Metalinguistic Skills in Children with ADHD

A Thesis

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Bryce Evan Palm

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Abstract

Purpose: Prior research has established positive relationships between language ability, executive function, and metalinguistic awareness in bilingual children. Little is known about how these skills relate in other populations. This study examined these relationships in children with attention deficit/hyperactivity disorder (ADHD) who are known to have weaknesses in executive function.

Method: Participants included 10 children with ADHD aged 6 to 7 years and 10 age-matched typically developing peers. Children completed a battery of cognitive, language, and metalinguistic awareness assessments. Parents completed a demographic questionnaire and several surveys regarding their child's development, including executive function abilities.

Results: There were no significant differences in between groups based on performance on any of the metalinguistic awareness assessments.

Conclusions: These results suggest a dissociation between executive function and metalinguistic skills in young children with ADHD. Future research examining a larger sample with a larger array of assessments is warranted.

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Introduction

Two constructs closely related to expressive language skills are metalinguistic awareness and executive function. Metalinguistic awareness reflects a person's awareness of language and the ability to think about language and its rules (Bialystok, 1986). Executive function is a broad term encompassing mental processes involved in control of behavior, such as planning, impulse control, working memory, and mental flexibility (Visser et al., 2014). Both constructs have been positively linked to performance on language tasks (Hirschman, 2000; Henry, Messer, & Nash 2012).

Bialystok (1986) suggests that key skills contributing to metalinguistic awareness are cognitive control and language analysis. As such, cognitive control is likely to be closely tied to executive function abilities and language analysis is likely to be closely tied to language abilities. For example, Bialystok and Barac (2012) examined the language skills, metalinguistic abilities, and executive function abilities of children in grades 2 through 5 attending Hebrew or French immersion program schools. Study results indicated that high performance on metalinguistic tasks was positively correlated with language ability based on the English Peabody Picture Vocabulary Test (PPVT-III:A; Dunn & Dunn, 1997). Additionally, stronger executive functioning skills were positively correlated with length of time spent in the immersion program. Thus, in this sample of bilingual children, there was a strong positive relationship between these three constructs.

This is one of the only studies known to examine all three of these constructs in parallel. Bilinguals are a unique sample because they have strengths in all domains assessed. It is important to better understand these relationships, particularly when an individual has a known weakness in one area that may negatively impact other areas of development. One way to further understand the relationship between language skills, metalinguistic abilities, and executive function abilities is to examine their development in a population known to have weaknesses in these skills. In the current study, we examined these relationships in children with attention-deficit/hyperactivity disorder (ADHD). One of the core deficits of children with ADHD is executive dysfunction (Visser et al., 2014). Therefore, if executive function, language abilities, and metalinguistic abilities are all interconnected, we would expect that when compared to typically developing children, children with ADHD would have weak executive function skills as well as weaker language and metalinguistic abilities. Thus, the purpose of the current study is to compare the language skills, metalinguistic abilities, and executive function abilities of children with ADHD and typically developing children.

In the following sections, we first provide overviews of metalinguistic awareness and executive function. Then, given that much of the research on metalinguistic awareness has focused on bilingual children, we review what is known about the relationships between language skills, metalinguistic abilities, and executive function abilities in bilingual children. We end by discussing what is known about these skills in children with ADHD.

Literature Review

Metalinguistic Awareness

Bialystok (1986) describes metalinguistic ability as indicative of development of two separate parts of language processing: control of attention in selective linguistic processing and analysis of linguistic knowledge. Control of linguistic processing involves inhibiting immediate (and inaccurate) responses to unintuitive stimuli and the capability to distinguish between form and meaning in the event of conflict. Analysis of linguistic knowledge involves the use of explicit awareness of implicit rules of language to make judgments about language structure and form.

A variety of tasks have been developed that assess these two components of metalinguistic ability. For example, Bialystok (1986) developed a false grammaticality task, which assesses both control of attention and linguistic knowledge. In this task, participants were presented with four types of sentences: (a) grammatically and semantically normal (e.g., “I have two books”), (b) grammatically incorrect but semantically normal (e.g., “Yesterday I climb a tree”), (c) grammatically correct but semantically meaningless (e.g., “The car is reading”), and (d) grammatically incorrect and semantically meaningless (e.g., “The shoe are teaching”). Examiners instructed participants to judge sentences for grammatical correctness, but showed through examples that sentences that are semantically meaningless should be deemed acceptable. Detecting differences in semantic meaningfulness reflects attentional control. For example, given the sentence “The trees are running,” a child who correctly responds that the sentence *is* acceptable has strong control skills. Such a response demonstrates the ability to override an instinctive response that the sentence is “wrong” or ungrammatical and to instead consider the possibility that the sentence has correct form despite semantic meaninglessness. Detecting violations in grammaticality reflects linguistic knowledge. For example, given the sentence “The girl are running,” a child who correctly responds that the sentence is unacceptable has strong analytical skills, specifically, an awareness that verb agreement rules have been violated.

Metalinguistic skills begin developing early, with basic concepts of phonological, word, and structural awareness emerging as early as 3 years of age and continuing to develop in the coming months (Chaney, 1992). Many studies have shown the importance of metalinguistic knowledge to broader language development and use. For example, Hirschman (2000) administered over 50 half-hour metalinguistic training sessions to children averaging 10 years of age with specific language impairment (SLI). These sessions first focused on developing a coherent understanding of basic language concepts (e.g., subjects and objects of sentences, simple versus complex sentences, verbs and phrase structures) and later using this knowledge to analyze and retell short stories using complex sentences with appropriate conjunctions. Compared to children who did not receive similar training, the participants who received metalinguistic training showed marked improvement in use of complex sentences, and the greatest improvements were seen in those who had the greatest impairments. Thus, this study demonstrated a close relationship between the development of metalinguistic skills and later language development.

