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ATTENTIONAL TRAINING IN CHILDREN

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ABSTRACT

The study examined the link between attention and language production in preschool and school-age children. The participants consisted of ten children, differing in age (three to twelve) and language abilities. These participants were recruited from day cares, pre-schools, and schools in and surrounding the State College area. For the purpose of this study, only eight of these participants were evaluated; there were five males and three females. The mean age of these participants was seven years, two months. To test the link between attention and language production, the Expressive Vocabulary Test (EVT), Peabody Picture Vocabulary Test (PPVT), and Color-object Stroop Test were administered to the participants. The participants' results on these tasks illustrated that there was a correlation between the PPVT and EVT and the Color-Object interference effect. This correlation was stronger for the EVT than PPVT. These results may implicate that the attention and inhibition processes surrounding the interference effect may be affected by an individual's vocabulary size; alternatively, these results may show that vocabulary size is affected by the processes of attention and inhibition.

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Chapter 1: Specific Language Impairment and Attention

What is Specific Language Impairment?

Specific language impairment (SLI) refers to a "developmental condition in which children exhibit difficulty acquiring language in the absence of other neurodevelopmental, frank neurological, hearing, emotional, or nonverbal intellectual impairments" (Leonard, 1998, p. 3). Children with SLI demonstrate marked language difficulties in the absence of factors typically associated with other language impairments; SLI occurs in the absence of detriments of hearing loss, neurological damage, and mental retardation (Leonard, 1998).

The language difficulty often indicating that a child has SLI is a delayed onset of lexical access; lexical processes have been shown to be problematic in those with SLI through various clinical studies (Leonard, 1998; Tomblin, Records, & Zhang, 1996). Children with SLI typically exhibit a delayed onset, slowed acquisition, and compromised processing of lexical and grammatical forms (Catts, 1993). Accordingly, children with SLI often display slower reaction times in word recognition experiments, increased rates of phonological errors (Edwards & Lahey, 1996), and detriments in picture naming compared to their typically developing peers (Leonard, Nippold, Kail, & Hale, 1983). Correspondingly, children with SLI exhibit smaller vocabularies and a smaller number of words produced in spontaneous language samples than those of typical development (Watkins, Kelly, Harbers, & Hollis, 1995; Bishop, 1997).

Thus, language difficulties in children with SLI are typical. Children with SLI demonstrate an increased difficulty in applying, and acquiring, inflectional morphology and complex syntax compared to their typically developing peers (Leonard, 1998). In novel word learning tasks, children with SLI have exhibited poorer performance when compared with their peers. Specifically, in a previous study conducted by Rice and colleagues (1994), children with SLI required up to three times as many exposures to novel words in order to make gains comparable to their age-matched peers (Rice, Oetting, Marquis, & Bode, 1994). Moreover, children with SLI were noted as more likely to forget the learned words within a few days. Additionally, children with SLI were found to be more susceptible to external factors in novel word learning (Weismer & Hesketh, 1998); for example, children with SLI were shown to be more affected by a fast speaking rate than age and language matched peers (Weismer & Hesketh, 1996).

Nonetheless, children with SLI have age-appropriate intelligence (Leonard, 1998). These children's medical or developmental profiles reveal no obvious obstacles to their learning of language. It is often assumed that language itself is the problem; those with SLI are typically believed to have a primary linguistic deficit. However, children with SLI may also exhibit nonlinguistic cognitive and social cognitive deficits (Leonard, 1998).

It is feasible that language itself may be the problem. However, there are other possibilities. Researchers have found evidence of information processing deficits perhaps in the form of limited attention that may be the underlying cause(s) of the language deficits in children with SLI (Finneran, et al., 2009). That is, language itself may prove to not solely be the problem.

Theories Surrounding Specific Language Impairment and Attention

The etiology of SLI is unknown. However, there has been considerable evidence that points to other factors apart from language content and form as contributing factors to problems experienced by children with SLI (Leonard, Weismer, Miller, Francis, Tomblin, & Kail, 2007). That is, research has demonstrated that children with SLI have substantial impairments in the cognitive domain, even when little or no language is involved (Im-Bolter, Johnson, & Pascual-Leone, 2006). It has been proposed that processing limitations, in the form of speed of processing and working memory limitations, may significantly affect a child's ability to access language; these processing limitations affect language input and, once finally acquired, may ultimately detriment language usage (Leonard et al., 2007).

