SEMANTIC PROCESSING IN CHILDREN WITH READING COMPREHENSION DEFICITS

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Abstract

This investigation compared the semantic processing abilities of fourth-grade children with specific reading comprehension deficit (SRCD) to a chronological-age matched control group (4NR) and a younger, reading comprehension matched control group (2NR) on a single word shadowing task. During this experimental task, the children were expected to listen to a sentence and repeat the final word (cued by a change in speaker voice) of the sentence as fast and as accurately as possible. There were two experimental conditions: 1) a high cloze probability sentence condition in which the final word of the sentence or target word was semantically related to the sentence prime and 2) a low cloze probability sentence condition in which the target word was semantically anomalous to the sentence prime. All three groups of children displayed higher contextual effects in the high cloze probability condition compared to the low cloze probability condition. However, children with SRCD did not perform significantly different than controls in either experimental condition. These findings provide evidence of contextual enhancement within the single-word shadowing task, even for children with SRCD, and are discussed within the context of a semantic processing deficit theory in children with SRCD.

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Chapter I

Introduction

In the last several decades, the study of reading development in children has steadily increased. We have come to understand that reading development directly affects the academic and social achievements of an individual. As part of this work, researchers have investigated children who have problems learning to read. Much of this research has focused on children who have deficits in word recognition (Bruck, 1988; Rack, Snowling, & Olson, 1992; Stanovich & Siegel, 1994). Word recognition refers to the ability to transform print into sounds and words (decoding) as well as to identify and retrieve words from one's sight word vocabulary. Children with primary deficits in word recognition (i.e., individuals with dyslexia) have been found to have difficulties in phonological awareness and associated areas of phonological processing (Brady & Shankweiler, 1991; Catts, 1989, 1996; Stanovich & Siegel, 1994; Torgesen, Wagner, & Rashotte, 1994). This subgroup of poor readers has been differentiated from good readers on phonological tasks such as rhyme judgments, phoneme identification, and phoneme/syllable deletion. In addition, phonological awareness and phonological processing explain unique variance in reading ability over and above measures of non-verbal intelligence and other measures of language aptitude (Stanovich & Siegel, 1994; Catts, Gillispie, Leonard, Kail, & Miller, 2002).

While most research on poor readers emphasizes deficits in word recognition, some investigators have recently become interested in another group of poor readers: those with problems in reading comprehension. Reading comprehension is a complex process that requires lower-level processes (i.e., phonological, lexical) to decode print and higher-level processes (i.e., semantic, inference making) to comprehend the meaning. Some argue that most differences in reading comprehension, especially early in reading development, can be explained by problems in word recognition (Gottardo, Stanovich, & Siegel, 1996; Leather & Henry, 1994; Liberman & Shankweiler, 1991; Shankweiler, 1989; Shankweiler et al., 1999). Clearly, children with word recognition problems will have difficulty understanding text that contains words that are not easily or efficiently identified. However, there is evidence of poor readers who exhibit reading comprehension difficulties in the presence of adequate word recognition skills or individuals with specific reading comprehension difficulties (SRCD; Catts, Fey, Zhang, & Tomblin, 1998; Nation & Snowling, 1998a; Stothard & Hulme, 1995). This particular group has not been examined thoroughly. In fact, these children are rarely identified clinically as having a reading problem, and because of their adequate decoding skills, many are considered to be skilled readers (Nation, Clarke, Marshall, & Durand, 2004; Yuill & Oakhill, 1991). Unlike the converging evidence on the causal basis of word recognition problems, there is little consensus concerning the processing deficits of children with SRCD.

Linguistic Processing Deficits in Children with SRCD

Researchers have provided evidence to suggest that individuals with SRCD have "wide-ranging deficits with aspects of language processing" (Nation, 2001, p. 339). In an effort to investigate the language profile of children with SRCD and determine if this population has language problems, Nation, Clarke, Marshall, and Durand (2004) administered a battery of standardized language tests to 23 children with SRCD and 22 control participants. The children with SRCD performed significantly worse on all measures of semantic, syntax and morphology, and broader language skills. Interestingly, there were no group differences on three tasks that measured phonological abilities. These findings support other studies that found individuals with SRCD do not perform significantly different than good comprehenders on skills requiring phonological awareness and phonological processing such as phoneme deletion (Cain, Oakhill, & Bryant, 2000; Catts, Adlof, & Weismer, 2006), word reversal, letter strings (Cain, Oakhill, & Bryant, 2000), non-word repetition (Catts, Adlof, & Weismer, 2006) spoonerism production (Cain, Oakhill, & Bryant, 2000; Stothard & Hulme, 1995), rhyme judgment (Nation & Snowling, 1998a), rhyme production (Cain, Oakhill, & Bryant, 2000; Nation & Snowling, 1998a), non-word reading (Stothard & Hulme, 1995), and spelling (Stothard & Hulme, 1995) tasks.   This body of research concludes that children with SRCD have deficits in a broad range of language areas, yet their phonological skills are intact.

Other investigators have also suggested that children with SRCD have deficient listening (language) comprehension abilities (Catts, Adlof, & Weismer, 2006; Nation & Snowling, 1997; Oakhill, 1983). Stothard & Hulme (1992) provided evidence that linguistic comprehension is an important factor in reading comprehension. They investigated the association between reading comprehension and listening comprehension in children and reported high correlations between reading and listening comprehension across all readers and moderate correlations within subgroups of readers (i.e., SRCD group). In addition, they found that the SRCD group performed worse on a listening comprehension and receptive grammar test compared to an age-matched control group. However, the SRCD group performed similarly to a younger, comprehension age-matched control group. Stothard and Hulme (1992) concluded that children in the SRCD group have linguistic comprehension skills "in line" with their reading comprehension skills and therefore may be representative of a general comprehension problem.

Catts, Adlof, and Weismer (2006) also found that children with SRCD had deficits in language comprehension. They investigated a group of children that were older than those found in most other studies of poor readers. A group of eighth grade children with SRCD performed more poorly than a typical reader group and a poor decoder group on measures of receptive vocabulary, grammatical understanding, and discourse comprehension. When retrospectively analyzing the performance of these children, Catts, Adlof, and Weismer (2006) also found that eighth grade children with SRCD showed a similar profile of language comprehension deficits in kindergarten, second, and fourth grades.

Inference-Making Deficits in Children with SRCD

Along with linguistic comprehension deficits, SRCD children have been found to display difficulties in higher-level cognitive skills such as inference making

(Cain & Oakhill, 1999, 2006; Cain, Oakhill, Barnes, & Bryant, 2001; Catts, Adlof, & Weismer, 2006; Oakhill, 1982, 1984), comprehension monitoring, ability to structure stories, and knowledge of story title purpose (Cain & Oakhill, 2006). Inference making is a skill that requires the individual to access and integrate previously stored knowledge with newly acquired information for the purpose of enhancing comprehension. In reading, inference making failure may arise because the individual was unable to: (a) access previously stored knowledge, (b) access or store the correct premise from the text, (c) integrate previous knowledge and the new premise of the text, or (d) make the correct integration of previous knowledge with the new premise of the text (Cain, Oakhill, Barnes, & Bryant, 2001). Readers of different skill level may have differentiating causes of inference making failures.

To investigate the causal level of inference failure in children with SRCD, Cain et al. (2001) compared less-skilled reading comprehenders (operationally defined the same as SRCD) to skilled reading comprehenders on inference making ability while controlling for previous knowledge base. Investigators taught all of the children a series of novel facts (i.e., information about an imaginary planet) that provided background knowledge for the stories they were about to hear. Investigators read six story episodes to the children, each related to the novel knowledge base, and asked questions that assessed inference making. To ensure the stability of the novel knowledge base, the children were tested for their recall of the knowledge base before, immediately after, and one week after the story episodes and inference making questions. They found that less skilled comprehenders established fewer inferences than skilled comprehenders and the primary source of inference making failure in less skilled comprehenders was the inability to extract the correct premise of the text that was necessary to make the inference. On the other hand, the source of inference making failure in skilled comprehenders was often at the level of integrating the two units of information. Interestingly, the ability or inability to use knowledge base and literal information from the text was not an integral factor in inference making failure by either comprehension group.

Catts, Adlof, and Weismer (2006) also found inference-making performance differences between groups of children with SRCD compared to a typical reader group and a poor decoder group. These children listened to narrative passages and answered questions based on information explicitly stated in the text (premise questions) and questions that required an inference. Some of these inference questions required the children to connect information within a sentence or between adjacent sentences while other inference questions required distant information to be connected. The children with SRCD performed more poorly than the two control groups on inference-making questions. In addition, when knowledge of the premise was controlled, children with SRCD performed similarly to the other groups in the adjacent inference condition but more poorly in the distant inference condition. While Catts, Adlof, and Weismer (2006) concluded that their study provided evidence of language-based inference-making deficits in children with SRCD, they did acknowledge an alternative interpretation of problems in working memory.

Regardless of the level of failure, inference failure will result in "less detailed and integrated model of the text" (Cain, Oakhill, Barnes, & Bryant, 2001; p. 857) and thus affects overall comprehension of the text. When inference making is successful, there is evidence that individuals integrate these inferences into the overall comprehensive model of the text. For example, previous studies have displayed evidence that individuals respond as quickly to words related to inferred information from the text as words related to explicitly stated information from the text (Potts et al., 1988; Singer & Ferreira, 1983). Essentially, this suggests that inferred information is integrated and equally represented into the semantic system as much as information that is explicitly stated in text.

Semantic Processing Deficits in Children with SRCD

Since children with SRCD have difficulties with inference making and general comprehension failure, some theorists have hypothesized that these children have an underlying deficit in semantic processing (Nation, Adams, Bowyer-Crane, & Snowling, 1999; Nation, Marshall, & Snowling, 2001; Nation & Snowling, 1998a, 1998b, 1999). Contemporary theories of semantic processing are based on early work in spreading activation models (e.g., Collins & Loftus, 1975; Gernsbacher, 1990). Gernsbacher's (1990) Structure Building Framework model suggests that semantic features or memory traces are represented as nodes within an interactive network. When a semantic/memory node is activated, the information can be used for comprehension. In addition, Gernsbacher (1990) proposed two general cognitive mechanisms: enhancement and suppression. Enhancement boosts the activation of the nodes when the information is relevant and suppression dampens the activation of the nodes when the information is not useful or no longer necessary. Spreading activation theories are validated by numerous semantic priming studies in which the reaction to a semantic unit is enhanced (e.g., Neely, 1976, 1977; Simpson, 1984; Stanovich & West, 1983) by a previously presented and related semantic unit or suppressed by previously presented and ambiguous semantic unit (e.g., Gernsbacher & Faust, 1991).

In a series of investigations, Nation, Snowling, and colleagues have provided evidence for a semantic processing deficit in children with SRCD (Nation & Snowling, 1998a, 1998b, 1999; Nation, Adams, Bowyer-Crane, & Snowling, 1999; Nation, Marshall, & Snowling, 2001). In one of these studies, Nation, Marshall, and Snowling (2001) compared children with SRCD to normal readers on their ability to accurately and efficiently name pictures that varied in phonological and semantic characteristics. Children with SRCD performed similarly to controls when naming pictures that varied in length (phonological) but were slower and less accurate when naming pictures that have low frequency names (semantic). Nation, Marshall, and Snowling (2001) concluded that children with SRCD exhibit semantic processing weaknesses in the presence of intact phonological processing abilities.