Executive Function

Anderson (2002) proposed a model of executive function that comprises four interconnected domains: attentional control, cognitive flexibility, goal setting, and information processing. Attentional control consists of such skills as selective attention, inhibition, and self-regulation, and has effects on each of the other three domains. Cognitive flexibility encompasses working memory and feedback utilization. Goal setting includes skills such as planning and strategic organization. Information processing relates to efficiency and speed of processing.

Executive function in children is often measured by parent or teacher responses to standardized surveys, such as the Behavioral Rating Inventory of Executive Function (BRIEF; Gioia, Guy, Isquith, & Kenworthy, 1996). Experimental tasks are also commonly used to assess different aspects of executive function. Eriksen and Eriksen's (1974) flanker task remains a common task archetype for executive function assessment. In a given trial of a flanker task, participants view a stimulus in a central fixation point and make a response based on that stimulus, such as typing the letter presented or indicating which direction an arrow is pointing. The central stimulus is sometimes flanked by distractor stimuli, which may vary in factors such as time of presentation (preceding central stimulus or simultaneous presentation), visual and semantic similarity to the central stimulus, or proximity to the central stimulus. Certain flankers may directly contradict or support the central stimulus, such as directional arrows preceding presentation of a central arrow which may point the same direction as the central arrow or the opposite direction. Ability to inhibit responses based on contradictory flankers and to correctly attend to the central flanker reflects attentional control. Speed of response reflects information processing efficiency. Ability to correct patterns of erroneous response following initial errors reflects cognitive flexibility, as does ability to rapidly adjust to varied stimuli (i.e., to perform well on blocks of trials that mix both contradictory and supportive flankers, as opposed to blocks which only show supportive flankers or only show contradictory flankers).

Executive function has also been linked to language ability. For example, Kaushanskaya, Park, Gangopadhyay, Davidson, and Weismer (2017) examined relationships between performance on various executive function tasks and language tasks in typically developing children aged 8 to 11 years. While many associations were relatively weak, one noteworthy relationship was that between nonverbal inhibition and syntactic skills. Inhibition, as measured by a go/no-go task variant in which children were asked to respond to one specific stimulus but not to respond to a different specific stimulus, predicted 10.2% of variance in scores on the authors' syntactic composite, comprising relevant subtests of the Clinical Evaluation of Language Fundamentals—4th Edition (CELF-4; Semel, Wiig, & Secord, 2003) and Test of Language Development-Intermediate—4th Edition (TOLD-I:4; Hammill & Newcomer, 2008). Specifically, ability to inhibit inappropriate responses was positively correlated with syntactic ability. The authors suggested that these results demonstrate clear influence of a domain-general executive function, inhibitory control, on a language ability, syntactic skill. A greater body of research examining the relationships between executive function and language ability exists which is focused on the development of bilingual children and adults.

Metalinguistic Ability, Executive Function, and Language Development in Bilingual Children

Bilingual children demonstrate stronger performance on both executive function tasks and metalinguistic tasks compared to monolingual children (Bialystok & Viswanathan, 2009; Bialystok & Martin, 2004; Carlson & Meltzoff, 2008; Bialystok & Feng, 2009; Bialystok, 1986; Bialystok & Barac, 2012). For example, Bialystok and Viswanathan (2009) administered a task designed to probe multiple components of executive function. On a given trial, children were asked to observe a face in a central fixation point, with a box at both its left and right side. After a one-second interval, the face's eyes would briefly turn green or red, after which the face would disappear and an asterisk would briefly appear in one of the boxes. Two keys were designated on a computer keyboard to indicate "right" or "left." Children were asked to press the key corresponding to the asterisk's location if the eyes had appeared green, but the opposite if the eyes were red. Additionally, the eyes could be facing to the left, to the right, or neither direction. Blocks of trials were separated by single color or mixed color blocks as well as gaze change or neutral gaze blocks. Bialystok and Viswanathan found that, compared to monolingual children, bilingual children showed significant advantages in conditions testing inhibitory control in which they showed less reaction time difference between neutral gaze and gaze shift trials in mixed presentations. The bilingual children also outperformed the monolingual children on measures of cognitive flexibility in which they showed less reaction time difference between mixed color and single color presentations.

Similarly, Bialystok and Martin (2004) presented children with variants of Frye, Zelazo, and Palfai's (1996) dimensional change card sort task, in which participants were first asked to sort sets of cards by one feature (such as shape) and then asked to change sorting criteria to another feature (such as color). For example, children were presented a series of cards showing a blue circle, a red circle, a blue square, or a red square. For ten trials they were told to place these cards into either a "blue" box or a "red" box. They were then told that the game had changed and that they would now be sorting cards into a "circle" box or a "square box." Bialystok and Martin's results indicated that bilingual children had an advantage in attentional control and cognitive flexibility, demonstrating greater ability relative to monolingual peers to switch to different task instructions rather than perseverating on the old rules. While both groups averaged roughly 80-100% of items correctly sorted according to the stated rules of each task pre-switch, monolingual children saw a greater drop in performance post-switch than bilingual children, averaging only roughly 40-50% as opposed to 60-70% correct.

Bialystok and Feng (2009) more closely examined the relationship between executive function and language ability using a proactive interference task, which assesses the tendency to forget or fail to learn new information when extraneous objectives are presented. The proactive interference task broadly measures attentional control through selective attention and cognitive flexibility through working memory. The task involved memorizing five-item lists of words, with an interference task of counting up from random numbers for a brief period between each list. After counting for ten seconds, participants were asked to recall the words from that list. The contents of the lists remembered by participants served as the dependent variable. When vocabulary, measured by the Peabody Picture Vocabulary Test (PPVT-III:A; Dunn & Dunn, 1997), was controlled for, bilingual adults significantly outperformed monolingual adults on the task. There were no differences in performance between the bilingual and monolingual children, despite the bilingual children having smaller vocabularies. However, the bilingual children were less likely than the monolingual children to incorrectly recall a word from a prior trial. Bilingual children gave fewer answers total, but an equal number of correct ones. Monolingual children more commonly gave more incorrect answers, providing items from previous lists. The authors interpreted their findings as evidence that bilingual individuals may effectively bridge the gap in their language proficiency with their advantaged executive control to reach the performance levels of monolingual peers.

