorrect)
P	45. 3rd much –muth *(adv) P*	Stim45 (Incorrect)
V	46. 3rd hold – hold *(verb) V/L*	Stim46 (Correct)
V	47. 3rd kind – kind *(adj) V/L*	Stim47 (Correct)
V	48. 3rd warm –worm *(verb) V/L*	Stim48 (Incorrect)
V	49. 3rd done – dun *(verb) V/L*	Stim49 (Incorrect)
V	50. 3rd only – oanly *(adv) V/L*	Stim50 (Incorrect)
P	51. 4th cause – cause *(verb) P*	Stim51 (Correct)
P	52. 4th kiss – kiss *(verb) P*	Stim52 (Correct)
P	53. 4th hundred- hondred *(adj) P*	Stim53 (Incorrect)
P	54. 4th matter – metter (verb) *P*	Stim54 (Incorrect)
P	55. 4th bath – bathe *(verb) P*	Stim55 (Incorrect)
V	56. 4th through- through*(prep) V/L*	Stim56 (Correct)

V	57. 4th feather – feather *(n) V/L*	Stim57 (Correct)
V	58. 4th above – above *(prep) V/L*	Stim58 (Correct)
V	59. 4th country – cuntry *(n) V/L*	Stim59 (Incorrect)
V	60. 4th straight- strate *(adj) V/L*	Stim60 (Incorrect)

APPENDIX I: TASK DIRECTIONS

Reading (Semantic)

In a few moments, you will be asked to read a series of short sentences presented one at a time. A fixation point will be shown between each sentence to help you focus on the screen. Immediately after the fixation point appears on the screen, the next sentence will appear. Sentences will either make sense or seem a little strange. If you think the sentence makes sense, you will press the white button on the right. If the sentence does not make sense, you will press the black key to the left. Sentences will appear on the screen at a normal rate or at a fast rate. Please read each sentence as quickly as you can and press the corresponding button. Let's try some practice tasks. The first sentence (The pen is clear) does not make sense because pens are not clear and ink is not clear. The second sentence (The snail is quick) does not make sense because snails move slowly. The third sentence (She stood straight up) makes sense.

Reading (Syntactic)

In a few moments, you will be asked to read a series of short sentences presented one at a time. A fixation point will be shown between each sentence to help you focus on the screen. Immediately after the fixation point appears on the screen, the next sentence will appear. Sentences will either sound correct or have order errors or tense errors. If you think the sentence sounds correct, you will press the white button on the right. If the sentence contains order or tense errors, you will press the black key to the left. Sentences will appear on the screen at a normal rate or at a fast rate. Please read each sentence as quickly as you can and press the corresponding button. Let's try some practice tasks. The first sentence (I started before her) is correct because the words are in the correct order and the tense is correct. The second sentence (I counted my dime) is incorrect because you count dimes. The third sentence (The fresh is fruit) is incorrect because the words are not in the correct order.

Reading (Orthographic)

In a few moments, you will be asked to read a series of words presented one at a time. A fixation point will be shown between each sentence to help you focus on the screen. Immediately after the fixation point appears on the screen, the next sentence will appear. Words will either be spelled correctly or incorrectly. If you think the word is spelled correctly, you will press the white button on the right. If the word is spelled incorrectly, you will press the black key to the left. Words will appear on the screen at a normal rate or at a fast rate. Please read each word as quickly as you can and press the corresponding button. Let's try some practice tasks. The first word (green) is spelled incorrectly as grean. The second word (pick) is spelled correctly as pick. The third word (suit) is spelled incorrectly as sute.

Auditory (Semantic)

In a few moments, you will be asked to listen to a series of short sentences presented one at a time. A fixation point will be shown between each sentence to help you focus. Immediately after the fixation point appears on the screen, you will hear the next sentence. Sentences will either make sense or seem a little strange. If you think the sentence makes sense, you will press the white button on the right. If the sentence does not make sense, you will press the black key to the left. You will hear sentences at a normal rate or at a fast rate. Please listen to each sentence carefully and press the corresponding button as quickly as possible. Let's try some practice tasks. The first sentence (The king is rich) makes sense. The second sentence (The sea is dry) does not make sense because the sea is full of water. The third sentence (She will lead from behind) does not make sense because you lead from the front.

Auditory (Syntactic)

In a few moments, you will be asked to listen to a series of short sentences presented one at a time. A fixation point will be shown between each sentence to help you focus. Immediately after the fixation point appears on the screen, you will hear the next sentence. Sentences will either sound correct or have order errors or tense errors. If you think the sentence sounds correct, you will press the white button on the right. If the sentence contains order or tense errors, you will press the black key to the left. You will hear sentences at a normal rate or at a fast rate. Please listen to each sentence carefully and press the corresponding button as quickly as possible. Let's try some practice tasks. The first sentence (My foot dirty is) is incorrect because the words are not in the correct order. The second sentence (The vase is broken) is correct because the words are in the correct order and are in the right tense. The third sentence (She listen to music) is incorrect because the words are not in the correct tense.

Auditory (Reading/Orthographic)

In a few moments, you will be asked to read a series of words presented one at a time. You will hear the same word at the same time its being presented on the screen. A fixation point will be shown between each sentence to help you focus on the screen. Immediately after the fixation point appears on the screen, the next sentence will appear. Words on the screen will either be spelled correctly or incorrectly. If you think the word is spelled correctly, you will press the white button on the right. If the word is spelled incorrectly, you will press the black key to the left. Words will appear on the screen at a normal rate or at a fast rate. Please read each word as quickly as you can and press the corresponding button. Let's try some practice tasks. The first word (green) is spelled incorrectly as grean. The second word (pick) is spelled incorrectly as pike. The third word (suit) is spelled incorrectly as sute.

APPENDIX J: INDIVIDUAL REACTION TIMES FOR READING EXPERIENTAL TASKS

PART. ID	SEM 1200ms	SEM 600ms	SYN 1200ms	SYN 600ms	ORTHO 350ms	ORTHO 150ms
1	2047.86	2139.50	1896.36	2066.18	947.97	842.17
2	2256.73	2068.76	2440.97	1846.69	947.67	930.62
3	1639.79	1600.31	2587.41	1360.09	2532.12	2514.68
4	1180.95	554.22	768.53	1838.07	1404.30	1165.26
5	1921.30	2233.07	1764.09	2114.22	1112.87	1304.03
6	1290.27	1213.12	1257.21	1181.60	1147.23	1142.00
7	1228.83	1007.10	1323.70	725.12	695.87	1533.40
8	1398.27	1966.85	1470.47	1914.07	700.97	822.04
9	1512.21	1717.57	1572.76	1737.71	1077.64	1122.93
10	981.20	1338.69	885.16	1188.68	714.47	716.30
11	1927.21	2096.07	2090.21	2324.80	1585.43	1302.72
12	1861.04	1223.12	1458.57	2132.45	1665.57	1574.00
13	753.50	993.18	900.95	1320.14	762.70	800.76
14	1601.20	820.28	1328.41	1130.38	1049.00	1053.90
15	1988.79	1910.27	1137.11	1657.29	1712.14	1282.53
16	2203.39	2490.14	2272.21	2423.12	1407.68	1329.76
17	1239.54	1649.13	1474.74	1515.00	1572.03	1550.42
18	907.25	772.07	1837.47	681.78	331.85	547.83
19	873.23	832.43	1224.65	1363.53	837.30	906.67
20	897.41	1541.10	1202.84	1583.49	652.66	467.15
21	1715.72	1759.50	1103.92	578.84	757.92	1034.50
22	1549.03	1384.13	1606.46	1622.09	935.71	1076.37
23	1049.61	714.30	1988.32	1135.12	1043.86	1809.00
24	1186.20	1363.93	1098.09	1238.49	519.37	792.43
25	1507.63	1258.22	2052.19	1672.15	845.54	1322.90
26	1530.11	2116.00	1623.61	2307.49	1352.13	1153.73
27	1577.10	1451.10	1797.62	1643.51	1069.90	1192.53
28	1665.35	1021.09	1530.46	1056.97	977.70	919.52
29	836.43	1318.63	1443.11	1485.98	1028.67	858.23
30	670.96	1318.33	1091.44	1508.87	961.20	945.87
31	1273.70	1556.31	968.76	1312.48	655.53	702.80
32	1526.97	1814.93	1560.84	1966.75	875.97	801.72
33	1306.37	1363.28	1067.80	1178.48	490.00	632.53
34	908.57	690.50	1049.61	551.81	396.73	478.27
35	1440.57	1809.20	1473.77	1000.67	872.80	1001.10
36	1318.59	1677.07	1663.98	2041.79	1103.35	952.00
37	1287.55	1841.86	1400.61	1244.05	1094.97	1040.83
38	843.61	1513.79	1074.60	1656.83	899.03	1057.93
39	1115.80	1658.47	883.91	1594.84	860.07	1150.40
40	1730.58	1287.04	1982.19	1618.82	2032.79	2253.42
41	1410.30	2017.35	1564.66	1651.84	2008.38	1348.70

42	936.79	1913.50	1343.09	1560.71	891.33	943.10
43	2373.35	2292.00	2395.56	2387.25	1413.77	1413.87
44	1051.60	1352.32	1449.23	1378.64	869.32	802.20
45	1334.14	1220.87	1397.82	1916.09	1184.55	1055.87
46	1053.96	1252.03	1789.20	1613.64	1040.66	1248.72
47	981.70	919.00	1702.88	1003.22	607.93	1026.17
48	2038.10	2158.92	1663.28	1456.97	590.83	791.48
49	1992.30	1684.57	1287.45	959.80	813.33	1007.31
50	1700.38	2280.27	2252.26	2768.14	1347.83	1370.36

