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Comparisons Between Oral and Silent Reading in Developing Readers

by

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Abstract

The developmental reading achievements necessary for fluency require a reader who is quick, accurate, and automatic. For beginning readers assessment is done via oral reading tests. As readers progress through their education, they gradually transition to silent reading. Up to this point, many have assumed that silent reading skill develops naturally out of oral reading skill. This paper investigated the connections between oral and silent reading skill as well as general characteristics of oral and silent reading in second grade readers. As readers increased in skill level, their scores across all variables improved. Yet high and low skill readers at times approached the text in much different ways. In silent reading, low skill readers proceeded through the passage in a very unsystematic manner, suggesting that the processing demands of silent reading eroded their ability to read efficiently. For oral reading, we found that readers with higher skill utilized punctuation to not only read more expressively, but to also decrease their processing demands by utilizing natural breaks to gather ideas. This study provided a comprehensive basis for the differences in oral and silent reading behavior as skill level increased.

Introduction

Modern society allows near-immediate access to information – facts, knowledge, opinions, theories – in books and on-line. Nearly all of this information is in the form of written text. Hence, learners must be able to effortlessly and quickly decipher written text in order to react accordingly. Therefore, one of the first skills a new student must acquire is the ability to read.

A child's capacity to effortlessly read text is the foundation for all further learning and eventually self-expression. A fluent reader is able to easily decipher and decode text. Fluency can be defined as reading with accuracy, speed, and expression (National Reading Panel, 2000). Accuracy is the correct identification of words. Speed is achieved through automaticity, the skill of immediate identification of words. Reading with expression, known as prosody, is the ability to apply correct stress, intonation and timing of everyday speech during oral reading (Wise, Sovcik, Morris, Lovett, Wolf, Kuhn, Meisinger & Schwanenflugel, 2010). Fluency, therefore, depends on several levels of skills that a child must master.

Developmentally, one must master skills at the phonological, orthographic and morphologic level before higher-level skills such as comprehension can develop (Goodman, Libenson, & Wade-Wooley, 2010). Recent studies reveal that over 40% of fourth grade readers in the United States are not fluent readers (Daane, Campbell, Grigg, Goodman, & Oranje, 2005). This statistic is disconcerting because children who do not develop the key skills towards fluency in their early school years suffer later and struggle to learn and comprehend material in more advanced texts later on during their education (Miller & Schwanenflugel, 2008).

Fluency for developing readers is typically assessed via oral reading tasks due to their strong ability to predict young readers' comprehension (Kim, Wagner & Foster, 2011; Riedel, 2007). Yet eventually readers are expected to be fluent in silent reading skill as well as oral reading. Reading assessment beyond comprehension however is not possible in silent reading in the manner that oral reading provides. A silent reader who struggles with a lower level reading skill such as decoding will have low comprehension scores. Yet a reader who potentially struggles to integrate information, but is a strong decoder, will also have low comprehension scores. Therefore, the purpose of this paper is to investigate the relatedness of prosody, an oral reading skill, and eye movement behavior during silent reading in order to create more comprehensive reader evaluation standards in both oral and silent reading.

Prosody

Prosody, an aspect of oral reading fluency, is used as a means of evaluating reader skill level and identifying areas of strengths and deficits in underlying reading processes. The study of prosody began as an investigation of oral reading skill as an attempt to understand the different cognitive skills involved in reading.

Prosody is a complex system of stress, intonation and pausing used to express meaning and intent from a passage of text. Each of these components influence listener comprehension. English has a natural rhythm of stress and pausing which scaffolds meaning in a sentence as it is manipulated by a speaker. A change in pitch, or intonation, conveys, among other things, sentence type (Clay & Imlach, 1971). For example, a declarative sentence ends with a drop in pitch across the final syllables in the phrase, whereas a yes-no question ends with a strong upswing in pitch to convey uncertainty. Questions used to gather information, the so-called five-w questions (who, what, where, when, how) end with a flatter pitch (Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl 2004). These simple pitch differences at phrase endings allow a speaker to communicate and focus a listener to relevant aspects of a sentence.

Pausing is the final component of prosody, which is thought to aid in the processing of various ideas by readers and listeners. Pausing naturally occurs at phrase and clause boundaries, which group ideas (Chafe, 1988). Inappropriate pausing can be distracting and confusing for a listener. A common example of poor pausing can be seen while orally reading poetry. A reader who pauses at the end of each line instead of at the conclusion of a phrase or clause creates a disjointed passage of text that lacks meaning. Take the line from *A child said, What is the grass?* by Walt Whitman "A child said, What is the grass? Fetching it to me with full / hands; / How could I answer the child? … I do not know what it / is any more than he." If the reader paused at the end of each line, the phrase would be broken and disjointed. Whitman manipulated reader expectation by adding in appropriate breaks, causing for more attention to the content.

Poets utilize pausing to radically change the meaning of their text. They purposefully place breaks to force a reader to assimilate a particular idea before proceeding further in the text. Poets are masters of language and meaning. They also impart emphasis to particular ideas by manipulating stress in their works. Stress can serve to alter the rhythm of a passage. For example, iambic pentameter is a metrical rhythm that is traditionally used by poets that consists of five high and low stress pairs of syllables. Iambic pentameter is present in over seventy five percent of English-written poetry because it imitates the natural rhythm of speech and will therefore carry a reader as they encounter abstract metaphors and imagery (Nims, 1971). Without this natural rhythm, poetry becomes too disjointed to decipher.

Stress can also serve to change the meaning of a word. Some words of English with ambiguous meanings rely on stress for proper identification. For example the word "produce" can mean either a tangible thing that has been grown, or a verb about creation. If the stress emphasis is placed in the first half of the word, as in "PROduce," it can mean vegetables, whereas "proDUCE" is the verb form. This stress alternation not only changes the meaning of the actual word, it also changes the expectation of the words that would follow. If a sentence read "Mother went to the store and got produce…" the words that would follow would be a prepositional phrase about the location or quality of the vegetables. On the contrary the sentence “Working hard produces…” would need a direct object to follow and prepositional phrase would be completely out of place.

The above example is one instance where our use and manipulation of prosody must be extremely deliberate. In fact, text read without any form of prosody is difficult to comprehend. Yet applying prosody to a passage requires a reader to be fully aware of the meaning of a passage. If a reader is unable to predict the upcoming text they will lack the ability to impose prosodic structure on the text.

Prosody relies on the mastery of multiple skills and knowledge of the nature of language. Decoding and quick, automatic word recognition are the preliminary skills developed by readers. Word recognition and decoding rely on lower-level cognitive processes. Once these processes become automatic and accurate, a reader is able to focus more attention on gaining information and meaning from text. Clay and Imlach (1971) explored the underlying mechanisms involved in the development of perceptual and cognitive processes used for reading. Previous research showed that a reader’s behavior becomes patterned as s/he develops skill. Clay and Imlach believed that this pattern demonstrated the existence of underlying hierarchies in reading skill, rather than just lack of vocabulary and phoneme-grapheme associations. Therefore, they examined the linguistic skills of juncture, pitch and stress to examine underlying processes. They examined juncture, or a pause in the flow of oral reading, pitch, the expected rise and fall of the tone of the reader, and stress, measured by loudness.

Clay and Imlach assessed how reading behavior changed with increasingly difficult reading tasks. Results of this study indicated that juncture was correlated with reading ability: better readers made fewer pauses. Furthermore the best readers had a fall in pitch at the end of a sentence, whereas poor readers ended sentences with a sustained or raised pitch. The existence of a hierarchy was clear: reading with expression relies on the mastery of multiple perceptual and cognition skills which depend on reader skill not just knowledge of vocabulary.

Word recognition, another preliminary skill mastered by readers, affects performance of higher order processes. The ability to effortlessly recognize words and oral reading skill was examined by Herman (1985). She focused on decoding skill in passages of text to examine how word identification skills would improve. Herman predicted that, with repeated reading of a passage, decoding skills would approach automaticity, thereby freeing up processing attention, resulting in increased comprehension levels and improved prosody. After repeated practice, readers in her study improved in their speed and accuracy. Readers did not improve their frequency of pausing; they only improved their duration time while pausing. This improvement indicated that word recognition was becoming more automatic. Readers did not improve in their pausing frequency, phrasing, or intonation of the stories with practice, as was predicted. This study, however, was highly constrained. It contained only eight participants, all of who identified as very low skill readers. Compared to average or skilled readers, they would have had strong deficits in lower level processing skills. However, it became clear that decoding relies on lower level processing and use of those processes inhibits a reader's ability to read with strong prosody.

Once decoding skills are well established, as in more advanced readers, prosody should improve, but it was unclear how this improvement would be expressed. Research conducted by Cowie, Douglas-Cowie and Wichmann (2002) investigated reading fluency and expressiveness. They examined how fluency and expressiveness were related in highly skilled readers, and how expressive reading was characterized in these readers. Children, who rated as normal in academic and linguistic skill, were evaluated by researchers on their fluency and expressiveness as they read a passage. Results from this study indicate that fluency leads to expressiveness. A reader cannot be expressive without strong fluency skills. Expanding upon this study, Cowie et al. analyzed expressiveness in more depth. Using a statistical analysis, which evaluated changes in pitch contours by creating systematic descriptions, Cowie et al. were able to objectively support that fluency and timing (pausing) are related, as are expressiveness and pitch variation. Timing was directly related to fluency and pitch was related to expressiveness. These results were inter-related as well: pitch changes indicating expressiveness were only apparent in children who had some degree of fluency. Reader skill level is related to prosody in multiple ways. A reader who reads without pauses has mastered lower-level skills of decoding, but without the ability to read with appropriate pitch-contours they cannot be considered truly fluent.

Cowie's experiment demonstrated that aspects of prosody correspond to different hierarchical skills dependent upon reader fluency level. Schwanenflugel, Hamilton, Kuhn, Wisenbaker, and Stahl (2004) evaluated reader skill level and their corresponding prosodic skill level. Furthermore, the researchers hoped to gain further insight about the relatedness of the development of prosody and comprehension levels. Previous research by Karlin (1985) and Kuhn and Stahl (2003) found no direct connection to comprehension levels with prosodic skill increase, but an improvement in prosodic score did demonstrate mastery of different aspects of fluency. Since an increase in fluency should increase comprehension levels, Schwanenflugel et al. therefore examined prosody as a partial mediator in assisting comprehension. A reader's prosodic skill was represented via a spectogram analysis that transformed speech waves into visual representations of changes in pitch, loudness, duration and pausing. This study measured prosody via intersentential pause length means, intersentential pause length variances, intrasentential pause length means, child-adult final pitch matches and sentence final pitch declinations in an orally read passage. A decoding task and comprehension task were measured separately and determined reader skill level. Schwanenflugel et al. found a strong relationship between decoding skill and prosodic skill. As readers became skilled decoders, their prosodic profiles began to match those of adults. Their prosodic profile included short pauses between sentences, minimal variability in pause structures within a sentence, declarative sentences ending with a fall in pitch, and an overall pitch contour matching that of adults. When a child had fluent decoding skills, their freed attention resources then focused on prosodic skill. To investigate comprehension level and prosodic skill, the researchers created two models: prosody as a partial mediator and reading comprehension as a predictor of reading prosody. Neither model was found to be particularly revealing of the relatedness of these two variables. However, as had been shown by other prosody investigations, decoding speed was the major factor in strong prosodic reading and also improved comprehension.

Expanding upon Schwanenflugel et al. (2004), Miller and Schwanenflugel (2006) created passages containing syntactically complex sentences to further study prosody. The passage included multiple sentence types: declarative, quotatives, “wh” questions, “yes/no” questions and phrase final commas. These sentences were included in the passage to examine the prosodic behavior of children as they read various types of punctuation. Using reading skill level as a predictor of prosody, Miller and Schwanenflugel made several important observations. Good readers had fewer and shorter pauses at commas and at the end of sentences. Furthermore, in yes/no questions readers had a rise in pitch at the end, and a drop in pitch at the end of declarative sentences. Less skilled readers had lengthy and inappropriate pausing within and between sentences. They read internal commas as obligatory pauses. Furthermore, these readers had flat pitch changes at the end of sentences. These findings demonstrated that prosody emerges once a reader is quick, accurate and automatic in their reading skill, and that specific measures of pitch changes can be used as an important predictor of reading fluency. Miller and Schwanenflugel investigated prosody and comprehension. Beginning with reading skill level and comprehension, the researchers added prosodic variables to evaluate how the strength of the relationship changed with each marker of fluency. Pitch changes was the only prosodic variable that accounted for variance between comprehension and prosody. The researchers argued that because they used a passage with more syntactically complex phrases as compared to Schwaneflugel et al. (2004), they were able to find relatedness between pitch and comprehension. However, decoding skill still demonstrated the strongest indicator of reader prosodic skill level.

If prosody depends on mastery of lower-level component skills, Miller and Schwanenflugel wanted to know how prosody would change as a function of development. How prosodic skill changes with age and reading skill development was the focus of the next study by Miller and Schwanenflugel (2008). This longitudinal study focused on first and second grade students and later evaluated these children at the conclusion of third grade. Once again Miller and Schwanenflugel used a passage containing aspects that measured various areas of prosodic skill. They used pitch changes as a means of predicting comprehension levels. This study also investigated the relationship of pausal intrusions and development of skilled prosody. Miller and Schwanenflugel hypothesized that fewer pausal intrusions was related to adopting an adult intonation contour.

Through this study, Miller and Schwanenflugel found that as children accrued reading skill they had fewer and shorter pausal intrusions and their intonation contours became more adult-like. They confirmed that true prosodic reading is dependent upon a child's developing fluency. A child who had few pausal intrusions in first grade had intonation contours similar to adults by the end of second grade. Pitch was found to be a true predictor of fluent text reading skill and comprehension two years later. Also fewer pausal intrusions while reading correlated with increased comprehension.

Through these studies prosody has developed into a complex skill, with different levels indicating the source of reader skill deficits. The most basic skill of decoding is related to the ability to read prosodically. As skill level increases, intrasentential pausing decreases as a reader becomes able to gather more from context and read more smoothly. As a reader approaches fluency, their prosodic profile begins to contain pitch and intonation changes similar to adult models.

Studies continue to investigate the role of prosodic skill and comprehension. A recent study by Benjamin and Schwanenflugel (2010) investigated the impact of text difficulty on prosodic performance. This study examined various levels of prosody including loudness, duration, pitch and pausing which all are employed in prosody to give meaning to a text. Using spectograph analysis, the researchers were accurately able to analyze the relationship between prosody and skilled reading. Building off of Clay and Imlach (1971), the researchers used texts with increasing difficulty to assess both unskilled and skilled readers. As texts became more difficult, prosodic performance was impacted with increased pausing between words within a sentence. The researchers hypothesized that these pauses could be due to the increased complexity of grammar, but were also emphasized as readers struggled to read text with one breath. Fluent readers read with greater speed, and therefore had less inappropriate pausing because they were able to incorporate more words per breath. A significant finding of this study was the decreased variance between the relationship between prosodic skill and comprehension with the difficult text. Therefore, although the text was above the skill level of the readers, it more accurately predicted their comprehension level when compared to a simpler text. Prosody it appears, can predict comprehension levels if the passage can accurately assess a reader.

