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**Observing Relationships Between Hyperactivity and Impulsivity and
Language Performance in Typically Developing 5-Year-Olds**

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by

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Abstract

Observing Relationships Between Hyperactivity and Impulsivity and Language Performance in Typically Developing 5-Year-Olds

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This study seeks to observe connections between hyperactivity/impulsivity or inattention with expressive or receptive language performance in typically developing five year olds. The hypothesis of the study is that higher hyperactivity/impulsivity is related to lower scores in expressive language and higher inattention is related to lower scores in receptive language. The study was performed by comparing results of the Clinical Evaluation of Language Fundamentals - Fifth Edition (CELF-5) with the Attention Deficit Hyperactivity Disorder Rating Scale (ADHD-RS) Parent Report. No significant correlations were observed between hyperactivity/impulsivity or inattention with the expressive or receptive composite scores of the CELF-5. However, two CELF-5 subtests, Following Directions and Recalling Sentences, were significantly correlated with inattention, suggesting a relationship with working memory. Future studies may include children who have been diagnosed with ADHD or Specific Language Impairment (SLI) to observe whether or not more salient differences in hyperactivity/impulsivity,

inattention, receptive language, or expressive language produce significant correlations between these measures.

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Chapter 1: Introduction

Communication is a multi-faceted process, often involving multiple layers of cognition on the part of more than one individual. The combination of attention, self-moderation, and linguistic skill is essential for development of effective communication (Darcy, Mora, & Daidone, 2014). Attention, though comprised of various aspects such as selectivity and switching between focuses, can be simply understood in common vernacular as something similar to concentration (Bjorklund, 2005). Evidence indicates that inhibition (also referred to in some cases as self moderation or self control) is a process affected by hyperactivity and impulsivity (Oosterlaan and Sergeant, 1996; Berlin & Bohlin, 2002). “Self-control—or the capacity to inhibit or delay one’s initial motor (and perhaps emotional) responses to an event—is a critical foundation for the performance of any task”, including communication (Barkley, 1998, p. 69). Language, the means for communication, may be separated into five structural components: phonology, semantics, syntax, morphology, and pragmatics (Brandone, Salkind, Golinkoff, & Hirsh-Pasek, 2011). Language is both expressed (when communicated to a partner) and received (when communicated from a partner). When any of these domains - - attention, inhibition, or language-- are compromised, a communication breakdown is likely to occur. This study seeks to observe relation between hyperactivity/impulsivity or inattention and language performance in typically developing five-year-old children. In particular, this study is interested in whether these cognitive processes are selectively related to expressive versus receptive language.

Significance of the project

This study is significant because it contributes to understanding the relationship between the basic cognitive processes of attention and self-moderation with language. It

is essential to determine this because children may present with higher instances of these characteristics even if they do not bear a diagnosis such as Attention Deficit-Hyperactivity Disorder (ADHD). Not only could findings contribute to theoretical constructs of the relationship between cognition and linguistics, but are also relevant to any child who presents with elevated inattention or hyperactivity/impulsivity. If an easily-administered parent or teacher report scale could make valid differential predictions about a child's language development, it may be possible to predict potential problems and make anticipatory adjustments in academic settings. This has value for children, parents, teachers, and health professionals alike.

Language and ADHD

There is a strong foundation of literature describing the effects of an ADHD diagnosis on language performance. Evidence suggests children who screen positive for ADHD may be 29% more likely to have long-term language problems that may compromise academic functioning (Sciberras et al., 2014). DeParma, Geffner, and Martin (2011) found impairments in both receptive and expressive language in a study of 100 school-aged children diagnosed with ADHD. Redmond, Thompson, and Goldstein (2011) determined that children with ADHD had a slightly poorer overall language competency than typically-developing peers given tasks of both narrative comprehension and verbal response production, but markedly better language competency compared to children with Specific Language Impairment. Oram, Fine, Okamoto, & Tannock (1999) reported a study noting that children with ADHD had particular difficulty with the non-cloze Formulated Sentences subtest, compared to other subtests of expressive language and comprehension of the CELF-R. These studies look for an association between an ADHD diagnosis and various aspects of language. While we can safely conclude that an ADHD

diagnosis is related to various impairments in language, what is missing from the literature above is whether there is a differential language profile for children who present with distinct issues in inattentiveness or hyperactive/impulsivity.