APPENDIX K: INDIVIDUAL ACCURACY SCORES FOR READING EXPERIENTAL TASKS

PART. ID	SEM 1200ms	SEM 600ms	SYN 1200ms	SYNT 600ms	ORTHO 350ms	ORTHO 150ms
1	50.00	43.33	55.56	46.67	83.33	76.67
2	50.00	60.00	42.22	55.56	73.33	76.67
3	56.67	53.33	55.56	55.56	63.33	36.67
4	56.67	53.33	46.67	73.33	66.67	66.67
5	76.67	70.00	84.44	80.00	83.33	86.67
6	63.33	46.67	60.00	53.33	60.00	43.33
7	63.33	53.33	44.44	51.11	80.00	80.00
8	96.67	83.33	84.44	82.22	90.00	86.67
9	80.00	53.33	88.89	60.00	60.00	80.00
10	86.67	76.67	66.67	60.00	90.00	90.00
11	83.33	70.00	68.89	68.89	63.33	63.33
12	50.00	40.00	75.56	60.00	70.00	76.67
13	100.00	83.33	82.22	91.11	83.33	90.00
14	36.67	63.33	53.33	51.11	76.67	80.00
15	63.33	50.00	55.56	48.89	86.67	90.00
16	83.33	73.33	86.67	71.11	86.67	86.67
17	56.67	46.67	44.44	42.22	73.33	63.33
18	56.67	60.00	64.44	46.67	33.33	66.67
19	73.33	46.67	53.33	57.78	70.00	73.33
20	63.33	60.00	64.44	57.78	73.33	53.33
21	70.00	70.00	17.78	31.11	53.33	60.00
22	70.00	56.67	44.44	57.78	66.67	83.33
23	40.00	40.00	73.33	57.78	76.67	70.00
24	70.00	56.67	51.11	55.56	70.00	83.33
25	80.00	50.00	62.22	48.89	53.33	80.00
26	83.33	76.67	82.22	64.44	86.67	96.67
27	53.33	60.00	64.44	51.11	76.67	90.00
28	20.00	46.67	24.44	28.89	46.67	66.67
29	80.00	80.00	91.11	80.00	90.00	90.00
30	93.33	96.67	91.11	91.11	96.67	93.33
31	73.33	83.33	82.22	60.00	100.00	86.67
32	83.33	73.33	60.00	60.00	80.00	86.67
33	66.67	56.67	64.44	64.44	70.00	63.33
34	56.67	53.33	55.56	28.89	36.67	53.33
35	76.67	70.00	31.11	53.33	86.67	83.33
36	73.33	83.33	86.67	82.20	90.00	76.67
37	63.33	60.00	55.56	48.89	83.33	80.00
38	90.00	83.33	86.67	66.67	86.67	93.33
39	93.33	80.00	77.78	66.67	80.00	90.00
40	16.67	63.33	40.00	57.78	40.00	36.67

41	70.00	60.00	77.78	75.56	86.67	93.33
42	86.67	83.33	86.67	80.00	76.67	96.67
43	53.33	70.00	64.44	55.56	83.33	90.00
44	73.33	70.00	60.00	60.00	66.67	66.67
45	50.00	53.33	37.78	60.00	80.00	90.00
46	43.33	60.00	75.56	53.33	60.00	70.00
47	46.67	63.33	53.33	46.67	53.33	46.67
48	66.67	53.33	51.11	48.89	53.33	60.00
49	66.67	56.67	51.11	46.67	53.33	63.33
50	93.33	76.67	84.44	80.00	86.67	83.33

APPENDIX L: INDIVIDUAL REACTION TIMES FOR AUDITORY EXPERIENTAL TASKS

PART. ID	SEM N	SEM TC	SYN N	SYN TC	ORTHO N/150	ORTHO TC/100
1	948.70	839.90	896.60	988.60	1056.17	724.43
2	1694.13	2039.41	1813.79	2375.23	2358.27	1777.97
3	2380.54	2062.15	1153.31	1345.00	2735.19	1656.80
4	1410.23	1736.90	1047.42	942.03	697.97	1700.00
5	1411.72	1521.79	1390.02	1718.09	2185.69	1797.83
6	1182.53	1326.37	1355.07	1399.98	925.90	851.07
7	1003.07	1324.40	1439.96	1657.68	1898.28	1316.60
8	1554.67	1459.13	1237.69	1932.66	1247.61	914.20
9	1391.71	1515.43	1251.67	1464.50	1457.30	1090.43
10	731.76	840.53	659.05	701.60	905.87	922.63
11	2203.00	1594.28	1753.86	1740.33	1934.59	1948.48
12	1564.00	1802.48	1691.96	1157.12	1941.57	1518.53
13	823.03	1211.27	882.48	1002.78	793.23	833.60
14	1005.66	526.20	513.18	624.37	271.30	1343.47
15	1286.43	1100.93	1030.33	1251.33	1531.60	1425.10
16	2102.84	2363.93	1872.05	2185.33	1293.40	1722.00
17	1380.31	1761.47	2149.67	1526.08	2149.93	1737.83
18	238.65	323.36	736.34	488.63	1266.27	721.86
19	876.43	975.83	1089.84	1333.09	1192.23	1042.43
20	930.60	1382.00	776.84	861.93	784.31	778.54
21	1078.46	856.67	1058.90	1367.57	276.07	418.42
22	1422.60	1391.79	1046.98	1265.84	1497.07	1391.37
23	1740.03	1397.73	1251.89	1610.52	1055.13	1172.55
24	1283.10	1190.40	881.89	1123.93	1122.72	1098.60
25	993.83	825.14	700.16	678.27	898.43	1106.00
26	1591.32	1620.76	1171.42	1571.83	986.40	918.27
27	1424.77	1567.17	1316.91	1597.48	1687.47	1789.63
28	1951.10	1724.36	1216.95	1289.38	2113.48	1845.07
29	1369.00	1694.37	1414.67	1761.83	1473.40	1433.21
30	1170.79	1664.79	1157.73	1885.62	1305.23	1351.47
31	849.33	1223.67	1131.71	1361.68	939.90	748.63
32	1521.73	2010.14	1347.38	1994.57	1033.41	1323.37
33	1070.77	821.00	651.16	870.76	1177.97	760.60
34	1166.75	872.03	1087.67	904.18	1262.30	818.90
35	1178.70	1068.97	1048.16	1451.49	1451.83	1466.47
36	1483.41	1544.38	1535.43	1890.59	1481.37	1270.57
37	1547.23	1336.79	1462.73	1761.35	2126.80	1331.13
38	1346.21	1249.13	1359.64	1164.20	1866.50	1410.54
39	1282.86	1484.11	986.61	1341.29	1727.21	1178.13
40	1493.28	1464.17	1533.44	1754.98	2004.52	816.61
41	1171.27	1238.33	1659.53	1850.56	1264.17	1507.52

42	1057.40	1263.37	990.13	1243.82	1446.63	1257.97
43	1376.07	1996.41	1647.93	1570.91	2078.62	1507.18
44	1447.30	1532.48	1072.42	1322.07	1033.93	1023.53
45	1128.80	1082.28	1009.80	1217.42	1231.03	1033.77
46	1767.13	1733.50	1220.34	1546.50	2097.18	1561.79
47	1440.37	1313.53	1152.05	1146.76	1725.11	2160.41
48	763.90	1467.46	1324.33	1823.75	1808.39	1527.44
49	1310.90	1730.97	823.24	1192.87	2202.10	2183.38
50	2423.07	2104.79	1578.84	1734.49	1795.66	1678.69

APPENDIX M: INDIVIDUAL ACCURACY SCORES FOR AUDITORY EXPERIENTAL TASKS

PART. ID	SEM N	SEM TC	SYN N	SYN TC	ORTHO N/150	ORTHO TC/100
1	80.00	43.33	73.33	66.67	66.67	66.67
2	66.67	53.33	80.00	62.22	70.00	56.67
3	70.00	73.33	88.89	51.11	46.67	56.67
4	63.33	80.00	84.44	57.78	36.67	80.00
5	76.67	73.33	84.44	77.78	66.67	80.00
6	63.33	66.67	82.22	68.89	40.00	30.00
7	73.33	66.67	75.56	71.11	56.67	76.67
8	83.33	73.33	84.44	68.89	80.00	76.67
9	60.00	53.33	88.89	66.67	66.67	86.67
10	86.67	70.00	80.00	64.44	86.67	76.67
11	73.33	63.33	68.89	55.56	66.67	70.00
12	70.00	73.33	77.78	46.67	43.33	60.00
13	83.33	50.00	91.11	73.33	70.00	93.33
14	63.33	50.00	57.78	42.22	53.33	66.67
15	76.67	63.33	80.00	60.00	83.33	70.00
16	80.00	73.33	73.33	73.33	83.33	90.00
17	86.67	43.33	84.44	44.44	50.00	36.67
18	30.00	13.33	77.78	55.56	56.67	50.00
19	76.67	43.33	84.44	68.89	53.33	53.33
20	70.00	63.33	44.44	53.33	53.33	56.67
21	83.33	66.67	57.78	60.00	46.67	43.33
22	86.67	63.33	95.56	80.00	63.33	63.33
23	83.33	70.00	84.44	77.78	66.67	56.67
24	86.67	63.33	80.00	62.22	66.67	70.00
25	83.33	60.00	77.78	68.89	56.67	60.00
26	76.67	66.67	84.44	66.67	86.67	83.33
27	90.00	66.67	66.67	60.00	80.00	66.67
28	70.00	46.67	75.56	66.67	43.33	60.00
29	83.33	73.33	80.00	66.67	66.67	50.00
30	93.33	80.00	86.67	71.11	96.67	90.00
31	80.00	76.67	88.89	71.11	86.67	93.33
32	96.67	70.00	97.78	62.22	70.00	70.00
33	86.67	73.33	84.44	68.89	56.67	56.67
34	66.67	46.67	57.78	53.33	60.00	46.67
35	80.00	60.00	80.00	71.11	66.67	80.00
36	83.33	66.67	71.11	71.11	76.67	90.00
37	76.67	66.67	75.56	33.33	70.00	76.67
38	83.33	70.00	80.00	80.00	80.00	80.00
39	83.33	70.00	77.78	62.22	73.33	83.33
40	73.33	63.33	57.78	60.00	40.00	33.33

41	83.33	66.67	93.33	84.44	76.67	86.67
42	90.00	86.67	91.11	82.22	83.33	90.00
43	76.67	80.00	75.56	62.22	60.00	76.67
44	93.33	73.33	55.56	57.78	63.33	83.33
45	60.00	63.33	77.78	77.78	56.67	86.67
46	66.67	80.00	73.33	64.44	40.00	50.00
47	76.67	63.33	64.44	44.44	53.33	66.67
48	70.00	56.67	60.00	60.00	66.67	53.33
49	90.00	80.00	93.33	77.78	43.33	33.33
50	76.67	73.33	93.33	82.22	80.00	83.33