In another study in which phonological and semantic variables were manipulated, Nation, Adams, Bowyer-Crane, and Snowling (1999) hypothesized that a verbal recall task would reflect the same language mechanisms responsible for language comprehension. They compared a group of good readers to a group with SRCD on serial word recall tasks that varied in phonological and semantic conditions. They found that both groups showed normal effects of phonological variables during serial word recall. More specifically, lexicality (words versus non-words) and word length affected both groups similarly. However, when the stimuli were comprised of concrete and abstract words, the SRCD group showed a significant difference in performance compared to the good comprehenders. The SRCD group recalled as many concrete words but not as many abstract words. This finding would be expected in a semantic processing deficit theory because we would expect abstract words to have fewer and weaker semantic connections. The semantic characteristics of abstract words may exacerbate the difficulty that the SRCD group already has in activating semantic units. However, neither Nation, Marshall, and Snowling (2001) nor Nation, Adams, Browyer-Crane, and Snowling (1999) controlled for differences in vocabulary. If the children with SRCD in these studies had poorer vocabulary skills than controls, then one could argue that the children with SRCD had poorer lexical knowledge rather than a deficient semantic processing system.

More recently, Weekes et al. (2008) supported the Nation et al. (1999) conclusion that children with SRCD have reduced sensitivity to abstract semantic features. In the Weekes et al. (2008) experiment, children with SRCD were compared to a normal reader group on their ability to recall and recognize two types of word lists, words that were semantically (e.g., medicine, health, hospital) and phonologically (e.g., pole, bowl, hole) related. The children from both groups studied the two types of word lists. Then, they were asked to perform two tasks: 1) a recall of words from the list and 2) a forced choice recognition task of target words and critical words (or foils that were semantically or phonologically related but not part of the studied list). Children in the SRCD group produced fewer false recollections in the semantic task list conditions compared to normal readers, which suggested that these children had difficulty inferring and/or using the semantic theme of the studied list. In contrast, the SRCD group did not differ from normal readers on false recollections for words in the phonological task list condition. In the forced choice recognition task, children with SRCD recognized fewer critical words (foils) in the semantic task. This suggests that they were not as susceptible to semantically related foils as the normal reader group. In the phonological condition of the forced choice recognition task, the two groups did not differ significantly. These findings supported previous studies that showed individuals with SRCD have intact phonological processing but deficient semantic processing of language, which affect their ability to perceive and comprehend. In a later section, the Weekes et al. (2008) results will also be discussed relative to the theoretical mechanisms of enhancement and suppression.

In another study, Nation and Snowling (1998a) compared children with SRCD to normal readers (matched on age and non-word reading) on different tasks of semantic and phonological processing. They found that the SRCD group performed more slowly and were less accurate on the two semantic processing tasks (i.e., synonym judgment and semantic fluency); however, they performed similarly on the phonological processing tasks (i.e., rhyme judgment and rhyme fluency). They suggested that semantic knowledge of individuals with SRCD are not only weaker than age-matched controls but also that their semantic abilities are less developed than their abilities in the phonologic domain. Again, this investigation supports the hypothesis that children with SRCD have deficits in semantic processing and not in phonological processing.

Additionally, Nation and Snowling (1998a) compared a group of children with SRCD to a normal reader group on a word recognition task that included low frequency and exception or irregular words. According to Stanovich's Interactive-Compensatory Model (Stanovich, 1980; Stanovich, West, & Freeman, 1981) and connectionist models (i.e., Plaut et al., 1996) of reading, the recognition of low frequency and irregular words is supported by contextual cues. These models hypothesize that low frequency words may not be recognized by an individual's sight word lexicon because of likely limited experience with these words. And irregular words may be difficult to decode because these words do not follow patterns and consistent orthography of other words. As a result, readers are likely to use contextual information and cues to predict the lexical entity of these difficult words. Reading that is facilitated by contextual cues may rely on higher-level language processing skills (e.g., semantic processing). However, the children with SRCD had specific difficulties reading words in both the low frequency and irregular word conditions. Nation and Snowling (1998a) concluded that semantic deficits underlie the reading comprehension difficulties of their experimental group and that these semantic deficits "may constrain not only comprehension, but also the development of skilled word recognition" (p. 98) by limiting contextual enhancement and the exposure to low-frequency and irregular words.

Interestingly, in a post-hoc analysis, Nation and Snowling (1998a) found that when the two groups were split on a measure of receptive vocabulary (rather than comprehension abilities) the results were similar. The low vocabulary group was less accurate when reading low frequency and irregular words than the high vocabulary group. It would have been more interesting to see the group comparisons on all of the tasks with a group of children with SRCD and a control group matched for age, non-word decoding, and receptive vocabulary. If the children with SRCD were still outperformed by the control group on semantic processing tasks, then it could be concluded that the semantic deficits of the children with SRCD go beyond vocabulary size and implicate an inefficient semantic structure. In a theory of semantic processing, this would equate to having the same number of semantic/memory nodes but the activation of these nodes are limited and/or inefficient.

Semantic Priming and Contextual Enhancement in Children with SRCD

Nation and Snowling (1999) extended the understanding of semantic processing problems in children with SRCD using a semantic priming paradigm, which included the use of context or a prime to enhance lexical judgment. A group of normal reading children and a group of children with poor reading comprehension, matched on age, decoding ability, and non-verbal ability, were instructed to push a button if an auditorially presented stimulus was a word and another button if the stimulus was not a word. The words were presented in an online, serial format. The participants responded to randomly presented target, prime, non-word, and filler word stimuli. Investigators were particularly interested in the response times of the target stimuli that were preceded by semantically related primes.

The prime/target stimuli were administered within four conditions that varied in semantic relation (category versus function related) and lexical association (associated versus non-associated). The four experimental conditions were as follows: 1) category related and lexically associated (e.g., dog/cat), 2) category related and lexically non-associated (e.g., green/pink), 3) function related and lexically associated (e.g., hammer/nail), and 4) function related and lexically non-associated (e.g., lounge/sofa). The function-related and category-related distinction is important because some researchers hypothesize that category-related connections are more abstract and develop later in children (Blewitt & Topino, 1991; Nelson, 1982; Petry, 1977). Nation and Snowling (1999) found that children with SRCD displayed significant enhancement in function-related conditions but only showed significant enhancement in category-related conditions when the words were also lexically associated. The children with SRCD did not display significant enhancement in the category-related and lexically non-associated condition. These findings suggest that children with comprehension problems display enhancement when words are functionally related and lexically associated. It can also be concluded that children with SRCD are able to automatically access functionally related semantic information during online tasks but more abstract, category-related semantic information may only be enhanced with a lexical association boost.

Nation and Snowling (1998b) used another semantic priming or contextual enhancement paradigm within a series of two experiments to study children with SRCD. In the first experiment, they administered tests of listening comprehension, reading comprehension, word recognition, and non-word decoding, as well as measures of phonological processing, semantic processing, and contextual enhancement to ninety-two, 7 to 10-year-old children. To measure phonological and semantic processing, accuracy rates and RTs during rhyme and synonym judgment tasks were used. In the rhyme judgment task, the children listened to two words and decided if the words rhymed. In the synonym judgment task, the children listened to two words and decided if they had similar meanings. To measure the effects of context (or contextual enhancement) on word recognition, the children read words presented in isolation and then in another testing session read the same words presented after an auditory sentence prime. They found that reading and listening comprehension scores were highly correlated and each was more correlated with measures of semantic processing than phonological processing. In contrast, they found that word recognition and non-word reading scores were highly correlated and each was more correlated with measures of phonological processing than semantic processing.

In this same experiment, Nation and Snowling (1998b) also challenged other researchers who concluded that less-skilled readers use contextual cues more than skilled readers. Stanovich, West, and Freeman (1981) used absolute difference scores to measure contextual effects in poor readers and, as a result, may have created an illusion that less-skilled readers use contextual cues more than skilled readers do. Nation and Snowling (1998b) argued because skilled readers have less room for improvement (Chapman et al., 1994; Tunmer & Chapman, 1998) or in this case, less room for enhancement, then less-skilled readers may only appear to be benefiting more from context. Nation and Snowling (1998b) confirmed this assumption when they found poorer readers to be less affected by contextual priming (reading target words following an auditory sentence prime) than skilled readers when analyzing the data using a relative contextual effects method. The relative contextual effects method calculates contextual effects with respect to a baseline for a particular stimulus. In this case, the reaction time of the stimulus in isolation served as the baseline for when the same stimulus is reacted to after a contextual prime (Nation & Snowling, 1998b).

To further demonstrate the relationship between comprehension abilities and semantic processing as well as the relationship between contextual enhancement and reading ability, Nation and Snowling (1998b) conducted a second experiment in which they compared three groups of readers on a relative contextual effects measure (same measure as the first experiment). All three groups (normal, SRCD, poor decoder) were matched on word recognition. As would be expected, the SRCD group performed more poorly than the other two groups on the tests of reading and listening comprehension. The poor decoder group, despite being older than the other two groups, was outperformed by the other groups on the non-word-decoding task. Nation and Snowling (1998b) found that despite their match on word recognition skills, the poor decoders displayed the greatest relative contextual enhancement and the SRCD group displayed the least. Based on the findings from both experiments, Nation and Snowling (1998b) concluded semantic abilities significantly contribute to comprehension abilities as well as contextual enhancement abilities. Children with comprehension problems likely have semantic deficits and, as a result, their word recognition skills are not enhanced by contextual information.

The above review of the literature indicates that children with SRCD have difficulty recalling abstract words (Nation, Adams, Bowyer-Crane, & Snowling, 1999), recalling words that are semantically related (Weekes et al., 2008), as well as making synonym judgments and retrieving synonyms (Nation & Snowling, 1998a). Clearly, children with SRCD display higher-level, semantic processing deficits that could underlie their comprehension problems. Additionally, it appears that children with SRCD have difficulty using semantic/contextual information to react faster during lexical decision and word recognition tasks (Nation & Snowling, 1998b, 1999). Also, recall that Weekes et al. (2008) found children with SRCD were not able to use the semantic relationship of a list of words to help them recall that list as well as normal readers. Although the Weekes et al. (2008) investigation compared accuracy rates and not reaction time, this was still evidence that children with SRCD are less affected by contextual enhancement compared to normal readers.

While Nation and Snowling (1998b, 1999) demonstrated that children with SRCD have less efficient contextual enhancement abilities than controls, they did not address the performance of children with SRCD within the context of irrelevant or anomalous information that needs to be suppressed. In contrast, there are several studies that investigate the suppression mechanisms of less skilled comprehenders (e.g., Cain, 2006) but only one that addressed both enhancement and suppression in children with SRCD (Weekes et al., 2008).

Semantic Priming and Suppression in Children with SRCD

According to Gernsbacher and colleagues (e.g., Gernsbacher, 1990; Gernbacher & Faust, 1991; Gernsbacher & St. John, 2001), before a lexical or semantic task can be completed, inappropriate or irrelevant information needs to be suppressed. Suppression is defined as controlled and directed reduction in activation of competing semantic representations and "plays a fundamental role in language comprehension" (Gernsbacher & St. John, 2001, p. 48).

Liu et al. (1997) considered Gernsbacher's Structure Building Framework model (1990) when they developed a study that addressed not only enhancement but also suppression during an auditory word repetition task with sentential semantic priming. Liu et al. (1997) found robust priming effects in normal children, young adults, and seniors when the participants were asked to repeat the final word of a sentence. All three groups displayed contextual enhancement by reacting faster to targets in the presence of semantically related sentence primes (i.e., "He mailed the letter without a STAMP") and contextual suppression by reacting slower to targets in the presence of semantically anomalous sentence primes (i.e., "They went to see the famous LEMON"). In post hoc comparisons, Liu et al. (1997) reported that these three groups did not perform differently in contextual enhancement but the seniors displayed significantly more processing time (or less efficient suppression) in the presence of semantically anomalous sentence primes. Liu et al. (1997) compared this to other research that suggested that older adults decrease in their efficiency to inhibit (i.e., Hasher & Zacks, 1988). Liu et al. (1997) did not use samples of individuals with language or reading problems but one might predict that individuals with semantic processing deficits might perform differently than control groups when suppression of irrelevant or competing semantic information is necessary to complete a task.