Building a linguistic profile for children who present as inattentive

To date, several studies have been conducted to investigate the role of attention in language and communication. As mentioned previously, attention comes in a variety of forms and may affect different processes related to language. Gomes, Wolfson, & Halperin (2007) indicate that “mechanisms responsible for arousal, orienting, selective allocation of attention, and sustained attention,” as well as visual and auditory attention, are subcomponents of the attentional system (page 660). Some of these components of attention are likely to play a role in receptive language, or the perception of a communicated message.

Because language is typically perceived auditorily and visually, one aspect of attention that relates directly to reception of language is auditory attention. Several studies have been published to demonstrate that auditory attention is related to language processing (Gomes et al., 2007; Montgomery, 2008; Victorino, 2011). One such study demonstrated how the brain is attentive to linguistic auditory input and therefore responds faster to it (Shytrov, Kuiala, & Pulvermuller, 2010). Gomes et al. (2007) indicate that receptive, not expressive, language was more affected by lack of auditory attention, stating, “language proficiency [in auditory-attention tasks] was linked to omission errors (misses) rather than commission errors (false alarms), suggesting issues with attention rather than inhibitory control” (p. 665). While the findings of this study regarding auditory attention may not be generalized to all areas of attention, the study suggests that receptive language might be more affected by a lack of attention.

In order to build a linguistic profile for children who display inattentive tendencies, one might turn to diagnosis of the ADHD-I subtype for clues about what to expect from such a child. Symptoms of inattention such as, “does not seem to listen when spoken to directly” or “fails to give close attention to details” contribute to a general picture of a child who may have difficulty with tasks of receptive language (Barkley, 1998, p. 68). Though research has yet to produce a strong foundation for the effects of all aspects of attention on expressive versus receptive language, it is reasonable to conclude that children who are classified as inattentive will have difficulty with tasks of receptive language.

Building a linguistic profile for children who present as hyperactive/ impulsive

When a child presents with hyperactive/impulsive tendencies, a different language profile might be expected. To gain a better understanding of how these characteristics present, it is helpful to review symptoms of hyperactivity/impulsivity that would lead to a differential diagnosis of this subtype of ADHD. Diagnostic indicators of hyperactivity/impulsivity include that the child “talks excessively,” “blurts out answers before questions have been completed,” and “interrupts or intrudes on others” (Barkley, 1998, p. 68). Sagvolden, Johansen, Aase, & Russell (2005) also found that children with the ADHD hyperactive/impulsive subtype manifest with impulsive responding, distractibility, and memory retrieval problems.

Research has shown that inhibition is a process affected by hyperactivity and impulsivity (Oosterlaan & Sergeant, 1996; Berlin & Bohlin, 2002). Bjorkland (2005) points out that “‘not doing’ something is actually a very active process in itself” (pg.134). This may be especially true for hyperactive/impulsive children, who are required to consistently allocate cognitive resources to inhibiting what is natural to them. Ward

(2015) refers to inhibition as “receiving input but not responding to the input” (pg.70). An extension of this line of reasoning would suggest that receptive language is intact, but breakdown would occur in expressive language. Effective expressive language requires more than articulatory formation of words; the words must be aptly chosen and put together in a logical manner. Therefore, while a hyperactive/impulsive child may have no issues with the physiological means of producing expressive output (i.e., the child “talks excessively”), the quality of that output may be diminished. Impulsive responses from the hyperactive/impulsive child, then, could contribute to a lower expressive language profile.

Hypothesis

The present study examines how inattention and hyperactivity/impulsivity relate to language performance. Though studies have been conducted that contribute to a linguistic profile for children who present with inattention or hyperactivity/impulsivity, a direct connection between receptive and expressive language and these processes has yet to be investigated. By looking for correlations between typically-developing five-year-olds’ performance on the ADHD Rating Scale and the CELF, it may be possible to parse out whether or not there is a relationship between hyperactivity/impulsivity and inattention with aspects of language in typically developing children. Because of the findings of the aforementioned studies, the hypothesis of this study is that higher hyperactivity/impulsivity will be related to lower expressive language and that higher inattention will be related to lower receptive language.