Kail & Salthouse (1994) have affirmed that processing limitations can be considered from different perspectives. That is, processing limitations can be interpreted to mean that the functions of memory responsible for temporary computations are restricted; there is too little work space. Similarly, processing limitations can be considered from perspective energy - the energy necessary for a task is depleted before the entire task is complete. These two perspectives are often discussed in terms of processing capacity and are often defined by working memory. Working memory is used to store small amounts of information briefly; the information in the working memory is available to be transformed and manipulated. Processing limitations can also be viewed in the realm of time; if the information is not processed quickly enough, it is vulnerable to decay and interference. This is typically discussed in terms of processing speed (Leonard, et al., 2007).

Working memory and processing speed have been proposed by researchers to be impaired in children with SLI. For example, investigators, like that of Baddeley (2001), have argued that the underlying impairment in children with SLI involves difficulty in the processing and storing of novel phonological information in the phonological working memory. Baddeley and others argue that deficits in the ability to maintain phonological information in working memory may result in the language deficits seen in those with SLI (Baddeley, 2001).

According to Baddeley (2001), working memory is divided in components of the central executive function, the visuospatial sketch pad, and the phonological loop. The central executive function is believed to be responsible for coordinating information from the phonological loop and the visuospatial sketch pad; the central executive function is seen as the attentional controller. In the working memory model, phonological working memory is comprised of the central executive function and the phonological loop – the system responsible for maintaining and manipulating a phonological representation of a novel word in phonological working memory. This model explains that difficulty maintaining novel phonological forms in working memory would result in difficulty processing and learning semantic features associated with phonological form (Gathercole & Baddeley, 1990).

Baddeley (2001) explains that the working memory, and each of its components, plays a role in children with SLI. However, the generalized slowing hypothesis examines a proposed overall limitation in processing capacity. The generalized slowing hypothesis proposes that children with SLI show a generalized slowed response time in comparison with their age-matched peers in a variety of linguistic and nonlinguistic tasks (Windsor & Hwang, 1999). This hypothesis declares that children with SLI respond more slowly than normally developing children on all types of tasks; they respond more slowly by a constant proportion (Miller, Kail, Leonard, & Tomblin, 2001).

Interpretation of slower response times across tasks performed by children with SLI asserts that children with SLI show a generalized limitation in processing capacity; the underlying deficit in SLI is seen as due to a global mechanism that affects aspects of cognitive and linguistic processing (Windsor & Hwang, 1999). The framework of the limited processing capacity account explicates that the effective use of one's language requires coordination of linguistic, cognitive, and social skills; the availability of cognitive resources, such as inhibition, affects this ability. Thus, the view of a proportional slowing is based upon the assumption that any given task involves several processes; the response times for children with normal language development are influenced by the time required for each of these processes (Windsor & Hwang, 1999).

The theory behind a limited processing capacity in the generalized slowing hypothesis adheres to the idea that children with SLI have reduced cognitive resources to allocate toward these on-going processes; accordingly, performance suffers if the cognitive demand is greater than the resources available. Hence, this theory is rooted in the fact that factors such as complexity, amount of material, and time constraints – rather than specific type of material – affect performance on different tasks (Im-Bolter, Johnson, Pascual-Leone, 2007).

It is important to note that the generalized slowing hypothesis proposed that SLI children were uniformly slower than typically developing peers regardless of task and domain (Im-Bolter, Johnson, Pascual-Leone, 2007). However, other researchers have reported the SLI children's slower response times are a function of domain- or process- specificity; there is debate as to whether limitations are more wide-spread or are confined to select domains. Such views find support in studies of cognitive aging, which have shown that some domains and processes do not show the same pattern of slowing as others (Leonard, et al., 2007).

Additional studies are considered when looking at probable underlying causes in children with SLI. The aforementioned Baddeley's working memory model focuses primarily on working memory and its parts; the hypothesis of generalized slowing focuses chiefly on overall processing capacity limitations. Additionally, speed of processing, in correlation with processing capacity, has proven to be significant in theories associated with SLI. Specifically, studies have shown that even at low levels of processing, with working memory demands kept to a minimum, the speed of processing information is often slower in children with SLI. This may be attributed to the amount of knowledge encompassed by the individual, which slower response times typically reflect (Leonard, et al., 2007).

Theories, like that of Baddeley's working memory model, the generalized slowing hypothesis, and insufficiencies in auditory perception, associate the underlying etiology of SLI in children to be directly related the child's associated deficits. However, it has been speculated that the limited processing abilities and poor language ability associated with SLI are conditions that co-occur without a direct cause and effect.