Eye Movements

By examining the behavior of the eyes, one can explore the underlying processes involved in reading. With increasing technological advances, the ability to explore the connectedness of eye movement and reading ability continues to improve. Rayner (1998), in a review, describes various studied aspects of eye movement research. As a person reads text, their eyes are in motion during saccades and at rest during fixations. Mean saccade length is 7-9 letter spaces in adult readers. During a saccade the eyes move rapidly, at times 500 degrees per second. Therefore the ability to obtain information during a saccade is greatly reduced. While most saccades move the eyes forward in a text, about 10-15% of the time they also make regressions, or saccadic movements of the eyes to the left. Between saccades, the eye fixates on a point, usually lasting 200-250 ms.

Eye movements during reading have been shown to reflect characteristics of the text. For example, content words are fixated 85% of the time, whereas functions words, which are usually less than 4 characters, are fixated only 35% of the time. As the length of a word increases, so does its fixation probability. Furthermore, the corresponding saccade length depends on word boundary information and word predictability, such that longer words and low frequency words are less likely to be skipped (Rayner, 1998).

The eyes move due to lexical factors. In a study by Morris, Rayner and Pollatsek (1990) the researchers manipulated information in the parafoveal area. The parafovea is unable to process information fully because it has low acuity. Yet, as the researchers demonstrated, once the eye has fixated on a word it utilizes information in this area to influence movements. Letter information in the parafovea determined when the eyes moved, whereas manipulations of space in the parafovea determined saccade length and where the eyes moved. Therefore eye movement control depends upon two components: perceptual and lexical properties. Perceptual cues tell the eye where to land via parafoveal processing and lexical cues tell the eye when to move, after sufficient processing of text (Morris, Rayner, & Pollatsek, 1990).

Most studies in eye movement research have focused on how both skilled and unskilled adult readers handle challenging reading situations. Researchers have investigated what aspects of the visual field can cause the eye to move sooner or later while processing, how text complexity affects overall behavior and how lexical aspects of words influence reader expectation of text while reading.

The frequency of a word greatly determines how it is read in text. Short frequent words, such as articles, are often skipped by readers of all ages. One main tactic employed by the eyes is to use information in the parafovea to help decide if a word should be skipped over during a saccade. Drieghe, Rayner and Pollatsek (2005), manipulated information in the parafovea to see what changes would induce word skipping. When a predictable word was in the parafoveal preview, word skipping rates increased, as compared to using a nonword instead. This result indicated firstly that the eye monitors information in the parafoveal region, and processes it to an extent that could cause word skipping. Yet, this processing is not complete: nonwords that looked similar to target predictable words were also skipped, indicating that the eye uses incomplete information to decide its movement. The eyes take a risk by using this partial processing in the hope that skipping will ultimately save time. Eye movement behavior uses a mechanism of early recognition to reduce its cognitive load by partially processing predictable words.

Drieghe, Desmet and Brysbaert (2007) further explored how processing ease influences eye movement behavior. In a follow up study they manipulated the predictability of target words based on text that preceded the target word. Specifically, the researchers altered the predictability of target pronouns. They found that readers would skip the pronoun if it was redundant based on previous text. This strategic positioning of the eyes demonstrates that linguistic factors directly influence eye movement behavior.

Ashby, Rayner and Clifton (2005) explored how the lexical properties of words could disrupt reading behavior of high and average skill adult readers as sentence construct varied. First, the researchers assessed how reader skill would impact eye movement behavior for high and low frequency words in non-constraining sentence constructs. As was expected, the groups showed differences in their gaze durations of the target words based on skill, with the highly skilled readers having a shorter gaze duration. Average skill readers also regressed from the target word more frequently and spent more time re-reading prior text. Furthermore, the behavior of readers after they left the target region did not change based on target word frequency (high or low), suggesting that behavior due to a word's frequency is due to lexical access processes only present in initial word reading. Next the researchers embedded either high or low frequency words in a normal or in constraining sentence contexts. This second experiment demonstrated that predictability and frequency of a word independently affects processing time. A frequency effect of words was not found to be significant in gaze duration. Yet behavior after a low frequency word differed according to skill group. For average readers, there was a spillover time in lexical processing after the target word shown by their higher rereading frequency of previous text. Overall this study demonstrated that as a reader increases in skill, their eye movement behavior will change with lexical processing demands of the text. The researchers hypothesized that with increased skill, a reader is able to automatically decipher text in the moment, whereas an average reader uses additional time after the target word to process text and is unable to effectively decipher low frequency words in unpredictable contexts. Lexical aspects of words such as their frequency, but also their context, impact a reader's ability to easily decipher text and can be examined through eye movement studies.

Reingold, Yang and Rayner (2010) investigated further evidence for lexical control of eye movement behavior. Using case alternation (horse vs hOrSe) as well as measure of word frequency, Reingold et al. provided strong evidence for lexical processing as the main contributing factor of eye movement control. A word's frequency impacted initial fixation time, indicating early lexical processing. Fixations due to case alternation of a word demonstrated later attentional, lexical and post-lexical processing, as shown by total gaze duration of a word. The research indicated that the duration of the first fixation in multiple first-pass fixations represents early lexical processing, and word frequency is the main contributing factor. Word frequency, not case alternation, determined the ease of lexical processing and was reflected in first fixation duration.

Children and Eye Movement Behavior

A young reader however, is building fluency from very beginner stages. Reading fluency is related to mastery of a hierarchical structure of lower level subcomponents that build upon one another so that information may be transferred to higher level comprehension processes. This hierarchy starts with the simple memorization of the connections between letters and words, building into effective word recall until automatic skills of word retrieval develop (Schwanenflugel et al., 2006).

Reading is not a natural act, like language acquisition. Reading requires the mastery and integration of two tasks: recognizing words in a text and then understanding them once they have been recognized. Basically, reading requires decoding skills and comprehension skills (Gough, 1996). With practice they learn how to simultaneously decode text while retaining a working representation of the passage. This allows them to integrate the new information effortlessly for maximum comprehension. Jenkin et al. (2003) demonstrated that fluent reading of text accounts for additional variance in reading comprehension beyond single word reading alone. Therefore, as decoding and word recognition skills develop, children are potentially using their freed cognitive resources to create a more complex representation of the passage via punctuation and grammar (Schwanenflugel et al., 2006). Therefore the main controlling factors in a child's eye movements are the linguistic aspects of text. A child must be able to assign meaning to a word so they can incorporate that word into the rest of the story. Therefore a child's ability to easily approach text and decipher its meaning is highly dependent upon her ability to understand the character of each word in the text and seamlessly knit each word together into a larger frame of understanding.

A child's fixation patterns vary from that of adults. This variation is due to their lack of ease in processing text, potentially due to high decoding demands (Hyona & Olson, 1995). For example, readers in second grade have fixation times of 260-360 ms and up to 33% of eye movements are regressions (Rayner, 1998). Studies on children's eye movement patterns have focused on the same issues as adults but have an increased focus on aspects of reading that challenge less-fluent readers such as word length and predictability.

Fixation durations, the amount of time between saccades, are longer and more frequent, with shorter saccades, along with increased number of regressions in children. With increasing reading skill however, all of these behaviors become more efficient resulting in shorter fixations, longer saccades and fewer regressions. In an experiment designed to test differences between adults and children's approaches to long words, Joseph, Liversedge, Blythe, White, and Rayner (2009) found that children exhibited strong effects due to word length. Their gaze durations and refixation probabilities were significantly higher than that of adults, suggesting that they took longer to process long words than adults. This could be due to their smaller perceptual span, or the region of effective vision during fixations. Rayner (1986) argued that beginning readers struggle in part due to their smaller perceptual spans. A reduced perceptual span limits the amount the eye can fixate on in one gaze. This means that to complete processing the eyes much refixate or move on with incomplete lexical processing. The researchers suggested that with increased skill, readers are able to initiate a saccade before processing is finished. The ability to leave a word with partial information is a skill that must be learned, and children who lack this skill are only able to move after full lexical access of the word has been accomplished. Refixations on a word demonstrate a reader who is unaware or unable to move prematurely due to processing demands. So while low frequency words trouble readers, young readers also struggle to handle large words.

These studies demonstrate that the act of decoding text influences eye reader behavior and that with an increase in skill these behaviors become more efficient reflecting the reduced processing ease. Yet reader fluency resulting in comprehension varies as a reader develops skill. In examining this variance Walczyk and Taylor (1996) proposed an interactive model of reading where both the aspects of bottom-up processing, the hierarchical arrangement of reading skill, interacts with the top-down processes that focus on knowledge and expectations of text. Walczyk and Taylor (1996) argue that when a reader utilizes their metacognitive skills, they can alter their behavior to minimize strain. They called this the Compensatory-Encoding model. In this model, readers would react to situations that impaired their comprehension, which were either due to subcomponent inefficiencies or due to small verbal working memory. They found that better readers, who were more metacognitively active, were more likely to re-read text when necessary and slow their reading rate as text difficulty increased. Therefore, while a reader's eye movements reflect the lexical processing of text, a reader's expectation and interpretation of their own skill influences their eye behavior and strategy to approaching text.

Silent and Oral Reading

As research has shown, the development of fluency depends on mastery of an essential hierarchy of various reading skills. One of the largest components of this hierarchy is our knowledge of the lexical components of words. Our reading ease is challenged as we interpret the meaning of text based on its lexical properties. Because we first learn to talk and then to read, we have an underlying knowledge and ability to recognize how words fit together in a sentence. The transition of speaking to reading requires readers to decode the phonemic components of words into logical words and phrases. Mastery of this skill can be measured by the correctness in the phrasing, intonation and pausing when reading written text. Yet in silent reading, a reader must be able to still combine words into meaningful phrases, but without the scaffolding of oral cues. Silent reading skill is the hallmark of true fluency; so, despite similarities between silent and oral reading, a reader lacks the oral cues during silent reading and must use other tactics to assign meaning to text. Therefore, a proper assessment of silent reading fluency is necessary to ensuring the development of fluency in readers.

One of the greatest assumptions about the development of silent reading is that it naturally builds off of oral reading skill. Oral reading, however, has features that are not necessary in silent reading. These features include punctuation pauses for clauses and at the conclusion of sentences. Hirotani, Frazier and Rayner (2005) found that eyes pause at punctuation that ends sentences and clauses, regardless of the complexity of the phrase. Previous research had suggested that these pauses were due to lexical processing, but there was no change in pause length when sentence complexity was experimentally manipulated. Therefore the pause is not due to increased processing but rather due to punctuation cues. This effect could be a strong indication of implicit prosody that would exist in silent reading due to knowledge carried over from oral reading.

When a reader decodes oral text the phonological characteristics of words help encode a word's meaning in short-term memory. Phonology, for a new reader, draws attention to the order and identity of letters in words and maps into a complete phonological representation of a word. Yet a silent reader who encounters unfamiliar text, and does not use oral cues to guide their reading, must employ different mechanisms to assign meaning and to decode the word. DeJong and Share (2007) investigated how orthographic learning could differ in both oral and silent reading tasks. More specifically, the researchers assessed the self-teaching hypothesis, which states that the ability to translate unfamiliar printed words into their spoken equivalents is a central means to acquiring orthographic representations. They wanted to see how decoding skill of pseudowords would differ in both conditions. Citing Poeppel (2001), they argued that silent and oral reading do not share identical patterns of cognitive processing as shown by different brain pathways for auditory-motor and lexical-semantic pathways.

DeJong and Share (2007) found that readers acquired more orthographic knowledge in the oral reading condition.

They presumed that this result was due to accurate decoding of the word during its first representations as the word was read aloud. Furthermore, reading comprehension was higher in the oral condition, suggesting that overt phonology scaffolded understanding and integration of information within and across sentences in text. Oral reading had full phonological code representation compared to silent reading. So while this study investigated orthographic learning, a skill not traditionally attributed to fluency, the impact of the condition either impaired or assisted young readers in acquiring information about the text. Therefore, from this study, oral versus silent reading affected higher-order processes in different ways.

Oral reading and silent reading are two skills that are highly intertwined in the early years of reading education. To date, the most effective method of assessment of reader fluency has been oral reading proficiency. Yet silent, not oral, reading skill is what is necessary in later stages of life and therefore there is a need to create a method to assess silent reading skill. It is assumed that silent reading skill develops naturally from oral reading. Reading fluently is comprised of both word-level reading skills and language processing skills. Therefore, our ability to determine the extent to which these skills overlap, and the manner in which they do so, is vital in ensuring that silent readers progress to high skill levels.

Silent reading fluency is often assessed by reader speed. A fast reader must be accurate and automatic; both of these skills are related to fluency. The relationship of eye movement parameters and reading speed was investigated by Sovik, Arntzen and Samuelstuen (2000). Using speed as their measure of fluency, they examined both oral and silent reading speed as well as four eye movement parameters associated with reading speed: recognition span (number of words in a fixation), average fixation time, number of progressive saccades and the number of regressive saccades. The study indicated that in 8-10 year olds, who have developing reading skills, recognition span, average fixation time and frequency of regressive saccades all correlated to silent reading speed. Furthermore, average fixation duration and frequency of regressive saccades were significantly correlated with speed in oral reading. This study presents evidence for connections between oral reading and silent reading. A reader who was fluent, as determined by reading speed, had short average fixation durations and low frequency of regressive saccades in both oral and silent reading tasks. Sovik et al. (2000) were able to identify eye movement behaviors that correlated with strong reading skill.

One of the few studies to investigate the connections between oral reading fluency, silent reading fluency, reading comprehension and listening comprehension was conducted by Kim, Wagner and Foster in 2011. In the study, four important questions were examined. Firstly, are oral reading fluency and silent reading fluency measures related to a single underlying ability? Secondly, do oral reading fluency and silent reading fluency compare as predictors of reading comprehension? Thirdly, to what extent are oral reading fluency, silent reading fluency, and reading comprehension predicted by decoding fluency and listening comprehension? Finally, how does reading skill level change these relationships?

To evaluate these questions, 316 first grade students were assessed on their listening skill, decoding ability, oral reading skill and silent reading skill. By using a large array of different tests to evaluate various reader skills, the researchers hoped to determine how development of different skill could lead to better performance in oral versus silent reading.

As predicted, Kim et al. found that oral reading fluency and silent reading fluency tasks measure distinct, yet highly related, underlying skills. For the sample used, oral reading fluency was a better predictor of reading comprehension than silent reading fluency. Furthermore, as shown by previous studies, average readers were impacted by decoding fluency, which predicted their oral reading fluency, their silent reading fluency and their reading comprehension level. Skilled readers' fluency levels were better predicted by listening comprehension than decoding skill and skilled readers read more accurately in context than in a list form. This finding suggests that skilled readers benefit from context to decode words at their more advanced fluency stage. Silent reading fluency predicted comprehension levels better in skilled versus average readers, suggesting that comprehension in silent reading relies on strong fluency skills. Therefore, in order to develop readers who comprehend texts while reading silently, we must identify ways to improve fluency rates in both oral and silent reading. Furthermore, from this study, oral reading fluency related to single word decoding, yet also skilled readers read more accurately in non-list formats.

Current Study

The current study aimed to explore the extent to which silent and oral reading skill overlap and how various linguistic factors affected reader performance. This study examined how the skills related to both oral and silent reading differed and either supported or hindered comprehension in beginning readers.

The first part of this study assessed overall passage reading skill in silent and oral reading. I wanted to investigate how general reading characteristics in silent and oral reading changed due to reader skill level. A child's oral reading skill was measured by her prosodic profile. A reader's ability to use appropriate stress, intonation and pausing across a variety of sentence types was determined by her prosodic profile. Frequency of regressive oral reading behavior was also measured and assessed on whether it was due to single word decoding errors or larger text integration errors.