There have been studies demonstrating that less-skilled comprehenders are poorer and/or slower at rejecting incorrect forms of homophones (Gernsbacher, Varner, & Faust, 1990), rejecting inappropriate meanings to homophones (Gernsbacher & Faust, 1991), and less able to ignore written words superimposed on pictures (Gernsbacher & Faust, 1991). There is also evidence that children with SRCD are less likely to suppress disconfirmed sentence endings of a sentence completion task when recalling these words later (Cain, 2006). These findings suggest that children with SRCD have more limited suppression mechanisms or need more time to suppress anomalous or irrelevant information. However, this is in contrast with a recent investigation that did not find evidence of deficient suppression mechanisms in children with SRCD (Weekes et al., 2008). Weekes et al. (2008) employed a forced choice recognition task that included semantically related foils and found that children with SRCD had fewer false positive responses to semantically related foils compared to normal readers. Weekes et al. (2008) concluded that this finding provided “no evidence of deficient inhibitory mechanisms in poor comprehenders” (p. 229).

Purpose of this Investigation

As described previously, other researchers investigating children with SRCD have employed a variety of experimental tasks intended to target these children’s semantic processing abilities. However, no study has investigated the enhancement and suppression effects of an online, auditorially presented, semantic processing task that requires the children with SRCD to extend their semantic activation over the length of a sentence versus a word. In addition, the use of an auditory task permits access to the semantic processing system while eliminating the effects of printed word recognition abilities that could be a confound in a group of poor readers (despite the attempt to control for word recognition methodologically).

An example of such a task is Liu et al.'s (1997) "single-word shadowing" task. This online, auditory only, semantic priming task was developed to study lexical access in young children and older adults. The participants were required to repeat the final word of a sentence. The final word was either semantically related or semantically anomalous to the sentence prime. Liu et al. (1997) suggested that the “single-word shadowing” task had three major advantages: (1) the purely auditory task could be used with non-proficient readers, (2) there was no metalinguistic component, and (3) the identity of the target word is not known in advance (in contrast with word monitoring). In addition, guessing could be eliminated which sometimes confounds choice tasks such as lexical decision-making.

This investigation implemented a modified version of Liu et al.'s (1997) single-word shadowing task to compare a group of children with SRCD to a group of normal readers (NR) matched on age and non-word decoding, as well as a younger group matched on reading comprehension. The single-word shadowing task consisted of two conditions in which: (1) the sentence prime and target have high cloze probability as demonstrated by Bloom and Fischler (1980) and (2) the sentence prime and target have low (zero) cloze probability as demonstrated by Bloom and Fischler (1980). This investigation also applied Nation and Snowling's (1998b) relative contextual effects methods to eliminate probable ceiling effects on contextual enhancement by the normal readers. To be able to calculate relative contextual effects, the target words used in the single-word shadowing task were used in a neutral, single-word task as a baseline measure of response time. Additionally, the use of high and low cloze probability conditions allowed the investigator to address both contextual enhancement and suppression, which will provide a better understanding of the integrity of the semantic processing system in children with SRCD. Last, a measure of receptive vocabulary was employed as a covariate to control for vocabulary effects on semantic processing and determine if semantic deficits go beyond vocabulary size.

Four predictions are proposed for the present study:

1. All children will exhibit evidence of contextual enhancement in the high-cloze probability sentence conditions or when a sentence prime is semantically related to the final word of the sentence (target word).
2. Children with SRCD will exhibit evidence of a semantic processing deficit by displaying less contextual enhancement when compared to normal readers in high-cloze probability sentence conditions or when a sentence prime is semantically related to the final word of the sentence (target word).
3. Children with SRCD will exhibit evidence of a semantic processing deficit by displaying deficient suppression of anomalous semantic information. This will be highlighted when children with SRCD display smaller contextual effects or more processing time than normal readers during the low-cloze probability sentence condition or when a sentence prime is semantically unrelated to the final word of the sentence (target word).
4. When controlling for receptive vocabulary, the semantic processing deficit of children with SRCD will still be present.

Chapter II

Method

Participants

Sixty children participated in the study. The sample comprised 12 fourth-grade children with specific reading comprehension deficit (SRCD), 34 fourth-grade children with normal reading abilities (4NR) and 14 second-grade children (2NR) with normal reading abilities. The children were recruited from the Desoto, Oskaloosa, and Topeka school districts in Kansas, as well as the Horizon Academy, a school in the Kansas City area for children with learning disabilities. The investigator applied to conduct research with each school district and with the Horizon Academy. After approval was obtained, the school principal and/or speech-language pathologist was contacted to inquire about possible participants that fit the populations of interest. The school sent a letter and informed consent form home to parents. Once parental permission was obtained, these children were asked for their verbal consent to participate in the study.

The SRCD group consisted of children ranging from 9 years, 7 months to 10 years; 10 months of age (mean age = 10 years, 1.5 months). The 4NR group consisted of children ranging from 9 years, 3 months to 10 years, 9 months (mean age = 10 years, 0 months). The 2NR group consisted of children ranging from 7 years, 10 months to 8 years, 8 months of age (mean age = 8 years, 3.1 months). All children were native English speakers and passed an unaided hearing screening as part of the study or within a year of their participation in the study. The children did not have history of cognitive and neurological disorders and displayed normal non-verbal intelligence, as measured by the Block Design-No Time Bonus subtest of the Wechsler Intelligence Scale for Children-IV (WISC-IV; Wechsler, 2003). In addition, three of the children in the SRCD group had a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD). Analyses were performed with these children in and out of the SRCD group. Additional adjustments were made when these children were removed from the group (see Results section).

The SRCD and 4NR groups were matched on chronological age and word recognition abilities. The word recognition match was based on the standard score from the Word Identification and Word Attack subtests of the Woodcock Reading Mastery Test - Revised (WRMT-R; Woodcock, 1987). Children in both groups scored at or above the 16th percentile on the Word Identification and Word Attack subtests of the WRMT-R. However, the SRCD and 4NR reader groups differed on reading comprehension abilities, as measured by the comprehension score of the Gray Oral Reading Test-4 (GORT-4; Weiderholt and Bryant, 2001). Each of the children in the 4NR group scored at or above one standard deviation below the mean (standard score 7 and higher) on the Comprehension Score of the GORT-4 while each of the children in the SRCD group scored below one standard deviation below the mean (standard score of 6 or below). Consequently, differences in the SRCD and 4NR reader groups are confined to reading comprehension.

The SRCD and 2NR groups were matched on reading comprehension abilities. Reading comprehension was based on the raw score from the

Comprehension Score of the GORT-4. However, for these two groups to match Comprehension raw score of the GORT-4, second grade children who performed higher than the 50th percentile on the Comprehension Score were excluded from the 2NR group. Additionally, the SRCD and 2NR groups scored at or above the 16th percentile, when compared to their respective age groups, on the Word Identification and Word Attack subtests of the WRMT-R. Consequently, these two groups had similar reading comprehension skills, in light of their age and word recognition differences.

Table 1 summarizes the group means and standard deviations for age, reading ability, and non-verbal intelligence. To confirm the planned group similarities and differences, SPSS 16.0 for Windows was employed to run a series of general linear model univariate analyses on chronological age, reading ability, receptive vocabulary, and non-verbal intelligence measures. It is important to note that SPSS 16.0 for Windows uses Partial Eta Squared (η_p^2) to estimate effect sizes.

As expected, the three groups differed significantly in chronological age ($F(2,57) = 130.1$, $p < .001$, $\eta_p^2 = .82$), raw Comprehension Score of the GORT-4 ($F(2, 57) = 46.3$, $p < .001$, $\eta_p^2 = .62$), GORT-4 Comprehension standard score ($F(2, 57) = 28.2$, $p < .001$, $\eta_p^2 = .50$), as well as the Word Identification subtest ($F(2, 57) = 7.9$, $p = .001$, $\eta_p^2 = .22$) and Word Attack subtest of the WMRT-R ($F(2, 57) = 8.6$, $p = .001$, $\eta_p^2 = .23$). Post hoc analysis revealed that the 2NR group was significantly younger than both the children with SRCD, $p < .001$, $d = 5.83$, and 4NR group, $p < .001$, $d = 5.22$ but that children with SRCD were no different in age than the 4NR group, $p = .92$, $d = .33$. Other post hoc analyses revealed that children with SRCD performed significantly lower than the 4NR group on raw Comprehension score of the GORT-4 ($p < .001$, $d = 2.95$) and the GORT-4 Comprehension standard score ($p < .001$, $d = 2.70$). Additionally, children with SRCD did not differ from the 2NR group on the raw Comprehension score of the GORT-4, $p = .36$, $d = .84$ while the difference between the 2NR and 4NR groups on the GORT-4 Comprehension standard score approached significance, $p = .052$, $d = .80$. Last, children with SRCD outperformed the 2NR group on both raw scores of the Word Identification ($p = .013$, $d = 1.35$) and Word Attack ($p = .002$, $d = 1.31$) subtests of the WMRT-R. More importantly, children with SRCD did not differ from the 4NR group on these same word reading subtests (Word Identification: $p > .99$, $d = .06$; Word Attack: $p > .99$, $d = .25$.

The analyses confirmed that children with SRCD did not differ from their chronological age-matched peers (4NR) on measures of chronological age, word identification, word attack, and non-verbal intelligence but did differ than the 4NR group on comprehension. In addition, the analysis confirmed that the comprehension raw score of the GORT-4 was not significantly different between the SRCD and 2NR groups. An unexpected finding was that the three groups did not significantly differ on a measure of receptive vocabulary (PPVT-III), $F(2, 57) = 2.61$, $p = .08$. Therefore, any results indicating a semantic processing deficit in children with SRCD would have occurred despite similar skills in receptive vocabulary.

Table 1.

Group Means (SDs) on Measures of Chronological Age, Reading Ability, Receptive Vocabulary, and Non-Verbal Intelligence.