Additionally, it has been presumed that limited processing abilities, like that of limited working memory capacity, have the potential to create language difficulties. Yet, the causal effect of the limited working memory on language is thought to be able to be minimized under certain language learning conditions. Thus, if children with SLI have optimum language input, their processing speed and/or working memory limitations may be less cumbersome (Leonard, et al., 2007).

Recently, investigators have considered the possibility that attention or executive function in Baddeley's terms underlies language difficulties in children with SLI (Im-Bolter, Johnson, & Pascual-Leone, 2006; Finneran, Francis, & Leonard, 2009). Im-bolter, Johnson, & Pascual-Leone (2006) affirmed that children with SLI have difficulty with the classic stroop task. The classic Stroop task traditionally involves reading, limiting its use with children. The names of colors are printed in the ink of another color (e.g., the word "green" printed in red ink). Participants are asked to read the word or name the ink color. This task has been a source of many important insights into adult cognition, attentional control mechanisms, and the neural bases of cognition. Thus, in order to use with children with SLI, the child must be a well-practiced reader (Prevor & Diamond, 2005). Therefore, there is a need to study children's attentional control using a task that does not involve reading.

The Color-Object Stroop Task and Attentional Training

The Color-Object Stroop task has been described as, "a source for many important insights into attentional control mechanisms and neural bases of cognition" (Prevor & Diamond, 2005, p. 257). The task's basis is founded on the over-learned tendency of individuals to attend to what the object is and to pay less attention to its color (Prevor & Diamond, 2005).

It has been concluded that older children and adults are inclined to classify items by shape, or by object kind, rather than color; they are more likely to generalize a new word to other stimuli of the same shape or kind rather than color (Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2003). There is much evidence that from early to later childhood there is a progression from focusing on color to focusing on shape (Suchman & Trabasso, 1966, as cited in Prevor & Diamond, 2005). Prevor & Diamond (2005) concluded that from 3 to 3 ½ years onward the progression shifts from a preference to attend to color to a partiality to attend to shape.

In order to investigate aspects of a preferential attention to shape, a Color-Object Stroop task is often administered. According to Prevor & Diamond (2005), the Color-Object Stroop task typically consists of several conditions. The congruent condition illustrates familiar objects drawn in their usual color; the incongruent condition displays familiar objects drawn in an uncharacteristic color. A neutral condition depicts familiar objects that have no particular color associated with them. The baseline color-naming conditions are related to un-nameable abstract shapes drawn in a color (Prevor & Diamond, 2005).

To evaluate color-object interference in each of these conditions, "Stroop interference" is observed (Prevor & Diamond, 2005, p. 258). This interference has been shown by several studies to be stronger in children than in adults (Jongen & Jonkman, 2008). Cramer (1967) tested Stroop interference in four to five year old children. The results of a similar study conducted by Prevor & Diamond (2005) paralleled these outcomes.

The outcomes of these studies are important in understanding the characteristics in which young children attend to when recognizing, and ultimately learning, novel objects. In the Cramer (1967) study, no difference was observed in the speed for naming the color, where no form was present, or naming the form, where no color was present. Children were faster and more accurate at naming the object presented than at naming its color; they were as fast to name the object no matter the color. It was noted that the color in which the object was drawn had little effect on the child's ability to name the object (Cramer, 1967, as cited in Prevor & Diamond, 2005).

The Stroop interference was greatest for incongruent stimuli. Yet, the presence of any nameable object interfered with the color-naming. Children experienced greater interference when they have to inhibit responding on the basis of object kind in order to name a color than they do when required to name the object, not its color (Prevor & Diamond, 2005). Exercising this inhibitory control is demanding; the toll it took can be seen in the lengthened response times and decreased accuracy over time (Prevor & Diamond, 2005). The development of executive attentional control is needed to overcome this interference (Prevor & Diamond, 2005).

Comparing children with SLI to typically developing peers on the performance of the Color-Object Stroop task will allow further insight into the idea that attention is related to children's lexical learning. It was projected in the current study that there would be a strong association between the interference effect and the participants' vocabulary measures. It is anticipated that with a larger vocabulary size, the presence of the interference effect will be smaller. In children with SLI, or those individuals with smaller vocabularies, it is expected that a larger presence of the interference effect will be seen in comparison with that of their typically developing peers.