Chapter 2: Methods

Participants and Procedure

The subject group consisted of 115 typically-developing five-year-olds from Austin, Texas. These children were recruited via a database of families who had previously participated in studies through the University of Texas at Austin, cold calls of phone numbers obtained through Austin Independent School District, mailed flyers, and various advertisements. All respondents were included given their adherence to the inclusion criteria described below.

Demographically, the subjects were split evenly between sexes (58 girls and 57 boys). 32% self-identified as Hispanic/Latino. Furthermore, participants were from a wide span of incomes: 10% (12 participants) \$0 – 25,000/year, 16% (18 participants) \$25,000-50,000/year, 10% (11 participants) \$50,000-75,000/year, 19% (22 participants) \$75,000-100,000/year, 35% (41 participants) \$100,000+, and 9% (11 participants) did not report. No exclusions were made on the basis of demographic information. Inclusion criteria included age (the child had to be between 4;11 and 5;11 to qualify for the study), handedness (only right-handed children were included), and a non-remarkable developmental and medical history. Exclusionary factors in developmental history included any history of speech/language disorders (diagnosis and/or treatment), history of ADHD, or any learning disability. Exclusionary factors in medical history were any surgeries or medical procedures that may have resulted in metallic objects left inside the body, as this could impede magnetic resonance imaging (MRI) scanning that the participants were informed they may qualify for at a later date.

Data was collected by research assistants and associates in a testing block of approximately 1.5 hours. The testing battery administered to the participants included the Comprehensive Evaluation of Language Fundamentals- Fifth Edition (CELF-5; Wiig,

Semel, & Secord, 2013) to evaluate different aspects of language competence. The participants were also administered the nonverbal subtest of the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 2004). During this time, the parent(s) of the subject completed the Attention Deficit Hyperactivity Disorder Rating Scale IV (ADHD-RS; DuPaul, Power, Anastopoulos, & Reid, 1998). Subjects and their parents were informed of the minimal risks related to the study, which included becoming tired, bored, or uncomfortable. Participants had the ability to withdraw at any time for any reason.

Assessment Tools

The assessment tools used in this study were the ADHD-RS and the CELF-5. Written based on the DSM-IV criteria, the ADHD-RS is an 18-item parent-report measure that seeks to identify the presence of behaviors associated with Attention Deficit Hyperactivity Disorder. The assessment is intended as a screening measure and breaks down into nine questions each for inattention (IA) and hyperactivity-impulsivity (HI). Parents have the opportunity to rate their child's exhibition of the given behavior on a 4-point Likert scale. Scores for inattention and hyperactivity/impulsivity are obtained by adding the ratings of the 4-point Likert scale (values from 0-3) for a total raw score out of 27 for each subscale. Test-retest reliability (Pearson product-moment correlation coefficients) of the parent report version is as follows: Total score = .85, Inattention = .78, and Hyperactivity-Impulsivity = .86. Alpha coefficients for internal consistency is as follows: Total score = .92, Inattention = .86, and Hyperactivity-Impulsivity = .88. In regards to predictive validity, in a clinical setting, the combined subscale of both IA and HI for the parent report is 60% accurate (DuPaul, Power, Anastopoulos, & Reid, 1998). This measure acted as the predictive variable.

The CELF-5 is intended as a diagnostic measure of both expressive and receptive language, of which seven subtests were administered to each participant in this study. Internal consistency reliability coefficients range from .75 to .98 across age groups. The test has been deemed valid for its diagnostic accuracy, with a cut score of -1.3 SD as optimal, resulting in 97% sensitivity and 97% specificity (Wiig, Semel, & Secord, 2013). Tests include Word Classes (understanding relationships between associated words), Following Directions (using working memory to execute verbal directions), Formulated Sentences (constructing semantically and grammatically correct sentences), Recalling Sentences (reproducing sentence structures), Sentence Comprehension (understanding grammar at the sentence level), Linguistic Concepts (understanding concepts that require logical operations or connectives), and Word Structure (understanding morphological rules of English). This assessment acted as the outcome variable.