For oral reading, I hypothesized that skill level would determine the strength of a child's prosodic profile. As skill improved, I hypothesized that children would read with better intonation as well as have fewer and shorter pauses throughout the passage. I hypothesized that skilled readers would have a higher frequency of phrase versus single word re-reading behavior.

For silent reading, children's reading skill was evaluated by eye movement behavior. The general characteristics of silent reading measured were the frequency of regressive saccades, average first fixation duration, average gaze duration, average total time on each word, frequency of skipping, and mean saccade length. In silent reading, I hypothesized that with increasing skill, readers would have larger saccades, shorter first fixation, gaze duration, and total time, fewer regressions to previous text, as well as less frequent skipping behavior.

Based on studies of eye movement behavior and Walczyk's model of compensatory mechanisms, this study also addressed how young, unskilled readers approached familiar and unfamiliar words embedded in a passage. The goal of this research was to investigate the different strategies second graders employed as they encountered high and low frequency words. Eye movement studies as well as prosody investigations have demonstrated that a strong indicator of reader skill level is connected to a reader's ability to decode unfamiliar words. Silent reading decoding behavior was measured by first fixation duration and gaze duration on target words. The length of the first fixation duration and gaze duration indicated the time needed to accurately access the lexical component of a word or the time needed to decode a word encountered in text. Oral reading decoding ability was determined by the frequency and length of pausal intrusions before and after the target words as well as time producing the target word. By measuring pause durations before and after the target word we could assess the cognitive strain of decoding and integration, and the time spent producing the word would represent actual decoding time. Furthermore decoding ability was measured by the Woodcock Johnson Word Attack subtest. I hypothesized for oral reading that as readers encountered low frequency words there would be longer pauses before and after the target word. Furthermore, I also hypothesized that readers in the oral reading would utilize decoding more frequently than in the silent condition. I hypothesized that decoding in silent readers is characterized by longer first fixation durations and gaze durations for low versus high frequency words.

The final part of this study investigated connections between silent and oral reading fluency as previously examined by Kim, Wagner and Foster (2011). How can measures of oral reading fluency predict silent reading performance? Does silent reading skill truly build off of oral reading skill? How did lower level components of reading, such as decoding, compare across oral and silent reading as well to external measures of decoding? Furthermore, how did measures of higher level processing during reading also compare for oral and silent reading tasks? Using the same experimental passages, oral reading fluency was compared to silent reading fluency. Measures of oral and silent reading fluency remained the same. Comprehension was measured by using the Woodcock Johnson subtest of Passage Comprehension. Based on previous research, I hypothesized that a reader must first utilize the scaffolding of oral reading skills in tasks such as decoding and word identification, before they would develop silent reading fluency. In lower level skills, I hypothesized that silent readers who were characterized in their oral reading by frequent pausal intrusions, as well as long pauses before and after target words would have long first fixation durations and gaze durations. For characteristics of higher level processing, I hypothesized that readers with strong prosody, with control over pitch, stress and pausing, would also read with less skipping, shorter total time measures and few instances of regression.

Method

Participants

This study included 135 second-grade students currently enrolled in three different elementary schools in Georgia. Second-grade students were ideal to study since reading fluency is usually achieved during the second grade (Chall, 1996; Kuhn & Stahl, 2003, Rasinski, Padak, Linek, & Sturtevant, 1994). The students who participated in the study all spoke English as their first language and did not have special education needs. Only students who achieved greater than 20 Words Read Correctly Minute (WRCM) at the first grade level and did not exceed 100 WRCM at the third grade level were eligible for the study. Students were assessed on both oral and silent reading proficiency.

Readers were assessed via Woodcock Johnson tests and categorized into three different skill levels based on their Broad Reading Score, a composite score of Woodcock Johnson tests. The levels were high, medium, and low skill readers.

Materials

Students were evaluated on their reading ability by measures gathered from two experimental passages. All participants were assessed in their oral reading skills by reading the story “Molly”. A different story was used to assess silent reading skill, “Sammy”.

Oral reading assessment. All participants read an experimenter-created story that was similar in length and structure to typical classroom stories. The story “Molly” contained 355 words. “Molly” contained 5 low frequency words and 5 high frequency words. Embedded within the story were declarative sentences ending with multisyllabic words, yes-no questions, wh-questions, adjectival commas, quote phrases, and phrase-final commas. This experimenter-developed passage was designed to assess various components of oral reading skill. The passage was devised to obtain differences in prosodic characteristic by eliciting changes in pitch and pause frequency. The computer program Pratt measured the targeted variables within the story. Pitch was measured in the ends of declarative, yn and wh-question sentences by measuring the change in pitch across the final word of the phrase. Pause length means were measured before and after target words, as well across adjectival, clause, quote, sentence and paragraph boundaries. These measures indicated how readers utilized punctuation as well as their approach to familiar and unfamiliar words. In this study we also measured instances of oral regressions and uncorrected errors. We calculated the amount of uncorrected errors throughout the passage as well as the number of phrase and single word repetitions. In six sentences we also measured the mean number of sentence and word intrusions. A word intrusion consisted of any pause that interrupted a particular word, while a sentence intrusion was any abnormal pause within the sentence.

Silent reading assessment. Silent reading skill was gauged by tracking eye movement patterns of each student as they read novel experimenter-developed passages which were similar in length and structure to passages on which they received instruction during the school year. The story "Sammy" was 178 words long and had 6 high frequency words and 6 low frequency words embedded in the passage. Sammy was designed to assess fixation on novel and familiar words as well as investigate other measures of developing reader eye movement behavior that are typically assessed in adults. The eye movements of the participants were superimposed onto an image of the passage. The passage was sectioned into grids around each word so as to measure the eye movements relative to the words in the passage. These measures included measures associated with initial processing such as first fixation, gaze duration and intraword regression. First fixation is the amount of time that the eyes spend on the initial fixation. Intraword regressions measure the amount of refixations of the eyes on the same word without leaving and gaze duration measures the total time fixated on the word without any interword regressions. Later processing measures were also assessed. These measure include total time, skipping, fixation count and interword regressions. Total time measures the total amount of time spent on each word, including regressions back to the word. Skipping measured the average amount of words skipped in each saccade. Fixation count measured the total number of fixations within the passage and interword regressions measured all eye movements that regressed across words.

External fluency assessment. Readers were assessed on their levels of phonological achievement, phonetic knowledge and other oral language abilities by using tests by Woodcock Johnson III. These tests provided an external basis for comparing fluency levels of reading external to the actual experiment. The first of these tests was a Letter Word Identification test which assessed a participant's word decoding skills by evaluating how skillfully a participant pronounces words in a list, demonstrating knowledge of phoneme/grapheme connections. Participants would work through the list until there were six consecutive errors, at which point the end point would be established. The next test investigated reader skill on passage reading abilities. In this test, a reader would receive a score on fluency level, measured by the number of correctly read words a minute, as well as a comprehension score from post-passage questions. Readers were also assessed on their ability to decode words, in the Woodcock Johnson test of Word Attack. In this test readers are assessed on their ability to decode non-real words, which assessed their ability to apply correct rules for word decoding without the constraint of previous vocabulary knowledge. These tests provided a strong base point for a developing reader's skill level. From this external data we categorized readers based on a Broad Reading score, composed of all the Woodcock Johnson test scores. Readers were classified as either low, medium, or high skill readers.

Procedure

Oral reading assessment involved asking the student to read aloud the story Molly, providing words on which the student hesitates for 3 seconds and marking errors (omissions, substitutions, & mispronunciations).

For silent reading assessment the passages that participants read was presented on a computer screen and the students were asked to read the material silently for comprehension. The students were prompted to “Do their best reading”. In all cases, onset of presentation of each trial was experimenter controlled and participants pressed a key to indicate they had finished reading and the passage then disappeared from the screen.

Apparatus

Oral reading skill was assessed by audio recording students’ reading of the passage using an Audio Technica AT2020USB Condense USB Microphone and analyzed using the RF32 Lab Automation time frequency analysis software.

Silent reading was assessed via eye tracking. Eye tracking data were collected using an EyeLink 1000 monitoring system manufactured by SR Research Ltd. Participants sat 55 centimeters away from a display screen with the EyeLink monitoring system positioned below the screen. Participants used a free standing chin rest with forehead bar to stabilize their gaze. The EyeLink system was interfaced with a laptop computer and a full-size flat screen monitor. It had a sampling rate of 250 Hz, resolution of .25 degrees of visual angle, and a range of 50 degrees horizontally and 40 degrees vertically. It typically took 2-5 minutes to calibrate a participant to the system.

Results

In this study, for the various measures considered, participants were grouped by their Broad Reading Score. From the Broad Reading Score we created three groups low skill (*N*=46) medium skill (*N*=42) and high skill readers (*N*=45). For oral reading assessment, audio wave files were analyzed using Pratt. Pitch changes at sentence endings were measured by determining the pitch difference across the final word in the phrase. Pause means were determined by measuring the length of time at the end of one word and start of the next. Similarly target words were measured by the beginning of pronunciation until the entire word had been attempted. These measures were then averaged for a total mean score for each measure. Silent reading was evaluated by taking an average of each individual measure for each subject from the passage.

General Prosody Characteristics

As previous research has demonstrated, the strength of a child's prosodic profile indicates the strengths and weaknesses of her developing oral reading skills. In order to properly evaluate beginning readers, prosody was measured across multiple aspects that contribute to strong prosodic reading. These components included pausing, pitch changes, and word and sentence intrusions. Pausing was measured across adjective and clause boundaries, after quotes, and at the end of declarative sentences and paragraphs. Pitch changes were evaluated at the ends of declarative sentences, wh-question and yn-question sentences as well as overall pitch differences within a sentence. Finally I examined word and sentence intrusions. I hypothesized that with increasing reading skill that the measures of all of these components would mature and improve, contributing to an overall stronger prosodic profile consisting of appropriate pausing, the use of pitch to convey sentence type as well as infrequent word and sentence intrusions.

Pauses in oral reading convey important information. They signify a change of point of view, such as after quotes, they can summarize an idea and emphasize particular ideas or statements. Analyzing pause skill therefore allows us to evaluate how readers approach punctuation, changes in point of view, and their ability to comprehend ideas as they progress through the text.

To evaluate differences in reader skill level I created a 3 (skill level) X 5 (pause type) mixed measures ANOVA to examine differences in pause time. Skill level was composed of three levels: low, medium, and high skill readers. Pause type consisted of adjectival, clause, sentence, quote, and paragraph pauses. I found a main effect of pause type $F(4,524)=58.42$, $MSe=.070$, $p<.001$. Readers approached pause type with significantly different length of pauses. See Figure 1. Differences between adjectival and clause pause lengths approached significance $p=.067$. Adjectival pauses were significantly shorter than sentence, quote and paragraph pauses, $ps<.001$. Pause lengths at clause boundaries were significantly shorter than quote, $p=.038$, and paragraph, $p<.001$ but not at sentence endings

$p=.336$. Sentence pauses were not significantly shorter than quote pauses, $p=1.00$, but were significantly different than paragraph pauses $p<.001$. Paragraph pause means were significantly different than all other pause types, $p<.001$. These differences show that readers read with increasing pauses across adjective, clause, sentence, quote and paragraph boundaries as was expected.

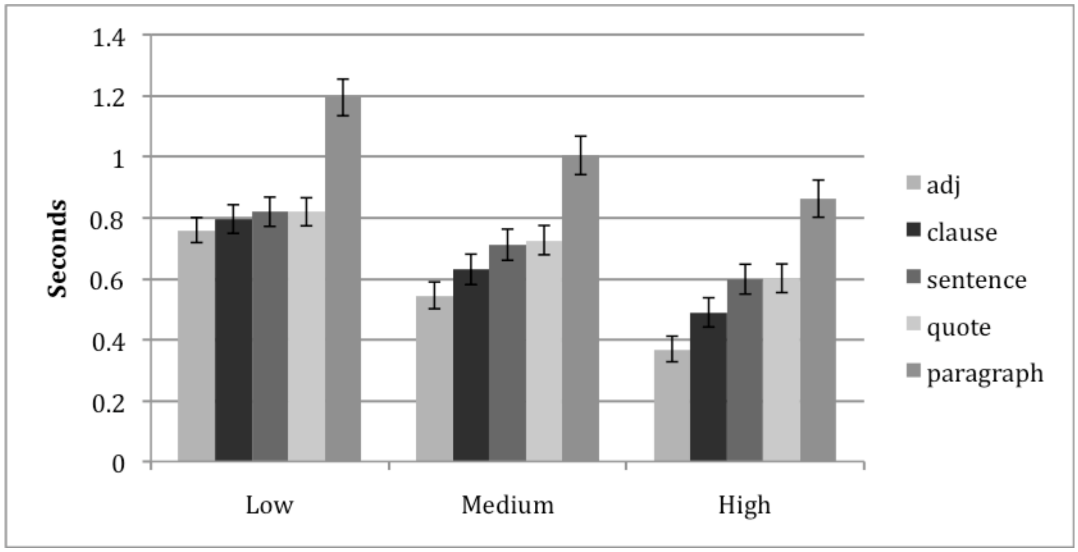

Figure 1: Average Pause Length Means by Skill Level

There was also a main effect for group $F(2, 131)=17.85$, $MSe=.227$, $p<001$. As readers increased in skill level, they made overall shorter pauses. Low skill readers had on average ($M=.877$) longer pauses than medium ($M=.723$), $p=.008$ and high skill ($M=.584$) readers, $p<.001$. Medium and high skill readers also differed significantly, $p=.020$. The interaction of pause and group type was not significant $F(8,134)=.950$, $MSe=.950$, $p<.475$.

Previous research indicated that a reader's ability to apply correct pitch changes at sentence endings was only possible once fluency was established (Cowie et al., 2002). Within our experimental passage I embedded declarative sentences, wh-question sentences, and yn-question sentences. Each of these sentence types conveys a different type of information and ends in different types of pitch changes. A declarative sentence ends with a drop in pitch, wh-question with a stable pitch and yn-question with an upswing in pitch (Schwanenflugel & Miller, 2006). I hypothesized, with Cowie et al., 2002 and Schwanenflugel and Miller (2006), that as reader skill levels approached fluency, their pitch contours would become more appropriate and expressive and that readers would read each sentence type with different magnitudes of pitch differences.

I analyzed how readers approached different sentence types and their pitch control as compared by group. I created a 3 (skill level) X 3 (sentence type) mixed measures ANOVA design. Readers were grouped on skill level: low, medium, high. Pitch difference was measured at the end of declarative, wh-question, and yn-question sentences. There was a main effect for pitch $F(2, 260)=253.39$, $MSe=3260.34$, $p<.001$. See Figure 2. Readers recognized that declarative sentences ended in a drop in pitch and that wh-question and yn-question sentences end with a positive pitch change. I found a significant difference between declarative sentences when compared to wh and yn-question sentences, $p<.001$. While Schwanenflugel and Miller (2006) suggested that readers would read a yn-question with a larger upswing in pitch than a wh-question, we found no significant difference of this difference, $p=.691$.