Chapter 2: Method

Participants

The participants in this study were ten preschool and school-age children. Of these participants, there were six males and four females. The mean age of the participants was six years, four months. The age range was 3:0 to 12:3. These participants were recruited from day cares, pre-schools, and schools in and surrounding the State College area. Informed consent was obtained from a guardian of each child before testing. Two of these participants were ultimately excluded from the study. The excluded participants were only able to name one color correctly in the Color-Object Stroop task.

Of the remaining participants, there were five males and three females. The mean age of these participants was seven years, two months. The age range that existed in these participants was 4:6 to 12:3. All of the participants had IQs within the normal range; the average participant IQ was 104.71, though one of the participant's IQ data was not complete. These participants were placed into two categories according to their Expressive Vocabulary Test (EVT) raw scores. The two groups are illustrated in Table 2-1. One group consisted of four children (mean age 4:4) identified by the study as having the lowest EVT raw scores of the eight children evaluated. There were three males and one female in this group. A second group of four children (mean age 9:6) had the highest EVT raw scores of the eight children evaluated. There was one male and three females in this group.

Equipment

In order to obtain a satisfactory, representative speech sample from each participant, audio and video recording were utilized. The EVT test was audio recorded; the Color-Object Stroop task was both audio and video recorded. The computer software program E-prime was used on a desktop computer to administer the Color-Object Stroop task (Psychology Software Tools, Inc., 2009). In order to analyze the participants' responses during the Color-Object Stroop task, *Sound Forge Pro 10* was used. This software program is equipped with a set of audio processes, tools, and effects for manipulating audio files; the *Sound Forge Pro 10* computer software allows for analyzing and synthesizing speech. In addition, high-quality pictures, such as speech waveforms, can be created. Equipped with the ability to analyze waveforms, the latencies in each of the participants' responses were measured (Sony Creative Software, 2010).

Procedure

The participants in the study were recruited to the Language and Literacy Research Initiative (LLRI). Recruitment was done primarily through flyer dispersal to day cares, pre-schools, and schools in the State College area. These flyers invited families of children with language learning difficulties to participate in research.

If a family expressed interest in the study, a researcher from the LLRI department called the family to conduct a brief phone survey to determine if the child was a match the study. The child was considered a match for the study if the child was age three to twelve and displayed any indication of a language and/or reading impairment without an additional disorder or if the child was typically developing. The presence of an addition disorder was determined by asking the parents if the child had ever been labeled as an individual displaying signs of “autism”, “Downs syndrome”, etc. Had the child been labeled as such, they were excluded from the study.

The eight pre-school and school age children who were ultimately evaluated in the current study were invited to take part in two sessions at the Department of Communication Sciences and Disorders at the University of Pennsylvania’s University Park campus. Each session lasted for approximately an hour and a half. Consent was obtained before the commencement of each session. This consent form explained particular elements of the sessions; for example, the participant(s) of the study were able to withdraw from the study at any time. Assent was also obtained; the subjects of this study were children and thus, as minors, were not able to give their consent. Yet, their agreement to participate was ultimately required.

The sessions included many different administrated tests, including hearing, speech, and language tests. In the first session, the LLRI examiners administered the Clinical Evaluation of Language Fundamentals (CELF-4) test and the Wechsler Adult Intelligence Scale (WASI) to older participants (Semel, Wiig, & Secord, 2003); the CELF-4 test and the Leiter Brief were conducted with younger participants (Roid, & Miller, 1997). The CELF-4 assessment aims to determine the language and communicative strengths and weaknesses. This study specifically evaluated the results associated with the standard score for each participant’s language; this aids in determining if a language deficit exists (Pearson Education, Inc., 2008). The WASI was test administered to the older participants; this IQ test is a clinical assessment utilized to measure adult and adolescent intelligence (Taub, 2001). The Leiter Brief test was administered to the younger participants; this IQ test is a nonverbal test of intelligence and cognitive ability. Along with being nonverbal, the Leiter Brief test does not require the participant to read or write; thus, it is suitable for young children and adolescents (Johnston, 1982).

In the second session, the Language and Cognitive Development evaluators administered four different tests. Relevant to this study were the Peabody Picture Vocabulary Test (PPVT), Expressive Vocabulary Test (EVT), and Color-Object Stroop task.