Measure	**SRCD (n=12)**	**4NR (n=34)**	**2NR (n=14)**	**F(2, 57)**
Chronological age (months)	121.5[a] (4.4)	120.0[a] (4.7)	99.1[b] (3.2)	131.0**
GORT-4				
Comprehension Raw	12.7[a] (3.7)	27.4[b] (6.1)	15.9[a] (4.1)	46.3**
Comprehension SS	5.6[b] (1.0)	10.1[a] (2.2)	8.7[a] (1.3)	28.1**
WRMT-R				
Word Identification Raw	69.8[a] (7.3)	70.2[a] (9.3)	59.7[b] (7.5)	7.9**
Word Identification SS	99.3 (8.9)	101.9 (9.8)	107.1 (9.3)	2.4
Word Attack Raw	33.9[a] (6.2)	32.5[a] (4.7)	26.6[b] (5.0)	8.6**
Word Attack SS	104.9 (10.6)	104.1 (8.2)	104.9 (6.8)	0.1
PPVT-IIIA				
SS	98.6 (14.0)	106.2 (8.3)	102.4 (10.6)	2.6
WISC-IV				
BD-NTB SS	9.8 (1.6)	10.0 (1.5)	10.0 (1.6)	0.04

Means with superscript [a] were not statistically significant in pairwise comparisons
Means with superscript [b] were statistically significant from those with superscript [a] in pairwise comparisons ($p < .05$)
*$p < .05$
**$p < .01$
Raw - raw score
SS - standard score
GORT-4 - Gray Oral Reading Test – 4
WRMT-R - Woodcock Reading Mastery Test-Revised
PPVT-IIIA - Peabody Picture Vocabulary Test-III Form A
WISC-IV - Wechsler Children's Intelligence Scale-IV
BD-NTB - Block Design – No Time Bonus subtest

Thirty-two additional children were tested but did not qualify for the study, 16 second-graders and 16 fourth-graders. Five second-grade children did not qualify because they scored below the 16th percentile in word recognition. Eleven second-graders were removed from the study because their reading comprehension scores were above the 50th percentile. Of the fourth-grade children who did not qualify for the study, 6 scored higher than the 95th percentile on word recognition and reading comprehension, 4 scored below the 16th percentile in word recognition, 3 scored below the 16th percentile in word recognition and reading comprehension, 1 moved before completing the study, 1 presented with a severe articulation disorder, and 1 was diagnosed with Asperger's syndrome.

Materials

Non-experimental tasks. The Word Identification and Word Attack subtests of the WRMT-R (Form G) were administered to all participants for the purpose of documenting their word recognition abilities. In the Word Identification subtest, children were required to read aloud visually-presented words. The words ranged in regularity and frequency. In the Word Attack subtest, children were required to read aloud visually-presented non-words or low-frequency words. These words followed regular spelling patterns of English. The split-half reliability coefficient for the Word Identification and Word Attack subtests of the WRMT-R are .97 and .91, respectively. The investigator used these two subtests to match the SRCD and 4NR reader groups on word recognition skills and all participants scored at the 16th percentile or higher on these measures.

The comprehension score of the GORT-4 (Form B) was used to provide information regarding children's reading comprehension skills. The children were required to read a passage and respond to multiple-choice questions about the passage. The passages ranged in levels of vocabulary, sentence complexity, and difficulty of comprehension questions. The test-retest reliability of the GORT-4 Comprehension Score was .85. This measure was used to differentiate the SCRD and 4NR reader groups, as well as match the SCRD and 2NR reader groups.

The Peabody Picture Vocabulary Test-III Form A (PPVT-IIIA; Dunn & Dunn, 1997) was employed to document the children’s receptive vocabulary skills. For the PPVT-III, children were required to point to one of four pictures that best represented a word that was spoken by the examiner. The test-retest reliability of the PPVT-III is .88. This measure was used to control for vocabulary skills when analyzing the semantic processing abilities of children with SRCD.

The Block Design-No Time Bonus subtest of the Weschler Intelligence Scale for Children (WISC-III; Wechsler, 1991) was administered to verify that the children in the study had normal nonverbal cognitive abilities. In the Block Design-No Time Bonus subtest, the children were supplied with blocks whose sides displayed white and red triangles and squares. The children viewed a picture of a pattern on a card and were requested to match the design. The children did not earn bonus points based on the completion speed for each stimulus. The test-retest reliability of the Block Design-No Time Bonus subtest was .78.

Experimental measure. A modified version of Liu et al.'s (1997) "single-word shadowing task" was implemented for this investigation. In this task, the children listened to a sentence and repeated the final word of the sentence as fast as possible. The response time (RT) to each target word (final word) was measured and recorded using the experimental design software, PsyScope (Cohen, MacWhinney, Flatt, Provost, 1993; see Procedure section for details). Liu et al. (1997) designed this task by selecting sentences that were originally used by Bloom and Fischler (1980), who investigated the cloze probability for sentence contexts. The term "cloze probability" is defined as the probability that the final word of a sentence is predicted based on the context of that sentence. For example, the final words of the high-cloze probability sentences were predicted by at least 95% of the participants, whereas, no participants predicted the final word of the low cloze condition sentences. Thirty sentences with high cloze probability (.95 or above) and thirty sentences with low cloze probability (zero) from the Bloom and Fischler study were employed in this study (see Appendix A).

These sentences were digitally recorded by male and female speakers in a "neutral declarative sentence intonation with a falling tone on the final word" (p. 166). To cue participants to the target word (last word of the sentence), SoundEdit software was used to splice the beginning of the sentence, spoken by one speaker (i.e., the male speaker) to the target word spoken by the other speaker (i.e., the female speaker). The result was a sentence prime followed immediately by the target word to complete the sentence. Liu et al. (1997) found no evidence of gender presentation differences in response time to the target. Therefore, only the male to female version was employed in this study. The children were required to view a computer screen and listen to the sentences. After a visual prompt (***** presented on the computer screen), the sentence and target word was presented. The time between the visual prompt and the presentation of the sentence ranged between 100 and 500 milliseconds. The children were instructed to repeat the last word (target) of the sentence as fast and as accurately as possible (see instruction script in Appendix B). In all, sixty sentences (30 low cloze probability condition sentences and 30 high probability condition sentences) were randomly presented with a short break after 30 sentences. Henceforth, this experimental measure will be referred to as the sentence task.

In addition to the sentence task, a neutral, single-word task was developed using the target words. The neutral, single-word task consisted of the sixty target words from the sentence task and presented randomly as stimuli in a single-word repetition task. Using SoundEdit software, the target words from the sentence task (presented by the female voice) were used to create the targets for the neutral, single-word task. After a visual prompt (***** presented on the computer screen), the target word was auditorially presented. The time between the visual prompt and the presentation of the target word ranged between 100 and 500 milliseconds. The children were instructed to repeat the word as fast and accurately as possible (see instruction script in Appendix C). As in the sentence task, the children's RTs were measured and recorded. Therefore, the RTs to 60 sentences (30 high and 30 low cloze probability conditions) and 60 neutral, single-word task stimuli were obtained.

Procedure

The children were individually tested in 2 sessions. In the first session, a hearing screening was conducted (if a child had not passed a screening in the past year). Measures of reading comprehension (GORT-4), word identification (Word Identification subtest of the WRMT-R), word decoding (Word Attack subtest of the WRMT-R), and non-verbal intelligence (Block Design subtest of the WISC-III) were also administered. In addition, the neutral, single-word task was administered. The first session lasted approximately 45 minutes. If the child met the exclusionary and matching criteria for the study, then the child was invited back to the second testing session. In the second session, the sentence task and the measure of receptive vocabulary (PPVT-III) were administered. The second session was scheduled 5 – 10 days after the first session and was approximately thirty minutes in duration.

In the neutral, single-word task and the sentence tasks, the children wore headphones and listened to the stimuli played by a Macintosh computer (Operating System 8.6). A microphone was connected to the voice-operated relay of a button box that interfaced with the modem port of the computer. The experimental design software, PsyScope (Cohen, MacWhinney, Flatt, Provost, 1993), was employed to allow the investigator to manipulate and control experimental contingencies such as auditory presentation, latency of presentation, and stimuli randomization as well as record response time (RT) measurements. The experimental stimuli were presented in a randomized order for each participant. In the neutral, single-word task, the children were instructed to listen to the word (spoken by a female) and repeat it as fast as they could without making an error. In the sentence task, the children were instructed to listen to the sentences and repeat the last word (as indicated by the female voice) of the sentence as fast as they could without making an error. Appendix B and C contain the script that was read by the investigator for each child. For the neutral, single-word task and the sentence tasks, the children were given a short break after 30 stimuli were presented. Before resuming the task, the instructions were presented again.

It was possible for the children to begin saying the target word after hearing the first syllable of the word or before the target word was completely articulated. Thus, the software was configured to begin recording RTs from the beginning of the word in the neutral, single-word task and at the beginning of the sentence in the sentence conditions. Therefore, the RT of the target word in the neutral, single-word was a reaction from the beginning of the word rather than from the end of the word. Since the recording time began at the beginning of the sentence in the sentence task, the time length of the sentence prime leading up to but not including the target word needed to be subtracted from the sentence RT to ensure analogous measurements. To calculate the RT of the target word in the context of the sentence (for both high and low cloze sentence probability conditions), the investigator measured the time length of each sentence without the target word (sentence minus target; S-T). Each S-T time was entered in a spreadsheet software program as a constant for each participant. When the sentence condition RTs were measured, they were entered into another column of the spreadsheet. The spreadsheet software was programmed to calculate the difference between the measured RT and the S-T constant time to obtain the actual RT of the target word in the context of the sentence. This difference time was labeled Diff in the spreadsheet. The RT of the target word in the context of the sentence (Diff) was then compared to the RT of the target word without the context of a sentence (neutral, single-word task labeled Neutral in the spreadsheet). The spreadsheet software was programmed to calculate the contextual effects (ContFX) by subtracting the RT of the target in the context of the sentence (Diff) from the RT of the neutral, single-word task (Neutral). The ContFX is presented below:

ContFX (msec) = RT to target in neutral task - RT to target in a sentence

A positive ContFX time meant that a child's RT to the target was faster in the sentence condition than the single-word condition, also known as enhancement effects. A negative ContFX time meant that a child's RT to the target was slower in the sentence condition than the single-word condition, also known as suppression effects.

Data Removal

Responses in the neutral, single-word task and the sentence task conditions were scored as correct only if the entire word was accurately produced. Sometimes, children made a noise (i.e., cough) that registered a response with the timing mechanism or their response was too low in volume to be registered. These responses were marked as inaccurate. Any neutral, single-word task RTs or sentence condition RTs of inaccurate answers were removed from the data. 5.9% of RTs were removed from the data set because of inaccurate answers. This was less than the 10.1% inaccuracy rate for the children in the Liu et al. (1997) study. However, recall that Liu et al. (1997) did not include a neutral, single-word task and therefore only reported inaccuracy rates for the sentence condition tasks.

After inaccurate response times were removed, the group means for all neutral, single-word and sentence condition RTs were calculated. If an RT was more than two standard deviations from the group mean for a given stimulus, that RT was considered an outlier and removed from the analysis. The mean RT and standard deviation was recalculated. This procedure is common practice in RT studies (e.g., Bowers, Vigliocco, Stadthagen-Gonzalez, & Vinson, 1999; Kail, 1991). 3.8% of the RTs were removed because they were considered outliers. This was within the 1-5% range that Thompson (2006) reported was typical for studies with similar outlier removal procedures. In all, 9.7% of the data was removed as an inaccurate answer or an outlier.

Any child's RT removed from the data, for inaccurate answers or as outliers, ultimately made the ContFX for that target word impossible to calculate. Stimuli with more than 25% of participant data removed were excluded from the investigation. For the low cloze probability condition, 4 of 30 stimuli were excluded from the analysis because more than 25% of the participant data was removed. For the high cloze probability condition, 7 of 30 stimuli were excluded from the analysis because more than 25% of the participant data was removed. The stimuli that were removed from the analysis are marked by an asterisk (*) in Appendix A. Therefore, analysis of conditions included 26 low cloze probability condition stimuli and 23 high cloze probability condition stimuli, for a total of 49 of the 60 stimuli used in the analyses.

Chapter III

Results

To test the hypotheses of the study, the investigator employed SPSS 16.0 for Windows to run a general linear model repeated measure analysis of variance (ANOVA) with 1 between-subject factor (Group; SRCD, 4NR, and 2NR) and 1 within-subject factor (Condition; high and low cloze probability). The neutral, single-word task was not used in the analysis and was only used to calculate the dependent variable, contextual effects (ContFX) or the RT difference between the single-word task and the sentence task. As mentioned in the Introduction chapter, Nation and Snowling (1998b) used relative contextual effects during analyses. This procedure was considered for the present study but ultimately was not necessary. This consideration will be addressed at the end of this chapter. An alpha level of .05 was used for all statistical procedures in this investigation.