Data Reduction/Statistical Analyses

The assessment measures were scored according to the procedures named in their respective testing manuals. Percentile ranks were derived from raw scores on the CELF-5. Because percentile ranks for the ADHD-RS were grouped, raw scores from this measure were used in analyses. Pearson correlations were then run via SPSS Statistic Software Version 23 to assess statistical significance between the CELF-5 and the ADHD-RS. Variables compared included scores from the ADHD-RS for inattention and hyperactivity-impulsivity. Because the research question predicted possible differences in receptive and expressive language based on levels of inattention and hyperactivity/impulsivity, the CELF-5 subtests were also grouped by tests of expressive language (Formulated Sentences, Word Structure, and Recalling Sentences) and tests of receptive language (Sentence Comprehension, Linguistic Concepts, Word Classes, and Following

Directions) and run against the same ADHD-RS correlates. After these correlations were determined, a Fisher r-to-z transformation was performed between correlations that were deemed to be statistically significant to determine selectivity. Statistical significance was determined by a >0.05 critical alpha probability (p) value.

Chapter 3: Results

Table 1: Demographic characteristics

	Mean	Minimum	Maximum	SD
Age	5;7	4;11	5;11	0;2
Nonverbal IQ Percentile Rank	54.8	2	99	26.8
Receptive Language Index Percentile Rank	62.5	7	99.9	29.8
Expressive Language Index Percentile Rank	65.5	2	99	28.2
Inattention Raw Score	4.5	0	14	3.5
Hyperactivity/Impulsivity Raw Score	5.6	0	24	4.6
Sex, # of participants	57 male, 58 female			

Demographics

The participants in this study ranged in age from 4;11 to 5;11 and were nearly evenly split between males and females in the 115-participant sample. The participants' scores were consistent with typical development by having means near the middle of the percentile range in Nonverbal IQ, and Receptive and Expressive Language, and means on the low end of the range of raw scores in Inattention and Hyperactivity/ Impulsivity (see Table 1). Relatively large standard deviations indicate that some participants were representing both higher and lower ends of these characteristics.

Table 2: Correlation for composites

		CELF RLI %	CELF ELI %
ADHD RS IA	Pearson Correlation	-.117	-.134
	Sig. (2-tailed)	.212	.152
	N	115	115
ADHD RS HI	Pearson Correlation	-.068	-.075
	Sig. (2-tailed)	.471	.427
	N	115	115

Key: RLI=Receptive Language Index; ELI=Expressive Language Index; IA=Inattention;
HI= Hyperactivity/impulsivity

Table 3: Correlation for significant CELF subtests

		CELF FD %	CELF RS %
ADHD RS IA	Pearson Correlation	-.186*	-.209*
	Sig. (2-tailed)	.046	.025
	N	115	115
ADHD RS HI	Pearson Correlation	-.129	-.160
	Sig. (2-tailed)	.169	.087
	N	115	115
*. Correlation is significant at the 0.05 level (2-tailed).			

Key: FD=Following Directions; RS=Recalling Sentences; IA=Inattention;
HI=Hyperactivity/impulsivity