The session began with the administration of the PPVT. The PPVT is used to measure receptive vocabulary in children and adults; the test measures the degree to which spoken words are understood. There were two training items before the assessment begins; this ensured that the participant understood how to correctly perform the test. To determine where the PPVT assessment began, it was important to note the basal rules that accompany the vocabulary test. That is, the item set in which the child makes one or no errors; the initial starting point was determined by the participant's age (Dunn & Dunn, 2007).

Once starting point had been established, the examiner presented a series of pictures to the participant. There were four pictures on each page, and each of the pictures was numbered. The examiner stated a word describing one of the pictures. The individual was asked to point to the picture that the word describes. No reading or speaking was required by the participant. An answer was considered correct if the child pointed to the picture suggested by the examiner. Once the child had reached the "ceiling", or the item set in which the child makes eight or more errors, the PPVT was complete (Dunn, & Dunn, 2007). The PPVT was scored according to the manual; the task was scored by two different individuals on two different occasions. This ensured that the results were reliable and valid. The participants' raw scores and standard scores were considered in this study. The mean and standard deviation for each of these scores was calculated. Conclusions were drawn from the results.

Upon completion of the PPVT, a snack was given to the child if the parent permitted. If the parent had not permitted a snack, the child was nonetheless given a break during the evaluation process. Once the break was terminated, the Color-Object Stroop task was administered. This program was employed via E-prime software on a desktop computer. This test was audio and video recorded; the audio-visual recordings ensured test and evaluator reliability. The stimulus items used in the Color-Object Stroop task are listed in the Appendix. There were two training items before the Color-Object Stroop task began; this ensured that the participant understood how to correctly perform the test.

The Color-Object Stroop task was broken into three conditions in which children are asked to produce the name of an object or a color. In the Object Naming condition of the task, children were told to name the object that appears on the computer screen. This condition involves neutrally colored objects. Familiar objects presented had no particular color associated with them (e.g. yellow scissors). In the Color-Only condition, children were asked to name the color of an obscure shape. This condition is referred to as the baseline color-naming condition; un-nameable shapes were drawn in a particular color. Finally, the participant was asked to name the color of each object (Color-Object Interference condition). This condition again employs neutrally colored objects. Instead of naming the object, participants are asked to name the color of familiar objects with no canonical color (Prevor & Diamond, 2005).

The participants' responses during the Color-Object Stroop task were measured using the *Sound Forge Pro 10* software program. The participants' responses were measured in terms of latencies; this measure of time delay was determined by measuring the end of a given stimulus (a beep to signal that the participant was to respond) to the participant's definite response. The definite response was determined when the participant appeared satisfied with their response.

The obtained measurements were calculated in seconds; they were converted to milliseconds. The latency measurement was performed for each participant's response.

Once the latencies of each participant's responses were measured, an average latency time for each condition of the Color-Object Stroop task was calculated. That is, the average of the correct responses within each conditions of the task was calculated. Incorrect responses were not considered in the averages. The averaged results of the Color-Only Interference condition of the Color-Object Stroop task was subtracted from the averaged results of the Color-Only condition to determine the amount of interference effect that was seen within each participant. The interference effect could then be compared to other tests' results.

Additional measurements were extracted from the participants' responses. Average latency time for all incorrect and correct responses in throughout entire task and was also calculated. The number of correct and incorrect responses was counted for the overall Color-Object Stroop task. The number of correct responses was counted for each condition within the Color-Object Stroop task. Mean and standard deviation for each of these measurements was calculated. All results were organized into an Excel spreadsheet.

The Expressive Vocabulary Test (EVT) was administered after the completion of the Color-Object Stroop task. An audio recorder was used to record this test; this ensured the reliability of both the test and the evaluator. The EVT is an assessment of participants' expressive vocabulary and word retrieval; this vocabulary test asks the participant to label pictures and produce synonyms (Williams, 2007).

To begin the test, the evaluator presented a picture matching the child's chronological age. The participant was shown a picture and was instructed to respond to the examiner's command, question, or carrier phrase with a one-word response. If an error was made, a picture corresponding with a lower chronological age was shown until the child responded correctly to eight consecutive prompts. The EVT was administered until the participant made six mistakes in eight consecutive responses (Williams, 2007). The participant's responses were scored according to the EVT manual. All of the participants' responses were scored by two different individuals on two different occasions. This ensured that the results were reliable and valid. The participants' raw scores and standard scores were considered in this study. The mean and standard deviation for each of these scores was calculated.