The mean ContFX times for the three groups of children in both conditions are displayed in Table 2. The main effect for Group was not significant, $F(2, 57) = .01$, $p = .991$, $\eta_p^2 = .00$, meaning the 3 groups of children did not have ContFX times that were significantly different than one another. Total group ContFX means across conditions are also presented in Table 2. There was a significant main effect for Condition, $F(1, 57) = 91.3$, $p < .001$, meaning that the children performed differently in the high and low cloze probability conditions. This was a large difference ($\eta_p^2 = .62$). In addition, the ContFX for each of these conditions is significantly different than zero. The mean ContFX for the high and low-cloze probability sentence conditions are presented in Table 3. The interaction effect (Group x Condition) approached significance, $F(2, 57) = 2.22$, $p = .12$, $\eta_p^2 = .07$ and is displayed in Figure 1.

Table 2.

Group Contextual Effects Means (SDs) in Milliseconds and Total Contextual Effects in Milliseconds (across both conditions)

	CONDITION		
GROUPS	High	Low	Total
SRCD (n=12)	117.0 (123.8)	26.2 (101.2)	71.6 (110.1)
4NR (n = 34)	93.7 (135.6)	39.2 (127.9)	66.4 (129.1)
2NR (n = 14)	103.2 (176.4)	37.9 (163.0)	70.6 (168.2)

Table 3.

Condition Contextual Effects Means (SDs) in Milliseconds

Hi Cloze Probability	100.6 (141.7)**
Low Cloze Probability	36.3 (130.1)*

** $t(59) < .001$; mean comparison to value = 0

* $t(59) = .04$; mean comparison to value = 0

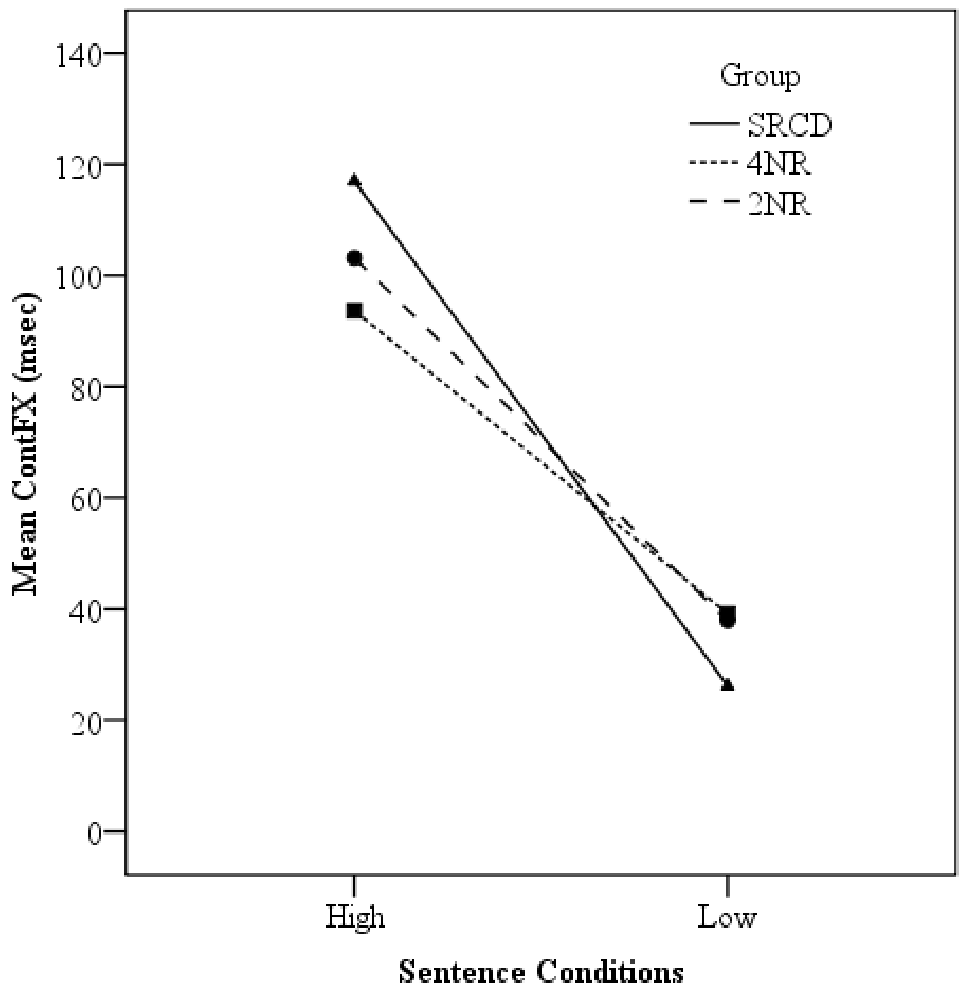

Figure 1. Mean contextual effects (ContFX) for condition by group (n=60)

The results of this analysis produced a significant main effect for condition but the main effect for group and the interaction effect between group and condition were not significant. As a result, the analysis of covariance (ANCOVA), with receptive vocabulary (PPVT-III) as the covariate, was not completed. There is an additional reason that the ANCOVA would be uninteresting and unnecessary. As stated previously, the three groups unexpectedly did not differ significantly in receptive vocabulary. Any results indicating a semantic processing deficit in children with SRCD would have occurred over and above receptive vocabulary.

As described in the Method section, RTs were removed from the data set because of stimulus-related errors and/or outliers. Outliers were identified for each stimulus by a RT that was 2 or more standard deviations from the mean of that stimulus. This procedure was completed for the purpose of removing stimulus RTs that were viewed as extraneous for a variety of reasons (i.e., inadvertent noise, measurement error). While this procedure removes stimulus outliers, it does not address participants that act as outliers across all of the stimuli.

Table 4 presents the descriptive statistics for High and Low ContFX means. The standard deviation and range of scores is evidence of extreme dispersion within the two conditions. Histograms of participant's mean ContFXs in High and Low sentence conditions better illustrates this dispersion as well as participant outliers (Figures 2 and 3). Also recall that three children in the SRCD group had been diagnosed with ADD/ADHD.

To explore this dispersion in performance across sentence conditions as well as the three children with ADD/ADHD, two additional general linear model repeated measure ANOVAs were conducted. One analysis removed participant outliers from each of the sentence conditions using the same removal process as the stimulus outliers. Participants with ContFXs greater than 2 standard deviations from the grand mean of that stimulus was removed. In all, four participants were removed, two children from the 4NR group (participant 15 and 57) and two children from the 2NR group (participant 28 and 32). The last analysis was performed after removing the three children in the SRCD group (participants 44, 75, and 83) who had a diagnosis of ADD/ADHD. Both of these additional analyses resulted in similar results to the original analysis, no main effect for group in the presence of a significant main effect for condition. And in both analyses, the main effect for condition meant that children had significantly higher ContFX times in the high cloze probability condition compared to the low cloze probability condition.

Table 4.

Descriptive Statistics of High and Low Contextual Effects (n = 60)

	Minimum	**Maximum**	**Mean**	**SD**
High ContFX	-320.06	413.18	100.58	141.70
Low ContFX	-355.50	376.00	36.28	130.14

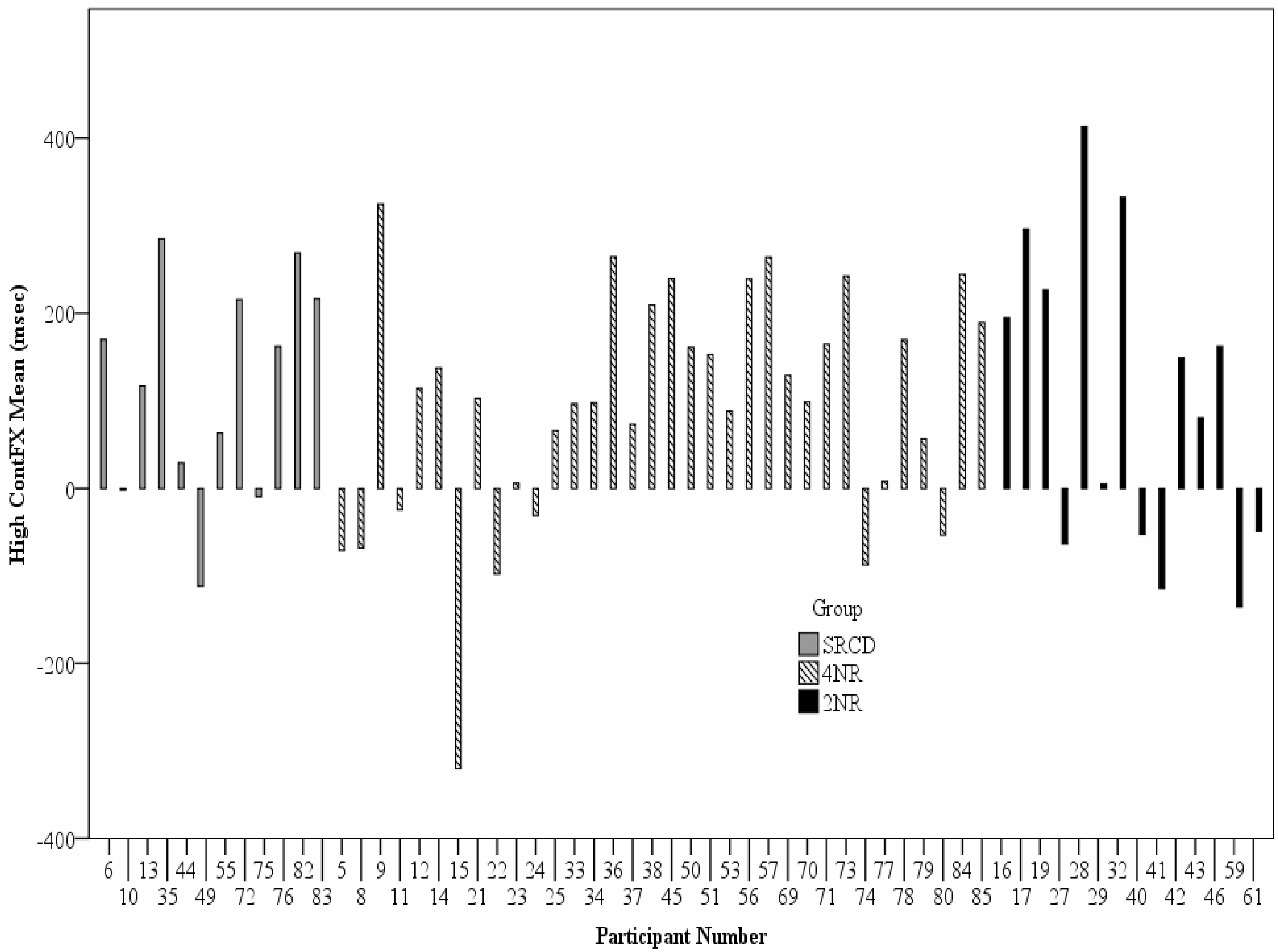

Figure 2. Histogram of Participant's High Contextual Effects (ContFX) Means in Groups