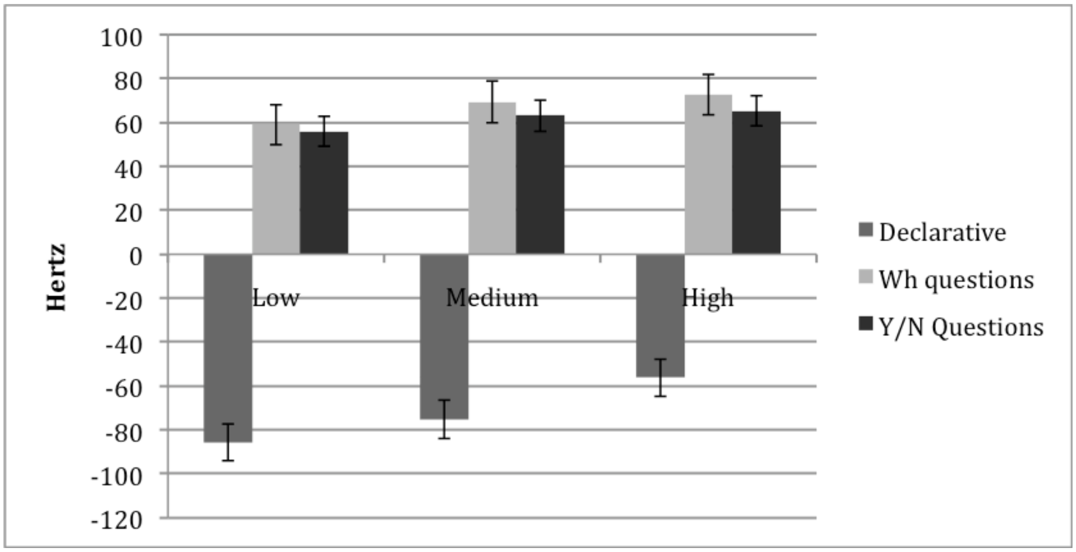

Figure 2: Mean Pitch Endings for Declarative, Wh-question, and YN-question sentences by skill level

There was also a main effect for skill level $F(2, 130)=3.991$, $MSe=10434.54$, $p=.021$. Low skill readers read with significantly less difference in pitch ($M=9.794$) than high skill readers ($M=27.265$), $p=.017$. Medium skill readers had no significant differences from low or high skill readers. There was not a significant interaction between the skill level and pitch difference $F(4, 260)=.463$, $MSe=1510.503$, $p=.763$. As skill level increased readers read with larger pitch differences.

The final measure of prosodic reading skill that I examined was word and sentence intrusions. A word intrusion consists of a pause within a word as it is being produced. A sentence intrusion is an irregular pause within a sentence that disrupts the flow of reading. Sentence and word intrusions were both related to decoding skill, where word intrusions represent direct interference of reading by decoding difficulties. Within the same experimental passage, I measured the average number of word and sentence intrusions within declarative sentences. Fluent readers progress through text with infrequent pauses and are not encumbered by the task of decoding unfamiliar words and text. Therefore, I hypothesized that readers would decrease in the number of word and sentence intrusions as skill level increased.

I created a 3 (skill level) X 2 (intrusion type) mixed measures ANOVA that examined reader skill level (low, medium, high) and intrusion type (word and sentence). There was a significant main effect for intrusion type, *F*(1,130)=.204.20, *MSe*=66.12, *p*<.001. Readers made significantly more sentence (*M*=1.678) than word (*M*=.680) intrusions. There was a main effect word for reader skill level as well *F*(2, 130)=49.03, *MSe*=21.552, *p*<.001. Significant differences were found between low (*M*=1.679), medium (*M*=1.149) and high (*M*=.707) skill readers, *p*<.001. Finally, there was also a significant interaction between intrusion type and skill level *F*(2, 130)=9.12, *MSe*=3.32, *p*<.001.

I then conducted one way ANOVAs for both word and sentence intrusions to investigate how skill level changed each of these variables. For word intrusions there was a significant effect of skill level F(2, 130)=19.55, MSe=4.07, p<.01. With increasing skill readers made fewer word intrusions. Low skill readers (M=.98) made significantly ps<.01 more word intrusions than medium (*M*=.67) and high (*M*=.39) skill readers. Medium and high skill readers also had significant differences, *p*=.02 in word intrusions.

Effects for sentence intrusions were also significantly different at all levels *F*(2,130)=37.62, *MSe*=.56, *p*<.01. Low skill (*M*=2.37) readers made significantly more sentence intrusions than medium (*M*=1.63) and high skill (*M*=1.03) readers, who also differed significantly, *ps*<.01. See Figure 3. Therefore as reader skill level increased, they significantly decreased both word and sentence intrusions and had greater sentences versus word intrusions. For less skilled readers, the proportion of the difference between word versus sentence intrusions was much greater than that of readers with high skill level.

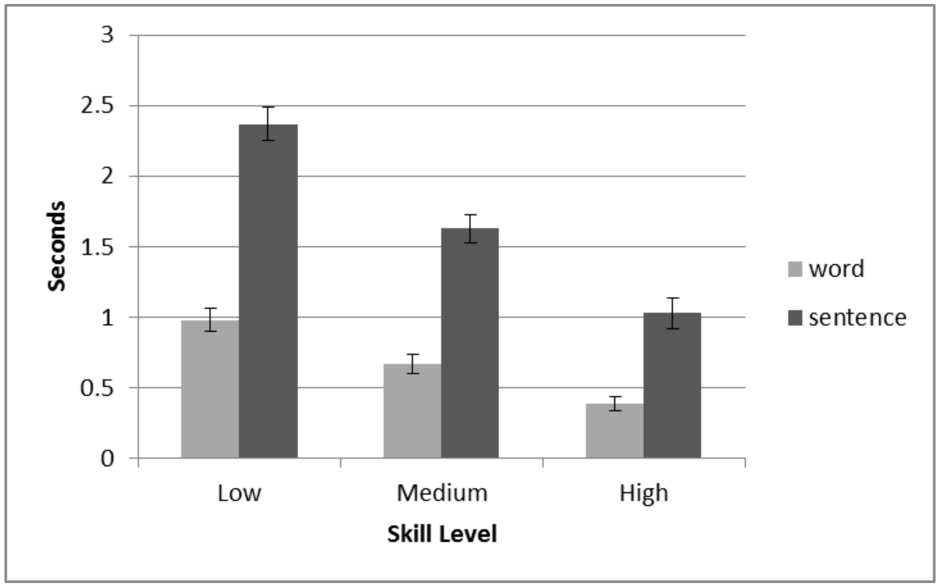

Figure 3: Word and Sentence Intrusion by Skill Level

Eye Movement Behavior

For silent reading I hypothesized that a reader's behavior would differ based on skill level. With fluency, I hypothesized that readers would be able to progress through a passage with shorter fixations, larger saccades, fewer regressions and would not need multiple eye movements to decode words. A fluent reader is an efficient reader, and so behavior that is inefficient reflects a lack of ease and skill. After taking an average value for first fixation, gaze duration, intraword regression, skipping and regressions, I conducted multiple one-way ANOVAs comparing reader skill level (low, medium, high) on the processing variable examined. I wanted to investigate which reading behaviors were significantly different based on skill level.

First fixation duration represents the amount of time that a reader spends fixated on a word on its initial fixation. For first fixation duration there were significant differences among reader skill level, $F(2,128)=11.844$, $MSe=987.30$, $p<.001$. As predicted, low skill readers ($M=296.37$) had significantly longer first fixation durations than high skilled readers ($M=264.87$), $p<.001$. Additionally, medium skill readers ($M=285.56$) spent significantly more time than high skill readers, $p=.009$. There was no significant difference between low and medium skill readers, $p > .05$. Thus, in general, as skill level increased, first fixation time decreased. See Figure 4.

For gaze duration, which is the sum of all consecutive fixations on a word before leaving that word, there were significant differences among all three groups, $F(2,128)=28.55$, $MSe=6071.36$, $p<.001$. Low skill readers ($M=470.83$) spent significantly more time than medium ($M=428.28$) and high skill readers ($M=349.43$) in gaze duration. All the differences were significant, $p < .05$. See Figure 4. Therefore, gaze duration times differed between each group as skill level increased.

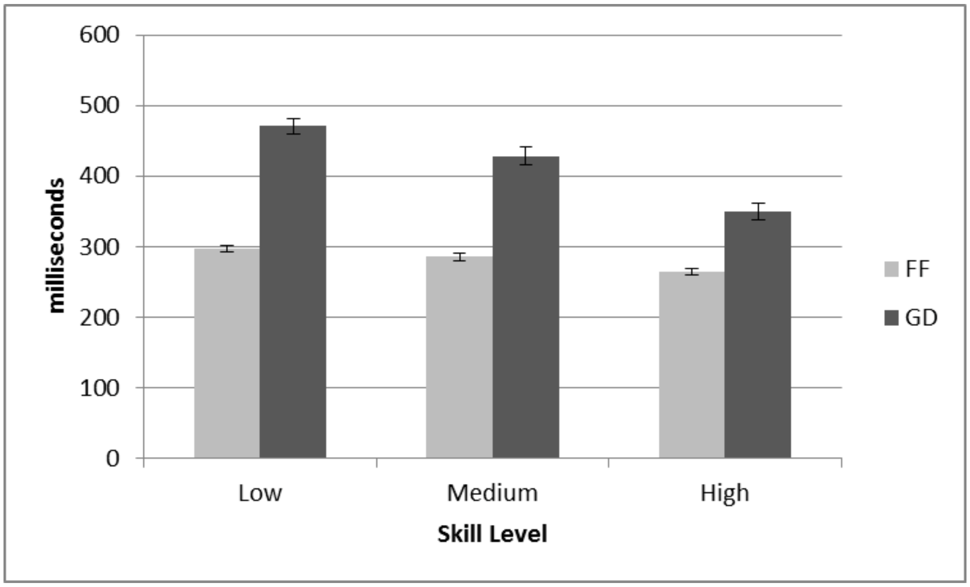

Figure 4: Initial Processing Measures Average First Fixation and Average Gaze Duration by Skill Level

As readers progress through text, their eyes make small movements within a word before moving forward in the text. These regressions are intraword regressions. Intraword regressions we believe reflect initial word processing, as these regressions re-orientate the eye across the different features of the word. I hypothesized that readers with higher skill would make fewer of these eye movements. There was a main effect of reader skill level for intraword regressions, $F(2,131)=9.27$, $MSe=.036$, $p<.001$. See Figure 5. While there was no significant difference between low ($M=0.274$) and medium skilled reader ($M=.256$), intraword regression frequency, highly skilled readers ($M=.144$) made significantly fewer intraword regressions than low and medium skill levels, $ps < .01$. As a reader increased in skill, his/her ability to process a word on an initial pass increased and they made fewer overall intraword regressions.

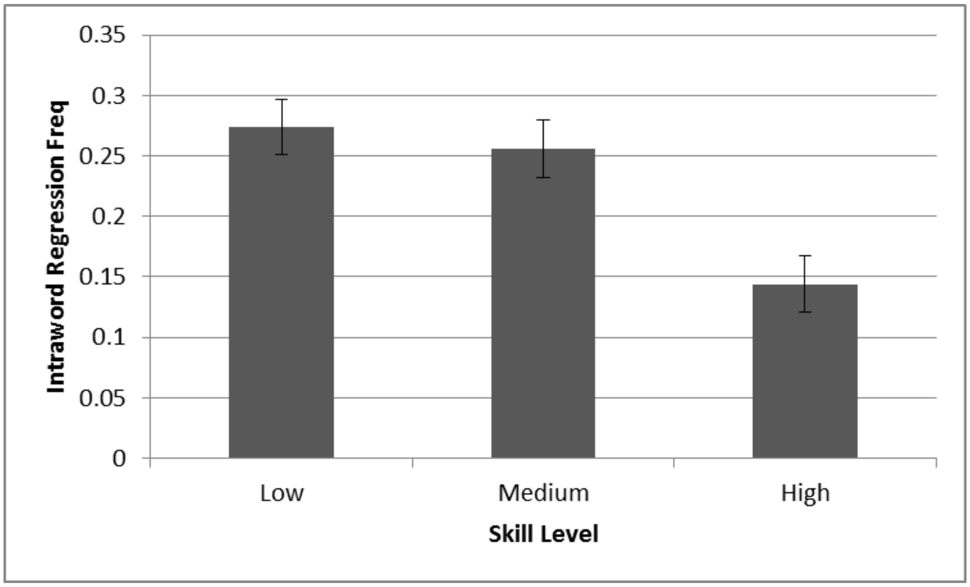

Figure 5: Average Intraword Regression Frequency by Skill Level

The next silent reading variable I examined was total reading time. Total reading time represents the sum of all fixations on a word, including regressions made back to the word. While total reading time improved across all three skill levels, $F(2,128)=18.92$, $MSe=27730.73$, $p<.001$, the only significant difference was found between low and high skill readers. See Figure 6. Low skill readers spent an average 702.28 ms on each word, while high skill readers spent instead 491.64 ms. This difference was significant, $p<.001$.

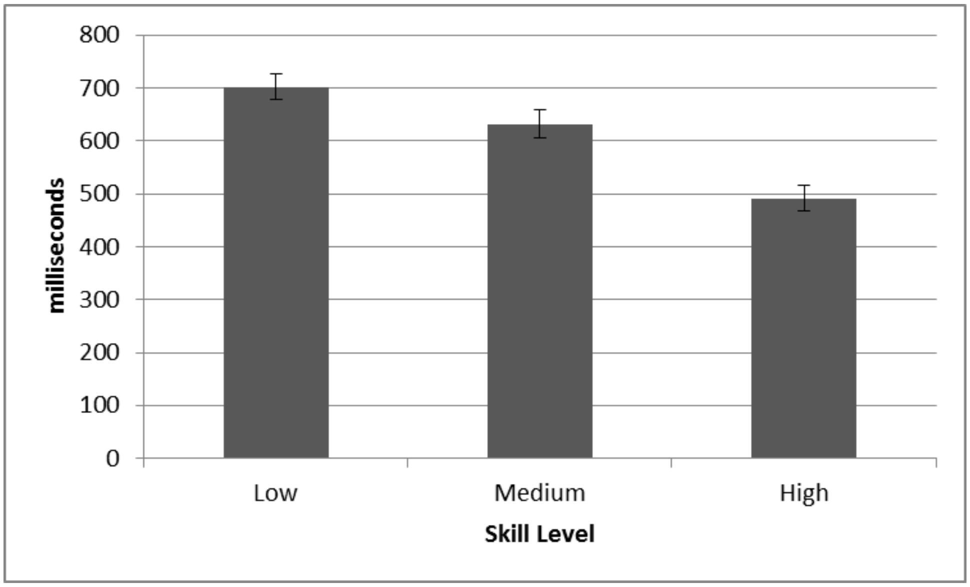

Figure 6: Average Total Time Per Word by Skill Level

One of the main differences between silent and oral reading is the ability to skip words. In oral reading, each word must be articulated, yet in silent reading, words can be skipped. As adult readers progress through text, their eyes do not fixate on every word. Content words are fixated 85% of the time and function words 35% of the time (Rayner, 1998). In examining this behavior in silent reading, I examined the proportion of words skipped in the passage. There was a main effect of skill level on skipping rate, $F(2,128)=5.56$, $MSe=.036$, $p=.05$. See Figure 7. Skipping rates between low ($M=0.519$) and medium ($M=0.421$) skill readers approached significance, $p=.054$ and demonstrated that less skilled readers do skip at a higher rate. The proportion of skipped words between low and high skill readers was significant. Low skill readers ($M=0.519$) skipped more frequently than high skill readers ($M=0.394$), $p=.006$. With increasing skill, readers make more initial fixations on more of the passage.