After completion of the second session evaluation, the Color-Object Stroop task and EVT audio tapes were converted to compact discs. This allowed for the analysis, synthesis, measurement, and interpretation of the participants' results to be completed on a desktop computer. The results of the testing were made available to the family upon request.

Chapter 3: Results

The eight participants evaluated in this study were grouped according to their EVT raw score results. When grouped by EVT raw score, the first group of participants had a mean IQ of 115 with a standard deviation of 12.16; these participants were measured to have mean CELF-4 language standard score of 101.50 with a standard deviation of 5.25. This group of participants was considered to be the group that scored lower in terms of their EVT raw scores; these participants had a mean EVT raw score of 63.50 with a standard deviation of 11.03. The second group of participants was considered to be the group that scored higher in terms of their EVT raw scores. This group of participants had a mean EVT raw score of 107.50 with a standard deviation of 23.43. Additionally, the second group of participants had a mean IQ score of 97 with a standard deviation of 12.43; they were measured to have a mean CELF-4 language standard score of 91.25 with a standard deviation of 25.44. These results are illustrated in Table 2-1.

The first group of participants scored lower than that of the second group on two out of the three other PPVT and EVT measures considered in this study. The first group of participants consisted of the children who were lower in age (age range 4:6 to 5:3); the second group of participants was comprised of the children who were older in age (age range 5:0 to 12:3). The first group had a mean PPVT raw score of 108.25 with a standard deviation of 14.08; the second group had a mean PPVT raw score of 132.25 with a standard deviation of 48.59. The first group had a mean EVT standard score of 100.50 with a standard deviation of 7.76; the second group of participants had a mean EVT standard score of 102 with a standard deviation of 21.86. The first group of participants scored considerably higher than that of the second group of participants in terms of the PPVT standard score. The first group of participants had a mean PPVT standard score of 118.50 with a standard deviation of 8.69; the second group of participants had a mean PPVT standard score of 93 with a standard deviation of 17.68.

The overall number of correct responses among the different conditions for the two groups of participants was considered. The first group of participants had a mean of 26.50 correct responses with a standard deviation of 5.80; there was a mean of 4.75 incorrect responses with a standard deviation of 3.86. The second group of participants had more correct responses and less incorrect responses in comparison to the first group. The second group displayed a mean of 34 correct responses with a standard deviation of 1.41 and a mean of 1 incorrect response with a standard deviation of 0.11.

The number of correct responses within different conditions in the Color-Object stroop task was also counted. Within these three conditions, the two groups of participants varied. The first group of participants had a mean of 7.50 correct in the Object Naming condition with a standard deviation of 5.06. In the Color-Only condition, they had a mean of 9.75 correct with a standard deviation of 1.50. The Color-Object Interference condition the group resulted in a mean of 7.75 with a standard deviation of 3.59. The second group of participants had a larger number or correct responses in each of the conditions. These individuals had a mean of 10.75 correct in the Object Naming condition with a standard deviation of 0.5. The Color-Only condition had a mean of 11 correct with a standard deviation of 0. The Color-Object Interference condition resulted in a mean of 10.75 with a standard deviation of 0.50. These results in comparison to the interference effect are depicted in Table 3-1.

Overall correct and incorrect latency times of the participants' responses throughout the entire Color-Object Stroop task were calculated. The first group of participants had an overall correct response latency time of 2306.78 ms with a standard deviation of 312.33. The second group of participants had a shorter overall correct response latency time of 1457.31 ms with a standard deviation of 521.62; the second group also had a shorter overall incorrect response latency time of 933.50 ms with a standard deviation of 1163.67.

The latencies measured from the two groups of participants in each condition of the Color-Object Stroop task illustrate additional differences. The first group of participants had a mean latency time of 1303.70 ms in the Object Naming condition with a standard deviation of 870.04; a mean of 2210.20 ms in the Color-Only condition with a standard deviation of 283.96; and a mean of 2749.15 ms in the Color-Only Interference condition with a standard deviation of 342.42. The second group of participants had a slower mean latency time of 1366.76 ms in the Object Naming condition with a standard deviation of 247.79; a faster mean of 1382.63 ms in the Color-Only condition with a standard deviation of 725.51; and a faster mean of 1647.09 ms in the Color-Only Interference condition with a standard deviation of 727.41. These results, along with these results in comparison to the interference effect, are displayed in Table 3-2.