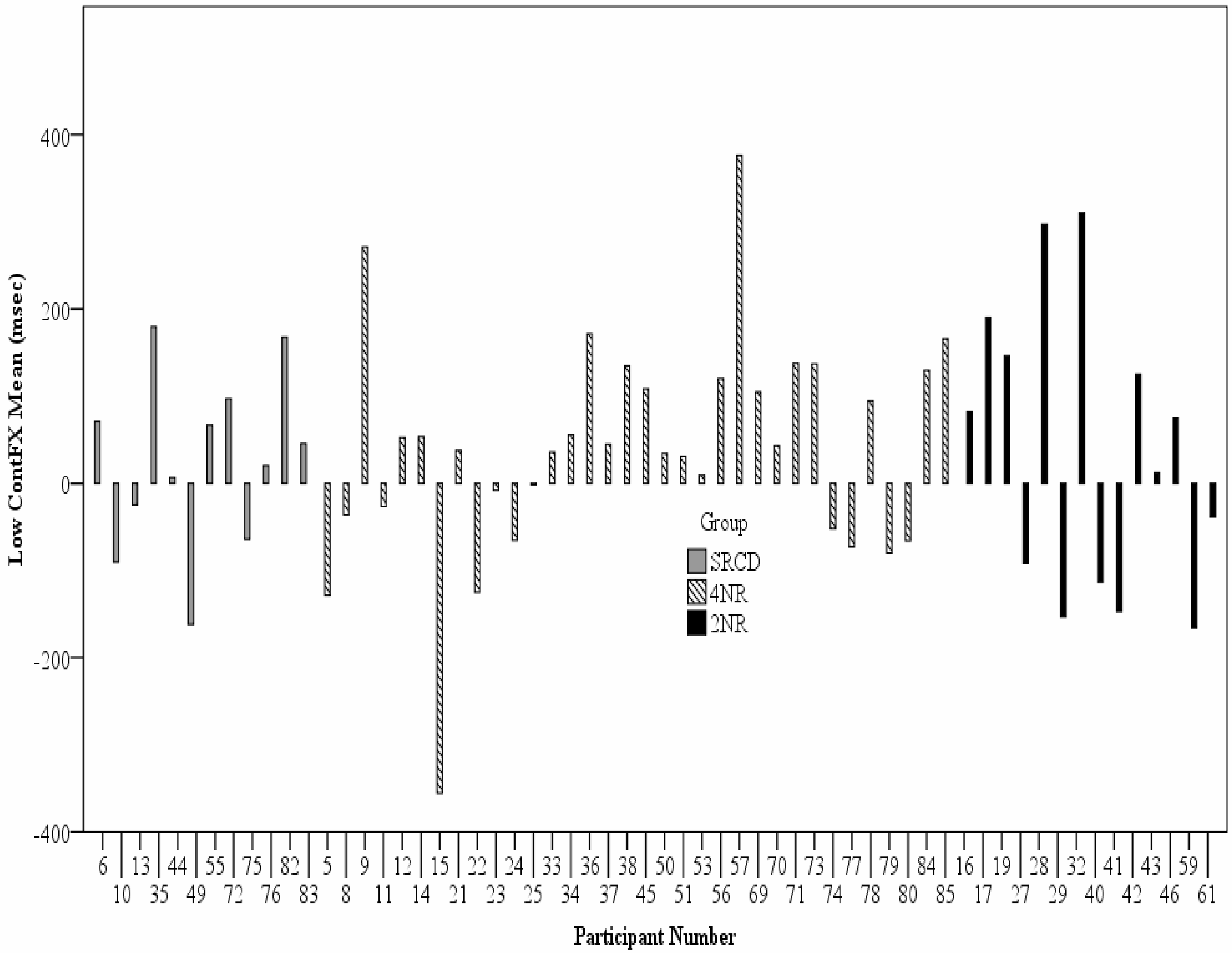

Figure 3. Histogram of Participant's Low Contextual Effects (ContFX) Mean in Groups

As suggested at the beginning of this chapter, children with normal reading abilities could be exhibiting efficient processing times when responding to words without context (single-word task), meaning it would be difficult for these children to respond faster to the target word, even in the context of a sentence. Essentially, good readers have less room for improvement than poor readers and therefore, poor readers may inaccurately appear to be benefiting more from the context of a sentence (Nation & Snowling, 1998b). Nation and Snowling (1998b) used a relative contextual effects ratio where the RTs of the neutral, single-word task served as a baseline to compare the ContFX times.

To determine if ContFX times needed to be transformed to relative contextual effects ratio, two independent ANOVAs were employed to compare group means on the neutral, single-word task RTs, one for target words that appear in the high cloze probability condition and one for target words that appear in the low cloze probability condition. The same participants as the original analysis were used (N=60). There were no main group effects for target words from the high cloze probability condition (F (2, 57 = .14 p = .87) and low cloze probability condition (F (2, 57) = .17, p = .85). Figure 6 displays the mean RTs for the neutral, single-word task for target words from the high and low cloze probability conditions. Since there were no group differences on RTs to target words without context, it was assumed that neither group was at an advantage for contextual effects. Therefore, there was no reason to transpose ContFX into relative contextual effects.

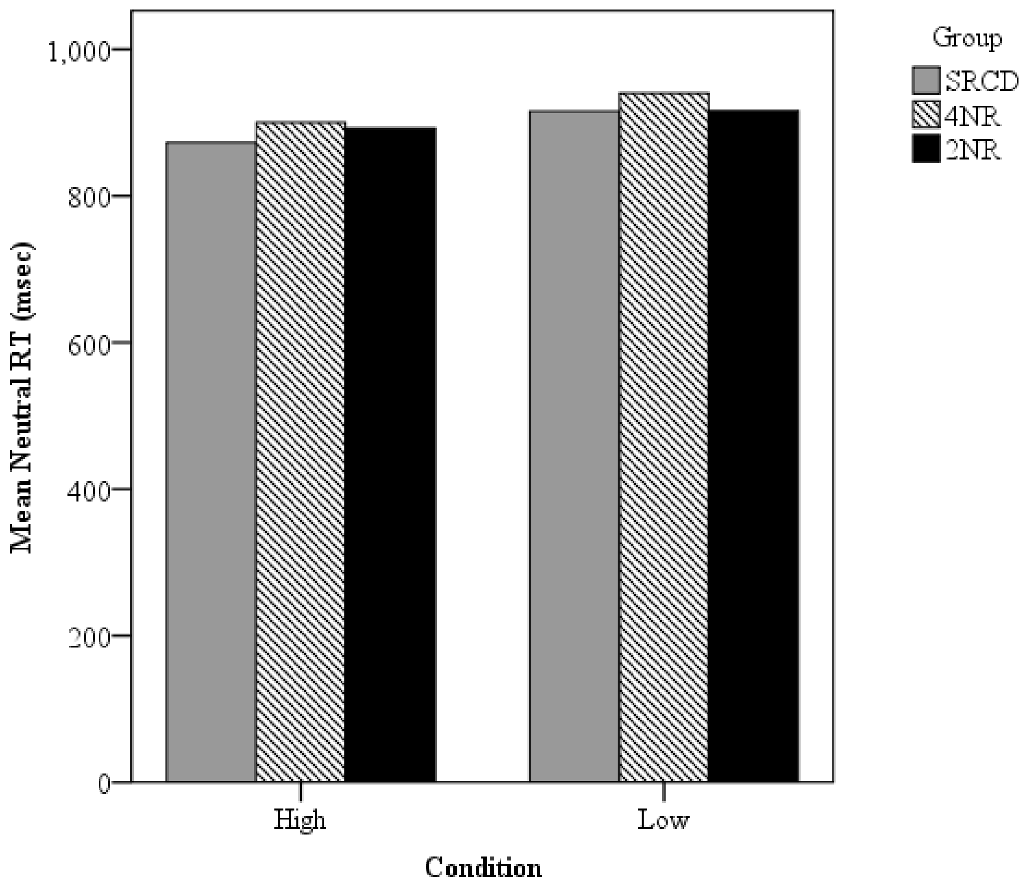

Figure 4. Group mean RTs for the neutral, single-word task (comprised of target words from the high and low sentence conditions).

Chapter 4

Discussion

Reading comprehension is a complex process that requires lower-level processes (i.e., phonological, lexical) to decode print and higher-level processes (i.e., semantic, inference making) to comprehend the meaning. By definition, children with SRCD do not have difficulties translating print into words. Consequently, researchers have concluded that unlike those with word recognition problems, children with SRCD do not have deficits in phonemic awareness and phonological processing (Cain, Oakhill, & Bryant, 2000; Catts, Adlof, & Weismer, 2006; Stothard & Hulme, 1995; Nation & Snowling, 1998a). Rather, there is a growing body of evidence that suggests children with SRCD have higher-level processing deficits, specifically semantic processing deficits (Nation, Adams, Bowyer-Crane, & Snowling, 1999; Nation & Snowling, 1998a, 1998b, 1999). Based on previous research, four primary predictions were proposed for this investigation:

1. All children will exhibit evidence of contextual enhancement in the high-cloze probability sentence conditions or when a sentence prime is semantically related to the final word of the sentence (target word).
2. Children with SRCD will exhibit evidence of a semantic processing deficit by displaying less contextual enhancement when compared to normal readers in high-cloze probability sentence conditions or when a sentence prime is semantically related to the final word of the sentence (target word).

3. Children with SRCD will exhibit evidence of semantic processing deficit by displaying deficient suppression of anomalous semantic information. This will be highlighted when children with SRCD display smaller contextual effects or more processing time than normal readers during the low-cloze probability sentence condition or when a sentence prime is semantically unrelated to the final word of the sentence (target word).
4. When controlling for receptive vocabulary, the semantic processing deficit of children with SRCD will still be present.

The contextual effects for each sentence condition (e.g., high and low cloze probability) across all three groups were significantly greater than zero. In other words, all of the children were faster to respond to the target word in the high-cloze probability sentence condition (prediction 1) compared to the target word in isolation. However, an unexpected finding was that the children also responded faster to the target word in the low-cloze probability sentence condition compared to the target word in isolation. In the high-cloze probability sentence condition, we would assume that the semantic features of the sentence primed the lexical retrieval and production of the target word. However, this would not be the case in the low-cloze probability sentence condition because the sentence and target word were semantically anomalous.

If the children were faster to react to the target word in both sentence conditions compared to target word in isolation even when the target word is semantically anomalous to the rest of the sentence, then the sentence condition must contain an advantage beyond semantic spreading activation. One explanation for the positive contextual effects in the low-cloze probability sentence condition could that the sentence conditions had a latency advantage over the single-word, neutral condition. Recall that in the single-word, neutral task, the latency of the visual stimulus on the computer (****) and the start of the target stimulus was randomly assigned between 100 and 500 milliseconds. However, the latency of the visual stimulus on the computer and the start of the target in the sentence conditions varied between 1289 and 2831 milliseconds (the length of time between the shortest and longest sentence primes). This range of 1542 milliseconds is larger than the 400-millisecond range of the single-word, neutral task, meaning it was the single-word, neutral task that had the latency advantage and not the sentence condition tasks. In other words, if latency was the primary factor, then the less variability in the latency of the single-word, neutral condition should have made it easier to anticipate the target presentation, resulting in shorter single-word, neutral task RTs and less room for positive ContFX. However, positive ContFX resulted in both conditions so an alternative explanation needs to be explored.

It is more likely that children had positive ContFX even when the sentence prime and target word were semantically anomalous because of spreading activation or priming in other linguistic domains such as syntax. Branigan, Pickering, and colleagues have contributed multiple studies in which the syntactic structure enhances the performance of individuals during production (i.e., Pickering & Branigan, 1999) and comprehension tasks (i.e., Branigan, Pickering, & McLean, 2005).