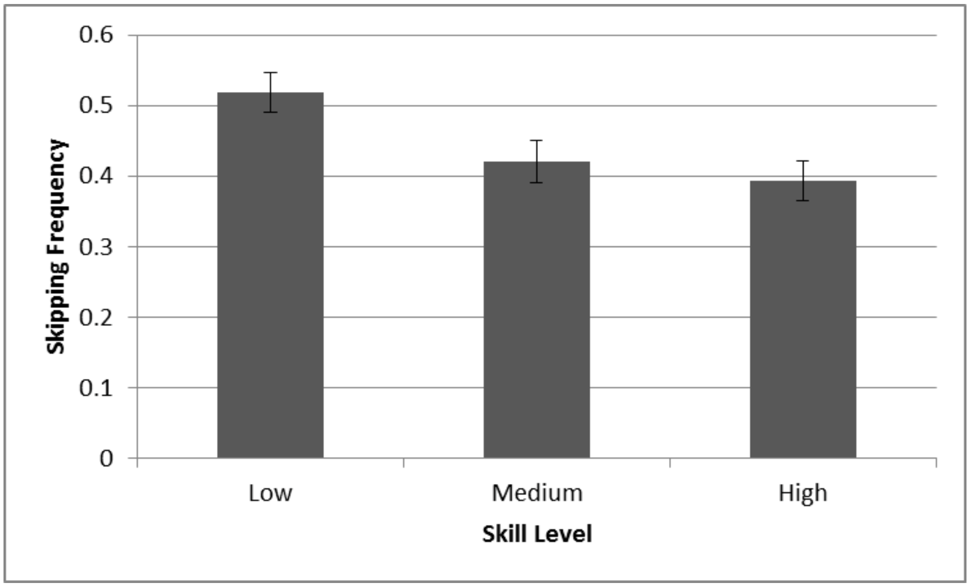

Figure 7: Average Frequency of Skipping Behavior by Skill Level

A skilled reader progresses through text with ease, making few regressions and as few fixations as possible. Unskilled readers, however, many times fixate on every word and sometimes fixate more than once. Therefore, measuring the overall fixation count in a passage can demonstrate the ease with which a reader examines text by measuring the average number of fixations per word. There was a significant main effect of reader skill level on total fixation count, $F(2,128)=4.66$, $MSe=10259.13$, $p=.011$. See Figure 8. I found that while low and medium skill readers showed no significance, $p=1.000$, medium and high skill readers did have significant differences. A medium skill reader ($M=298.923$) made significantly more fixations than a high skill reader ($M=235.844$), $p=.016$. Furthermore, high and low skill readers ($M=285.512$) showed differences that approached significance, $p=0.061$. Yet a low skill reader skipped more frequently than high skill readers and had increased fixations. Therefore, a low skill reader potentially examines text in a manner different from medium and high skill readers. They have a higher frequency of skipped words, but yet also have the largest fixation count, suggesting that they read in a non-systematic manner.

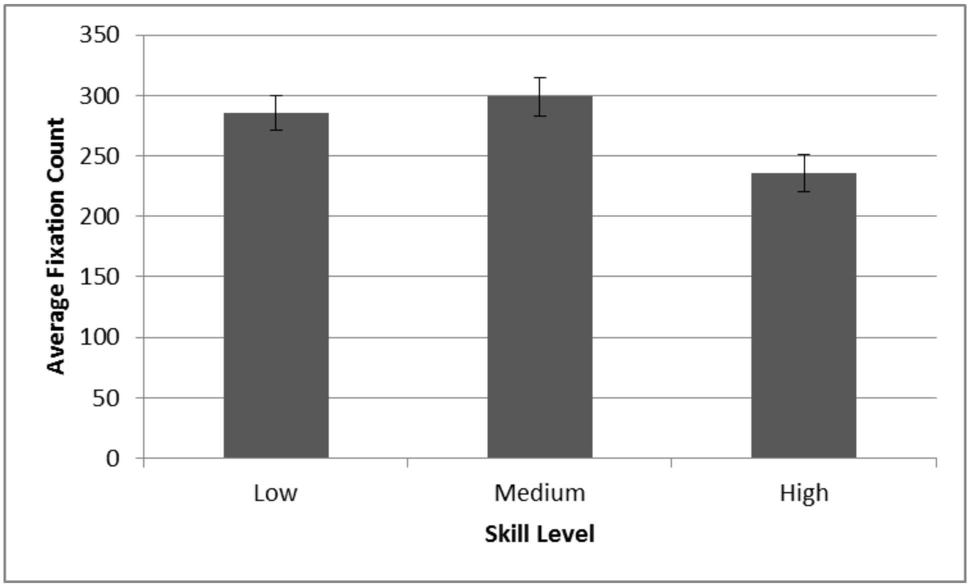

Figure 8: Average Fixation Count by Skill Level

We also measured total regression behavior. This measure counted the frequency of regressive saccades that were not within a word. This would include then any regression off of the fixated word to a previous word. While there were significant differences in intraword regressions between the three groups, overall regressive behavior was not found to be significant at any skill level $F(2,128)=.675$, $MSe=.019$, $p=.511$. See Figure 9. High skill readers made less regressive saccades ($M=0.330$) than medium skill readers ($M=0.365$) yet these differences were far from significant $p=.751$. Furthermore low skill readers made fewer regressive saccades than medium skill ($M=.349$) but this effect was not significant $p=1.00$

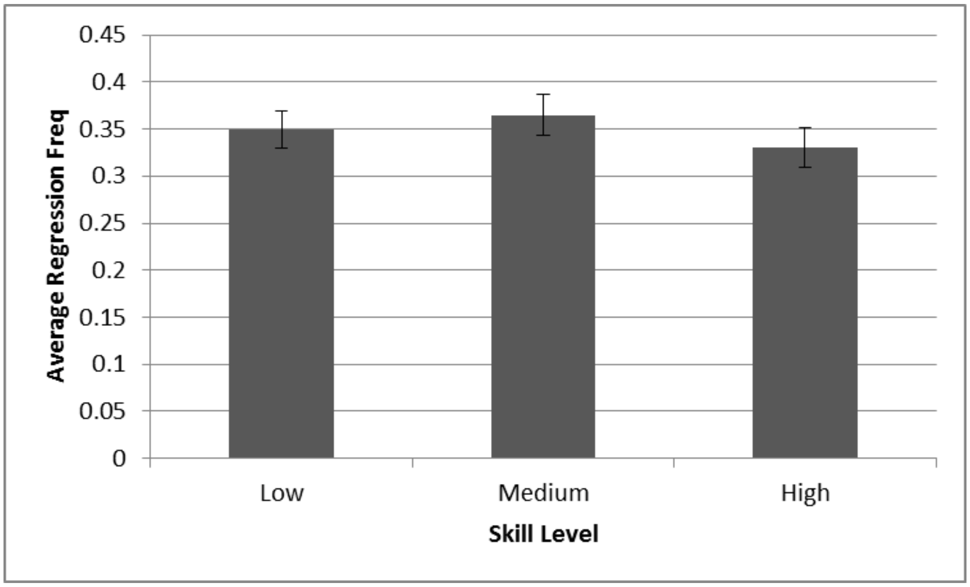

Figure 9: Average Regression Frequency by Skill Level

Oral Decoding Skill

Because decoding skill has been shown to relate most strongly to comprehension, in this experiment I examined how readers approach high and low frequency words embedded in a passage in both oral and silent reading conditions. For oral reading, I measured the pause before the target word, the time spent on the target word, and the pause after. Pausing, in general, aids in the processing of ideas therefore the pauses before and after reflect processing time, while time on the target word represented the amount of time needed to fully decode the word (Chafe, 1988). The pause before and after a target word, as well as the time producing each word was averaged into a composite score for high and low frequency conditions, in which there were 5 in each condition. In the silent reading condition, decoding behavior was measured by the time spent on the initial fixation, the gaze duration on that word and total time on the word which were averaged from the embedded targeted words in the passage. There were 6 high frequency words and 6 low frequency words.

The first aspect of decoding behavior I analyzed was the pause before the target word. The time spent pausing before a word may reflect how easily and readily a reader accesses a particular word's meaning in the mental lexicon. Therefore, I hypothesized there would be significant differences between pre-pause time and skill level. I ran a 3 (skill level) X 2 (frequency) mixed measures ANOVA with word frequency being the repeated measure. There was no main effect for frequency, $F(1,130)=3.46$, $MSe=0.528$, $p=.493$. There was a main effect for skill level, $F(2,130)=7.54$, $MSe=1.635$, $p=.001$. See Figure 10. Low skill readers ($M=.963$) made significantly longer pauses than medium skill ($M=.519$), $p=.022$ and high skill readers ($M=.363$), $p=.001$. There was no significant difference between low and medium skill readers, $p=1.00$. There was an interaction effect for word frequency and reader skill level, $F(2,130)=3.10$, $MSe=.528$, $p=.049$. When readers were separated by skill level, high skill readers' behavior towards high and low frequency words changed in comparison to low and medium skill readers. While low and medium skill readers spent similar amounts of time pausing before both low and high frequency words, high skill readers reacted differently. High skill readers spent longer on the pause before low frequency words than high frequency words, approaching significance $F(1,44)=3.70$, $p=.06$, $MSe=.85$. This change demonstrates that processing effects of word frequency started to appear only once readers had higher reader skill levels.

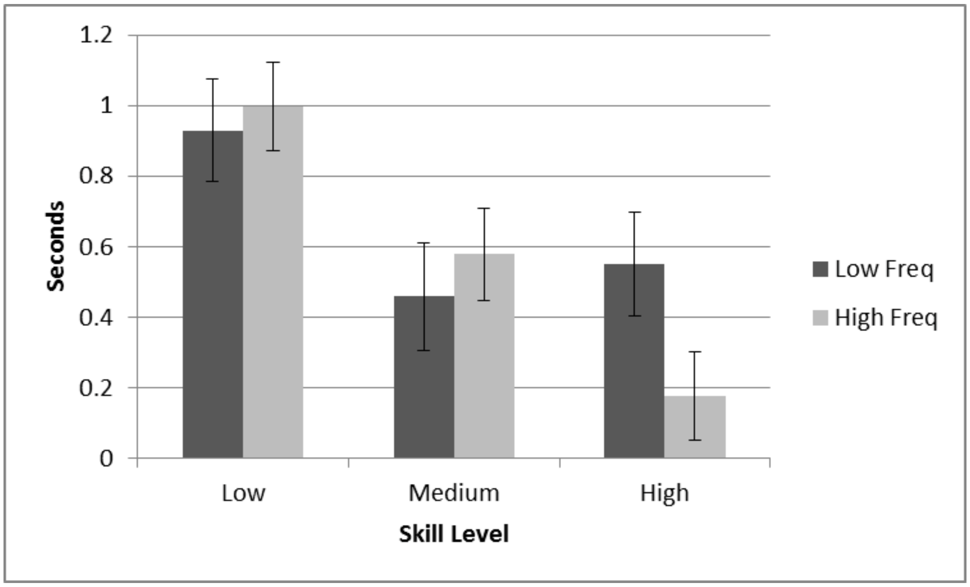

Figure 10: Average Pre-pause Time by Word Frequency and Skill Level

The time spent producing a target word can indicate the processing ease. Time spent producing the word was measured from when the reader first attempted the word and ended when that attempt ended with a pause. Therefore a reader who stuttered or hesitated while reading the word would have an increased time compared to a reader who produced the word with greater ease. To compare groups and word frequency I ran a one-way repeated measures ANOVA. Skill group consisted of low, medium and high skill readers and the repeated measure of word frequency included the time spent on high and low frequency words. There was a main effect for skill group $F(2,130)=17.49$, $MSe=.250$, $p<.001$. See Figure 11. As readers increased in skill they spent significantly less time producing both high and low frequency words. There was no main effect for word frequency, although values approached significance $F(1,130)=3.46$, $MSe=.38$, $p=.065$. There was a significant interaction for word frequency and skill level $F(1,130)=614.02$, $MSe=154.07$, $p<.001$.

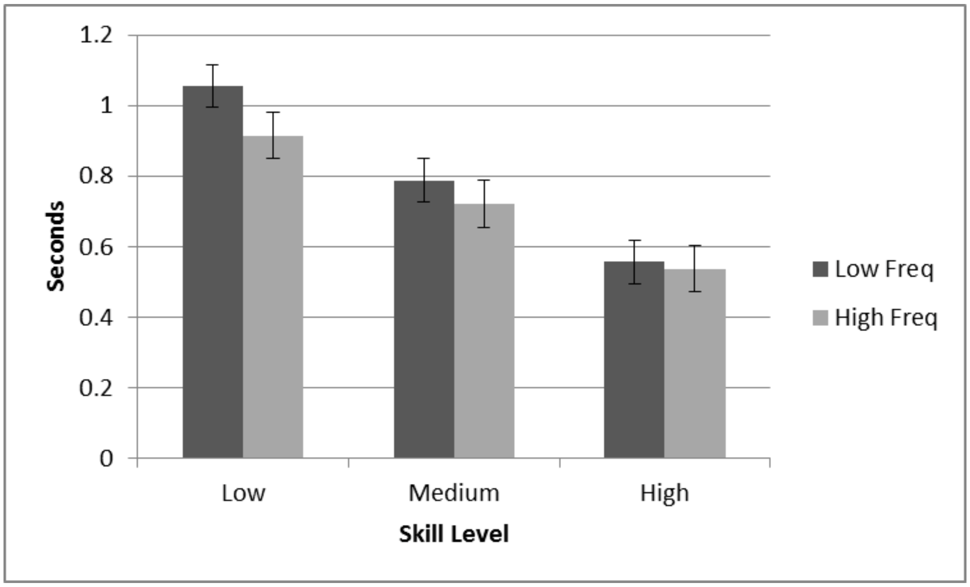

Figure 11: Average Time on Target Word by Word Frequency and Skill Level

The pause after a target word is a measure that assesses spill-over processing. That is, sometimes a reader continues to process a word after word recognition is achieved. A reader who is able to quickly decode a word and is familiar with its meaning should have a shorter post-target word pause because there are no left-over processing demands. Therefore I hypothesized that with increasing skill level, post-target word pause time would decrease. I ran a one way ANOVA with word frequency as the repeated measure and skill level the dependent measure. There was no main effect of word frequency, $F(1,130)=.342$, $MSe=.056$, $p=.560$ and no interaction effect, $F(2,130)=.933$, $MSe=.052$, $p=.396$. There was a main effect for reader skill level $F(2,130)=9.802$, $MSe=.16$, $p<.001$. See Figure 12. Low skill readers ($M=.529$) spent significantly more time reading than high skill readers ($M=.268$), $p<.001$. There were no significant differences between low and medium ($M=.385$), $p=.060$ and high and medium skill readers, $p=.165$. As readers increased in skill level they had significantly shorter post target word pauses.