Bialystok (1986) administered the previously discussed false grammaticality test, which included four sentence types (i.e., grammatically and semantically correct, grammatically incorrect but semantically correct, grammatically correct but semantically meaningless, grammatically incorrect and semantically meaningless) plus a simple syntactic correction task, to bilingual and monolingual children aged 5-9 years. For the sentences that assessed linguistic analysis, there were no significant differences between the bilingual children and monolingual children. However, for the sentences that assessed control of processing, the bilingual children significantly outperformed monolingual children. Thus, there was a clear difference in linguistic analysis and control, with the bilingual children having stronger control abilities which Bialystok proposes are linked closely to executive function skills.

More recently, Bialystok and Barac (2012) conducted one of the few studies examining language, metalinguistic ability, and executive function simultaneously. Participants included children in grades 2 through 5 of Hebrew and French immersion program schools who varied in their primary language and time spent in the immersion program. Children were tested on both metalinguistic awareness tasks and executive control tasks. Metalinguistic tasks included the Wug Task and the grammaticality judgment task. Executive control tasks included a flanker task (Eriksen & Eriksen, 1974) and a dimensional change card sort task. High performance on metalinguistic tasks was correlated with high proficiency in the language of testing, as determined by performance on the English PPVT. High performance on executive control tasks was positively correlated with length of time spent in the immersion program. Past studies have shown that bilingual children do have advantages compared to typically developing children on metalinguistic tasks, but it would seem that past a certain level of bilingual experience the advantages suffer from diminishing returns. The authors suggested the possibility that bilingualism gives children an initial boost into figuring out structural relations within language, but after that first burst more bilingual experience does not move that development any farther forward.

Thus, studies involving bilingual children demonstrate strong relationships between executive function, metalinguistic awareness, and language ability, even at young ages. To further examine robustness of the relationships between these skills, it is important to consider populations other than bilingual children. Here, we examine the skills of children with ADHD, who are known to have weaknesses in executive functioning.

Executive Function Skills of Children with ADHD

Parent reports on the National Survey of Children's Health show a recent increase in prevalence of diagnosis of ADHD in American 4- to 17-year-olds, from 9.5% in 2007 to 11% in 2011, with 83% of those with a prior diagnosis still reported as having it. ADHD is marked by many symptoms, chiefly including: difficulty sustaining attention, impulsive behavior, and hyperactivity (Visser et al., 2014).

A meta-analysis (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) of 83 studies comparing executive function skills between individuals with and without ADHD found that the children with ADHD demonstrated significant deficits on each of the 13 executive function tasks examined, such as card sorting, repeating a sequence of numbers backwards from memory, and completing mazes without backtracking or crossing at any point. Effect sizes ranged from .46 to .69, with the most stable and prominent deficits on tasks assessing inhibition, planning, and working memory. The authors note that the deficits are not totally universal, but are clearly sufficiently commonplace to consider executive function difficulty a major feature of ADHD.

Effects of ADHD on executive function are robust enough that these differences emerge in individual studies. For example, Carte, Nigg, and Hinshaw (1996) compared boys with ADHD aged 6 to 12 years to TD peers on a variety of tasks, including maze tracing, rapid automatized naming (RAN), and a gross motor battery. They found children with ADHD showed significant impairments on many of the tasks, particularly those that required controlled processing, such as different conditions of RAN. RAN of pictures or objects has greater selective attention demands than the more automatic RAN of digits, which have minimal semantic content. Children with ADHD showed greater performance deficits compared to TD children on picture RAN than digit RAN.

This pattern of executive dysfunction has been documented based on parent report as well. In one study (Gioia, Isquith, Kenworthy, & Barton, 2002), researchers used the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Guy, Isquith, & Kenworthy, 1996), a parent and teacher rating scale, to analyze the executive function skills of children with ADHD (mean age 10.9 years, SD = 3.3). Parents rated their children with ADHD as having significant executive dysfunction compared to TD peers in areas such as planning and organization, working memory, and inhibition. In many domains, parents scored their children with ADHD lower in executive function skills than populations with traumatic brain injury or reading disorders. The authors described ADHD as “the ultimate developmental manifestation of executive dysfunction” (Gioia, Isquith, Kenworthy, & Barton, 2002).

These associated executive function deficits are not transient. They remain stable for many years, possibly the individual's entire lifespan. One study demonstrated this by following up with adolescents with ADHD and a history of executive function deficits seven years after their original study, when they were young adults. When completing the same tasks again, roughly 69% of the 26 participants still scored within the range classifying them as having executive function deficits (Biederman et al., 2007).

The existence of executive function deficits in ADHD gives rise to the question of other possible deficits. If executive function skills are linked to skills in other domains, then we should expect to see similar patterns of additional deficits in children with ADHD. Specifically, if there are links between language performance and executive function in other populations, we would expect to see language delays or difficulty in control of language use in children with ADHD.

Language Skills of Children with ADHD

A strong relationship between executive functioning and language performance exists in children with language impairment as well as children with ADHD (Tannock & Schachar, 1996; Geurts & Embrechts, 2008; Wassenbuerg et al., 2010; Helland, Posserud, Helland, Heimann, & Lundervold, 2016; Kim & Kaiser, 2000). For example, children with specific language impairment (SLI), which is often characterized as a disorder solely of language function, typically show executive function deficits (Henry, Messer, & Nash, 2012; Hughes, Turkstra, & Wulfeck, 2009; Kaushanskaya, Park, Gangopadhyay, Davidson, & Weismer, 2017). Henry, Messer, and Nash (2012) found that even with verbal IQ and performance on verbal task variants controlled for, children with SLI performed significantly lower on working memory, nonverbal inhibition, and nonverbal planning measures compared to TD peers. Hughes, Turkstra, and Wulfeck (2009) found that 57% of parents of teens with SLI rated their children as having clinically significant executive dysfunction on the BRIEF.