Initial interpretation of the positive contextual effects in sentences compared to the words in isolation might lead one to believe that the analysis is only revealing enhancement effects. However, all three repeated measure ANOVAs revealed a significant condition effect with children having higher contextual effects to target words in the high-cloze probability sentence condition compared to the low cloze probability condition. In other words, the children responded faster to target words in sentences that were semantically related to the target word (high cloze probability condition) compared to target words in sentences that were semantically unrelated to the target word (low cloze probability condition). This difference between the contextual effects in high- and low-cloze probability conditions could be explained as the children displaying less contextual enhancement in the low-cloze probability condition. On the other hand, this difference could be explained as the children needing more processing time (less contextual effects) to suppress the semantically anomalous sentence prime to be able to successfully repeat the final word of the sentence. The main effect for condition and the validity of experimental task representing contextual enhancement and/or suppression will be discussed later in this chapter.

In contrast to the significant main effect for condition, there was no significant main effect for group in any of the three repeated measures ANOVAs. The performance of children with SRCD did not differ significantly from the second- and fourth-grade normal reader groups as proposed in predictions 2 and 3. Children with SRCD were predicted to display smaller contextual enhancement in the high cloze probability condition because they would not activate or efficiently activate the same semantic information as normal readers. Also, children with SRCD were predicted to display smaller contextual effects in the low-cloze probability sentence conditions because these children were expected to be deficient at suppressing irrelevant semantic information. Not only did all three groups perform not differ statistically in both sentence conditions, but children with SRCD exhibited slightly higher ContFX means compared to the two control groups in the high-cloze probability sentence condition. However, this was not a significant difference. In other words, children with SRCD did not display deficiencies in semantic spreading activation as measured by this task. These results did not support a semantic processing deficit in children with SRCD. Last, recall an analysis of covariance (ANCOVA), with receptive vocabulary as the covariant, was planned to provide evidence for a semantic processing deficit in children with SRCD that is beyond a vocabulary deficit. However, the ANCOVA was not performed due to a lack of statistical evidence for the semantic processing deficit theory.

The results of these analyses were unexpected and did not support a hypothesis of a semantic processing deficit in children with SRCD. Three possibilities for these unexpected findings will be discussed. One, the GORT-4 may not have been a valid measure of reading comprehension. Two, the processing demands of the high-cloze condition of the single-word shadowing task may not tax the semantic processing system as much as the word recognition, semantic judgment, verbal working memory, and inference-making tasks of previous studies. In addition, the processing demands of the low-cloze condition of the single-word shadowing task may not be a valid measure of a suppression mechanism. Last, a possible lexical association boost in the high-cloze probability sentence condition may have confounded the results of this study.

Validity of the GORT-4

As described in the Method section, children were grouped primarily on the GORT-4 Comprehension Score. Since the conceptualization and implementation of this investigation, the validity of the GORT-4 has been questioned. Keenan and Betjemann (2006) questioned the content and concurrent validity of the GORT-4 Comprehension Score because they found that some of the questions are passage-independent, meaning they could be answered correctly above a level of chance without reading the passage. In addition, they found that passage-independent items were not sensitive to reading disability, defined as a word-decoding problem. Specifically, children with reading disability performed significantly lower than normal readers on passage-dependent items but similarly on passage-independent items. They did not investigate the sensitivity of the Comprehension Score to a group with SRCD but they did find that the GORT-4 Comprehension Score did not significantly correlate with performance on other measures of comprehension.

Keenan and Betjemann (2006) did not investigate the specificity of the GORT-4 to diagnosing reading disability. Based on their results, it is hypothesized that the GORT-4 may under-identify poor readers, especially those with SRCD. Children who perform poorly on the GORT-4 Comprehension score despite test questions that can be correctly answered (above a level of chance) without having read the passage suggests that the score is biased towards under-identifying children with reading comprehension deficits. In other words, the GORT-4 is more susceptible to Type II errors (false negatives) than Type I errors (false positives). If the GORT-4 does under-identify poor comprehenders then it is possible that the children with SRCD in the current study were not all truly children with comprehension difficulties because they performed poorly despite the presence of passage-independent questions. An alternate possibility is that these children do not have reading comprehension deficits but rather deficits in general world knowledge or the type of knowledge that would allow them to answer a comprehension question correctly without having read the passage. In contrast, there may be children in the normal reader groups that were not identified by the GORT-4 because of the presence of passage independent questions but would have been categorized as SRCD if another measure of reading comprehension was used. Consequently, these are possible explanations for why the children with SRCD in the current study did not perform significantly different than the control groups and did not provide evidence for a semantic processing deficit.

Cutting and Scarborough (2006) investigated the validity of an earlier version of the GORT-4, the Gray Oral Reading Test – 3 (GORT-3; Weiderholt & Bryant, 1992), as well as two other commonly used measures of reading comprehension, the Wechsler Individual Achievement Test (WIAT; Wechsler, 1992) and the Gates-MacGinitie Reading Test – Revised (G-M; MacGinitie, MacGinitie, Maria, & Dreyer, 2000). They found that the contributions of word identification, oral language, and other cognitive skills (i.e., verbal memory, immediate recall, etc.) varied significantly among these three measures of reading comprehension. Specifically, word recognition and oral language skills accounted for approximately 49% of the total variance of the GORT-3 compared to 67% and 72% for the WIAT and G-M, respectively. This suggested that there was still a large proportion of the GORT-3 variance that is unexplained compared to the other measures. When reading speed, verbal memory, rapid serial naming, IQ, and attention were added to their hierarchical linear regression models only reading speed accounted for significant additional variance in reading comprehension. Reading speed accounted for the most variance in the GORT-3, approximately 6% additional variance above and beyond word identification and oral language abilities compared to 1% and 2% in the WIAT and G-M, respectively.

To further investigate oral language skills, lexical and sentence processing composite measures were used to identify differential contributions to these three reading comprehension measures. The GORT-3 was significantly less well correlated with a composite measure of sentence processing than both the WIAT and the G-M.

Additionally, only a composite measure of lexical processing made unique contributions in predicting GORT-3 scores. Whereas the GORT-3 was the only one of the three measures in which sentence processing did not make unique contributions to reading comprehension. Cutting and Scarborough (2006) concluded, “different measures of reading comprehension may make differential demands on vocabulary knowledge and sentence-processing abilities” (p. 293).

To combat the limitations of reading comprehension measures, this study could have considered using a composite score of multiple measures of reading comprehension when differentiating groups of children based on reading comprehension. However, in an unpublished study, Hogan and Catts (2007) had similar findings to the present study when using a composite measure with adults. They used the same single-word shadowing task with adults with SRCD and the reading groups were based on a composite measure of reading comprehension. Similar to the findings of the current study, Hogan and Catts (2007) found significant task condition effects but did not find significant group or interaction effects.

Despite the limitations of the GORT-3 and GORT-4, the Hogan and Catts (2007) study provides evidence that using only one measure of reading comprehension in the current study may not be a weakness of the study methodology. Furthermore, the Hogan and Catts (2007) study combined with the results of the current study indicate that the single-word shadowing task may not be sensitive to the semantic processing deficits that have been evident in other research (i.e., Nation, Marshall, & Snowling, 2001; Nation & Snowling, 1998a, 1998b). Therefore, the processing demands of the single-word shadowing task need to be examined further and compared to the processing demands of tasks from these other studies.

Processing Demands of the Single-Word Shadowing Task

The body of literature on contextual effects in reading prior to the mid-1990s was dominated by studies that found poor readers (usually defined as poor in word recognition) to have the same or larger contextual effects than normal readers (i.e., Simpson, Lorsbach, & Whitehouse, 1983; Stanovich, West, & Freeman, 1981) during word recognition tasks. The consensus was that children with word recognition problems used contextual cues to aid their prediction during word recognition more so than normal readers. In contrast, normal readers do not use context as much to aid word recognition because their efficient orthographic processing systems already result in good word recognition. Instead, skilled readers use context to facilitate comprehension processes (Stanovich, 1982).

Some of this confusion and discussion in the literature caused Stanovich (1982, 1986) to warn about the importance of understanding the processing level of contextual effect tasks. Stanovich (1982) wrote:

> Too often the term "context-effect" is used loosely, without a specification of the level in the processing system at which the contextual variable is presumed to have an effect. This can lead to considerable confusion in comparing theoretical positions and empirical results. (p. 550)

In light of these comments and the unexpected findings of the current study, the processing demands of the single-word shadowing task should be analyzed further.

If one considers Stanovich's Interactive-Compensatory Model (1980), which states that reading performance is best explained by both bottom-up and top-down processes (interactive) as well as an individual's reliance on the stronger of the two processes (compensatory), then theoretically, the single-word shadowing task should have exposed the semantic processing abilities of children with SRCD. Children with SRCD have been found in previous studies (i.e., Nation & Snowling, 1998b, 1999) to struggle with top-down processing or using higher-level semantic processes to assist with lower level processing. Children with SRCD were also expected to perform more poorly in the present study. It is now apparent that, while the single-word shadowing task displayed significant stimulus condition effects, the task was not sensitive to the deficits in semantic processing that children with SRCD have been proposed to exhibit. One possible explanation for this unexpected finding is that the processing demands of the single-word shadowing task are not as "high" or demanding as the semantic processing tasks of other studies.

Recall that in previous studies, children with SRCD performed worse than controls on semantic processing tasks such as semantic fluency (Nation & Snowling, 1998a), synonym judgment (Nation & Snowling, 1998a), and semantic priming tasks such as word recognition in the context of semantic primes (Nation & Snowling, 1998a, 1998b). In addition, other high-level processing tasks have been used to support the semantic processing deficit theory such as verbal serial recall (Nation et al., 1999; Weekes et al., 2008), verbal working memory (Nation et al., 1999), and inference-making tasks (Cain et al., 2001; Catts, Adlof, & Weismer, 2006). In all of these tasks, there was a metalinguistic component such as maintaining the semantic category of a semantic fluency task, making a judgment about the semantic relationship of word pairs, or holding semantic information in memory so that it can be used later. These tasks are in stark contrast to characteristics of the high-cloze probability sentence condition of the single-word shadowing task in two ways.

One, the single-word shadowing task was employed because there were no metalinguistic components. In other words, listening to sentences and repeating the final word of sentences only required lexical retrieval and verbally producing a single word while being implicitly affected by spreading activation of semantic information, especially in the high-cloze probability sentence condition. The high probability sentence condition of the single-word shadowing task did not require higher-level processes such as working memory, long-term memory, and inference making. In addition, this purely auditory task removed confounding factors of other studies, such as the effect of word recognition abilities during word reading tasks. Only one other known study has used a task with limited metalinguistic components to investigate the semantic processing abilities of children with SRCD (Nation & Snowling, 1999). Nation and Snowling (1999) used a lexical decision task within a semantic priming paradigm to demonstrate that children with SRCD have semantic processing deficits. However, there is another perspective to Nation and Snowling's (1999) findings that may provide an explanation for the unexpected findings of the current investigation. This possible explanation will be discussed in the next section.

Two, the high-cloze probability sentence condition used sentence primes comprised of words that were semantically related and these semantic relations were functional and categorical. Therefore, the words of the sentence prime had what some would label concrete relationships (as opposed to abstract). Consequently, the target words in the high-cloze probability sentence condition had concrete relations to the sentence prime. This is important because other researchers have suggested that children with SRCD do not exhibit difficulties with concrete semantic relationships, rather they struggle with abstract semantic relations (Nation et. al., 1999; Weekes et al., 2008). If children with SRCD only have difficulties with abstract semantic relations and not concrete relations, then the high-cloze probability sentence condition of the experimental task may not be sensitive enough to differentiate the SRCD group from controls. This may be an explanation for why the children with SRCD in this study performed similarly to the normal reader groups in the high-cloze probability sentence condition.