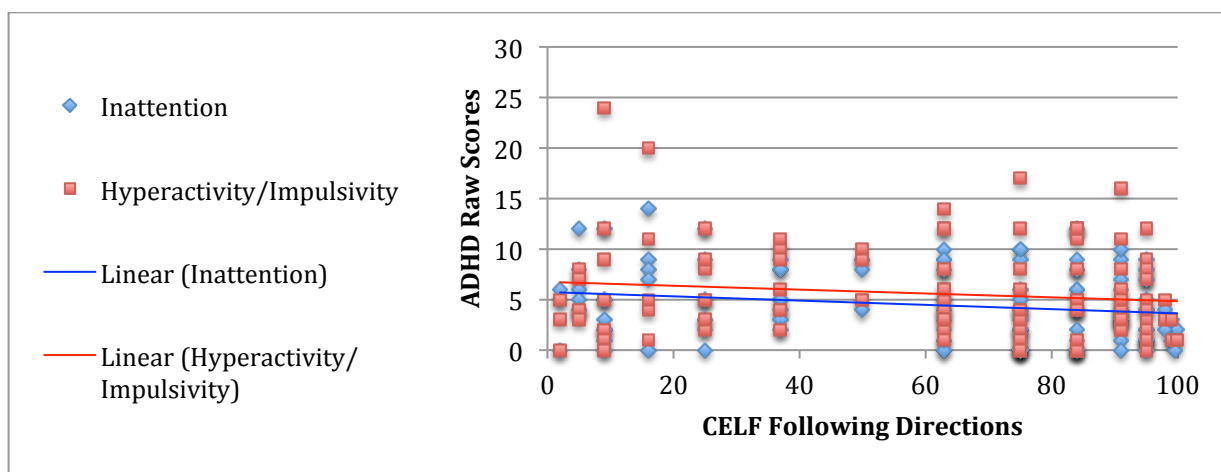
Overview of results

Several correlations were run using the SPSS program. The purpose of running Pearson correlations was to determine whether or not there was a relationship between variables. Because this study is interested in the relationship between hyperactivity/impulsivity and inattention with expressive and receptive language, correlations were run between measures of these variables. Table 2 illustrates the results of the correlation between raw scores of inattention and hyperactivity/impulsivity with the percentile ranks of Receptive Language Index and Expressive Language Index scores of the CELF-5. The Receptive Language Index (a combination of the Sentence Comprehension, Word Classes, and Following Directions subtests) and the Expressive Language Index (a combination of the Word Structure, Formulating Sentences, and Recalling Sentences subtests) were not significant for either ADHD-RS measures of inattention or hyperactivity/impulsivity, as was hypothesized. Though not significant, there was a negative correlation between both inattention and hyperactivity/impulsivity with the receptive and expressive values, indicating that higher scores indicating hyperactivity/impulsivity or inattention were related to lower scores in receptive and expressive language.

Because the correlations between the receptive and expressive index scores were not significant with either hyperactivity/impulsivity or inattention, an exploratory correlation was run between the ADHD-RS raw scores of hyperactivity/impulsivity and inattention with the individual subtests of the CELF. This analysis revealed two subtests were significantly correlated with inattention at the 0.05 significance level: Following Directions (FD), $r = -.186$, $n = 115$, $p = .046$, and Recalling Sentences (RS), $r = -.209$, $n = 115$, $p = .025$ (Table 3). These correlations are negative, indicating that as raw scores of

inattention (and therefore presence of inattentive qualities) increase, scores in Following Directions and Recalling Sentences decrease.

Figure 1. Scatterplot of correlation of Following Directions with Inattention and Hyperactivity/impulsivity