The interference effect was calculated from the results of the Color-Only condition and Color-Object Interference condition; the Color-Only condition was subtracted from the Color-Object Interference condition. The first group of participants displayed an average interference effect measurement of 538.95 with a standard deviation of 462.47. The second group of participants displayed a smaller average interference effect measurement of 264.45 with a standard deviation of 202.26. Notably, the first group of participants displayed more errors and longer response times than that of the second group of participants; the interference effect was seen in two out of the four participants. The second group of participants was far more accurate in their responses; this amount of accuracy displayed a lesser presence of the interference effect.

The interference effect calculated in the Color-Object Stroop test compared to PPVT and EVT results showed correlations between the interference effect and the vocabulary test scores. The correlation between the PPVT raw scores and the interference effect was -0.19; the correlation between their EVT raw scores and the interference effect was -0.32. The PPVT raw score results for the participants were on average higher than that of the EVT results; there was a smaller correlation between the PPVT raw score results and the interference effect. The EVT raw scores were lower than that of the PPVT raw scores; the interference effect correlation was stronger in the EVT raw score results. This can be seen in Table 3-3. Therefore, it is possible that the attention and inhibition processes surrounding the interference effect may be affected by an individual’s vocabulary size.

Chapter 4: Discussion

Limited processing capacity theories suggest that capacity limitations, perhaps in the form of limited attention, constrain lexical learning in children with SLI. The objective of this study was to evaluate more precisely the theories related to attention in order to determine a relationship between the attention and inhibition process surrounding the interference effect and a child's vocabulary size.

The Color-Object Stroop task's results were noted. The first group, the group with the smaller expressive vocabularies, had fewer correct answers in the overall task and in each condition when compared with the second group, the group with the larger expressive vocabularies. The first group deviated further from the norm than the second group. Moreover, the first group of participants had longer latency times in two of the three conditions; these longer latencies times were seen in the Color-Only and Color Object Interference conditions. These results show that the first group was unable to name the color and object associated with color as quickly as the second group. However, the second group of participants deviated further from the norm in the latency times of the Color-Only and Color-Object Interference conditions. Yet, it is shown that the interference effect was seen more within the first group than the second group. With fewer correct answers showing a larger interference effect, the results show a larger correlation between the first group's vocabulary size and attentional processes.

When the PPVT and EVT were compared with the interference effect seen within the Color-Object Stroop task, there was a noted correlation. This correlation was seen more with the EVT results; the raw scores of the EVT were lower and presented a larger correlation with the interference effect. The correlation with the PPVT and the interference effect were lower because overall the participants had larger raw scores in this task. Thus, it can be interpreted that both receptive and expressive vocabulary is affected by the attention and inhibition process that is observed within the Color-Object Stroop task. This was especially so for the children's lower vocabulary measures. Therefore, it was seen that the smaller the child's vocabulary, the larger the interference effect.

These results have displayed an association between the inhibition and attentional process surrounding the interference effect and the children's vocabulary size. There are at least two possible explanations for this result. That is, a child may have an extensive vocabulary which allows them to attend to the object's name instead of its color. Conversely, it may be interpreted that as a child focuses on an object's shape, rather than other aspects like that of color, the child is able to further their individual lexical learning. It is possible that (1) children with fewer attentional resources learn fewer words or (2) having large vocabularies directs children's attention to relevant processes.

It is important to note that there are variables that have likely affected these results; the study conducted had limitations. Specifically, there was a small sample size evaluated; only eight children were ultimately included in the investigated two participant groups. Moreover, the eight evaluated participants in this study varied in age (4:6 to 12:3). The nearly eight-year age difference between two of the participants may have caused variations in the results. Had a larger sample size and/or specific age group been targeted, the results may have proven different.

Therefore, there are several aspects of this study that are worth further investigation. The next step in this study may be to look at the age related differences within the children in this study. The comparisons between the two groups in this study were between children who were very different in age; the first group varied from the second group by nearly eight years. Thus, it would be important to look at groups of children where these age differences are more controlled. Moreover, since the present study only looked at mostly typically developing children, children with SLI should be included in future research. In comparing children with SLI to their typically developing peers, it would be more possible to determine if these results are conclusive. If the same results were presented, it would provide support for capitation and limitation theories that surround attentional training and children with SLI.

Nonetheless, the results of this study present clinical implications. Specifically, the correlation between the presence of the interference effect and the vocabulary size measured in the PPVT and EVT represent support for attentional training in children with SLI. As the interference effect was proven to be seen in children with smaller vocabularies, teaching children to attend to the right cues may provide them benefit. This attentional training may inhibit the presence of the interference effect and allow for the increase of a child's lexical learning.