In conjunction with deficits in executive function, children with ADHD also demonstrate difficulty across many language domains that may manifest as SLI. For example, in a meta-analysis of 13 studies, Tannock and Schachar (1996) estimated that roughly 50% of children with ADHD have comorbid SLI. This is much greater overlap than chance alone would predict, implying a common underlying cause. Perhaps the most well-documented area of language deficit in children with ADHD is pragmatic ability. Researchers have linked ADHD to reduced pragmatic skills, such as overly stereotyped conversations, impulse responses, inappropriate conversational participation, and difficulty developing and maintaining social relationships (Geurts & Embrechts, 2008). However, alongside pragmatic deficits, children with ADHD often show delayed onset of word combinations, demonstrate a greater usage of revisions and unclear referents, and have difficulties learning and reading (Redmond, 2004).

A significant pattern that emerges across examinations of possible language impairments in ADHD is weaker performance on language comprehension tasks compared to TD peers. Wassenburg et al. (2010) tested complex sentence comprehension in children and adolescents with and without ADHD. Measures included variants of the Assessment Battery for Children – Language (ABC-L; Christensen, 1993), containing items such as, “I had breakfast after I had walked the dog. What did I do first?”, and the Token Test (TT-A; Lezak, Howieson, & Loring, 2004), containing items such as, “After picking up the large red rectangle, pick up the small yellow circle.” The authors found that while there were minimal differences in accuracy between groups, both children and teens with ADHD performed significantly more slowly than their age-matched peers. Comprehension was overall less efficient in participants with ADHD than in controls.

Another study (Helland, Posserud, Helland, Heimann, & Lundervold, 2016) made use of parent reports from over 5,000 parents of children aged 7-9 years; some typically developing, some with ADHD, some with reading disorder, and some with comorbid ADHD and reading disorder. Experimenters identified language impairment in over 40% of the children with ADHD-only and over 80% of the children with comorbid ADHD and reading disorder. Again, receptive language problems were more prominent in the ADHD group, while the reading disorder group showed more expressive and phonological problems.

Kim and Kaiser (2000) administered multiple language measures including the Test of Language Development (TOLD-2 Primary; Hammill, 1987) to 11 typically developing children and 11 children with ADHD ages 6 to 8 years. The TOLD-2 Primary contains seven subtests, each associated with a different domain of language use: picture vocabulary, oral vocabulary, grammatic understanding, sentence imitation, grammatic completion, word discrimination, and word articulation. Though children with ADHD showed no significant differences with peers on some subtests, they performed significantly worse than TD peers on the sentence imitation and word articulation subtests.

Thus, it is clear that most children with ADHD have significant weaknesses in executive function and that many have significant weaknesses in language based on early expressive deficits like delayed word combination onset, pragmatic deficits, and receptive language deficits. Given what is known about the advantages bilinguals have in both executive function tasks and metalinguistic control tasks, we expect children with ADHD, who have known deficits in inhibitory control, to show metalinguistic deficits compared to TD children. However, no major studies have directly assessed the metalinguistic skills (as defined by Bialystok) of children with ADHD. The current study aimed to determine if children with ADHD have weaker metalinguistic awareness skills than typically developing children. Children with ADHD were matched on age, gender, and socioeconomic status and completed a brief battery of metalinguistic tasks. We predicted that the children with ADHD would demonstrate significantly weaker performance compared to TD children on all tasks.

Method

Participants

The current study included 20 children between the ages of 6 and 7 years. All participants were recruited and completed experimental tasks at the Minnesota State Fair during one of three years (2014, 2015, or 2016). As part of a larger study, approximately 750 children between the ages of 3 and 9 years completed the experimental protocol. Given the potential confounds presented by multilingualism and comorbid disorders of communication, only data from monolingual children whose parents indicated that the child had a history of ADHD, but no other conditions (e.g., were not receiving special speech-language or reading services) were included in the study. Twelve children in the sample matched these criteria, 10 of whom were between the ages of 6 and 7 years. Two children who were outside of this age range (i.e., 5 years; 2 months and 8;8) were excluded from the study to increase sample homogeneity. We matched the 10 participants with ADHD to 10 typically developing children from the larger sample based on age, sex, and socioeconomic status. Table 1 contains a summary of the participant characteristics.

Table 1

Demographic Characteristics

Characteristic	**ADHD** (*n* = 10)	**TD** (*n* = 10)
Sex		
male:female	6:4	6:4
Age (years)		
Mean	7.15	7.08
SD	0.60	0.61
Min-Max	6.17-7.92	6.25-7.92
Household Income		
0-50k	6	4
50-150k	2	4
>150k	2	2
Ethnicity		
African-American	1	1
Asian-American	0	1
Hispanic/Latino	0	1

White/Caucasian	8	7
Multiracial	1	0

Study Tasks

Prior to completing any study tasks, parents provided written consent. Child participants received a small stuffed animal as compensation for participation in the study. Children completed the Matrices subtest of the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman, 1997), followed by the Recalling Sentences subtest of the Clinical Evaluation of Language Fundamentals-4 (CELF-4), and a metalinguistic probe. Parents completed several questionnaires regarding their child's developmental history, including a demographic questionnaire and the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000). Due to time constraints, two participants in the ADHD group did not complete the Recalling Sentences subtest of the CELF-4, and parents of three participants in the ADHD group did not complete the BRIEF.

KBIT-2 Matrices. The Matrices subtest of the KBIT-2 assesses nonverbal intelligence. On each trial, the examiner displays images to the examinee. The images reflect a pattern with a missing piece. The examinee must point to the picture that best completes the pattern. The KBIT-2 is normed for people ages 4-90 years, with 125 individuals comprising the normative age-group from ages 5 to 10 years. Between ages 4 and 18 years the nonverbal IQ score has a high internal consistency reliability (Cronbach's $\alpha = .86$), and its moderate-to-high correlations with results of similar tests indicate high concurrent validity.

