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The role of executive functions in depression and attention-deficit/hyperactivity disorder (ADHD) symptomatology.

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Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that is characterized by symptoms of inattention, impulsivity, and hyperactivity that interfere with functioning in multiple areas of life (American Psychiatric Association, 2013). Individuals diagnosed with ADHD are more likely to experience comorbid depression symptoms. The present study examines the associations among ADHD symptoms, depression symptoms, and EF deficits with the aim of improving differential diagnosis. Parents of children aged 8-12 completed ratings of ADHD symptoms and children completed ratings of depression (N=27). Preliminary analyses document a positive relation between ADHD symptoms and EFs (p<.05). ADHD symptoms were unrelated to depression symptoms in the present study. Preliminary analyses document relations between specific depression symptoms (i.e., ineffectiveness) and specific EFs (i.e., working memory, planning/organization, and organization of materials). Clinical/research implications will be discussed.

Keywords: ADHD, depression, executive function

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that affects about 5% of children worldwide (American Psychiatric Association, 2013). ADHD is characterized by symptoms of inattentiveness, impulsivity, and hyperactivity that interfere with functioning in multiple areas of life and often persists into adulthood. For example, van Lieshout et al. (2016) found that 86.5% of study participants still met DSM-5 criteria for ADHD in late adolescence and young adulthood in a 6-year follow-up study. Without treatment, ADHD is related to many negative long-term outcomes, including behavioral, academic, and social problems (Shaw et al., 2012).

Children diagnosed with ADHD are also more likely to have other mental health/neurodevelopmental disorders than typically-developing children (Larson et al., 2010). Larson et al. found that 14% of children with ADHD experience comorbid depression compared to only 1% of children without ADHD having depression. A meta-analysis of diagnostic comorbidity of common child and adolescent psychiatric disorders by Angold et al. (1999) found that ADHD and depression had an odds ratio of 5.5, meaning that having ADHD puts you at 5.5 times greater odds of having depression. Biederman et al. (1995) addresses concerns that the diagnosis of comorbid ADHD/major depressive disorder (MD) is caused by diagnostic overlap, meaning diagnosing two disorders from the same set of symptoms or counting symptoms twice, by using two different methods to adjust for diagnostic overlap. They found that 70-97% of the children diagnosed with severe major depression maintained their diagnosis after adjusting for overlap with ADHD symptoms and 78-86% of those diagnosed with ADHD maintained their diagnosis after adjusting for overlap with depression symptoms. Understanding the extent to which ADHD symptoms are related to depression symptoms is particularly important, as there is evidence that children with comorbid ADHD/depression have more social and

psychopathological impairment than those with ADHD alone. For example, Blackman et al. (2005) found while children with ADHD were more impaired socially than non-ADHD subjects, regardless of depression diagnosis, those with ADHD and depression were even more socially impaired than those with ADHD alone. They also found that those with ADHD and depression were significantly more impaired in anxiety and depression than both the control group and the non-depressed ADHD group.

Presently, the etiology of ADHD and comorbid depression symptoms is unknown. Mick et al. (2003) found evidence that comorbid ADHD/MD is an etiologically distinct subtype in the families of girls with ADHD, but not in the families of boys with ADHD. For boys, ADHD and MD have common familial risk factors, but are influenced by non-familial environmental factors. Those with ADHD and comorbid depression have been found to have worse outcomes than those with ADHD alone (Blackman et al., 2005; Fischer et al., 2007) For example, those with ADHD and comorbid depression have greater social impairment (Blackman et al., 2005) and are more likely to have generalized anxiety disorder and social phobia (Fischer et al., 2007). Both ADHD symptoms and depression symptoms are related to deficits in executive functions (Wagner et al., 2011, Willcutt et al., 2005). EFs are control mechanisms that coordinate a number of separate but related complex cognitive processes that are used to guide everyday behavior (Miyake et al., 2000). EF-related processes include working memory, inhibition, emotional control, and organization/planning (Gioia et al., 2000).

Several models of ADHD propose that the symptoms of ADHD are associated with underlying deficits in executive functions (EFs; Barkley, 1997; Castellanos et al., 2006; Rapport et al., 2008). Working memory is one EF process/domain that is implicated in ADHD samples (Willcutt et al., 2005). According to Shah and Miyake (1999), working memory involves the

"control, regulation, and active maintenance of task-relevant information." A study by Rapport et al. (2008) found that boys with ADHD perform significantly worse on working memory tasks than boys without ADHD. Stevens et al. (2002) found that children with ADHD have deficits in inhibitory control compared with typically developing children. Inhibition is "withholding of responding, delayed responding, cessation of ongoing responses, and resisting distraction or disruption by competing events" (Barkley, 1997). A meta-analysis of EFs and ADHD found medium effect sizes for behavioral inhibition and ADHD (Willcutt et al., 2005).

Depression severity has been found to be associated with executive function impairments (Hawkey, 2017; McDermott and Ebneier, 2009; Wagner et al., 2011). For example, Wagner et al. (2011) found that executive function deficit was significantly related to depression status as compared with healthy controls. McDermott and Ebneier (2009) also found significant correlations between depression severity and executive function. There are very few studies that have examined relations between subscales of the Children's Depression Inventory (CDI) and executive functions. Cosi et al. (2011) investigated the relations between subscales of the CDI (e.g., anhedonia, negative mood, negative self-esteem, ineffectiveness, and interpersonal problems) with three factors of the Barratt Impulsiveness Scale-11 for children (BIS-11c; e.g., motor impulsivity, non-planning impulsivity, and cognitive impulsivity). All depression symptoms were significantly correlated with each of the three impulsivity factors, except negative mood was not significantly correlated with non-planning impulsivity. Kavanaugh and Holler (2014) examined the relations between the subscales of the CDI (e.g., anhedonia, negative mood, negative self-esteem, ineffectiveness, and interpersonal problems) and executive functions (e.g., planning/problem-solving, set-shifting/cognitive flexibility, response vinhibition/interference control, fluency, and working memory/simple attention). Other than

these two studies, researchers have defined depression globally by examining the relationship between a summative score depression severity. The present study is unique in that we attempt to understand the relations among a number of separate (but related) depressive factors and several EF domains (e.g., inhibition, set-shifting, emotional control, initiation, working memory, planning/organization, organization of materials, and monitoring).