APPENDIX N: INDIVIDUAL ACCURACY SCORES FOR PHONTIC AND NONPHONETIC WORD TYPE FOR READING EXPERIENTAL TASKS

PART. ID	PHONETIC N/350ms	NONPHON N/350ms	PHONETIC TC/150ms	NONPHON TC/150ms
1	86.67	80.00	73.33	80.00
2	73.33	73.33	66.67	86.67
3	60.00	66.67	40.00	33.33
4	73.33	60.00	80.00	53.33
5	86.67	80.00	100.00	73.33
6	53.33	66.67	40.00	46.67
7	80.00	80.00	93.33	66.67
8	100.00	80.00	80.00	93.33
9	60.00	60.00	93.33	66.67
10	86.67	93.33	93.33	86.67
11	66.67	60.00	66.67	60.00
12	66.67	73.33	86.67	66.67
13	86.67	80.00	86.67	93.33
14	86.67	66.67	86.67	73.33
15	86.67	86.67	100.00	80.00
16	73.33	100.00	93.33	80.00
17	73.33	73.33	80.00	46.67
18	33.33	33.33	73.33	60.00
19	80.00	60.00	80.00	66.67
20	73.33	73.33	53.33	53.33
21	60.00	46.67	53.33	66.67
22	73.33	60.00	100.00	66.67
23	80.00	73.33	73.33	66.67
24	73.33	66.67	73.33	93.33
25	40.00	66.67	86.67	73.33
26	86.67	86.67	93.33	100.00
27	80.00	73.33	100.00	80.00
28	46.67	46.67	66.67	66.67
29	93.33	86.67	100.00	80.00
30	93.33	100.00	86.67	100.00
31	100.00	100.00	86.67	86.67
32	86.67	73.33	93.33	80.00
33	73.33	66.67	73.33	53.33
34	26.67	46.67	53.33	53.33
35	86.67	86.67	80.00	86.67
36	86.67	93.33	86.67	66.67
37	93.33	73.33	80.00	80.00
38	86.67	86.67	100.00	86.67
39	80.00	80.00	93.33	86.67
40	40.00	40.00	33.33	40.00

41	86.67	86.67	93.33	93.33
42	80.00	73.33	100.00	93.33
43	93.33	73.33	100.00	80.00
44	73.33	60.00	66.67	66.67
45	73.33	86.67	86.67	93.33
46	60.00	60.00	80.00	60.00
47	46.67	60.00	46.67	46.67
48	60.00	46.67	73.33	46.67
49	46.67	60.00	60.00	66.67
50	80.00	93.33	80.00	86.67

APPENDIX O: INDIVIDUAL ACCURACY SCORES FOR PHONETIC AND NONPHONETIC WORD TYPE FOR AUDITORY EXPERIENTAL TASKS

PART. ID	PHONETIC N/150ms	NONPHON N/150ms	PHONETIC TC/100ms	NONPHON TC/100ms
1	66.67	66.67	73.33	60.00
2	60.00	80.00	86.67	26.67
3	66.67	26.67	73.33	40.00
4	33.33	40.00	86.67	73.33
5	86.67	46.67	93.33	66.67
6	53.33	26.67	40.00	20.00
7	73.33	40.00	80.00	73.33
8	73.33	86.67	86.67	66.67
9	80.00	53.33	86.67	86.67
10	80.00	93.33	86.67	66.67
11	60.00	73.33	73.33	66.67
12	33.33	53.33	53.33	66.67
13	80.00	60.00	93.33	93.33
14	53.33	53.33	66.67	66.67
15	93.33	73.33	66.67	73.33
16	73.33	93.33	93.33	86.67
17	53.33	46.67	40.00	33.33
18	46.67	66.67	33.33	66.67
19	60.00	46.67	60.00	46.67
20	60.00	46.67	46.67	66.67
21	46.67	46.67	46.67	40.00
22	66.67	60.00	66.67	60.00
23	66.67	66.67	60.00	53.33
24	60.00	73.33	73.33	66.67
25	66.67	46.67	53.33	66.67
26	80.00	93.33	80.00	86.67
27	93.33	66.67	86.67	46.67
28	40.00	46.67	53.33	66.67
29	66.67	66.67	46.67	53.33
30	93.33	100.00	93.33	86.67
31	80.00	93.33	93.33	93.33
32	73.33	66.67	66.67	73.33
33	60.00	53.33	46.67	66.67
34	53.33	66.67	33.33	60.00
35	66.67	66.67	86.67	73.33
36	73.33	80.00	86.67	93.33
37	80.00	60.00	80.00	73.33
38	86.67	73.33	73.33	86.67
39	66.67	80.00	80.00	86.67
40	33.33	46.67	33.33	33.33

41	73.33	80.00	93.33	80.00
42	93.33	73.33	93.33	86.67
43	60.00	60.00	73.33	80.00
44	66.67	60.00	80.00	86.67
45	46.67	66.67	93.33	80.00
46	33.33	46.67	53.33	46.67
47	73.33	33.33	80.00	53.33
48	73.33	60.00	60.00	46.67
49	46.67	40.00	33.33	33.33
50	80.00	80.00	93.33	73.33

APPENDIX P: INDIVIDUAL STANDARD SCORES FOR PRE-EXPERIENTAL TESTS

PART. ID	PPVT-4	WRMT-R (ID)	WRMT-R (Attack)	TOWRE (SWE)	TOWRE (PDE)	TOWRE (TWRE)	GOR-4 (Rate)	GORT- 4 (Accuracy)	GORT-4 (Fluency)	GORT- 4 (Comp.)	GORT-4 (ORQ)
1	97	108	106	98	97	97	7	11	9	14	109
2	101	105	98	98	94	95	4	8	6	11	91
3	121	110	121	95	106	101	6	8	7	7	82
4	135	133	141	126	123	129	16	16	17	19	148
5	123	126	135	121	117	123	14	14	14	15	127
6	114	93	96	87	88	85	5	4	4	9	79
7	106	99	90	95	92	92	7	7	7	12	97
8	121	117	118	97	93	94	12	12	12	15	121
9	100	112	113	114	105	111	14	14	14	10	112
10	107	108	100	113	103	110	14	13	14	11	115
11	103	107	103	110	102	107	13	11	12	14	118
12	99	119	126	107	97	102	13	13	13	12	115
13	130	136	140	124	130	132	17	17	18	19	148
14	118	111	124	111	105	110	12	11	11	12	109
15	110	114	109	113	105	111	13	13	13	11	112
16	110	119	141	108	110	111	12	13	13	13	118
17	106	101	103	95	89	90	7	8	7	10	91
18	116	110	112	112	107	111	9	11	10	7	91
19	105	104	104	111	104	109	10	12	11	14	115
20	91	110	103	114	102	110	12	12	12	13	115
21	119	101	98	107	100	104	11	10	11	13	112
22	129	105	99	98	91	93	8	7	7	14	103
23	130	114	118	118	105	114	14	12	13	14	121
24	119	125	131	118	122	124	13	11	12	14	118
25	109	120	123	112	115	116	13	14	13	10	109
26	130	131	136	131	135	140	16	17	17	13	130
27	103	109	105	106	102	105	11	9	9	12	103
28	118	92	100	89	91	88	4	4	4	8	76
29	131	112	98	102	103	103	13	12	13	16	127

30	112	118	128	126	136	137	17	15	17	18	145
31	127	120	119	122	124	128	15	14	15	9	112
32	119	107	101	109	105	108	13	10	12	15	121
33	115	98	98	92	95	92	9	9	9	12	103
34	91	88	85	90	80	82	5	5	5	8	79
35	126	107	94	107	104	107	14	12	13	14	121
36	103	115	99	110	103	108	13	12	13	13	118
37	115	108	110	119	124	126	14	14	14	16	130
38	140	114	99	109	110	111	14	13	14	16	130
39	103	109	109	117	116	120	13	11	12	13	115
40	108	92	92	79	86	79	5	4	5	6	73
41	103	119	125	121	119	124	13	13	13	12	115
42	116	116	125	122	112	120	15	13	14	16	130
43	111	113	117	113	99	107	11	10	10	6	88
44	104	117	104	122	122	126	14	10	12	12	112
45	98	102	106	108	98	104	11	10	10	7	91
46	110	111	120	102	101	102	11	11	11	12	109
47	89	90	85	84	80	78	6	4	5	7	76
48	86	110	111	105	106	107	8	8	8	8	88
49	126	94	100	85	87	83	7	5	6	14	100
50	126	125	135	119	119	123	13	13	13	16	127

PART. ID	TOLD Listen	TOLD Organize	TOLD Speak	TOLD Gram	TOLD Semantic	TOLD Spoken Lang.	CTOPP PA	CTOPP PM	RAN Objects	RAN Colors	RAN Numbers	RAN (Letters)	RAN (2-Set)	RAN (3-Set)
1	105	102	112	118	96	107	97	121	77	85	85	77	79	82
2	105	105	115	116	102	109	112	106	81	64	73	70	69	72
3	117	114	112	123	106	116	127	106	93	102	112	105	105	104
4	131	123	109	121	123	124	136	109	109	115	121	124	121	113
5	116	108	106	118	104	111	97	106	87	101	112	99	101	95
6	119	117	100	113	112	114	91	85	86	94	92	89	86	84
7	113	89	100	102	100	100	91	94	118	101	113	114	124	108
8	113	113	112	112	116	115	94	115	78	72	76	77	80	85
9	119	108	106	114	110	113	109	106	102	122	132	116	110	117
10	116	110	118	116	116	117	100	103	83	95	76	96	90	78
11	111	94	92	92	106	98	85	100	74	81	114	100	116	108
12	105	108	124	120	114	118	121	103	93	121	109	108	118	101
13	121	121	112	118	122	121	106	100	138	129	117	111	122	121
14	117	109	106	113	108	112	106	106	101	113	105	103	104	105
15	114	114	91	109	104	107	100	103	111	100	110	111	111	113
16	117	111	100	115	104	110	121	115	82	79	95	90	94	91
17	114	89	85	100	92	95	115	85	98	103	100	103	95	97
18	108	109	103	102	112	107	97	85	98	85	92	103	97	101
19	102	106	103	108	100	104	124	112	97	115	102	108	105	113
20	100	92	91	92	96	93	97	100	91	96	76	100	82	75
21	124	105	118	122	112	118	103	100	104	107	111	98	111	106
22	119	117	119	119	119	120	115	124	56	75	76	77	87	80
23	117	123	128	117	129	125	106	109	107	104	109	105	101	113
24	119	111	128	113	127	122	112	91	111	106	114	116	115	115
25	119	94	109	111	104	108	106	97	101	93	98	105	96	111
26	114	114	122	108	127	118	121	100	107	90	110	114	103	108
27	100	81	97	78	106	90	85	103	90	104	120	121	111	111
28	105	111	112	104	117	110	115	112	82	66	87	82	82	79