CELF-4 Recalling Sentences. In the Recalling Sentences subtest of the CELF-4, the examiner presents sentences of increasing length and complexity that the examinee must recall and repeat verbatim. Points are deducted from a maximum possible score of 3 per sentence based on frequency and severity of errors in morphological, syntactic, or semantic repetition. The subtest has a mean scaled score of 10, with higher scores indicating better performance. This subtest is primarily an assessment of expressive syntactic and grammatical language abilities, and can be especially useful in identifying SLI given that difficulties with recalling sentences is often a key weakness of children with SLI (Petrucelli, Bavin, & Bretherton, 2012). The CELF-4 is normed on 2,650 students aged 5 to 21 years. The CELF-4 Recalling Sentences subtest has a test-retest reliability of .88-.94 depending on the age group, with high internal consistency and inter-scorer agreement. Regarding the validity of the test at large, studies on validity were conducted with students with prior diagnoses and found very high sensitivity and specificity (with a CELF-4 score 1.5 standard deviations below the mean, sensitivity was 1.00 while specificity was .89).

Metalinguistic Awareness Probe. The metalinguistic awareness probe consisted of four separate tasks. For each, examiners presented images on an iPad to participants. The examiners asked the participants questions regarding images they saw. The examiner marked the child's responses on a paper protocol.

The first task was a word manipulation task, which was modeled after Chaney's (1992) variant of Smith & Tager-Flusberg's (1982) word/referent differentiation task. During this task, examiners told participants that they were "making up a new language."

Examiners presented participants with pictures of four common objects and told them new labels for each. For example, the examiner first showed a picture of a carrot and told the participant that in their new language they would call the carrot a “gok.” The examiner then removed the picture and asked the child four simple yes/no questions about the object (e.g., “Can you eat a gok? Does a gok have wheels?”). There were four objects, each with four related questions to total a maximum score of 16. The task assesses metalinguistic analysis by determining the child’s awareness that objects and their labels are separable and that a novel label can be applied without changing the features of the object.

The second task was the word swap task, modeled after Piaget’s sun-moon problem (1929). Examiners asked participants to “suppose that everyone in the world agreed that from now on we will call the sun the moon and the moon will be called the sun,” and posed four questions about this scenario. For example, the examiner showed a picture of the sun and asked, “What would this be called?”. Then, the examiner removed the picture and asked, “What would the sky look like when you see this?” Examiners also presented children with similar questions regarding swapping the words for cat and dog. There were a total of eight questions for this task. This task assesses metalinguistic control with items that can easily elicit impulsive, incorrect responses and which require active label switching to answer correctly.

The third task was a variation of Berko’s Wug Task (Berko, 1958). Examiners presented pictures of various objects, animals, or humans, sometimes performing activities. Examiners then orally presented sentences describing the pictures using a nonsense word to label a given creature or activity, and asked the children to complete a second sentence. For example, presenting a man balancing a ball on his nose, experimenters told children, “This is a man who knows how to zib,” and then asked, “What is he doing? He is…” with a correct response being “zibbing.” The task probes a child’s awareness of the rules of language and ability to apply the rules to new words, thus providing a simple assessment of metalinguistic analysis abilities. In total, there were seventeen items on this task, assessing ten different grammatical rules and constructs.

The fourth task was an abridged variant of Bialystok’s (1986) previously described grammatical judgment task. This task comprised 13 sentences: three grammatically and semantically correct (“I have two books”), three grammatically incorrect but semantically appropriate (“Yesterday I climb a tree”), four grammatically correct but semantically inappropriate (“I have the tree’s boot”), and three both grammatically incorrect and semantically inappropriate (“The shoe are teaching”). Correctly answering “yes” to grammatically correct sentences and “no” to grammar violations demonstrated metalinguistic analysis through applied knowledge of grammatical rules. Correctly answering “yes” to both semantically appropriate and semantically inappropriate responses demonstrated metalinguistic control through ability to override the impulsive “incorrect” response to semantically inappropriate sentences because of instructions to treat such sentences as correct.

BRIEF. The BRIEF is a survey completed by parents regarding executive function behaviors of their child. The survey covers a variety of domains of executive function. The Global Executive Composite takes into account all subscales, including inhibition, shifting attention, emotional control, initiation, working memory, planning and organization, organization of materials, and monitoring. The inhibition subscale consists of questions relating to how well the child is able to control his or her own impulses. The working memory subscale includes questions relating to the child's ability to retain information briefly as is required for goal-making and task completion. Higher scores indicate executive dysfunction, with the typical functioning cutoff at a scaled score of 65. The Parent Form variant of the BRIEF was normed on 1,419 typically developing children between ages 5 and 18 years as well as a small control group of adolescents with traumatic brain injury. It has high internal consistency (Cronbach's $\alpha = 0.8$) and test-retest reliability of $r = 0.81$, and high predictive validity.

Communication Questionnaire. In addition to the BRIEF, parents completed a 19-item Likert-type scale survey (1 = never, 3 = occasionally, 5 = frequently) regarding their child's executive function and language behaviors. The survey consisted of questions on attention (e.g., "How often does your child become very distracted in noisy, busy situations?"), receptive language (e.g., "How often does your child understand a story that is read out loud?"), expressive language (e.g., "How often does your child use age-appropriate words in everyday conversation?), social skills (e.g., "How often does your child share information when talking one-on-one with a friend?"), and miscellaneous items which did not fit into other categories (e.g., "How often does your child become frustrated, sometimes to the point of losing emotional control?"). This questionnaire was designed as part of the larger Minnesota State Fair study as an additional brief screener for parent perception of language or executive function deficits.

Demographic Questionnaire. Parents provided information on their child's age, sex, ethnicity, primary language, and number of siblings. They also answered diagnostic history questions - for example, stating whether their child had diagnoses of ADHD or autism spectrum disorder (ASD), or had past or current participation in speech/language therapy services. Parents also provided information on household income and education history.