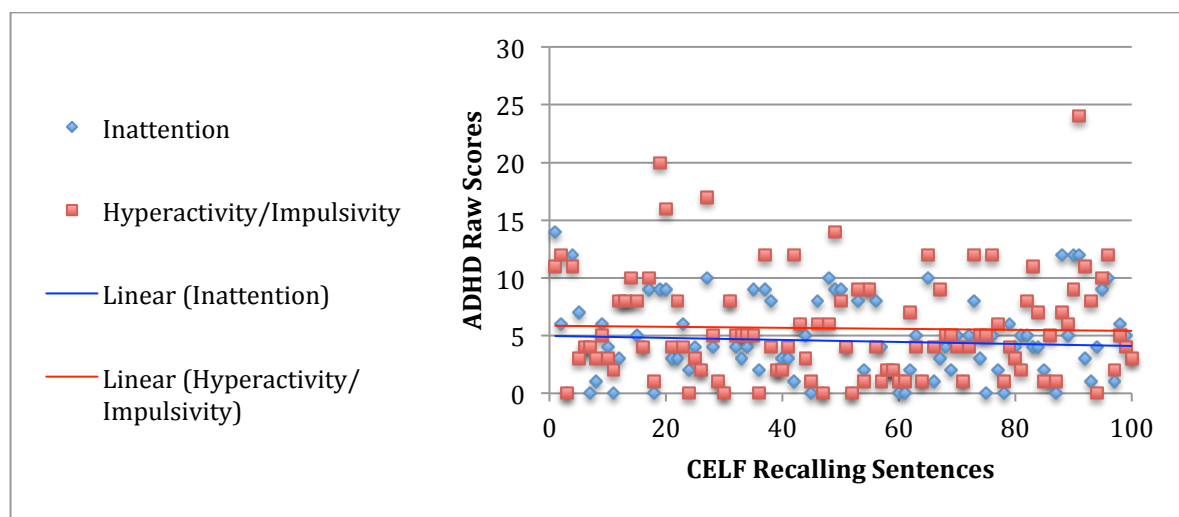


Results from Significant Subtests

The Following Directions subtest of the CELF-5 was determined to be significant at the 0.05 significance level with the ADHD-RS subtest of Inattention. Figure 1 illustrates the correlation between the percentile ranks of CELF-5 Following Directions and the raw scores of the ADHD-RS subtests of Inattention (in blue) and Hyperactivity/Impulsivity (in red). A negative line of regression indicates that as ADHD-RS raw scores rise (meaning parents reported more instances of symptoms of hyperactivity/impulsivity and inattention), scores in Following Directions decreased.

A Fisher z-test was performed to compare the correlation between inattention and Following Directions subtest and the correlations between inattention and the rest of the CELF subtests to determine whether or not low performances in Following Directions may be considered selective for inattention. Results indicated that there was no significant difference between the correlation of Following Directions and inattention compared to the correlations between other CELF subtests and inattention. Thus, the correlation is not specific to Following Directions. Another Fisher z-test compared the correlation between Following Directions and inattention with the correlation between Following Directions and hyperactivity/impulsivity. Results indicated that the correlation between Following Directions and inattention were not significantly different from the correlation between Following Directions and hyperactivity/impulsivity and thus not specific to inattention.

Figure 2. Scatterplot of correlation of Recalling Sentences with Inattention and Hyperactivity/impulsivity



Similarly, the Recalling Sentences subtest of the CELF-5 was determined to be significant at the 0.05 significance level with the ADHD-RS subtest of Inattention. Figure 2 illustrates the correlation between the percentile ranks of CELF-5 Recalling Sentences and the raw scores of the ADHD-RS subtests of Inattention (in blue) and Hyperactivity/Impulsivity (in red). A negative line of regression indicates that as parents reported increased instances of inattentive behavior, scores in Recalling Sentences decreased.

Again, a Fisher z-test was performed to compare the correlation between inattention and Recalling Sentences subtest and the correlations between inattention and the rest of the CELF subtests to determine whether or not low performances in Recalling Sentences may be considered selective for inattention. Results indicated that there was no significant difference between the correlation of Recalling Sentences and inattention compared to the correlations between other CELF subtests and inattention. Thus, the correlation is not specific to Recalling Sentences. Another Fisher z-test compared the correlation between Recalling Sentences and inattention with the correlation between Recalling Sentences and hyperactivity/impulsivity. Results indicated that the correlation between Recalling Sentences and inattention were not significantly different from the correlation between Recalling Sentences and hyperactivity/impulsivity and thus not specific to inattention.

Chapter 4: Discussion

Summary

This study attempted to determine whether or not higher hyperactivity/impulsivity was related to lower expressive language, and higher inattention was related to lower receptive language, in typically developing 5-year-olds. Up to this point, few studies have examined whether or not this conclusion might be drawn. Though there is reason to think children who are inattentive may have more trouble with receptive language (Barkley, 1998) and children who are hyperactive/impulsive may perform more poorly on tasks of expressive language (Sagvolden et al., 2005), a study seeking out correlations between these specific behavioral/linguistic modalities had yet to be conducted.