29	113	105	118	112	114	114	118	100	84	89	122	94	105	93
30	113	108	115	114	112	114	91	121	107	100	114	117	113	114
31	121	113	124	126	116	123	115	109	117	133	132	119	121	111
32	116	102	124	104	126	116	103	94	107	123	120	104	106	114
33	102	105	106	104	106	105	103	85	99	90	96	77	96	102
34	84	81	80	82	77	77	82	91	107	132	113	98	101	107
35	108	119	112	102	126	115	91	97	93	94	103	90	101	92
36	108	102	112	110	106	108	94	79	87	96	117	121	118	105
37	111	113	127	120	116	119	124	91	110	94	115	102	112	104
38	119	129	118	114	134	126	112	100	80	70	103	98	106	92
39	116	108	121	112	120	117	106	103	99	105	99	98	102	109
40	108	100	100	94	112	103	85	79	102	102	95	103	90	97
41	111	108	121	112	116	115	112	91	102	104	107	100	113	103
42	119	119	106	112	120	117	103	91	119	118	109	98	110	106
43	97	94	97	92	100	95	94	82	92	98	108	107	105	101
44	100	110	109	104	110	107	94	79	97	87	106	105	119	113
45	97	92	100	98	94	95	103	118	107	104	105	98	96	89
46	105	100	91	96	102	98	112	91	101	87	102	96	111	92
47	92	81	95	88	88	86	82	103	85	107	112	102	104	103
48	102	83	106	96	98	96	109	79	107	117	121	127	123	125
49	119	119	115	118	120	120	115	94	111	113	109	100	87	99
50	111	123	103	111	115	114	115	94	86	89	107	113	103	111

APPENDIX Q: CORRELATIONS BETWEEN PRE-EXPERIMENTAL TESTS AND REACTION TIME FOR READING EXPERIMENTAL TASKS

Pre-Experimantal Tests		ReadSemantic RT 1200	ReadSemantic RT 600	ReadSyntactic RT 1200	ReadSyntactic RT 600	ReadOrtho RT 350	ReadOrtho RT 150
RAVENSraw	Pearson Corr	-.258	-.064	-.147	.069	.015	.005
	Sig. (2-tailed)	.071	.659	.309	.633	.918	.971
RAVENSpr	Pearson Corr	-.124	-.038	-.056	.085	.115	.114
	Sig. (2-tailed)	.391	.793	.700	.559	.428	.430
PPVT4SS	Pearson Corr	-.131	-.057	-.134	.004	.056	.109
	Sig. (2-tailed)	.364	.696	.352	.978	.701	.450
WRMTRwordidSS	Pearson Corr	-.046	.228	-.019	.502**	.144	.007
	Sig. (2-tailed)	.751	.112	.894	.000	.319	.960
WRMTwordattackSS	Pearson Corr	.091	.203	.095	.474**	.266	.169
	Sig. (2-tailed)	.530	.158	.513	.001	.062	.242
TOWREsweSS	Pearson Corr	-.208	.164	-.194	.320*	-.003	-.168
	Sig. (2-tailed)	.147	.257	.176	.024	.981	.244
TOWREpdeSS	Pearson Corr	-.218	.174	-.170	.269	.058	-.081
	Sig. (2-tailed)	.129	.227	.239	.059	.689	.577
TOWREtwreSS	Pearson Corr	-.216	.177	-.184	.302*	.032	-.124
	Sig. (2-tailed)	.133	.219	.200	.033	.827	.391
GORTrateSS	Pearson Corr	-.291*	.131	-.315*	.317*	-.014	-.151
	Sig. (2-tailed)	.040	.364	.026	.025	.923	.296
GORTaccuracySS	Pearson Corr	-.184	.199	-.181	.405**	.051	-.125
	Sig. (2-tailed)	.200	.165	.208	.004	.724	.386
GORTfluencySS	Pearson Corr	-.264	.154	-.280*	.351*	.013	-.149
	Sig. (2-tailed)	.064	.285	.049	.012	.926	.301
GORTcomp.SS	Pearson Corr	-.266	.089	-.339*	.207	-.127	-.212
	Sig. (2-tailed)	.062	.538	.016	.150	.379	.139
GORTorq	Pearson Corr	-.289*	.140	-.338*	.315*	-.058	-.197
	Sig. (2-tailed)	.042	.331	.016	.026	.690	.171

TOLDlisteningSS	Pearson Corr	-.012	.071	-.213	.045	.163	.208
	Sig. (2-tailed)	.936	.622	.138	.754	.257	.147
TOLDorganizingSS	Pearson Corr	-.094	.041	-.175	.079	.134	.069
	Sig. (2-tailed)	.514	.775	.223	.585	.353	.632
TOLDspeakingSS	Pearson Corr	-.044	.068	-.152	-.006	-.059	-.033
	Sig. (2-tailed)	.762	.640	.292	.965	.684	.822
TOLDgrammarSS	Pearson Corr	.053	.107	-.158	.055	.126	.099
	Sig. (2-tailed)	.716	.458	.273	.705	.383	.492
TOLDsemanticsSS	Pearson Corr	-.145	.028	-.223	.051	.032	.045
	Sig. (2-tailed)	.314	.849	.120	.726	.827	.759
TOLDspoken lang.SS	Pearson Corr	-.060	.070	-.221	.058	.094	.086
	Sig. (2-tailed)	.678	.628	.123	.691	.515	.555
CTOPP – PA SS	Pearson Corr	.067	.034	-.026	.185	.268	.156
	Sig. (2-tailed)	.645	.813	.856	.199	.060	.279
CTOPP – PM SS	Pearson Corr	.035	-.055	-.047	.158	.015	-.017
	Sig. (2-tailed)	.807	.703	.745	.274	.915	.905
RANobjectsSS	Pearson Corr	-.281*	-.246	-.407**	-.331*	-.109	-.029
	Sig. (2-tailed)	.048	.085	.003	.019	.450	.839
RANcolorsSS	Pearson Corr	-.194	-.266	-.394**	-.239	-.055	-.021
	Sig. (2-tailed)	.176	.062	.005	.095	.703	.884
RANnumbersSS	Pearson Corr	-.087	-.042	-.140	-.016	.107	.117
	Sig. (2-tailed)	.549	.775	.333	.910	.459	.417
RANlettersSS	Pearson Corr	-.156	-.135	-.153	.055	.116	.149
	Sig. (2-tailed)	.279	.350	.290	.706	.424	.300
RAN2setSS	Pearson Corr	-.226	-.115	-.259	-.036	.074	.081
	Sig. (2-tailed)	.114	.427	.069	.803	.608	.577
RAN3setSS	Pearson Corr	-.139	-.114	-.151	-.055	.005	.099
	Sig. (2-tailed)	.336	.430	.296	.706	.972	.494

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX R: CORRELATIONS BETWEEN PRE-EXPERIMENTAL TESTS AND ACCURACY FOR READING EXPERIMENTAL TASKS

Pre-Experimantal Tests		ReadSemantic Acc 1200	ReadSemantic Acc 600	ReadSyntactic Acc 1200	ReadSyntactic Acc 600	ReadOrtho Acc 350	ReadOrtho Acc 150
RAVENSraw	Pearson Corr	.339*	.375**	.335*	.503**	.233	.322*
	Sig. (2-tailed)	.016	.007	.017	.000	.103	.023
RAVENSpr	Pearson Corr	.199	.199	.216	.360*	.141	.219
	Sig. (2-tailed)	.166	.165	.131	.010	.328	.126
PPVT4SS	Pearson Corr	.256	.315*	.154	.307*	.280*	.291*
	Sig. (2-tailed)	.072	.026	.287	.030	.049	.040
WRMTRwordidSS	Pearson Corr	.498**	.373**	.567**	.652**	.524**	.570**
	Sig. (2-tailed)	.000	.008	.000	.000	.000	.000
WRMTwordattackSS	Pearson Corr	.295*	.197	.480**	.524**	.333*	.413**
	Sig. (2-tailed)	.037	.171	.000	.000	.018	.003
TOWREsweSS	Pearson Corr	.506**	.398**	.470**	.504**	.519**	.627**
	Sig. (2-tailed)	.000	.004	.001	.000	.000	.000
TOWREpdeSS	Pearson Corr	.524**	.466**	.465**	.543**	.486**	.531**
	Sig. (2-tailed)	.000	.001	.001	.000	.000	.000
TOWREtwreSS	Pearson Corr	.526**	.444**	.479**	.536**	.519**	.592**
	Sig. (2-tailed)	.000	.001	.000	.000	.000	.000
GORTrateSS	Pearson Corr	.614**	.538**	.582**	.632**	.607**	.659**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
GORTaccuracySS	Pearson Corr	.574**	.406**	.585**	.603**	.607**	.655**
	Sig. (2-tailed)	.000	.003	.000	.000	.000	.000
GORTfluencySS	Pearson Corr	.616**	.519**	.597**	.651**	.614**	.649**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
GORTcomp.SS	Pearson Corr	.575**	.400**	.367**	.598**	.508**	.473**
	Sig. (2-tailed)	.000	.004	.009	.000	.000	.001
GORTorq	Pearson Corr	.657**	.508**	.537**	.687**	.624**	.624**

	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000
TOLDlisteningSS	Pearson Corr	.373**	.210	.165	.316*	.250	.245
	Sig. (2-tailed)	.008	.144	.253	.025	.080	.087
TOLDorganizingSS	Pearson Corr	.309*	.232	.241	.386**	.308*	.276
	Sig. (2-tailed)	.029	.105	.092	.006	.030	.052
TOLDspeakingSS	Pearson Corr	.244	.213	.138	.239	.350*	.376**
	Sig. (2-tailed)	.088	.138	.340	.094	.013	.007
TOLDgrammarSS	Pearson Corr	.301*	.115	.186	.303*	.354*	.251
	Sig. (2-tailed)	.033	.428	.195	.032	.012	.078
TOLDsemanticsSS	Pearson Corr	.329*	.335*	.208	.359*	.291*	.387**
	Sig. (2-tailed)	.020	.017	.147	.010	.040	.006
TOLDspoken lang.SS	Pearson Corr	.360*	.257	.228	.380**	.369**	.359*
	Sig. (2-tailed)	.010	.072	.111	.006	.008	.010
CTOPP – PA SS	Pearson Corr	.059	-.164	.050	.088	.145	.160
	Sig. (2-tailed)	.685	.256	.729	.542	.317	.267
CTOPP – PM SS	Pearson Corr	.083	-.005	.035	.130	.307*	.308*
	Sig. (2-tailed)	.568	.975	.808	.369	.030	.030
RANobjectsSS	Pearson Corr	.052	.031	.009	.027	-.001	.096
	Sig. (2-tailed)	.718	.828	.950	.855	.993	.507
RANcolorsSS	Pearson Corr	.034	-.065	.051	-.020	-.064	-.051
	Sig. (2-tailed)	.812	.654	.725	.892	.658	.725
RANnumbersSS	Pearson Corr	.144	.138	.237	.142	.097	.119
	Sig. (2-tailed)	.317	.340	.098	.326	.501	.409
RANlettersSS	Pearson Corr	.113	.093	.208	.146	.068	.077
	Sig. (2-tailed)	.434	.521	.147	.313	.637	.594
RAN2setSS	Pearson Corr	.233	.199	.238	.238	.161	.191
	Sig. (2-tailed)	.104	.166	.097	.096	.263	.185
RAN3setSS	Pearson Corr	.244	.084	.199	.142	-.027	.092