In total, the study protocol required approximately 30 minutes to complete. Tests were administered by trained undergraduate and graduate students in the University of Minnesota's Department of Speech-Language-Hearing Sciences. Examiners checked their scoring of all protocols at a later date. All scores were double checked by a second trained research assistant. All data entry was completed two times by two trained researched assistants. This process mitigated data entry errors. Data entry differences were resolved before conducting final analyses.

Statistical Analyses

Performance on intelligence and executive function measures, as well as the experimenter-generated communication questionnaire, was compared to ensure groups were appropriately balanced and appropriately divided. To determine if children with ADHD demonstrate significant differences in metalinguistic awareness skills compared to TD children, average performance on each metalinguistic study task was compared using a 2-sample t-test. Pearson correlations were obtained to discern how performance on each metalinguistic task was related to each broader skill domain assessed. Cohen's *d* (Cohen, 1988), which denotes the standardized difference between mean performance of two groups, is also reported to show effect size. Low values, such as 0.2, indicate that while the difference may be statistically significant, the difference may not be clinically meaningful. Higher values such as 0.8 or even in excess of 1.0 indicate that the difference between groups is clinically meaningful.

Results

To ensure that the study groups were well matched on key study variables, we compared the ADHD and TD group performance on the KBIT-2 and CELF-4 and parent responses on the BRIEF and communication questionnaire (CQ). There were no significant differences between groups in performance on the KBIT-2, $t(18) = .449$, $p = .66$, or the Recalling Sentences subtest of the CELF-4, $t(16) = .69$, $p = .50$. There were differences between groups in parent response on the BRIEF Inhibition subscale, $t(15) = 3.71$, $p = .01$, Working Memory subscale, $t(15) = 3.23$, $p = .01$, and Global Executive Composite, $t(15) = 2.63$, $p = .02$. These results indicated no overt differences between groups on intelligence or expressive language functioning, but clear differences in various executive function skills, which we would expect given that all of the participants in the ADHD group had a history of ADHD. Significant group differences emerged in parent response on the CQ in its entirety, $t(17) = 2.27$, $p = .04$. When examining subscales individually, significant group differences were found on the attention subscale, $t(17) = 3.08$, $p = .01$, the social subscale, $t(18) = 2.21$, $p = .04$, and the receptive language subscale, $t(18) = 2.67$, $p = .02$, showing that children with ADHD were, on average, perceived by their parents as having deficits in these domains compared to TD peers.

Table 2

Cognitive, Language, and Behavioral Characteristics

Characteristic	**ADHD**	**TD**	***p*-value**	**Effect size (*d*)**

KBIT-2 Matrices[a]					
	Mean	107.2	104.6	.66	.20
	SD	15.80	9.25		
	Min-Max	76-132	85-118		
CELF-4 Recalling Sentences[b]					
	Mean	10.4	11.0	.50	-.17
	SD	3.74	3.30		
	Min-Max	6-16	4-14		
BRIEF Inhibition Subscore					
	Mean	70	54.3	.01*	1.56
	SD	9.57	10.35		
	Min-Max	54-85	41-75		
BRIEF Working Memory Subscore					
	Mean	70.1	51.4	.01*	1.55
	SD	13.25	10.71		
	Min-Max	50-85	36-68		
BRIEF Global Executive Composite					
	Mean	69.0	53.8	.02*	1.24
	SD	14.5	9.41		
	Min-Max	52-93	43-71		

CQ All					
	Mean	66.5	75.2	.04*	1.03
	SD	7.00	9.69		
	Min-Max	56-79	53-89		
CQ Attention					
	Mean	10.6	14.1	.01*	1.39
	SD	2.07	2.89		
	Min-Max	7-13	10-18		
CQ Receptive					
	Mean	13.9	16.5	.02*	1.19
	SD	1.91	2.42		
	Min-Max	11-17	12-20		
CQ Expressive					
	Mean	17.0	17.9	.45	0.34
	SD	2.00	3.11		
	Min-Max	14-20	10-20		
CQ Social					
	Mean	14.3	16.7	.04*	.99
	SD	2.41	2.45		
	Min-Max	11-19	14-20		
CQ Other					
	Mean	10.7	11.0	.79	.12

	SD	1.57	3.20
	Min-Max	9-13	4-14

[a]Normative mean = 100, SD = 15; [b]Normative mean = 10, SD = 2.7

To answer the question of whether children with ADHD and TD children differ in metalinguistic awareness, we compared the ADHD and TD groups' performance on each of the four metalinguistic tasks. There were no group differences in performance on the Word Manipulation task, $t(18) = 1.21$, $p = .24$, Word Swap Task, $t(18) = .58$, $p = .57$, Wug Task, $t(18) = .29$, $p = .78$, or Grammatical Judgment task, $t(18) = .27$, $p = .79$. While there were no significant differences, the TD group means were consistently higher than the ADHD means on each measure. The effect size for each task was quite small except for the moderate effect size for the Word Manipulation task. Additionally, the Word Manipulation effect size may be skewed by a single low-performing outlier in the ADHD group. This suggests that any group differences are of minimal clinical significance.