After analysis, the results of this study indicate that expressive/receptive language and hyperactivity/impulsivity or inattention are not related. No significant correlations were observed in the receptive/expressive composite scores and either hyperactivity/impulsivity or inattention. Significant Pearson correlations were found between inattention and the Recalling Sentences and Following Directions subtests of the CELF-5. Counter to the hypothesis of this study, one subtest significantly correlated with inattention, Following Directions, is considered a receptive language task, while the other, Recalling Sentences, is considered an expressive language task (though it may be argued this subtest has a significant receptive language demand). Furthermore, analysis using the Fisher z-test indicated that, though the correlations were significant, differences between the correlations did not indicate that Recalling Sentences and Following Directions were specific to inattention.

In seeking an explanation as to why Recalling Sentences and Following Directions were significantly correlated with inattention, it may be noted that both are

tasks of working memory. During the Recalling Sentences subtest, the participant is verbally presented with a sentence and asked to repeat it. Sentences increase in length and complexity as the subtest progresses. This task involves auditory memory but also working memory, because the child must remember the end of the sentence while verbalizing the beginning. In the Following Directions subtest, the participant is given one, two, and three step commands that gradually increase in complexity. The participant is sometimes required to hold the first step presented while acting first on the second step presented, requiring working memory.

This is an interesting addition to published research, which indicates that children with ADHD may have difficulties with verbal working memory, specifically in number recall (Hutchinson, Bayin, & Efron, 2012). In addition, a study conducted by Jonsdottir, Bouma, Sergeant, & Scherder (2005) indicated that children with ADHD combined subtype did not have significant working memory impairments in spatial working memory but did have difficulty with tasks of verbal working memory. These studies indicate that ADHD seems to be more associated with tasks of working memory that require verbal output; however, a meta-analysis conducted by Martinussen, Hayden, Hogg-Johnson, and Tannock (2005) indicates that visuospatial working memory may more impaired in children with ADHD. Currently, published research suggests that both verbal and visuospatial working memory may be compromised in children with ADHD symptoms.

Several studies have looked for relationships between subtypes and specific areas of working memory, with inconsistent results. Kuntsi, Oosterlaan, & Stevenson (2001) found that children who were hyperactive had difficulty with working memory when tested with a counting and sentence span task, but were not compared to children with the inattentive subtype. Several studies have also been conducted that indicate verbal

working memory is impaired in children with inattentive qualities (Rogers, Hwang, Toplak, Weiss, & Tannock, 2011; Gray, Rogers, Martinussen, & Tannock, 2015; Constance, 2013). A study conducted to differentiate working memory impairments in adults by ADHD subtype did not find significant differences between subtypes (Schweitzer, Hanford, & Medoff, 2006). With these findings in mind, our study adds an important component to the literature by suggesting that inattention is associated with language processing performance on tasks with high verbal working memory demands.

Limitations and Future Directions.

One limitation of the study is that it was conducted on typically developing five-year-olds. These were not children with affirmative diagnoses of ADHD of any subtype (hyperactivity/impulsivity, inattention, or combined), nor children diagnosed with receptive or expressive language impairments. It is possible that the relatively mild presence of hyperactive/impulsive or inattentive traits in these typically-developing children was not enough to show a difference between proficiency in receptive or expressive language. Future studies should examine children who have been previously diagnosed with ADHD, who may presumably have higher manifestations of hyperactivity/impulsivity and/or inattention.

Another consideration for future research would be to administer the ADHD-RS for teachers rather than parents, as research has demonstrated that, though both the parent and teacher ratings are valid, teachers demonstrate a better ability to differentiate between children with low and high levels of hyperactivity/impulsivity and inattention (Makransky & Bilenberg, 2014). Perhaps this method of collecting data on hyperactivity/impulsivity and inattention would render more polarized high and low raw

scores that may correlate more strongly with measures of expressive or receptive language.

Conclusions

This study set out to observe relationships between hyperactivity/impulsivity and inattention with receptive and expressive language in typically-developing five-year-olds. Though the hypothesis that higher hyperactivity/impulsivity would be related to lower expressive language and higher inattention with be related to lower receptive language was not confirmed, other significant correlations were observed. The ADHD-RS scale of inattention was significantly correlated with the Following Directions and Recalling Sentences subtests of the CELF. Further research is needed to determine the extent of the relationship between verbal working memory and inattention in typically developing children and those with ADHD.

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