Chapter 5:

Specific Language Impairment Linked to Attention?

In summary, the children's vocabulary size in this study appeared to be related to the attention and inhibition process associated with the interference effect. The correlation between the receptive and expressive vocabulary tests and the interference effect has shown that vocabulary size has ties with attention. Those with a smaller vocabulary results presented a larger interference effect. The larger scores on the PPVT task showed a smaller correlation with the interference effect; the smaller scores on the EVT, indicating smaller vocabulary, resulted in a larger correlation with the interference effect. Future studies should investigate if this finding of larger interference effect in children with small as compared to large vocabularies is true for children with SLI as compared to typically developing children.

Table 2-1: Characteristics of Participants Evaluated in Study

Group 1	**CELF Score**	**IQ**	**Age (Months)**	**EVT Raw Score**	**EVT Standard Score**	**PPVT Standard Score**
Child 1	96	N/A	55.2	47	89	111
Child 2	106	109	56.8	68	104	115
Child 3	106	129	57.3	69	106	131
Child 4	98	107	64.2	70	103	117
Group 2						
Child 5	106	111	60.5	86	124	101
Child 6	82	91	105.5	93	88	81
Child 7	60	83	149	102	79	76
Child 8	117	103	147.9	149	117	114

Table 3-1: Mean and Standard Deviation of Number Correct in Each Condition in Color-Object Stroop Task

Group 1	**Object Naming**	**Color-Only**	**Object-Color Interference**
Child 1	11	8	7
Child 2	0	9	10
Child 3	10	11	3
Child 4	9	11	11
Mean	7.50	9.75	7.75
Standard Deviation	5.06	1.50	3.59
Group 2			
Child 5	10	11	11
Child 6	11	11	11
Child 7	11	11	11
Child 8	11	11	10
Mean	10.75	11	10.75
Standard Deviation	0.5	0	0.5

Table 3-2: Mean and Standard Deviation of Average Latency and the Interference Effect in Each Condition in Color-Object Stroop Task

Group 1	**Object Naming**	**Color-Only**	**Color-Object Interference**	**Interference Effect**
Child 1	1701.09	2251	2362.42	111.42
Child 2	0	2248.33	3193.40	945.07
Child 3	1793.50	1827.45	2760.33	932.88
Child 4	1720.22	2514	2680.45	166.45
Mean	1303.70	2210.19	2749.15	538.95
Standard Deviation	870.04	283.96	342.42	462.47
Group 2				
Child 5	1700.30	2469.81	2689.36	219.55
Child 6	1149	1045.09	1604	558.90
Child 7	1405.90	974.27	1151.90	177.63
Child 8	1211.81	1041.36	1143.10	101.73
Mean	1366.75	1382.63	1647.09	264.45
Standard Deviation	247.79	725.51	727.41	202.26

Table 3-3: PPVT and EVT Raw Score Correlation to the Interference Effect

Group 1	**PPVT Raw Scores**	**EVT Raw Scores**	**Interference Effect**
Child 1	92	47	111.42
Child 2	103	68	945.07
Child 3	125	69	932.88
Child 4	113	70	166.45
Group 2			
Child 5	83	86	219.55
Child 6	114	93	558.90
Child 7	134	102	177.63
Child 8	198	149	101.73
Correlation	-0.19	-0.32	

Appendix: Color-Object Stroop Task Stimulus Items

Color-Object Stroop Task Stimulus Items: Stimulus items were given at random. Target responses were object names, colors of un-nameable shapes, and colors of objects.

Object Naming Condition	
Scissors (yellow)	Fish (green)
Book (orange)	Kite (green)
Telephone (brown)	Chair (red)
Dinosaur (red)	Cow (yellow)
Cake (yellow)	House (brown)
Bird (orange)	
Color-Only Condition Stimuli	
Brown (with obscure shape)	Red (with obscure shape)
Yellow (with obscure shape)	Yellow (with obscure shape)
Red (with obscure shape)	Orange (with obscure shape)
Brown (with obscure shape)	Red (with obscure shape)
Green (with obscure shape)	Green (with obscure shape)
Orange (with obscure shape)	
Color-Object Interference Condition	
Green (kite)	Yellow (cake)
Red (dinosaur)	Brown (house)
Brown (telephone)	Red (chair)

Orange (bird)	Yellow (cow)
Orange (book)	Green (fish)
Yellow (scissors)	

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