Sig. (2-tailed)	.087	.562	.166	.324	.851	.527

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX S: CORRELATIONS BETWEEN PRE-EXPERIMENTAL TESTS AND REACTION TIME FOR AUDITORY EXPERIMENTAL TASKS

Pre-Experimantal Tests		Aud Semantic RT N	Aud Semantic RT TC	Aud Syntactic RT N	Aud Syntactic RT TC	Aud Ortho RT N 150	Aud Ortho RT TC 100
RAVENSraw	Pearson Corr	-.194	-.103	-.235	-.100	-.205	-.141
	Sig. (2-tailed)	.176	.477	.101	.490	.153	.329
RAVENSpr	Pearson Corr	-.168	-.100	-.247	-.121	-.176	-.087
	Sig. (2-tailed)	.244	.488	.084	.401	.221	.548
PPVT4SS	Pearson Corr	.162	.085	-.123	-.023	-.113	.009
	Sig. (2-tailed)	.260	.556	.393	.876	.436	.951
WRMTRwordidSS	Pearson Corr	.054	.171	-.012	.056	-.247	-.036
	Sig. (2-tailed)	.708	.234	.932	.698	.084	.806
WRMTwordattackSS	Pearson Corr	.171	.242	.004	.040	-.158	.072
	Sig. (2-tailed)	.236	.091	.975	.780	.273	.620
TOWREsweSS	Pearson Corr	-.118	-.021	-.112	-.006	-.370**	-.156
	Sig. (2-tailed)	.416	.885	.438	.969	.008	.278
TOWREpdeSS	Pearson Corr	-.036	.058	-.122	.060	-.270	-.128
	Sig. (2-tailed)	.804	.691	.399	.680	.058	.376
TOWREtwreSS	Pearson Corr	-.076	.019	-.123	.031	-.326*	-.147
	Sig. (2-tailed)	.602	.893	.396	.831	.021	.309
GORTrateSS	Pearson Corr	-.073	-.011	-.138	-.001	-.398**	-.136
	Sig. (2-tailed)	.613	.938	.339	.993	.004	.345
GORTaccuracySS	Pearson Corr	-.096	-.036	-.097	-.014	-.351*	-.188
	Sig. (2-tailed)	.505	.805	.502	.921	.012	.191
GORTfluencySS	Pearson Corr	-.084	-.007	-.117	.008	-.389**	-.177
	Sig. (2-tailed)	.561	.961	.419	.958	.005	.219
GORTcomp.SS	Pearson Corr	.081	.122	-.054	.142	-.241	.058
	Sig. (2-tailed)	.578	.398	.711	.325	.092	.689
GORTorq	Pearson Corr	-.001	.063	-.093	.083	-.349*	-.067

	Sig. (2-tailed)	.992	.666	.521	.564	.013	.642
TOLDlisteningSS	Pearson Corr	.035	.067	-.084	.004	-.235	-.034
	Sig. (2-tailed)	.809	.645	.563	.980	.101	.813
TOLDorganizingSS	Pearson Corr	.160	.064	-.157	-.043	-.132	-.068
	Sig. (2-tailed)	.266	.658	.275	.767	.359	.638
TOLDspeakingSS	Pearson Corr	-.005	.030	-.127	.118	-.155	-.136
	Sig. (2-tailed)	.971	.836	.381	.416	.283	.347
TOLDgrammarSS	Pearson Corr	.031	.036	-.107	.005	-.162	-.122
	Sig. (2-tailed)	.829	.805	.461	.974	.262	.398
TOLDsemanticsSS	Pearson Corr	.095	.089	-.124	.053	-.161	-.051
	Sig. (2-tailed)	.513	.539	.390	.715	.265	.726
TOLDspoken lang.SS	Pearson Corr	.069	.065	-.138	.027	-.196	-.107
	Sig. (2-tailed)	.633	.654	.338	.855	.173	.462
CTOPP – PA SS	Pearson Corr	.232	.307*	.083	.027	.078	.181
	Sig. (2-tailed)	.106	.030	.566	.854	.591	.210
CTOPP – PM SS	Pearson Corr	.129	.034	-.158	-.012	-.148	.076
	Sig. (2-tailed)	.370	.815	.272	.933	.304	.598
RANobjectsSS	Pearson Corr	-.360*	-.187	-.246	-.152	-.230	-.256
	Sig. (2-tailed)	.010	.193	.085	.291	.107	.073
RANcolorsSS	Pearson Corr	-.346*	-.157	-.186	-.221	-.259	-.162
	Sig. (2-tailed)	.014	.275	.197	.122	.070	.261
RANnumbersSS	Pearson Corr	.049	.130	.129	.141	.006	.159
	Sig. (2-tailed)	.736	.368	.373	.329	.964	.270
RANlettersSS	Pearson Corr	-.106	.080	.035	-.013	-.087	.060
	Sig. (2-tailed)	.462	.582	.810	.931	.549	.679
RAN2setSS	Pearson Corr	-.066	.010	.079	.040	-.084	.052
	Sig. (2-tailed)	.651	.945	.588	.781	.561	.720
RAN3setSS	Pearson Corr	-.075	-.041	-.061	.000	-.155	-.022

Sig. (2-tailed)	.605	.775	.676	1.000	.281	.881

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX T: CORRELATIONS BETWEEN PRE-EXPERIMENTAL TESTS AND ACCURACY FOR AUDITORY EXPERIMENTAL TASKS

Pre-Experimantal Tests		Aud Semantic Acc N	Aud Semantic Acc TC	Aud Syntactic Acc N	Aud Syntactic Acc TC	Aud Ortho Acc N 150	Aud Ortho Acc TC 100
RAVENSraw	Pearson Corr	.081	.200	.491**	.413**	.180	.404**
	Sig. (2-tailed)	.577	.165	.000	.003	.211	.004
RAVENSpr	Pearson Corr	-.032	.126	.447**	.386**	.090	.258
	Sig. (2-tailed)	.826	.384	.001	.006	.533	.071
PPVT4SS	Pearson Corr	.186	.269	.544**	.368**	.100	.132
	Sig. (2-tailed)	.197	.059	.000	.009	.488	.361
WRMTRwordidSS	Pearson Corr	.126	.254	.315*	.236	.447**	.629**
	Sig. (2-tailed)	.383	.075	.026	.099	.001	.000
WRMTwordattackSS	Pearson Corr	-.012	.243	.350*	.189	.259	.477**
	Sig. (2-tailed)	.935	.089	.013	.190	.070	.000
TOWREsweSS	Pearson Corr	.119	.188	.206	.169	.542**	.694**
	Sig. (2-tailed)	.409	.190	.151	.242	.000	.000
TOWREpdeSS	Pearson Corr	.187	.225	.271	.171	.522**	.645**
	Sig. (2-tailed)	.193	.117	.057	.234	.000	.000
TOWREtwreSS	Pearson Corr	.156	.214	.241	.174	.548**	.686**
	Sig. (2-tailed)	.278	.136	.092	.226	.000	.000
GORTrateSS	Pearson Corr	.299*	.383**	.242	.210	.549**	.697**
	Sig. (2-tailed)	.035	.006	.091	.143	.000	.000
GORTaccuracySS	Pearson Corr	.108	.184	.293*	.184	.532**	.659**
	Sig. (2-tailed)	.456	.201	.039	.200	.000	.000
GORTfluencySS	Pearson Corr	.217	.301*	.274	.208	.552**	.693**
	Sig. (2-tailed)	.130	.033	.054	.148	.000	.000
GORTcomp.SS	Pearson Corr	.455**	.322*	.345*	.286*	.345*	.375**
	Sig. (2-tailed)	.001	.023	.014	.044	.014	.007
GORTorq	Pearson Corr	.366**	.350*	.339*	.270	.501**	.595**

	Sig. (2-tailed)	.009	.013	.016	.058	.000	.000
TOLDlisteningSS	Pearson Corr	.179	.253	.503**	.266	.109	.168
	Sig. (2-tailed)	.214	.076	.000	.062	.450	.244
TOLDorganizingSS	Pearson Corr	.102	.238	.556**	.402**	.179	.259
	Sig. (2-tailed)	.481	.096	.000	.004	.213	.070
TOLDspeakingSS	Pearson Corr	.334*	.236	.421**	.215	.273	.272
	Sig. (2-tailed)	.018	.099	.002	.133	.055	.056
TOLDgrammarSS	Pearson Corr	.139	.213	.526**	.249	.138	.224
	Sig. (2-tailed)	.336	.137	.000	.081	.339	.118
TOLDsemanticsSS	Pearson Corr	.286*	.295*	.493**	.354*	.246	.270
	Sig. (2-tailed)	.044	.037	.000	.012	.085	.058
TOLDspoken lang.SS	Pearson Corr	.240	.293*	.580**	.341*	.218	.279
	Sig. (2-tailed)	.093	.039	.000	.015	.128	.050
CTOPP – PA SS	Pearson Corr	-.040	.118	.439**	.027	-.106	.051
	Sig. (2-tailed)	.783	.413	.001	.853	.463	.725
CTOPP – PM SS	Pearson Corr	.036	.014	.252	.200	.207	.275
	Sig. (2-tailed)	.806	.922	.078	.164	.150	.054
RANobjectsSS	Pearson Corr	.019	.057	.097	-.027	.003	.144
	Sig. (2-tailed)	.897	.695	.504	.853	.985	.319
RANcolorsSS	Pearson Corr	.040	.058	.054	-.138	-.086	.052
	Sig. (2-tailed)	.781	.689	.708	.338	.555	.717
RANnumbersSS	Pearson Corr	.088	.232	.119	-.063	.107	.270
	Sig. (2-tailed)	.545	.105	.412	.664	.461	.058
RANlettersSS	Pearson Corr	-.018	.113	-.050	-.128	.127	.258
	Sig. (2-tailed)	.902	.433	.731	.375	.380	.071
RAN2setSS	Pearson Corr	.105	.245	.003	-.090	.147	.402**
	Sig. (2-tailed)	.466	.086	.986	.534	.309	.004
RAN3setSS	Pearson Corr	.140	.067	.092	-.076	.159	.242