Table 3

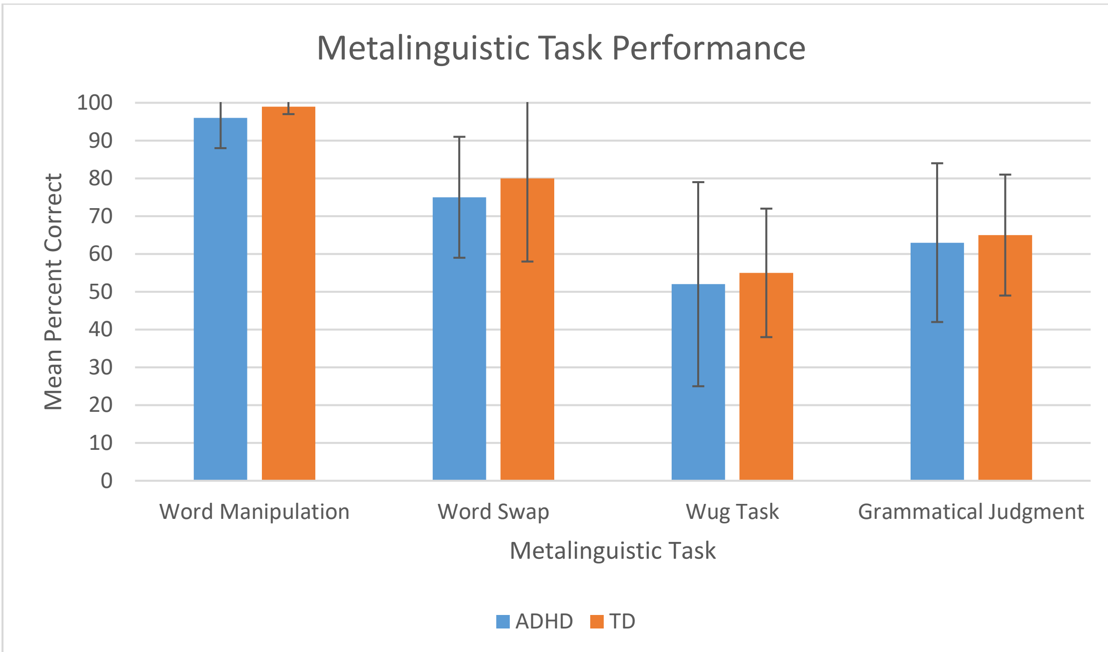
Metalinguistic Task Performance

Metalinguistic Task		**ADHD**	**TD**	***p*-value**	**Effect size (*d*)**
Task 1: Word Manipulation % Correct					
	Mean	96	99	.24	$d = 0.51$
	SD	8	2		

Min-Max	75-100	94-100		
Task 2: Word Swap % Correct				
Mean	75	80	.57	*d* = 0.26
SD	16	22		
Min-Max	50-100	38-100		
Task 3: Wug Task % Correct				
Mean	52	55	.78	*d* = 0.13
SD	27	17		
Min-Max	0-82	24-76		
Task 4: Grammatical Judgment % Correct				
Mean	63	65	.79	*d* = 0.11
SD	21	16		
Min-Max	31-100	46-100		

Figure 1

Metalinguistic Task Performance



As the different sentence subtypes of the grammatical judgment task assess different aspects of metalinguistic awareness, we also compared the ADHD and TD groups' performance on each of the sentence subtypes. There were no group differences in performance on the Grammatical/Meaningful sentences, $t(18) = .54$, $p = .60$, the Agrammatical/Meaningful sentences, $t(18) = .67$, $p = .51$, the Grammatical/Meaningless sentences, $t(18) = 0$, $p = 1.0$ or the Agrammatical/Meaningless sentences, $t(18) = .89$, $p = .38$. The effect size for each task ranged from low-moderate (Agrammatical/Meaningless, $d = 0.38$) to nonexistent (Grammatical/Meaningless, $d = 0$). This suggests that any group differences are of relatively small clinical significance.

Table 4

Grammatical Judgment Task Performance

Metalinguistic Task		**ADHD**	**TD**	***p*-value**	**Effect size (*d*)**
Grammatical/Meaningful % Correct					
	Mean	83	90	.60	*d* = 0.25
	SD	32	22		
	Min-Max	0-100	33-100		
Agrammatical/Meaningful % Correct					
	Mean	60	50	.51	*d* = 0.30
	SD	38	28		
	Min-Max	0-100	0-100		
Grammatical/Meaningless % Correct					
	Mean	48	48	1.0	*d* = 0
	SD	51	40		
	Min-Max	0-100	0-100		
Agrammatical/Meaningless % Correct					
	Mean	67	80	.38	*d* = 0.38

SD	35	32
Min-Max	0-100	0-100

Finally, we examined the relationships between cognitive, language, and metalinguistic performance for each of the study groups. In children with ADHD, we found no significant correlations between performance on the metalinguistic tasks and KBIT scores, nor between metalinguistic performance and BRIEF scores. However, we did find significant positive correlations between scores on the Recalling Sentences subtest of the CELF-4 and performance on the Word Swap task, $r(6) = .77$, $p = .03$, Wug Task, $r(6) = .77$, $p = .03$, and Grammatical Judgment Task, $r(6) = .82$, $p = .01$.

Table 5

Correlations of Metalinguistic Task Performance with Cognitive, Language, and Behavioral Characteristics of Children with ADHD

Task	**KBIT**	**Recalling Sentences**	**BRIEF (Inhibit)**	**BRIEF (WM)**	**BRIEF (GEC)**
Word Manip.					
Correlation	.19	-.42	-.20	-.15	-.31
p-value	.60	.30	.67	.72	.50
Word Swap					
Correlation	.42	**.77**	-.02	-.10	.12
p-value	.27	.03*	.97	.83	.81
Wug Task					
Correlation	.30	.77*	-.21	-.49	-.19

p-value	.41	.03*	.66	.26	.80
Gram. Judg.					
Correlation	.53	.82*	-.06	.01	.24
p-value	.11	.01*	.90	.99	.60

For the TD group, we found no significant correlations between performance on the metalinguistic tasks and KBIT scores, nor between performance and BRIEF scores. We found a significant positive correlation between scores on the Recalling Sentences subtest of the CELF-4 and performance on the Wug Task, $r(8) = .94$, $p < .001$.