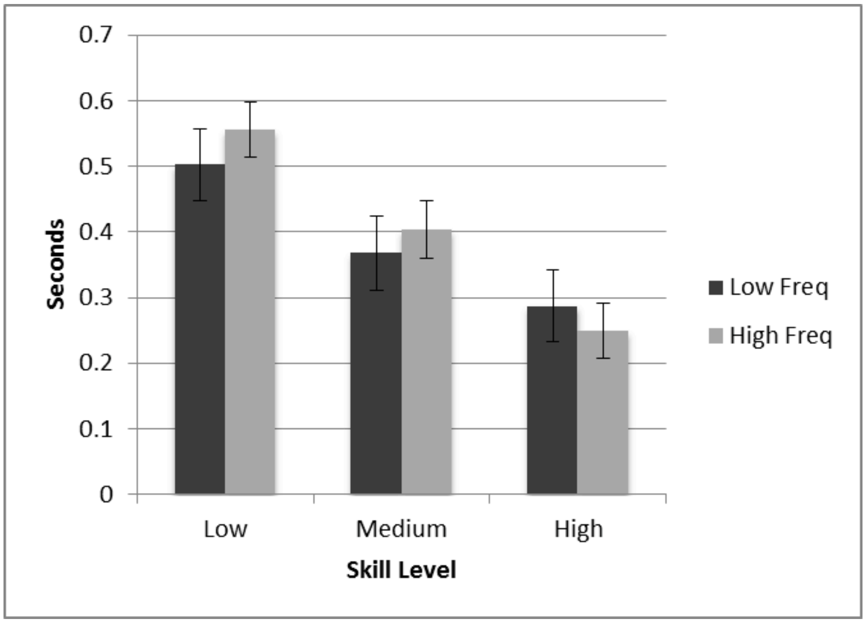

Figure 12: Average Post Pause Time by Word Frequency and Skill Level

While reading orally, readers made regressions to previous text. I calculated the amount of regressions that they made throughout the passage to examine this behavior. Regressions were categorized into single word regressions where a single word was repeated, or phrase regressions where a string of words was repeated. These measures would reflect how readers approached decoding and error checking. To examine oral regression behavior and skill level I created a 3x2 mixed measures ANOVA. I examined skill level (low, medium, high) and type of regression behavior (phrase or single word). There was a main effect for regression type $F(1, 131)=13.91$, $MSe=173.52$, $p<.001$. Readers overall made more single word regressions ($M=6.14$) than phrase regressions ($M=4.53$). There was no significant effect for skill level $F(2, 131)=1.806$, $MSe=68.566$, $p=.168$. See Figure 13. While with an increase in skill level decreased regressive behavior, there were no significant difference between groups. The interaction between reader skill and regression type was not significant $F(2,131)=.835$, $MSe=10.42$, $p=.436$.

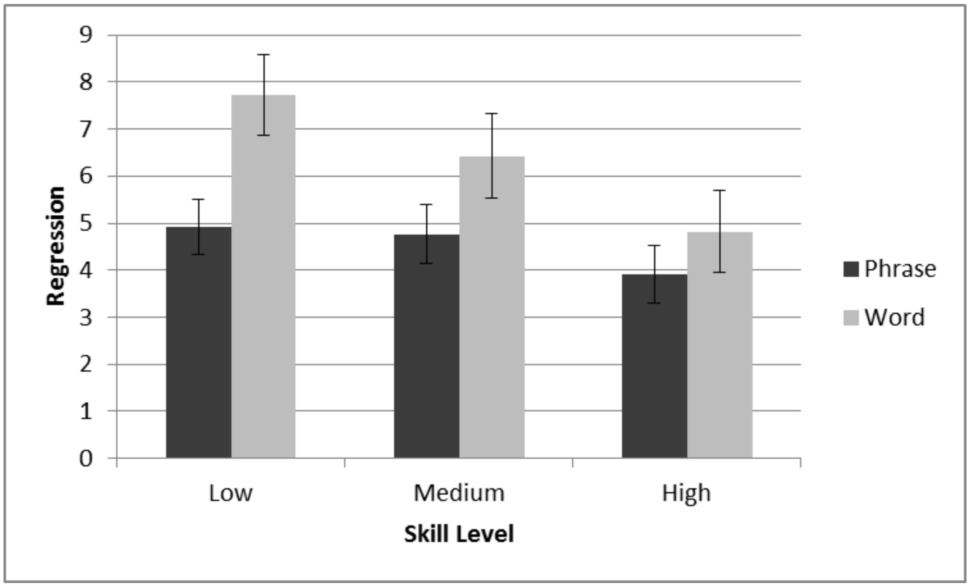

Figure 13: Total Oral Regressions by Type and Skill Level

In addition to oral regression behavior, I also examined how frequently readers would progress through the text with uncorrected errors. The frequency of these errors would highlight the extent to which readers comprehended what they were reading as well as their ability to properly decode words. I conducted a one-way ANOVA that examined reader skill level (low, medium, high) on the number of uncorrected errors through the passage. This effect was found to be significant $F(2, 131)=26.55$, $MSe=362.82$, $p<.001$. See Figure 14. Low skill readers ($M=9.89$) made significantly more errors than medium ($M=7.50$), $p=.008$ and high ($M=4.29$), $p<.001$ skill readers. Medium and high skill readers also had significant differences $p<.001$. Therefore, a skill to being a strong decoder also includes the ability to recognize errors in oral reading. Low skill readers had significantly more errors than medium and high skill readers, demonstrating that their low fluency also resulted in less recognition of mistakes.

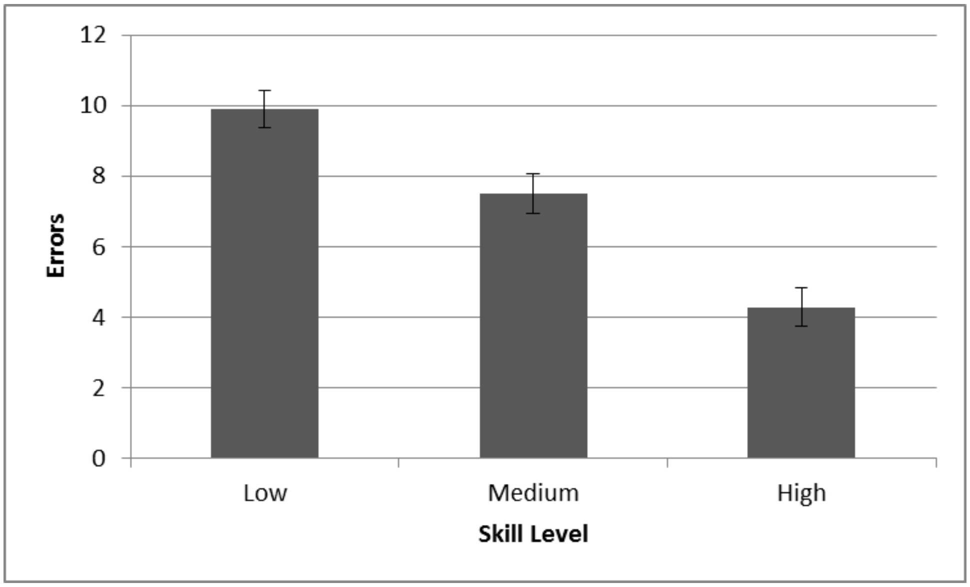

Figure 14: Total Uncorrected Oral Errors by Skill Level

Silent Decoding Skill

For silent reading behavior I examined first fixation duration, gaze duration and total time spent on high versus low frequency words. Children's eye movements are affected based on the processing load of the text encountered (Hyona & Olson, 1995). Research by Ashby et al. (2005) furthermore demonstrated that word frequency disrupts reading behavior. The researchers found that gaze duration and regression frequency changed based on word frequency, but that behavior after the target word was not disrupted. From these findings, I hypothesized that a reader's ability to process high or low frequency words could be revealed in measures that assess initial processing: first fixation and gaze duration. Reingold et al. (2010) also found that later processing of text was reflected in total time measures, so I also assessed how total time on high versus low frequency words was impacted by reader skill level. The values for each of these measures are an average score from either the 6 high frequency words or 6 low frequency words. All three of these measures were examined using a 3 (skill level) X 2 (word frequency) mixed measures design.

For first fixation duration there was no main effect for word frequency, $F(1,131)=.019$, $MSe=3806.34$, $p=.660$. There was a main effect for skill group, $F(2,131)=5.868$, $MSe=5561.77$, $p=.004$. See Figure 15. Low skill readers ($M=302.886$) spent significantly more time on initial fixation time than high skill readers ($M=269.64$), $p=.009$. Medium skill readers ($M=302.445$) and high skill readers also had significant differences, p=.013. There was no significant difference between low and medium skill readers. As reader skill increased, initial fixation time on high and low frequency words decreased. There was no significance from the interaction of skill group and word frequency, $F(2,131)=.19$, MSe=718.98, p=.828.

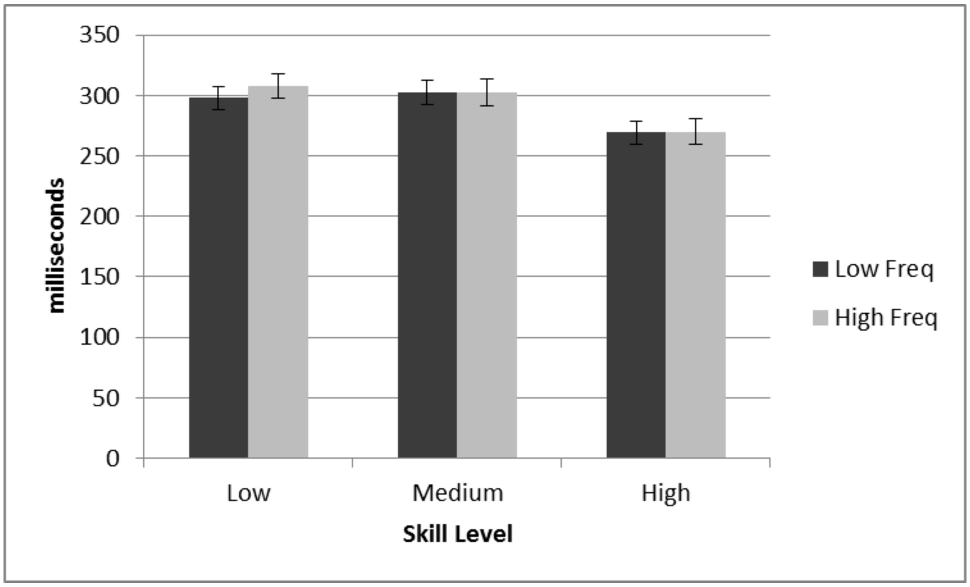

Figure 15: Average First Fixation by Word Frequency and Skill Level

Next I assessed gaze duration on high and low frequency words based on skill level. In a mixed measures 3 (skill level) X 2 (word frequency) design, both of the main effects were significant. Word frequency had a significant effect, $F(1,131)=19.712$, $MSe=519650.69$, $p<.001$. Low frequency words ($M=552.79$) had significantly longer gaze durations than high frequency words ($M=464.62$). There was also a main effect of skill level, $F(2,131)=15.78$, $MSe=820788.69$, $p<.001$. See Figure 16. Low skill readers ($M=594.06$) had significantly longer gaze durations than high skill readers ($M=406.83$) $p<.001$. Medium skill readers ($M=525.22$) also had significantly longer gaze durations than high skill readers, $p=.002$. As readers increased in skill, their gaze durations decreased on high and low frequency words. There was not a significant interaction between gaze duration and word frequency $F(2,131)=1.651$, $MSe=26362.46$, $p=.20$.

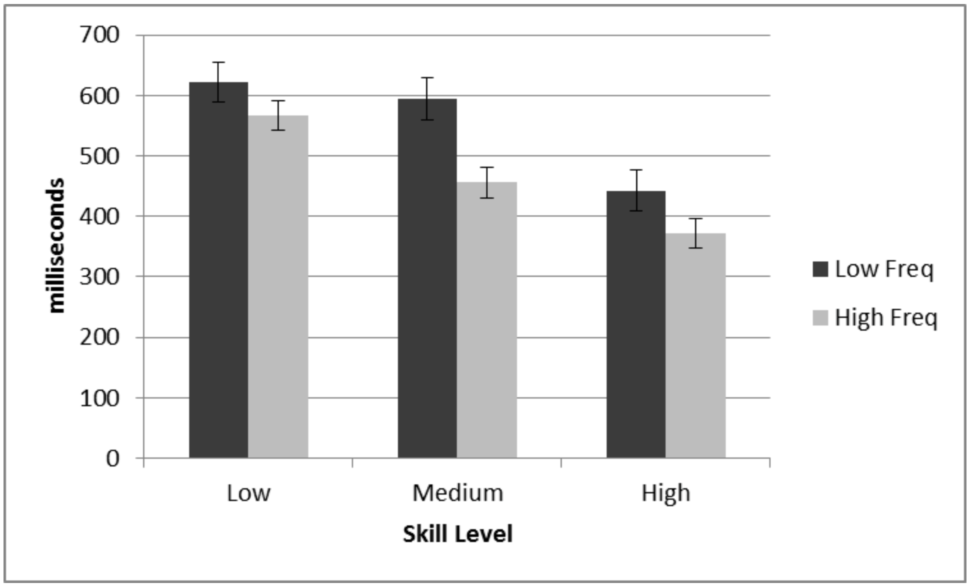

Figure 16: Average Gaze Duration by Word Frequency and Skill Level

For post word processing, total time measures included any interword regression fixations back to the target word. A 3 (skill level) X 2 (word frequency) mixed measures design was used to assess how these variables impacted total time. There was a main effect for word frequency, $F(1,131)=15.29$, $MSe=79765.96$, $p<.001$. Readers spent significantly less time on high frequency ($M=697.03$) words compared to low frequency ($M=832.078$) words. There was also a main effect for skill level, $F(2,131)=3.55$, $MSe=209739.64$, $p<.001$. See Figure 17. Low skill readers ($M=894.09$) spent significantly more time overall than high skill readers ($M=592.09$) $p<.001$. Medium skill readers ($M=807.49$) also spent significantly more time than high skill readers $p=.007$. As skill level increased, total time on words decreased. There was a significant interaction between skill level and total time on high or low frequency words $F(2,131)=3.55$, $MSe=.79765.96$, $p=.03$. As readers increased in skill, the difference in the amount of time they spent on a high versus a low frequency word differed in a significant manner.

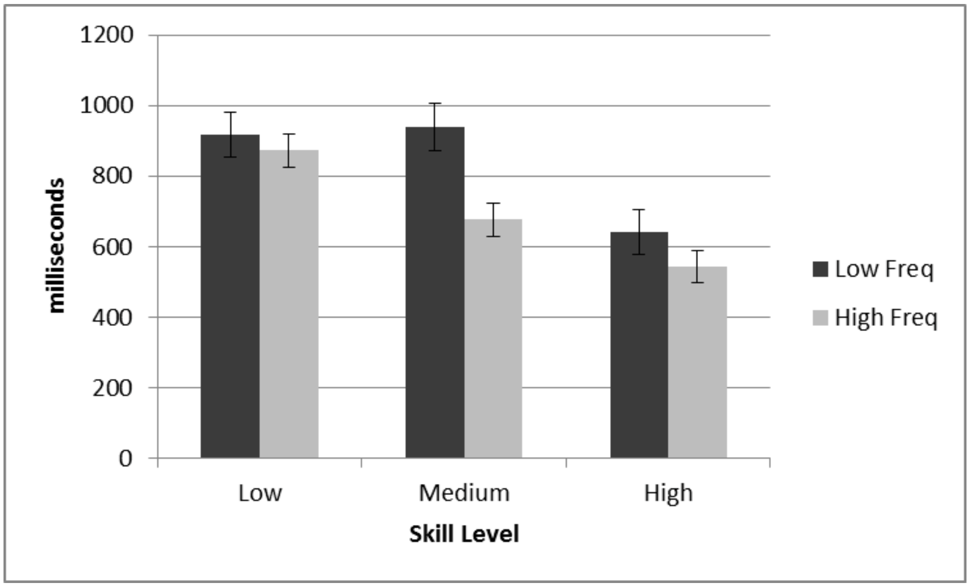

Figure 17: Average Total Time by Word Frequency and Skill Level

Correlations

While I investigated components of oral and silent reading separately, I was also interested in how these variables compared to one another. I therefore compared the global measures obtained from “Molly” and those obtained from “Sammy”. I wanted to investigate the extent these variables overlap and connect to one another. Do measures of oral reading accurately predict skill level and behaviors in silent reading? Do children react in the same manner as adults when faced with silent reading challenges or do their eye movements reveal different types of processing strategies?