Sig. (2-tailed)	.332	.645	.526	.600	.270	.091

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX U: CORRELATIONS BETWEEN PRE-EXPERIMENTAL TEST SCORES

Pre-Experimantal	Tests	RAVENS Raw	RAVENS PR	PPVT4 SS	WRMT-R Word ID SS	WRMT-R Word Attack SS	TOWRE SWE SS	TOWRE PDE SS	TOWRE TWRE SS
RAVENSraw	Pearson Corr	1	.904**	.498**	.460**	.441**	.360*	.415**	.396**
	Sig. (2-tailed)		.000	.000	.001	.001	.010	.003	.004
RAVENSpr	Pearson Corr	.904**	1	.473**	.444**	.497**	.316*	.379**	.358*
	Sig. (2-tailed)	.000		.001	.001	.000	.025	.007	.011
PPVT4SS	Pearson Corr	.498**	.473**	1	.404**	.349*	.255	.372**	.322*
	Sig. (2-tailed)	.000	.001		.004	.013	.073	.008	.023
WRMTRwordidSS	Pearson Corr	.460**	.444**	.404**	1	.863**	.832**	.833**	.853**
	Sig. (2-tailed)	.001	.001	.004		.000	.000	.000	.000
WRMTwordattack SS	Pearson Corr	.441**	.497**	.349*	.863**	1	.682**	.731**	.726**
	Sig. (2-tailed)	.001	.000	.013	.000		.000	.000	.000
TOWREsweSS	Pearson Corr	.360*	.316*	.255	.832**	.682**	1	.897**	.972**
	Sig. (2-tailed)	.010	.025	.073	.000	.000		.000	.000
TOWREpdeSS	Pearson Corr	.415**	.379**	.372**	.833**	.731**	.897**	1	.976**
	Sig. (2-tailed)	.003	.007	.008	.000	.000	.000		.000
TOWREtwreSS	Pearson Corr	.396**	.358*	.322*	.853**	.726**	.972**	.976**	1
	Sig. (2-tailed)	.004	.011	.023	.000	.000	.000	.000	
GORTrateSS	Pearson Corr	.490**	.385**	.373**	.795**	.599**	.882**	.802**	.861**
	Sig. (2-tailed)	.000	.006	.008	.000	.000	.000	.000	.000
GORTaccuracySS	Pearson Corr	.500**	.415**	.331*	.869**	.706**	.875**	.814**	.866**

	Sig. (2-tailed)	.000	.003	.019	.000	.000	.000	.000	.000
GORTfluencySS	Pearson Corr	.529**	.423**	.380**	.847**	.659**	.887**	.833**	.881**
	Sig. (2-tailed)	.000	.002	.006	.000	.000	.000	.000	.000
GORTcomp.SS	Pearson Corr	.283*	.143	.498**	.542**	.389**	.493**	.515**	.513**
	Sig. (2-tailed)	.046	.323	.000	.000	.005	.000	.000	.000
GORTorq	Pearson Corr	.449**	.316*	.481**	.770**	.581**	.771**	.749**	.777**
	Sig. (2-tailed)	.001	.025	.000	.000	.000	.000	.000	.000
TOLDlisteningSS	Pearson Corr	.469**	.475**	.672**	.458**	.449**	.340*	.427**	.392**
	Sig. (2-tailed)	.001	.000	.000	.001	.001	.016	.002	.005
TOLDorganizing SS	Pearson Corr	.482**	.491**	.777**	.441**	.417**	.353*	.433**	.403**
	Sig. (2-tailed)	.000	.000	.000	.001	.003	.012	.002	.004
TOLDspeakingSS	Pearson Corr	.324*	.253	.476**	.359*	.244	.354*	.454**	.416**
	Sig. (2-tailed)	.022	.077	.000	.010	.088	.012	.001	.003
TOLDgrammarSS	Pearson Corr	.386**	.360*	.538**	.431**	.433**	.319*	.412**	.375**
	Sig. (2-tailed)	.006	.010	.000	.002	.002	.024	.003	.007
TOLDsemanticsSS	Pearson Corr	.479**	.455**	.758**	.438**	.323*	.398**	.484**	.451**
	Sig. (2-tailed)	.000	.001	.000	.001	.022	.004	.000	.001
TOLDspoken lang. SS	Pearson Corr	.499**	.474**	.743**	.497**	.433**	.410**	.513**	.473**
	Sig. (2-tailed)	.000	.001	.000	.000	.002	.003	.000	.001
CTOPP – PA SS	Pearson Corr	.229	.291*	.420**	.388**	.483**	.268	.356*	.322*
	Sig. (2-tailed)	.110	.041	.002	.005	.000	.060	.011	.023
CTOPP – PM SS	Pearson Corr	.102	.075	.167	.140	.212	.110	.081	.099

	Sig. (2-tailed)	.480	.605	.246	.334	.140	.449	.575	.493
RANobjectsSS	Pearson Corr	.282*	.279*	.074	.228	.282*	.341*	.393**	.377**
	Sig. (2-tailed)	.047	.049	.612	.111	.047	.015	.005	.007
RANcolorsSS	Pearson Corr	.160	.141	-.137	.084	.144	.198	.127	.165
	Sig. (2-tailed)	.267	.328	.341	.561	.320	.167	.381	.253
RANnumbersSS	Pearson Corr	.090	.036	.111	.267	.220	.337*	.367**	.360*
	Sig. (2-tailed)	.534	.805	.443	.061	.125	.017	.009	.010
RANlettersSS	Pearson Corr	.094	.164	-.035	.408**	.336*	.476**	.466**	.484**
	Sig. (2-tailed)	.515	.255	.811	.003	.017	.000	.001	.000
RAN2setSS	Pearson Corr	.112	.081	.047	.417**	.291*	.496**	.491**	.503**
	Sig. (2-tailed)	.441	.577	.744	.003	.040	.000	.000	.000
RAN3setSS	Pearson Corr	.110	.110	.031	.351*	.326*	.435**	.472**	.463**
	Sig. (2-tailed)	.446	.447	.831	.012	.021	.002	.001	.001

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Pre-Experimantal Tests		GORT-4 Rate SS	GORT-4 Acc SS	GORT-4 Fluency SS	GORT-4 Comp. SS	GORT-4 ORQ
RAVENSraw	Pearson Corr	.490**	.500**	.529**	.283*	.449**
	Sig. (2-tailed)	.000	.000	.000	.046	.001
RAVENSpr	Pearson Corr	.385**	.415**	.423**	.143	.316*
	Sig. (2-tailed)	.006	.003	.002	.323	.025
PPVT4SS	Pearson Corr	.373**	.331*	.380**	.498**	.481**
	Sig. (2-tailed)	.008	.019	.006	.000	.000
WRMTRwordidSS	Pearson Corr	.795**	.869**	.847**	.542**	.770**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
WRMTwordattackSS	Pearson Corr	.599**	.706**	.659**	.389**	.581**
	Sig. (2-tailed)	.000	.000	.000	.005	.000
TOWREsweSS	Pearson Corr	.882**	.875**	.887**	.493**	.771**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
TOWREpdeSS	Pearson Corr	.802**	.814**	.833**	.515**	.749**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
TOWREtwreSS	Pearson Corr	.861**	.866**	.881**	.513**	.777**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
GORTrateSS	Pearson Corr	1	.902**	.971**	.625**	.888**
	Sig. (2-tailed)		.000	.000	.000	.000
GORTaccuracySS	Pearson Corr	.902**	1	.969**	.595**	.871**
	Sig. (2-tailed)	.000		.000	.000	.000
GORTfluencySS	Pearson Corr	.971**	.969**	1	.644**	.914**
	Sig. (2-tailed)	.000	.000		.000	.000
GORTcomp.SS	Pearson Corr	.625**	.595**	.644**	1	.898**
	Sig. (2-tailed)	.000	.000	.000		.000
GORTorq	Pearson Corr	.888**	.871**	.914**	.898**	1
	Sig. (2-tailed)	.000	.000	.000	.000	

TOLDlisteningSS	Pearson Corr	.419**	.416**	.446**	.484**	.512**
	Sig. (2-tailed)	.002	.003	.001	.000	.000
TOLDorganizingSS	Pearson Corr	.408**	.415**	.442**	.515**	.526**
	Sig. (2-tailed)	.003	.003	.001	.000	.000
TOLDspeakingSS	Pearson Corr	.380**	.344*	.390**	.383**	.429**
	Sig. (2-tailed)	.007	.015	.005	.006	.002
TOLDgrammarSS	Pearson Corr	.322*	.434**	.408**	.434**	.464**
	Sig. (2-tailed)	.023	.002	.003	.002	.001
TOLDsemanticsSS	Pearson Corr	.514**	.388**	.482**	.518**	.551**
	Sig. (2-tailed)	.000	.005	.000	.000	.000
TOLDspoken lang.SS	Pearson Corr	.482**	.470**	.511**	.540**	.579**
	Sig. (2-tailed)	.000	.001	.000	.000	.000
CTOPP – PA SS	Pearson Corr	.179	.350*	.277	.269	.303*
	Sig. (2-tailed)	.213	.013	.051	.059	.032
CTOPP – PM SS	Pearson Corr	.128	.237	.185	.275	.254
	Sig. (2-tailed)	.375	.098	.197	.053	.075
RANobjectsSS	Pearson Corr	.311*	.260	.310*	.092	.219
	Sig. (2-tailed)	.028	.068	.028	.523	.127
RANcolorsSS	Pearson Corr	.216	.116	.178	-.024	.084
	Sig. (2-tailed)	.133	.424	.217	.867	.564
RANnumbersSS	Pearson Corr	.396**	.256	.344*	.120	.260
	Sig. (2-tailed)	.004	.072	.014	.406	.069
RANlettersSS	Pearson Corr	.427**	.331*	.392**	.037	.243
	Sig. (2-tailed)	.002	.019	.005	.801	.088
RAN2setSS	Pearson Corr	.525**	.383**	.474**	.212	.382**
	Sig. (2-tailed)	.000	.006	.001	.139	.006
RAN3setSS	Pearson Corr	.413**	.301*	.369**	.146	.285*
	Sig. (2-tailed)	.003	.034	.008	.313	.045