Whereas it appears that the high-cloze probability sentence condition of the experimental task may not tax the semantic processing system the same way that other tasks used to support a semantic processing deficit in children with SRCD do, the processing demands of the low-cloze probability sentence condition is not as obvious. As expected, the low-cloze probability condition had significantly lower ContFX means than the high-cloze probability condition. However, it was not predicted that children with SRCD would perform similarly to the control groups on the low-cloze probability sentence condition. Nor was it predicted that all children would perform significantly faster in the low-cloze sentence condition compared to the same target in the single-word, neutral task (or ContFX significantly greater than zero). This raised the possibility that the low-cloze sentence condition may not be a valid measure of a suppression mechanism.

There are two possible explanations for the results of the low-cloze probability sentence condition. One, the low-cloze probability sentence condition required a higher-level process because the children needed to suppress or dampen the competing semantic spreading activation from the sentence prime in order to retrieve the semantically anomalous target word. Two, the low-cloze probability sentence condition was an equally difficult task but the target word was not facilitated by contextual enhancement. In other words, it could be the case that the low-cloze probability sentence condition resulted in less contextual enhancement rather than eliciting a suppression mechanism. Unfortunately, the empirical data and analytical results of this investigation are not sufficient to differentiate these two possibilities.

However, when one takes a closer examination of the sentence stimuli of both conditions, there is one significant difference. As described in the method section, the sentence condition comprises sentence primes from Bloom and Fischler's (1980) sentence completion norms study. Recall, the high cloze probability condition sentences comprise sentence primes that had final words predicted by at least 95% of the participants in the study. This didn't leave many other words that could be predicted by the participants when they heard these sentences. In fact, the average number of different words predicted in these high-cloze probability sentences was 1.4 words. For example, the prime, “She mailed the letter without a”, had only one word that participants used to complete that sentence prime (stamp). In contrast, the low-cloze probability condition sentences comprise sentence primes that had an average of 10.0 words as a possible cloze. For example, one prime, “The kind old man asked us to”, had 16 words used to complete that sentence prime (stay, help, leave, dinner, come, go, move, sing, dance, eat, listen, lunch, sit, stop, talk, wait). It is important to remember that none of these words was used as the target in the current study because the low-cloze condition was intended to have a semantically anomalous relationship (zero predictability). Instead, a target word that was not predicted in Bloom and Fischler’s study (1980) sentence completion study was selected for the low-cloze probability condition.

Clearly, due to the high predictability of the target word in the high-cloze probability sentence condition and the lack of competition from other words to be the possible cloze, this condition appears to be a strong measure of contextual enhancement. In contrast, in the low-cloze probability condition, one could argue that the children’s semantic activation was spread out over several possible words. With this in mind, it is difficult to determine if the sentences in the low-cloze probability condition just created more widespread semantic activation and prevented contextual enhancement (and thus lower ContFX means) or if these sentences elicited an additional processing mechanism, suppression, to overcome all of the possible lexical items being primed (and thus lower ContFX means). In hindsight, the low-cloze probability sentence condition could have been designed differently to create a better measure of suppression when compared to the high-cloze probability sentence condition. If a different group of high-cloze probability sentences were used but substituting the highly predictable cloze at the end of the sentence with a target word that was semantically anomalous (i.e., The bill was due at the end of the wish), then we could have been more confident that the high predictability of the sentence created spreading semantic activation that needed to be suppressed.

Lexical Association Boost?

Recall Nation and Snowling (1999) used a lexical decision task to evaluate the semantic priming effects in children with SRCD. The children were expected to decide the lexicality of a list of words comprised of target words that were randomly preceded by semantically related words, semantically unrelated words, and non-words. The semantic related prime and target word pairs varied in semantic relation (category versus function related) and lexical association (associated versus non-associated). Therefore, their study comprised four experimental conditions for the semantically related word pairs: 1) category related and lexically associated (e.g., dog/cat), 2) category related and lexically non-associated (e.g., green/pink), 3) function related and lexically associated (e.g., hammer/nail), and 4) function related and lexically non-associated (e.g., lounge/sofa). The function-related and category-related distinction is important because some researchers hypothesize that function-related connections are based on event-based experiences (Nelson, 1982) and category-related connections are more abstract and develop later in children (Blewitt & Topino, 1991; Nelson, 1982; Petry, 1977). If this is true, then children with SRCD might be expected to display less contextual enhancement when the word pairs are categorically related. Indeed, Nation and Snowling (1999) found that children with SRCD did not display significant enhancement in the category-related, non-associated word pair condition. When processing could only be supported by a categorical, semantic relationship, the children with SRCD did not show enhancement. In contrast, children with SRCD displayed significant enhancement in the category-related, associated word pair condition. Nation and Snowling (1999) conclude that this is evidence for a semantic processing deficit in children with SRCD because they are less efficient at using later developing, abstract, categorical information to enhance lexical processing. However, Nation and Snowling (1999) also concluded that children with SRCD may only show enhancement effects, especially of categorical relationships, as a result of a lexical association boost, rather than true semantic activation. This boost was enough for children with SRCD to perform like their normal peers in categorical- and function-related conditions.

So, is there a possible lexical association boost that explains why the children with SRCD in the current study did not show differences in contextual enhancement during the high-cloze probability sentence condition? Again considering Stanovich's Interactive-Compensatory Model (1980), a lexical association boost may be a compensatory mechanism for children with SRCD and allow them to perform similarly on semantic priming tasks that contain strong lexical associations. As previously discussed, the semantic relationship of the high cloze probability sentence primes and respective target words were also functional and categorical. However, were they also susceptible to strong lexical associations?

Recall that the experimental condition was designed using Bloom and Fischler's (1980) sentence completion norms. Bloom and Fischler (1980) presented sentences that induced high, medium, and low probability responses to healthy adults. Bloom and Fischler (1980) suggested that one advantage of their sentence-level completion task over more frequent single-word associative contexts was that sentence-level contexts had the potential to produce much higher completion probabilities. The example Bloom and Fischler (1980) used was that the sentence "She mailed the letter without a ______" elicited the word "stamp" 99% of the time whereas "letter-stamp" only has the associative probability of 7%. Therefore, it is unlikely that the reason children with SRCD in the present study did not perform significantly different than controls was due to a lexical association boost. Rather, the absence of group differences in the high cloze probability condition is likely due to the functional and categorical (or concrete) relationship of the sentence prime and the target word. Again, the processing demands of the high-cloze probability sentence condition may not be sensitive enough to differentiate the semantic processing abilities of children with SRCD and their peers.

Conclusions

The results of this study do not support a semantic processing deficit in children with SRCD. Children with SRCD did not display significantly different levels of enhancement compared to normal readers when they repeated the target word in the context of a semantically related sentence prime. When the target word was in the context of a semantically anomalous sentence prime, children with SRCD again did not perform significantly different than normal readers. These findings were unexpected but possibly explained by limitations in the content validity of the GORT-4 and limitations on the processing demands of the single-word shadowing task, especially the high-cloze probability sentence condition.

Future researchers should more carefully conceptualize and define the processing level of the semantic priming task used for exploring contextual effects in children with SRCD. In addition, researchers could use a reading comprehension measure with better content validity or a composite measure of reading comprehension to ensure the integrity of the experimental groups. Last, when investigating semantic priming in children with SRCD, researchers should be aware of a possible lexical association boost that could mask possible deficits in semantic enhancement.

In the light of the recent attention to children with SRCD, investigators interested in reading processes and individual differences in reading performance should consider this group of poor readers. Just as mounting research of the late twentieth century aided individuals with deficits in word recognition, the same effort should be afforded to understanding children with reading comprehension deficits.

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Appendix A: Single-Word Shadowing Stimuli

High cloze probability stimuli

1. He mailed the letter without a stamp.
2. Captain Sheir wanted to stay with the sinking ship.
*3. He liked lemon and sugar in his tea.
*4. The gambler had a streak of bad luck.
5. To keep the dogs out of the yard he put up a fence.
6. The children went outside to play.
7. Bill jumped in the lake and made a big splash.
8. Water and sunshine help plants grow.
9. At first the woman refused, but she changed her mind.
*10. The movie was so jammed they couldn't find a single seat.
*11. Father carved the turkey with a knife.
*12. She went to the salon to color her hair.
13. The rude waiter was not given a tip.
14. Sharon dried the bowls with a towel.
15. To pay for the car, Al simply wrote a check.
16. They sat together without speaking a single word.
17. Fred realized the old house was up for sale.
18. He wondered if the storm had done much damage.
19. Bob proposed, but she turned him down.
20. Joan fed her baby some warm milk.
21. At night the old woman locked the door.
22. The gas station is about two miles down the road.
23. He loosened the tie around his neck.
24. His job was to keep the sidewalk clean.
25. The lecture should last about one hour.
26. John swept the floor with a broom.
*27. His boss refused to give him a raise.
28. The governor vetoed the new bill.
*29. When the two met, one of them held out his hand.
30. I could not remember his name.

Low cloze probability stimuli

1. Some of the ashes dropped on the faith.
2. The birds in the yard ate every last trick.
3. Plants will not grow in dry foam.
4. Hank reached into his pocket to get the motor.
*5. Suzy liked to play with her toy bolt.
6. Even their friends were left in the form.
7. The final score of the game was real.
8. Helen reached up to dust the pearl.

9. Barry wisely chose to pay the list.
10. Larry chose not to join the wish.
11. The person who caught the thief deserves our steel.
12. Jim had learned the special passage by staff.
13. She cleaned the dirt from her terms.
14. The car stalled because the engine failed to fight.
15. He drove the nail into the moon.
16. They went to see the famous lemon.
17. The death of his dog was a great bride.
18. You could count on Dale on being late for blood.
19. There are times when life seems wise.
20. The kind old man asked us to race.
*21. The surface of the water was nice and round.
*22. The truck that Bill drove crashed into the term.
23. The storm made the air damp and fast.
24. The actor was praised for being very small.
25. Rushing out he forgot to take his belt.
*26. His ring fell into a hole in the bond.
27. He was soothed by the gentle total.
28. Every spring they held the annual firm.
29. They went to the rear of the long range.
30. In the distance they heard the walnut.

*These items were removed from the analysis due to high error rates.

Appendix B: Script for High and Low Probability Sentence Conditions

Now we are going to play a game on the computer. You will hear some sentences. For each sentence, a man will speak part of the sentence but a woman will speak the last word of the sentence. Please repeat the last word of the sentence as fast as you can but make sure you say the correct word. Do you understand? Also, please listen to the sentences carefully because some of the sentences will help you say the last word. However, some of the sentences will not help you. Are you ready? Here are some practice sentences.

Great job. Remember to say the last word of each sentence as fast as you can but make sure you say the correct word. Again, some of the sentences will help you say the last word and some of the sentences will not help you. Now, do the same thing with these sentences. Are you ready?

Great job. Here are some more sentences. Remember to say the last word of each sentence as fast as you can but make sure you say the correct word. Again, some of the sentences will help you say the last word and some of the sentences will not help you. Are you ready?

Appendix C: Script for Neutral, Single-Word Task

Now we are going to play a game on the computer. You are going to hear a list of words. Please repeat each word as fast as you can but make sure you say the correct word. Do you understand? Are you ready? Here is a practice round.

Great job. Remember to say the words as fast as you can but make sure you say the correct word. Now, do the same thing with this longer list of words. Are you ready?

Great job. Here is another list of words. Remember to say the words as fast as you can but make sure you say the correct word. Are you ready?