Readers who struggle to read fluently and effectively have behaviors that reflect the large processing demands that slow and strain their reading ability. I compared measures in silent and oral conditions that reflect the processing demands of reading to see if silent and oral reading place similar demands upon a reader.

By running bivariate correlations we hoped to determine the extent to which measures that indicate a reader who struggles with initial word recognition in silent reading, also corresponds with measures in oral reading that are thought to reflect word recognition skills. Therefore our silent reading variables included first fixation, gaze duration, skipping frequency and intraword regressions. These measures all reflect initial word processing and as readers increase in skill these measures decreased. The oral reading measures we examined were pauses after adjective and clause pauses, word and sentence intrusions, and decoding rereading frequency. Finally we also examined how standardized measures of decoding and word recognition also correlated with silent and oral reading measures. See Table 1. Adjective pauses did not correlate with any eye movement measures. Clause pauses however had significant correlation at the $p<.001$ level for first fixation ($r=.267$) gaze duration ($r=.475$) and intraword regression ($r=.327$). As readers took longer pauses at clause junctions, they also had longer first fixations, gaze durations and made more refixations on the target word demonstrating that processing load was high. Word and sentence intrusions had significant correlations with all silent reading measures at the $p<.001$ level. For word intrusions, or pauses within a word during oral reading, correlations were found between first fixation ($r=.216$), gaze duration ($r=.506$), word skipping ($r=.196$) and intraword regressions ($r = .424$). Readers who had more word intrusions also spent more time and skipped around within the passage more frequently within the silent passage. The next variable examined was decoding rereading behavior, which consisted of any repetition of a single word throughout the story. Decoding rereading was found to be significantly correlated ($p<.001$) with gaze duration ($r=.246$) and intraword regressions ($r=.176$). Readers who had more instances of decoding rereading also spent more time in their gaze and had more intraword regressions on a single word, indicating the need for more processing time.

Finally I ran bivariate correlations between silent reading measures of word identification skills and standardized tests of achievement, the Woodcock

Johnson tests. Word Attack assessed a participant's ability to apply phonetic rules to nonsense words. Skill level in this task had significant correlation (p<.001) to all measures of silent reading identification skills. Word attack correlated with first fixation (r=-.433), gaze duration (r=-.623), skipping frequency (r=-.189) as well as intraword regression (r=-.392). These correlations demonstrate that as word attack skill level increases, the time spent on word identification in silent reading decrease significantly. For oral reading, word attack skills correlated significantly (p<.001) for clause pause times (r=-.320). Word attack skills also correlated significantly (p<.001) with frequency of word (r=-.372) and sentence (r=-.426) intrusions. Decoding rereading behavior within an oral passage also significantly (p<.005) correlated with word attack skills (r=-.170). As a reader increased in word attack skills, their processing measures in oral reading decreased in time and frequency. The final correlation for word identification skill compared Woodcock Johnson word identification tasks and silent reading measures. Word identification relies on initial processing skills. Significant correlation (p<.005) was found between identification skills and first fixation duration (r=-.191) As readers improved in identification skills, their first fixation duration time decreased. Gaze duration also had significant correlation (r=-.314) at the p<.001 level, showing that overall processing of the word is reduced with strong word identification skills. Intraword regression frequency also correlated significantly with word identification skill (p<.005, r=-.210). Skipping however did not correlate with word identification skill at all, suggesting that skipping is not due to an inability to identify a word but rather due to other processing pressures. For oral reading, word identification skill correlated significantly ($p<.001$) for most measures. As a reader increased in identification skill their clause pause times decreased ($r=-.372$). A decrease in word ($r=-.519$) and sentence (.665) intrusions correlated significantly with an increase in word identification skill. Furthermore, children made fewer decoding rereading regressions ($r=-.276$) with an increase in skill. These measures demonstrate that clause pause, word and sentence intrusions, as well as decoding rereading in oral reading correlate significantly with word identification skills.

Table 1

Correlations of Initial Processing and Decoding Measures in Oral and Silent Reading and Woodcock Johnson Subtests

Oral Reading Measures	FF	GD	Skip	IA	WA	WI
Adj	-.127	.005	.144	.126	-.028	-.009
Clause	.267**	.475**	.119	.327**	-.320**	-.372**
Word Intrusions	.216**	.506**	.196**	.424**	-.372**	-.519**
Sentence Intrusions	.401**	.656**	.250**	.386**	-.426**	-.665**
Decoding ReReading	.130	.246**	.019	.176**	-.170*	-.276**
Word Attack	-.433**	-.623**	-.189*	-.392**	1	.666**
Word Identification	-.191*	-.314**	-.168	-.210*	.666**	1

*p<.05,**p<.01

Next I examined the extent to which markers of high prosodic skill correlated with eye movement measures of later processing. For oral reading I correlated pause lengths after clause, quote, sentence and paragraph endings as well as total uncorrected errors and oral regression within the passage. For silent reading, the measures of total time, regression frequency as well as total fixation count indicated later processing skill. See Table 2. Total time correlated significantly with all oral measures associated with higher levels of processing and or measures of comprehension processes. As reader total time increased, readers made significantly (p<.001) longer pauses after clause (r=.413), quote (r=.380), sentence (r=.243) and paragraph boundaries (r=.466). These strong correlations at punctuation boundaries strongly suggest that the pauses they elicit are associated with the processing of text. Furthermore, as readers made more oral regressions within the text, these correlated significantly (p<.001) with total time (r=.282). Uncorrected errors, which measured mistakes in oral reading, significantly (p<.005) correlated with total time as well (r=.206). Fixation count, which measures the average total number of fixations, had strong correlational relationships with oral reading measures as well. Fixation count correlated significantly (p<.005) with pauses at clause boundaries (r=.209) as well as quote boundaries (r=.187). As readers took longer pauses at paragraph boundaries, they also had higher fixation counts to a significant degree (p<.001, r=.300). While fixation count did not correlate as strongly as total time, it still indicates that the total number of fixations is a measure of later processing. Readers who had more oral regressions, also had higher fixation counts ($p<.005$, $r=.192$). This suggests that readers who make oral regressions are aware of the text, and so in silent reading make increased fixations. Silent reading regressions did not correlate with any of the higher order prosody measures of processing.

Table 2

Correlation of Silent Reading Measures of Delayed Processing and Oral Reading Measures of Higher Prosody

	Silent Reading		
Oral Reading Measures	Total Time	Fix Count	Regression
Clause	.413**	.209*	.029
Quote	.380**	.187*	.102
Sentence	.243**	.097	.126
Paragraph	.466**	.300**	.162
Uncorre. Error	.206*	.024	.042
Total Regress	.282**	.192*	.159

*p<.05,**p<.01

The final aspect of oral and silent reading that I compared, investigated the connections between later stages of processing of silent reading to measures of error checking in oral reading. I also compared these measures to our external tests of passage comprehension in the Woodcock Johnson tests of fluency. See Table 3. Total time significantly ($p<.001$) correlated with the amount of oral regressions readers made in the text ($r=.282$). Total time also significantly ($p<.005$) correlated with the amount of uncorrected errors ($r=.206$). Woodcock Johnson test of comprehension significantly ($p<.001$) correlated in a negative manner with total time ($r=-.429$). As readers improved in comprehension levels, their total time on words decreased. Silent reading regressions did not correlate significantly with any oral reading regressions and error measures, or Woodcock Johnson tests, indicating that when readers regress is not soley due to fluency and comprehension issues. Fixation count significantly correlated ($p<.005$) with total oral regressions ($r=.192$). It correlated negatively with Woodcock Johnson comprehension tests ($r=-.205$). For oral measures of error checking, significant ($p<.001$) correlation was found for uncorrected errors and Woodcock Johnson passage comprehension ($r=-.449$). As readers made increasing uncorrected errors, their passage comprehension levels decreased.

Table 3

Correlation of Oral and Silent Reading Regression Behavior and WJ Comprehension

Silent Reading	Oral Reading Total Regressions	Uncorrected Errors	WJ Test Comprehension
TT	.282**	.206*	-.429**
Reg	.159	.042	-.168
Fix Count	.192*	.024	-.205*
WJ Test Comprehension	-.076	-.449**	1

Discussion

General Prosody Characteristics

To properly evaluate prosodic skill in oral reading, I examined several measures across reader skill. These measures included pausing across a variety of structures, pitch changes at declarative, wh-question and yn-question sentences, and intrusions or interruptions of sentences and words. These measures allow us to create a comprehensive picture of true prosodic skill and evaluate how each skill builds upon the other and how they can demonstrate reader progress and overall fluency.

When I examined pause type and reader skill there were significant effects for both pause type and reader skill level. As previous research has supported, readers read punctuation in different manners and altered their pace and pausing in response to that punctuation (Schwanenflugel et al., 2004). An adult model of punctuation demonstrates that pause length will increase from adjective to clause to sentence to quote and finally at paragraph endings. The children in this study replicated most of this behavior. Differences between adjective and clause pause lengths approached significance, p=.07, with adjectival pauses being shorter than clause pauses. Clause boundaries were marked with significantly shorter pauses length means than quote and paragraph, but not sentences. Finally sentences were read with significantly shorter differences than paragraph pauses, but not quotes. Paragraph pauses were significantly longer than all other pause boundaries. The lack of differences between adjacent variables (in terms of length) demonstrate that recognizing how to properly use punctuation is a skill that must be learned and developed. The variation between the conditions demonstrate that readers are attempting to read with the correct pause structures but other aspects of fluency may prevent them from having clear graded differences. This finding is supported by the fact that overall high skill readers had significantly shorter pause means than low skill readers. Pausing in other instances has been related to decoding efforts, and so as readers became more proficient their overall pausing times decreased.

Furthermore, if the pause data was split by each skill level, we can really investigate how use of punctuation is affected by skill level. Low skill readers did not have any significant differences between pause length means and type except for paragraph pauses. High skill readers however, had significant differences for all measures except for between quote and sentence endings. Without the middle group, the differences of skill level are amplified. A reader with higher fluency utilizes punctuation in a significant manner, whereas a low skill reader treats all punctuation similarly.

If we compare pause data with silent reading measures as well as Woodcock Johnson tests of decoding and word identification, we can begin to identify what types of punctuation is readily identified by readers as helpful. There were no significant correlations between adjective pauses and initial processing measures of eye movement. Furthermore, adjectival pauses did not correlate with word attack or identification skills either, suggesting that for developing readers, adjectival pauses are not a distinct marker. Yet clause pauses significantly correlated with first fixation, gaze duration, intraword regressions and both measures of Woodcock Johnson word decoding. The differences between these two measures suggest that readers may treat them differently due to the information they represent. An adjectival pause merely separates items in a list, whereas a clause comma groups information, and so readers respond differently as they increase in skill level. A high skill reader, who reads with more focus on comprehension rather than decoding, will utilize punctuation to aid in understanding the text beyond a word level.

While pausing can indicate reader skill based on punctuation, word and sentence intrusions can demonstrate a lack of fluency and ease while reading (Chafe, 1988). Word and sentence intrusions are an abnormal pause during the course of a sentence or within an actual word. Word and sentence intrusion frequency was significantly connected to reader skill level. Furthermore, the type of intrusion is also changed significantly with increasing reader skill. Not only do high skill readers make fewer overall intrusions, they make fewer word than sentence intrusions. This effect was similar for low skill readers, who had a higher overall magnitude of word and sentence intrusions. Intrusions represent the lower levels of fluency and prosody: a reader who has low fluency skills will be unable to reader through a passage without word and sentence intrusions as they work to decode aspects that trouble them. Word intrusions correlated significantly with all measures of initial processing in eye movement as well as Woodcock Johnson tests of word fluency, demonstrating that word intrusions are strongly related to decoding skill and identification of words. Sentence intrusions furthermore correlated significantly with gaze duration, intraword regression frequency and Woodcock Johnson measures of word fluency. The differences between these two correlations suggests that sentence intrusions are an indicator of sentence level "decoding" skill. A reader who is able to see the sentence as whole, and work forward in a systematic and unhindered way would theoretically therefore have fewer instances of sentence intrusions. Without high levels of fluency, a reader has to add in pauses to process text or to take another breath. Even with high reader skill, readers still made significantly more sentence intrusions compared to word intrusions. Sentence intrusions therefore could represent, in fluency evaluations, an indicator of greater decoding skill yet still larger sentence level integration difficulties.

The next variable we assessed was pitch changes across sentence endings. Research by Cowie et al. (2002) demonstrated that expressiveness, or pitch variation, was a feature of prosodic reading that was expressed only when readers had achieved sufficient levels of fluency. Therefore we measured pitch at declarative, wh-question and yn-question sentences conclusions. In follow up research, Schwaneflugel and Miller (2006) examined more specifically how readers approach different sentence types. Declarative sentences are read with a declination or drop in pitch across the final syllables and wh-questions with stable pitch changes, and yn-questions with a large upswing in pitch. In their research Schwanenflugel and Miller compared a children's prosodic contour to that of adults who had achieved fluency. We found that developing readers treated these sentence types with significant differences, and that with increasing skill level the overall magnitude of pitch change became significantly larger. Unlike Schwaneflugel and Miller (2006) however, who suggested that readers show significant differences between wh-question and yn-questions, we found instead that readers approached these sentence types very similarly and would read with a sustained upswing in pitch. There was no significant difference between these two question types.

Overall these components support established conclusions about fluency and prosody. Low skill readers, who were not fluent, had much less pitch variation, appropriate pausing at punctuation and read in a halted manner that was interrupted and awkward. Yet as readers increased in skill level, their ability to manipulate written text expressively and smoothly increased dramatically. They read in a pace and manner that imitated oral speech, giving the story dimension and definite structures.

Eye Movement

Our ability to track developing readers' eye movements has revealed some very interesting findings. Eye tracking studies in the past that have dealt with struggling readers addressed their coping strategies by assessing adults with literacy deficits or have utilized moving window paradigms and other experimental designs to manipulate the information available to the reader. These studies widened our understanding of how the eyes react to different challenges, and in this study we can further that research on the basis of developing reader skill.

Measures used to assess initial processing time of the word such as first fixation duration, gaze duration and intraword regressions demonstrated significant differences between readers based on skill level. For first fixation duration, there were significant differences between low and medium reader skill compared to high skill readers. High skill readers spent significantly less time in their initial fixation than both low and medium skill level readers. As we hypothesized, this initial fixation demonstrates the ease to which a reader accesses the mental representation of a word in their lexicon. Therefore, high skill readers have more efficient access to these mental representations and therefore spend less time in their initial fixation, indicating reduced lexical processing (Reingold et al., 2010).

Gaze duration and intraword regression also represent initial processing time. Next to first fixation, they represent continued processing of a word (Ashby et al., 2005). Together these two measures represent the difficulties the reader has with a particular word. Therefore, as we expected, there were significant differences between the length of time and the amount of intraword regressions that a reader made based on skill level. For gaze duration, as a reader increased in skill they became significantly quicker in the amount of time they focused on a word. Intraword regression differences were significant between high skill readers, who made fewer, when compared to low and medium skill readers.