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Pre-Experimantal	Tests	TOLD Listen SS	TOLD Organize SS	TOLD Speak SS	TOLD Gram SS	TOLD Sem SS	TOLD Sp Lang. SS	CTOPP – PA SS	CTOPP – PM SS
RAVENSraw	Pearson Corr	.469**	.482**	.324*	.386**	.479**	.499**	.229	.102
	Sig. (2-tailed)	.001	.000	.022	.006	.000	.000	.110	.480
RAVENSpr	Pearson Corr	.475**	.491**	.253	.360*	.455**	.474**	.291*	.075
	Sig. (2-tailed)	.000	.000	.077	.010	.001	.001	.041	.605
PPVT4SS	Pearson Corr	.672**	.777**	.476**	.538**	.758**	.743**	.420**	.167
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.002	.246
WRMTRwordidSS	Pearson Corr	.458**	.441**	.359*	.431**	.438**	.497**	.388**	.140
	Sig. (2-tailed)	.001	.001	.010	.002	.001	.000	.005	.334
WRMTwordattack SS	Pearson Corr	.449**	.417**	.244	.433**	.323*	.433**	.483**	.212
	Sig. (2-tailed)	.001	.003	.088	.002	.022	.002	.000	.140
TOWREsweSS	Pearson Corr	.340*	.353*	.354*	.319*	.398**	.410**	.268	.110
	Sig. (2-tailed)	.016	.012	.012	.024	.004	.003	.060	.449
TOWREpdeSS	Pearson Corr	.427**	.433**	.454**	.412**	.484**	.513**	.356*	.081
	Sig. (2-tailed)	.002	.002	.001	.003	.000	.000	.011	.575
TOWREtwreSS	Pearson Corr	.392**	.403**	.416**	.375**	.451**	.473**	.322*	.099
	Sig. (2-tailed)	.005	.004	.003	.007	.001	.001	.023	.493
GORTrateSS	Pearson Corr	.419**	.408**	.380**	.322*	.514**	.482**	.179	.128
	Sig. (2-tailed)	.002	.003	.007	.023	.000	.000	.213	.375
GORTaccuracySS	Pearson Corr	.416**	.415**	.344*	.434**	.388**	.470**	.350*	.237
	Sig. (2-tailed)	.003	.003	.015	.002	.005	.001	.013	.098
GORTfluencySS	Pearson Corr	.446**	.442**	.390**	.408**	.482**	.511**	.277	.185
	Sig. (2-tailed)	.001	.001	.005	.003	.000	.000	.051	.197
GORTcomp.SS	Pearson Corr	.484**	.515**	.383**	.434**	.518**	.540**	.269	.275
	Sig. (2-tailed)	.000	.000	.006	.002	.000	.000	.059	.053

GORTorq	Pearson Corr	.512**	.526**	.429**	.464**	.551**	.579**	.303*	.254
	Sig. (2-tailed)	.000	.000	.002	.001	.000	.000	.032	.075
TOLDlisteningSS	Pearson Corr	1	.662**	.487**	.747**	.668**	.813**	.457**	.203
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.001	.157
TOLDorganizing SS	Pearson Corr	.662**	1	.564**	.751**	.793**	.886**	.483**	.214
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.136
TOLDspeakingSS	Pearson Corr	.487**	.564**	1	.699**	.753**	.826**	.437**	.215
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.002	.134
TOLDgrammarSS	Pearson Corr	.747**	.751**	.699**	1	.528**	.871**	.606**	.367**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.009
TOLDsemanticsSS	Pearson Corr	.668**	.793**	.753**	.528**	1	.876**	.353*	.068
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.012	.640
TOLDspoken lang. SS	Pearson Corr	.813**	.886**	.826**	.871**	.876**	1	.545**	.243
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.090
CTOPP – PA SS	Pearson Corr	.457**	.483**	.437**	.606**	.353*	.545**	1	.233
	Sig. (2-tailed)	.001	.000	.002	.000	.012	.000		.103
CTOPP – PM SS	Pearson Corr	.203	.214	.215	.367**	.068	.243	.233	1
	Sig. (2-tailed)	.157	.136	.134	.009	.640	.090	.103	
RANobjectsSS	Pearson Corr	.177	.037	.069	.063	.115	.106	.094	-.277
	Sig. (2-tailed)	.218	.796	.634	.662	.428	.466	.518	.051
RANcolorsSS	Pearson Corr	.057	-.161	-.015	.000	-.089	-.042	.012	-.142
	Sig. (2-tailed)	.696	.264	.920	.998	.538	.770	.933	.324
RANnumbersSS	Pearson Corr	.142	-.074	.079	-.004	.084	.050	.093	-.196
	Sig. (2-tailed)	.326	.609	.585	.980	.563	.729	.521	.172
RANlettersSS	Pearson Corr	.132	-.128	-.015	-.095	.058	-.015	.076	-.262
	Sig. (2-tailed)	.362	.377	.920	.513	.689	.920	.602	.066
RAN2setSS	Pearson Corr	.145	-.035	.090	.007	.131	.081	.080	-.270
	Sig. (2-tailed)	.315	.807	.533	.963	.365	.576	.581	.058

RAN3setSS	Pearson Corr	.147	-.047	.069	-.029	.113	.055	.046	-.266
	Sig. (2-tailed)	.309	.747	.633	.840	.434	.705	.752	.062

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

EXPERIMENTAL TASKS		RAN objects SS	RAN colors SS	RAN numbers SS	RAN letters SS	RAN 2set SS	RAN 3set SS
RAVENSraw	Pearson Corr	.282*	.160	.090	.094	.112	.110
	Sig. (2-tailed)	.047	.267	.534	.515	.441	.446
RAVENSper	Pearson Corr	.279*	.141	.036	.164	.081	.110
	Sig. (2-tailed)	.049	.328	.805	.255	.577	.447
PPVT4SS	Pearson Corr	.074	-.137	.111	-.035	.047	.031
	Sig. (2-tailed)	.612	.341	.443	.811	.744	.831
WRMTRwordidSS	Pearson Corr	.228	.084	.267	.408**	.417**	.351*
	Sig. (2-tailed)	.111	.561	.061	.003	.003	.012
WRMTwordattackSS	Pearson Corr	.282*	.144	.220	.336*	.291*	.326*
	Sig. (2-tailed)	.047	.320	.125	.017	.040	.021
TOWREsweSS	Pearson Corr	.341*	.198	.337*	.476**	.496**	.435**
	Sig. (2-tailed)	.015	.167	.017	.000	.000	.002
TOWREpdeSS	Pearson Corr	.393**	.127	.367**	.466**	.491**	.472**
	Sig. (2-tailed)	.005	.381	.009	.001	.000	.001
TOWREtwreSS	Pearson Corr	.377**	.165	.360*	.484**	.503**	.463**
	Sig. (2-tailed)	.007	.253	.010	.000	.000	.001
GORTrateSS	Pearson Corr	.311*	.216	.396**	.427**	.525**	.413**
	Sig. (2-tailed)	.028	.133	.004	.002	.000	.003
GORTaccuracySS	Pearson Corr	.260	.116	.256	.331*	.383**	.301*
	Sig. (2-tailed)	.068	.424	.072	.019	.006	.034
GORTfluencySS	Pearson Corr	.310*	.178	.344*	.392**	.474**	.369**
	Sig. (2-tailed)	.028	.217	.014	.005	.001	.008
GORTcomp.SS	Pearson Corr	.092	-.024	.120	.037	.212	.146
	Sig. (2-tailed)	.523	.867	.406	.801	.139	.313
GORTorq	Pearson Corr	.219	.084	.260	.243	.382**	.285*

	Sig. (2-tailed)	.127	.564	.069	.088	.006	.045
TOLDlisteningSS	Pearson Corr	.177	.057	.142	.132	.145	.147
	Sig. (2-tailed)	.218	.696	.326	.362	.315	.309
TOLDorganizingSS	Pearson Corr	.037	-.161	-.074	-.128	-.035	-.047
	Sig. (2-tailed)	.796	.264	.609	.377	.807	.747
TOLDspeakingSS	Pearson Corr	.069	-.015	.079	-.015	.090	.069
	Sig. (2-tailed)	.634	.920	.585	.920	.533	.633
TOLDgrammarSS	Pearson Corr	.063	.000	-.004	-.095	.007	-.029
	Sig. (2-tailed)	.662	.998	.980	.513	.963	.840
TOLDsemanticsSS	Pearson Corr	.115	-.089	.084	.058	.131	.113
	Sig. (2-tailed)	.428	.538	.563	.689	.365	.434
TOLDspoken lang.SS	Pearson Corr	.106	-.042	.050	-.015	.081	.055
	Sig. (2-tailed)	.466	.770	.729	.920	.576	.705
CTOPP – PA SS	Pearson Corr	.094	.012	.093	.076	.080	.046
	Sig. (2-tailed)	.518	.933	.521	.602	.581	.752
CTOPP – PM SS	Pearson Corr	-.277	-.142	-.196	-.262	-.270	-.266
	Sig. (2-tailed)	.051	.324	.172	.066	.058	.062
RANobjectsSS	Pearson Corr	1	.702**	.557**	.551**	.536**	.647**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
RANcolorsSS	Pearson Corr	.702**	1	.654**	.603**	.537**	.635**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
RANnumbersSS	Pearson Corr	.557**	.654**	1	.750**	.823**	.799**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
RANlettersSS	Pearson Corr	.551**	.603**	.750**	1	.775**	.782**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
RAN2setSS	Pearson Corr	.536**	.537**	.823**	.775**	1	.799**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
RAN3setSS	Pearson Corr	.647**	.635**	.799**	.782**	.799**	1

Sig. (2-tailed)	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX V: CORRELATIONS BETWEEN READING EXPERIMENTAL TASKS