Table 6

Correlations of Metalinguistic Task Performance with Cognitive, Language, and Behavioral Characteristics of TD Children

Task	**KBIT**	**Recalling Sentences**	**BRIEF (Inhibit)**	**BRIEF (WM)**	**BRIEF (GEC)**
Word Manip.					
Correlation	.10	-.01	-.06	-.28	-.08
p-value	.79	.97	.87	.43	.82
Word Swap					
Correlation	.28	.57	-.30	-.06	-.24
p-value	.43	.09	.40	.88	.50
Wug Task					
Correlation	.56	.94*	-.46	-.43	-.53

p-value	.09	<.001*	.18	.21	.11
Gram. Judg.					
Correlation	.25	.27	-.31	-.20	-.09
p-value	.48	.44	.38	.59	.81

Discussion

Our results indicated that there were no significant differences in the performance of children with ADHD and children with TD on four metalinguistic tasks assessing different components of metalinguistic skill. Parent reports on both the BRIEF and the experimenter-generated communication questionnaire indicated significant differences in executive function and receptive language characterized by greater concerns by parents of the children with ADHD. Thus, the current study suggests that children with ADHD do not show deficits in either metalinguistic control or metalinguistic analysis, despite reported weaknesses in both language and executive function. Children with ADHD did show weaker performance on each metalinguistic task, though not enough to reach the level of statistical significance. In general, the differences are small enough to suggest even with a significantly larger sample, any effect would be relatively minor. Additionally, children with ADHD had statistically significant correlations between the Recalling Sentences subtest and the Word Swap, Wug Task, and Grammatical Judgment Tasks. In contrast, for the TD children, the only significant correlation was between the Wug Task and Recalling Sentences. Children with ADHD seemed to have closer ties between their expressive language abilities and their metalinguistic task performance.

The sparsity of past studies in this domain makes comparison to existing literature difficult. Bialystok and Barac (2012) demonstrated a possible dissociation between the relevant skills. In their study, performance on metalinguistic tasks was linked to language proficiency, while performance on executive control tasks was linked to total time spent in an immersion program. Rather than there being a direct relationship between executive function, metalinguistic awareness, and language ability, it may be that executive function and metalinguistic awareness—while both related to language—are not directly related in themselves. The present study examined language skills, executive function, and metalinguistic skills in tandem, one of exceedingly few studies to do so. Unlike Bialystok and Barac, who examined an advantaged population, this study focused on a disordered population. Our findings suggest that language function, executive function, and metalinguistic ability do not all have a direct relationship with one another.

Though counterintuitive, these findings align with Bialystok and Barac's separation of correlations based on different aspects of language function. Executive function and metalinguistic performance were not as strongly correlated with one another in their work as with specific aspects of language (specifically, bilingual) experience. They suggested that representational structure is the aspect of language most important to metalinguistic performance, while certain domain-general systems that develop with time affect both language and executive function separately. This could explain the results we have obtained. Children with ADHD may have executive function deficits that are tied to certain language deficits, but not to metalinguistic deficits. They may have impairments in the kinds of domain-general systems Bialystok and Barac described as affecting executive function and specific aspects of language, but not in systems underpinning development of representational structure. This would correspond with Kim and Kaiser's

(2000) findings, that children with ADHD did not have significant deficits in vocabulary or grammatic understanding—representational structure, in other words—but showed impairment in the specific complex area of sentence imitation.

These results suggest that children with ADHD have minimal or no deficits in metalinguistic ability compared to typically developing peers. However, there are several study limitations that limit the generalizability of our findings.

Study Limitations

The present study has several limitations. First, our sample size was rather small, and while all children completed the main experimental (metalinguistic) tasks, not all children completed the Recalling Sentences portion of the CELF-4 or had the BRIEF or communication questionnaire completed by their parents. Our sample is also restricted to monolingual children aged 6-7, limiting the potential emergence of age-based or bilingual status interactions compared to previous work incorporating a larger range of ages or monolingual and bilingual children.

Second, the study is limited by a lack of formal and informal direct assessments of receptive language and executive function skills, to better compare both the groups and the various skills assessed. Future research including such tests, such as the full CELF-4 for language and tasks like the flanker task and dimensional card change sort task for executive function, should be more able to distinguish skill domains and connections between them in these groups. For example, it is possible that subtests of the CELF-4 assessing vocabulary would correlate more strongly with the Word Manipulation and Word Swap tasks, while subtests assessing grammatical skills would correlate more strongly with the Wug Task and Grammatical Judgment tasks.

Third, highly specified groups could prove valuable in future research endeavors. Past studies examining language impairment in children with ADHD have seemingly indicated that some children with ADHD meet criteria for language impairment, while some do not. Separating out children with both ADHD and language impairment from children with ADHD without language impairment could allow for differences to emerge more clearly. Additionally, it may be beneficial to divide children with ADHD based on their ADHD subtype. Several different subtypes of ADHD have been identified, varying in whether the presentation of the disorder primarily reflects inattentiveness, hyperactivity, or a combination, and children with different subtypes vary somewhat in their performance on executive function tasks (Nigg, Blaskey, Huang-Pollock, & Rappley, 2002). Identifying the subtypes in a group with ADHD may reveal differences in their performance.

Finally, the largest differences between groups are seen not on any of the experimental tasks or child measures, but on parent report forms. Parents indicated significant executive dysfunction, receptive language, and social language use concerns for children with ADHD as compared to TD children. This could be indicative of genuine differences in both executive function and language function, but it could demonstrate parental biases. Tannock and Schachar (1996) suggested that perceptions of children with ADHD are prone to biases; that it is often the case that certain behaviors (such as failure to follow instructions) may be falsely recognized as reflecting attention deficits when they may in fact reflect language deficits. However, the reverse may also hold. Parents may identify behaviors as language deficits that truly reflect attention deficits. Future research should include direct tests of receptive language and executive function to clarify this matter.

Study Conclusions

Children with ADHD do not appear to have any particular impairment in metalinguistic awareness or functioning, despite parent reports of executive dysfunction and receptive language difficulties. This study demonstrates the absence of a skill deficit in a population in which it may be expected. Given the results of the communication questionnaire, the study also demonstrates further evidence of a connection between ADHD and receptive language skills, supporting past findings of such a link. Future research should expand sample size and include formal assessments of executive function and receptive language skills, allowing for examination of groups in greater detail. Future research could also include more varied metalinguistic tasks.

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