Taken together, these measures support the lexical model of eye movement behavior, which suggests that eye movements reflect the ease and or difficulties of retrieving lexical information about the text being read (Ashby et al., 2005; Reingold et al., 2010). Low and medium skill readers, who are less fluent than high skill readers, spent more time in their initial fixation, overall gaze duration and made larger amounts of intraword regressions. Clearly these readers lacked the ease of progressing through text in a fluent and automatic manner.

The next eye movement variables we examined addressed comprehension measures: total reading time, skipping frequency, fixation count and regression frequency. While we found no significant differences between reader skill levels of regressive behavior, there were significant differences between reader skill levels of total time spent on a word. High skill readers spent significantly less time than low skill readers overall on each word. High skill readers also had significantly fewer fixations than low skill readers. Therefore, it seems safe to conclude that not only do low skill readers spend more initial time on the word, they increase the overall amount of time on a word with later regressions compared to high skill readers.

These measures really demonstrate the strain a developing reader may feel as they progress through a passage of text. While they have to decode the words as they come across them in the passage, they also have to maintain a representation of the previous parts of the story in their short term memory. Therefore, if they are taxed by the task of decoding it is reasonable to assume that they have to return to previous text in order to recall what they had read previously, and their comprehension levels will suffer due to overuse of cognitive resources on decoding (Gough, 1996).

Various models have proposed by the eyes skip words. Studies by Drieghe et al. (2005,2007) have demonstrated that the eyes skip when information is redundant due to previous text and in an effort to save processing demands. Yet, in developing readers I believe this is not the case. Unskilled readers skipped a much higher proportion as compared to high skill readers, and low and medium skill readers approached significant differences in skipping rates as well. Higher fluency levels did not correspond to significantly increased skipping frequency. Instead it appears, that low skill readers skip portions of the passage to potentially ease their processing loads.

If we combine these results with those obtained from fixation count we find some very interesting behaviors of low skilled readers. Total fixation count measures the total number of fixations a reader makes while progressing through the text. I found significant differences between medium skill readers and high skill readers, where a medium skill reader made significantly more fixations. Because measures for all other reading behaviors are greatest for low skill readers, such as fixation and gaze duration as well as intraword regressions, the fact that they then also have fewer overall total fixations than a medium skill readers strongly supports that they skip major portions of text. This inconsistency across different measures for low skill readers suggests that their silent reading behavior is unsystematic. Compared to high skill readers, they do not proceed through the text in a logical, consistent manner. Instead they skip around, reading portions at a time.

Another very interesting finding in this examination of silent reader eye movement behavior was their regression movements. No group had significant differences in the amount of regressive behavior that they performed due to large amounts of variance. I would hypothesize that the efficiency and use of they regressive saccades would differ based on how their eyes act in other measures. This finding is not completely surprising however, because even the most skilled reader at this level is still a new reader and is acquiring the skills and memory skills necessary to read long passages of text with high comprehension and retention of previous information.

Decoding Skill

For decoding behavior in oral and silent reading conditions, there were several interesting findings. In oral reading, decoding for high and low frequency words is measured by pauses before and after the word. Pauses before would indicate early processing, whereas pauses after indicate spillover processing demands. For pre pause data, there were no significant differences between high and low frequency words for low and medium skill readers. High skill readers however, had a very interesting effect. While low and medium skill readers spent comparable amounts of time before low and high frequency words, high skill readers differed. They spent longer before low frequency words, as predicted, compared to high frequency words in a manner that approached significance (p=.06). Therefore, only readers who had higher levels of fluency would demonstrate early processing of words based on their difficulty compared to less skilled readers.

For the time spent on the actual target word there were more significant interactions. I hypothesized that a reader with less skill would have significant differences in target times dependent upon the frequency level of the word. This hypothesis was supported by the data. Low skill readers showed significant differences between high and low frequency words, but this difference disappeared with higher fluency readers.

Pause time after target words had significant effects based on skill level, but not word frequency. Low skill readers spent more time than high skill readers after the target word. This supports my hypothesis that low skill readers would need more additional time, compared to high skill readers, to finish processing text after oral production of the word.

Silent reading measures of decoding included first fixation, gaze duration and total time. First fixation had effects based on reader skill level, but not word frequency. As skill level increased, readers had significantly shorter first fixations on both high and low frequency words. This indicates that as readers increased in skill their lexical access of words was approaching automaticity, a necessary condition of fluency. Their word recognition skills improved with greater reading skill level. Gaze duration revealed word frequency effects as well as skill level effects. Readers spent significantly longer on low frequency words compared to high frequency words. This effect indicates that word frequency did effect direct processing time of a word when a reader encountered it in the text. Skill level also had significant effects on gaze duration. As skill level increased, readers had shorter gaze durations. This supports the results from first fixation. As a reader increases in skill level, their ability to quickly access lexical and semantic information about a word's identity increases, and is reflected in their overall processing demands.

The differences between oral and silent reading are enhanced in oral verus silent reading. Readers in oral reading significantly altered their behavior before, during and after target words based on frequency. With increasing skill, readers were able to utilize the pause before a word to initiate decoding which resulted in decreased differences in production time due to word frequency and also a decrease in processing time after. In silent reading however, first fixation times remained fairly consistent with a change in word frequency and only improved slightly with an increase in skill level. Gaze duration demonstrated significant effects based on word frequency, with low frequent words have longer gaze durations relative to high frequency words. Low skill readers did not have significant differences in gaze duration based on frequency, unlike medium and high skill readers. Medium and high skill readers furthermore, had significant differences in the gaze durations of high and low frequency words. Medium skill readers spent significantly more time on low frequency words compared to high skill readers, and had the same effect for high frequency words as well. Similar to target time, gaze duration scores improved with an increase in skill, and for medium skill readers word frequency effects were observed, demonstrating some aspects of automaticity of high frequency words.

Oral and Silent Reading

Low and high skill readers had the most significant differences for the various measures of silent and oral reading. For silent reading, low skill readers had length first fixations, made more frequent intraword regressions resulting in longer gaze durations as well. As they read, each word had longer total time measures and they were more likely to skip words. Yet they had high fixation counts. These silent reading measures portray a reader who needs more time to process text but also does not progress though a passage in a systematic way. On the contrary, high skill readers are much more systematic in their reading approach. They have shorter first fixations, gaze durations and total time spent on words. High skill readers are less likely to skip words, and have lower fixation counts as well. Their behavior is more like that of an adult skilled reader.

Oral reading behavior of the high and low skill readers also has significant differences. Low skill readers have higher percentages of word and sentence intrusions which disrupts the flow of their oral reading. They pause with equal time at all boundaries except for those at paragraphs. Low skill readers had less pitch differences across declarative, wh and yn question sentences, yet they did distinguish pitch between declarative and question sentences.

Following up on the research of Kim, Wagner, and Foster (2011), I investigated to the extent oral and silent reading overlap and relate to overall fluency measures. First I correlated silent reading measures of initial processing to oral reading measures of decoding. Decoding effects are very prominent in oral reading because the word must be produced. Therefore, by running these correlations I hoped to elucidate the relatedness of initial processing measures in silent reading compared to oral reading. For all measures of oral reading decoding skill, there were significant correlations with silent reading measures of initial processing. Furthermore, all measures of oral decoding significantly correlated with Woodcock Johnson decoding skill indicator tests. Silent reading measures also correlated significantly to these tests, but not as strongly as in oral reading. This difference demonstrates that while eye movements can reveal decoding difficulties, oral reading assessment of decoding skill is a much stronger indicator compared to silent reading.

To expand upon these findings, I then ran an analysis of higher order prosody measures. As Schwanenflugel et al. (2004, 2006) suggest, development of an adult-like prosodic contour occurs at higher levels of fluency. Therefore, I wanted to investigate how measures of prosody that improved significantly with skill level correlated to later processing measures of silent reading. Do readers who take more time at clause and phrase boundaries, effectively gathering their thoughts, also have silent reading measures that reflect increased post processing? We found these connections to be significant for oral and silent reading. Readers who took longer pauses at clause, quote, sentence and paragraph boundaries also had significantly longer average total time per word. Fixation count however did not correlate as significantly and strongly to these oral reading variables. This suggests that the total number of fixations in a passage does not indicate higher levels of fluency, but rather how the eyes behave on each word is an indicator of greater fluency.

Taken together, these correlational analyses directly support the widely held idea that silent reading skill does build off of oral reading skill. Readers who had poor oral reading skills that indicated decoding difficulties such as high incidences of inappropriate pausing, had measures in silent reading that reflected the same underlying issues. One of the most important conclusions from the comparison of oral and silent reading fluency measures concerns low skill readers. Low skill readers are a group of readers who really struggle to progress through a passage of text. Each word is an ordeal that demands high focus and intricate decoding. Low skill readers, who struggle with decoding, react to silent reading tasks in a nonsystematic way. As Wayczyk and Taylor (1996) discussed, readers with greater skill were able to alter their reading behavior to ensure that comprehension levels remained high. As a high skill reader recognized the difficulty of the text, they responded by slowing down and re-reading greater portions of text. Yet, in silent reading we see that children with low skill also compensate. However, their ability to create coping strategies to deal with decoding difficulties are ineffective. Instead they read through the text nonsytematically, negatively impacting their comprehension ability. A text that is disjointed and read in parts cannot be understood to the same degree as a fluently read passage from start to finish. Decoding problems strongly hindered low ksill readers.

High skill readers, on the contrary, were able to progress through the passage with ease. While some words caused them to alter their behavior, this was not a constant challenge for them. Therefore their freed attentional resources focused on adding appropriate punctuation and pitch changes. Their silent reading behavior consisted of a reader who examined important words in the text and utilized incomplete processing to conclude the words in between. This did not negate their need for regressions, but it allowed them to keep a forward flow to their reading, connecting the ideas and elements of the story.

Overall, differences in silent and oral reading fluency are most apparent between low skill readers. When evaluating the components related to reading by Gough (1996) they consist of the ability to recognize words and then the ability to understand those words, in other words, decoding skill and comprehension skills. Low skill readers are primarily focused on decoding. Their oral reading prosodic profiles reflect a reader who does not read for content, with appropriate pausing and low incidences of word and sentence intrusions, but rather a reader who decodes each step of the way. Their decoding behavior is inefficient even in comparison to high skill oral readers who utilize pausing to group ideas and initial lexical access of unfamiliar words. When these low skill readers are then evaluated in silent reading, their ability to progress through text is compromised. They read unsystematically, jumping around the text and resulting in decreased comprehension. Their coping responses to high decoding demands are inefficient and ineffective.

This result is very important given the low literacy rates in America. Without proper identification of the deficits of low skill readers, whether it is at the most basic level of decoding, or maybe larger sentence level comprehension deficits, a child's ability to read silently is negatively impacted. As children progress through school, their reliance on silent reading skill becomes more important. Therefore, unless low skill readers can be effectively identified and assisted in decoding skills they will not be able to progress at the same rate as their more skilled counterparts. Instead, as text difficulties increase, they will still be hindered by decoding and further unable to have strong comprehension of the passage. Therefore, not only do programs need to be devised to identify low skill readers, but perhaps there should be greater emphasis on teaching proper silent reading behavior. Children with low skill need to learn appropriate coping mechanism when they feel overwhelmed in silent reading, instead of utilizing their non-systematic approach.

Therefore, potential areas of future research could assess how silent reading skill improves from more effective oral reading assessment and a greater focus on developing strong decoding skill. Further studies could also investigate the effectiveness of teaching coping skills to silent readers and helping them become more metacognitively aware of the demands of the text and how they should alter their behavior to maximize comprehension levels.

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APPENDIX A

Molly has guts at school [7]. She has more guts than anybody in the second grade. She can stand at the top of the monkey bars on one foot, [2] doesn't mind when Nicky leaves <u>dead</u> bugs in her desk, [2] and tells big kids to get lost when they pick on her. [6]

Today at lunch Molly said to me, "Beth, can you come to our <u>house</u> in the <u>country</u> this weekend? [3] The house is huge, [1] old, [1] and lots of fun. What do you think? [4] Will you visit for the weekend?" [3] [6]

But I have never been away from home. What if I get homesick? [4] What if they eat stuff I don't like? [4] What if there are lots of wild animals? [4] I was not sure I wanted to go. I was a little scared but said, "Sure, I would like to spend the weekend at your country house." [5]

My mom kissed me two times when I left. "One kiss for tonight, [2] one for tomorrow, [2] and then you will be home," [5] she said. I picked up my purple, [1] overstuffed, [1] and very heavy backpack, [2] said goodbye to my mom and hopped into the back seat of Molly's car. [6]

Molly's dog Butch sat between us. Butch was really big, [1] very furry, [1] and smelled like dog food. I'm kind of scared of big dogs. But did I show it? [3] No, I acted like I loved getting dog spit all over my face when he licked me. [6]

By noon we got to Molly's house. We ate a tasty lunch, [2] played some games, [2] and then picked berries [7]. We ate lots and lots of berries. Red juice got all over my face and hands. Later, Molly asked, "Would you like to pick wild <u>flowers</u> in the field?" [3] [5] The field was full of purple, [1] yellow, [1] and pink flowers [7]. We picked more flowers than we could carry[7]. [6]

By Sunday I was tired, [1] homesick, [1] and very <u>happy</u> that I visited Molly's house in the country[7]. As we were leaving, Molly said to me, "The weekend was great. Will you be my best friend?" [3] [5] We locked pinkies on it. I turned to Molly and asked, "What should we do next weekend?" [4] [5]

[1] Adjective Commas (10)
[2] Clause Commas (7)
[3] Y/N Questions (5)
[4] "Wh" Questions (5)
[5] Quotes (5)
[6] Paragraph Pauses (5)
[7] declarative sentence (5)
word = Low Frequency Word (5) Carroll et al. (1971)

guts (*U*=1.2085)
goodbye (*U*=3.9320)
furry (*U*=4.4987)
licked (*U*=8.3460)
tasty (*U*=4.4920)

word = High Frequency Word (5)

dead (U=103.45)
house (U=496.81)
country (U=406.70)
flowers (U=123.22)
happy (U=139.55)

355 words

APPENDIX B

Sammy and the Talking Melon

Word Frequency

High	**Low**
Sun (*U*=352.58)	Hoe (*U*=4.2678)
Spider (*U*=29.894)	Melons (*U*=1.0182)
House (*U*=496.81)	Thorn (*U*=3.9474)
Field (*U*=163.4)	Berry (*U*=2.2192)
Sky (*U*=165.45)	Gap (*U*=7.2017)
Garden (*U*=105.63)	Snooze (*U*=.1827)

One fine morning Sammy the Spider sat high up in a thorn tree looking down into Elephant's garden. Elephant was hoeing his melon patch. The ripe melons seemed to call out to Sammy, "We are so juicy and sweet! Come eat us!"

Sammy loved to eat melons, but he was much too lazy to grow them himself. So he sat up in the thorn tree, watching and waiting, while the sun rose high in the sky and the day grew warm. By the time noon came, it was too hot to work. Elephant put down his hoe and went inside his house for a snooze.

Here was the moment Sammy had been waiting for. He broke off a thorn and jumped down into the melon field. He used the thorn to make a gap in the biggest, ripest melon.

Sammy squeezed inside and started eating. He ate and ate until he was as round as a berry.

APPENDIX C

Data Viewer Silent Reading Analysis