EXPERIMENTAL TASKS		Read Sem RT 1200	Read Sem RT 600	Read Syn RT 1200	Read Syn RT 600	Read Ortho RT 350	Read Ortho RT 150	Read Sem Acc 1200	Read Sem Acc 600	Read Syn Acc 1200	Read Syn Acc 600	Read Ortho Acc 350	Read Ortho Acc 150
Read Semantic RT1200	Pearson Corr	1	.630**	.578**	.455**	.399**	.334*	-.242	-.250	-.243	-.218	-.044	-.035
	Sig. (2-tailed)		.000	.000	.001	.004	.018	.090	.080	.090	.128	.759	.807
Read Semantic RT 600	Pearson Corr	.630**	1	.417**	.616**	.279*	.091	.375**	.311*	.241	.230	.404**	.312*
	Sig. (2-tailed)	.000		.003	.000	.050	.531	.007	.028	.092	.109	.004	.027
Read Syntactic RT1200	Pearson Corr	.578**	.417**	1	.453**	.444**	.524**	-.261	-.160	.021	-.047	-.136	-.174
	Sig. (2-tailed)	.000	.003		.001	.001	.000	.067	.268	.887	.743	.345	.227
Read Syntactic RT 600	Pearson Corr	.455**	.616**	.453**	1	.469**	.241	.250	.214	.458**	.526**	.440**	.374**
	Sig. (2-tailed)	.001	.000	.001		.001	.092	.080	.136	.001	.000	.001	.008
Read Ortho RT 350	Pearson Corr	.399**	.279*	.444**	.469**	1	.818**	-.217	-.152	.036	.162	.113	-.117
	Sig. (2-tailed)	.004	.050	.001	.001		.000	.131	.293	.802	.262	.434	.417
Read Ortho RT 150	Pearson Corr	.334*	.091	.524**	.241	.818**	1	-.313*	-.252	-.062	.015	-.055	-.247
	Sig. (2-tailed)	.018	.531	.000	.092	.000		.027	.078	.667	.918	.703	.084
Read Semantic Acc1200	Pearson Corr	-.242	.375**	-.261	.250	-.217	-.313*	1	.651**	.577**	.615**	.506**	.532**
	Sig. (2-tailed)	.090	.007	.067	.080	.131	.027		.000	.000	.000	.000	.000
Read Semantic Acc600	Pearson Corr	-.250	.311*	-.160	.214	-.152	-.252	.651**	1	.535**	.643**	.512**	.468**
	Sig. (2-tailed)	.080	.028	.268	.136	.293	.078	.000		.000	.000	.000	.001
Read Syntactic Acc1200	Pearson Corr	-.243	.241	.021	.458**	.036	-.062	.577**	.535**	1	.737**	.490**	.463**
	Sig. (2-tailed)	.090	.092	.887	.001	.802	.667	.000	.000		.000	.000	.001

Read Syntactic Acc600	Pearson Corr	-.218	.230	-.047	.526**	.162	.015	.615**	.643**	.737**	1	.613**	.477**
	Sig. (2-tailed)	.128	.109	.743	.000	.262	.918	.000	.000	.000		.000	.000
Read Ortho Acc 350	Pearson Corr	-.044	.404**	-.136	.440**	.113	-.055	.506**	.512**	.490**	.613**	1	.729**
	Sig. (2-tailed)	.759	.004	.345	.001	.434	.703	.000	.000	.000	.000		.000
Read Ortho Acc 150	Pearson Corr	-.035	.312*	-.174	.374**	-.117	-.247	.532**	.468**	.463**	.477**	.729**	1
	Sig. (2-tailed)							.000	.001	.001	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX W: CORRELATIONS BETWEEN AUDITORY EXPERIMENTAL TASKS

EXPERIMENTAL TASKS		Aud Sem RT N	Aud Sem RT TC	Aud Syn RT N	Aud Syn RT TC	Aud Ortho RT N	Aud Ortho RT TC	Aud Sem Acc N	Aud Sem Acc TC	Aud Syn Acc N	Aud Syn Acc TC	Aud Ortho Acc N	Aud Ortho Acc TC
Aud Semantic RT N	Pearson Corr	1	.761**	.550**	.532**	.502**	.553**	.140	.384**	.134	-.013	-.024	.052
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.333	.006	.353	.929	.870	.718
Aud Semantic RT TC	Pearson Corr	.761**	1	.682**	.696**	.542**	.593**	.230	.495**	.230	.065	.044	.106
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.107	.000	.109	.652	.763	.465
Aud Syntactic RT N	Pearson Corr	.550**	.682**	1	.773**	.546**	.449**	.060	.131	.087	-.032	.066	-.002
	Sig. (2-tailed)	.000	.000		.000	.000	.001	.679	.364	.547	.823	.647	.988
Aud Syntactic RT TC	Pearson Corr	.532**	.696**	.773**	1	.418**	.353*	.271	.328*	.168	.195	.320*	.155
	Sig. (2-tailed)	.000	.000	.000		.003	.012	.057	.020	.244	.174	.023	.284
Aud Ortho RT N 150	Pearson Corr	.502**	.542**	.546**	.418**	1	.645**	-.055	.110	.151	-.082	-.119	-.159
	Sig. (2-tailed)	.000	.000	.000	.003		.000	.705	.445	.296	.574	.412	.269
Aud Ortho RT TC 100	Pearson Corr	.553**	.593**	.449**	.353*	.645**	1	.095	.236	.179	-.049	-.069	.017
	Sig. (2-tailed)	.000	.000	.001	.012	.000		.512	.098	.214	.737	.633	.904
Aud Semantic Acc N	Pearson Corr	.140	.230	.060	.271	-.055	.095	1	.536**	.224	.283*	.415**	.221
	Sig. (2-tailed)	.333	.107	.679	.057	.705	.512		.000	.117	.046	.003	.123
Aud Semantic Acc TC	Pearson Corr	.384**	.495**	.131	.328*	.110	.236	.536**	1	.202	.284*	.190	.294*
	Sig. (2-tailed)	.006	.000	.364	.020	.445	.098	.000		.159	.046	.186	.038
Aud Syntactic Acc N	Pearson Corr	.134	.230	.087	.168	.151	.179	.224	.202	1	.524**	.268	.266
	Sig. (2-tailed)	.353	.109	.547	.244	.296	.214	.117	.159		.000	.060	.062

Aud Syntactic Acc N	Pearson Corr	-.013	.065	-.032	.195	-.082	-.049	.283*	.284*	.524**	1	.352*	.323*
	Sig. (2-tailed)	.929	.652	.823	.174	.574	.737	.046	.046	.000		.012	.022
Aud Ortho Acc N 150	Pearson Corr	-.024	.044	.066	.320*	-.119	-.069	.415**	.190	.268	.352*	1	.685**
	Sig. (2-tailed)	.870	.763	.647	.023	.412	.633	.003	.186	.060	.012		.000
Aud Ortho Acc TC 100	Pearson Corr	.052	.106	-.002	.155	-.159	.017	.221	.294*	.266	.323*	.685**	1
	Sig. (2-tailed)	.718	.465	.988	.284	.269	.904	.123	.038	.062	.022	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX X: CORRELATIONS BETWEEN READING AND AUDITORY EXPERIMENTAL TASKS

EXPERIMENTAL TASKS		Read Sem RT	Read Sem RT	Read Syn RT	Read Syn RT	Read Ortho RT	Read Ortho RT	Read Sem Acc	Read Sem Acc	Read Syn Acc	Read Syn Acc	Read Ortho Acc	Read Ortho Acc
Aud Semantic RT N	Pearson Corr	.371**	.327*	.554**	.499**	.578**	.550**	-.074	.008	.100	.131	.066	-.124
	Sig. (2-tailed)	.008	.020	.000	.000	.000	.000	.608	.957	.492	.363	.648	.392
Aud Semantic RT TC	Pearson Corr	.364**	.428**	.448**	.575**	.476**	.412**	.060	.142	.216	.286*	.204	.014
	Sig. (2-tailed)	.009	.002	.001	.000	.000	.003	.678	.325	.132	.044	.156	.921
Aud Syntactic RT N	Pearson Corr	.357*	.431**	.462**	.467**	.506**	.438**	-.050	.008	.130	.137	.161	-.001
	Sig. (2-tailed)	.011	.002	.001	.001	.000	.001	.728	.958	.367	.344	.264	.994
Aud Syntactic RT TC	Pearson Corr	.350*	.565**	.424**	.435**	.323*	.284*	.138	.267	.190	.321*	.341*	.164
	Sig. (2-tailed)	.013	.000	.002	.002	.022	.046	.339	.060	.187	.023	.015	.255
Aud Ortho RT N 150	Pearson Corr	.337*	.297*	.491**	.192	.389**	.474**	-.216	-.125	-.021	-.072	-.116	-.157
	Sig. (2-tailed)	.017	.036	.000	.182	.005	.001	.132	.387	.887	.619	.423	.277
Aud Ortho RT TC 100	Pearson Corr	.348*	.199	.374**	.269	.342*	.325*	-.130	-.078	-.013	.043	.019	.014
	Sig. (2-tailed)	.013	.166	.007	.059	.015	.021	.369	.589	.931	.769	.897	.923
Aud Semantic Acc N	Pearson Corr	-.059	.281*	-.176	.121	-.028	-.014	.415**	.372**	.169	.281*	.472**	.337*
	Sig. (2-tailed)	.683	.048	.222	.404	.849	.923	.003	.008	.242	.048	.001	.017
Aud Semantic Acc TC	Pearson Corr	.058	.281*	-.056	.318*	.236	.243	.269	.384**	.340*	.445**	.433**	.211
	Sig. (2-tailed)	.688	.048	.701	.024	.099	.089	.059	.006	.016	.001	.002	.141
Aud Syntactic Acc N	Pearson Corr	-.028	.144	-.013	.215	.161	.126	.405**	.117	.308*	.413**	.362**	.440**
	Sig. (2-tailed)	.845	.319	.929	.133	.264	.383	.004	.420	.029	.003	.010	.001
Aud Syntactic	Pearson Corr	-.024	.207	-.005	.216	-.077	-.039	.389**	.270	.317*	.461**	.317*	.444**

Acc TC	Sig. (2-tailed)	.867	.149	.975	.131	.596	.790	.005	.058	.025	.001	.025	.001
Aud Ortho Acc N 150	Pearson Corr	-.078	.466**	-.052	.321*	-.119	-.258	.639**	.637**	.584**	.503**	.695**	.721**
	Sig. (2-tailed)	.591	.001	.719	.023	.411	.070	.000	.000	.000	.000	.000	.000
Aud Ortho Acc TC 100	Pearson Corr	-.102	.280*	-.117	.406**	-.001	-.147	.526**	.560**	.485**	.601**	.670**	.704**
	Sig. (2-tailed)	.483	.049	.419	.003	.996	.309	.000	.000	.000	.000	.000	.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).