The aim of this study is to investigate the relations between ADHD symptoms, depression symptoms, and executive functions. We expect to document a significant positive relationship between ADHD symptoms and depression symptoms, a significant positive relationship between ADHD symptoms and EF deficits, and a significant positive relationship between depression symptoms and EF deficits.

By examining these relations, we hope to gain a better understanding of the role of executive functions in both ADHD and depression symptoms. Knowing which EF deficits are common to both ADHD symptoms and depression symptoms and which are unique to each may improve differential diagnosis and the diagnosis of comorbid ADHD/depression.

Method

Participants

Thirty-six children between the ages of 8 and 12 were referred to the Behavior and Learning Lab at The University of Tennessee through the lab's website (www.behaviorandlearninglab.org) and through community and campus resources.

Measures

Executive function. The Behavior Rating Inventory of Executive Function (BRIEF) is an 86-item questionnaire given to parents and teachers that assesses the executive functions of children ages 5 through 18 through ratings of everyday behavior. We analyzed the global

executive composite (GEC) as well as the scores from each of the 8 subscales, Inhibition, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials and Monitor of the parent form of the BRIEF (Gioia et al., 2000). Gioia reported a Cronbach's alpha between .80 and .98 for BRIEF. Higher *T*-scores mean greater impairment.

ADHD symptoms. The Child Behavior Checklist (CBCL) is a 118-item checklists that assess for a broad range of symptoms in children ages 6-18. I analyzed the Attention Deficit/Hyperactivity Problems scale of the Child Behavior Checklist (CBCL). We chose this scale over the Attention Problems scale because it has been found to provide increased validity (Sisterè et al, 2014). The Attention Deficit/Hyperactivity Problems scale has a Cronbach's alpha of .85 (Nakamura et al. 2009). A *T*-score above 70 is in the clinical range (Shahid et al., 2011).

Depression symptoms. The Children's Depression Inventory (CDI) is a 27-item assessment of depressive symptoms in children between the ages of 7 and 17 (Kovacs, 2011). We analyzed the CDI total score and the following subscales: negative mood/physical symptoms, negative self-esteem, ineffectiveness, interpersonal problems. A meta-analysis of the reliability of the CDI found that the mean Cronbach's alpha for the total score of the CDI was .831 (Sun and Wang, 2015). *T*-scores between 65 and 69 are in the "Elevated" range and scores higher than 70 are in the "Very Elevated" range (Kovacs, 2011).

Procedure

Parents interested in the study completed a telephone screen consisting of questions from the Attention Deficit/Hyperactivity Disorder and Oppositional Defiant Disorder sections of the Child Symptom Inventory-4. Parents were mailed a package which included the BRIEF, the CBCL, and the TRF. Parents were instructed to complete the BRIEF and the CBCL and mail them back to the Behavior and Learning Lab. They were instructed to deliver the TRF to the

child's teacher who completed the measure and then mailed it to the Behavior and Learning Lab. After the packets were received by the research them, an appointment was made for the child and parent to visit the lab or the family was placed on the waitlist. Children participated in 4-6, 2-hour sessions, with breaks to reduce fatigue, where they completed computer-based tasks and formal assessments, including the CDI. Children with faster processing speed were about to complete the tasks in fewer sessions than those with slower processing speed. Children were informed that they could ask the research assistant to read the questions to them if they didn't understand or had difficulties reading. After completing all the sessions, parents were debriefed and given a written comprehensive report summarizing the findings from all the assessments.

Results

Bivariate correlations were utilized to examine the associations among ADHD symptoms, depression symptoms, and EFs deficits. We documented a nonsignificant relation between overall depression severity and ADHD Problems (r = .255, p = .199). We documented a significant positive relationship between ADHD Problems and our global EF measure (r = .707, p <.001). Our overall depression severity measure was not significantly related to the global EF measure (r = .139, p = .500). The relationship between the Ineffectiveness subscale and our global EF measure was nonsignificant yet trending (r = .377, p = .058) toward significance. Ineffectiveness was not significantly correlated with the Inhibit, Shift, Emotional Control, Initiate, or Monitor subscales. Ineffectiveness was significantly correlated with BRIEF Working Memory (r = .433, p = .027), Plan/Organize (r = .393, p = .047), and Organization of Materials (r = .493, p = .010) subscales.

Table 1

Means, standard deviations, and bivariate correlations among study variables

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1.	ADHD Problems	__														
2.	Depression Total	.255	__													
3.	Neg. Mood/Phys. Symp.	.348	.841**	__												
4.	Neg. Self Esteem	-.059	.824**	.581**	__											
5.	Ineffectiveness	.295	.791**	.471**	.525**	__										
6.	IntPersonal Prob.	.123	.776**	.632**	.661**	.432**	__									
7.	Global EF Deficits	.707**	.139	.093	-.111	.377	-.010	__								
8.	Inhibit	.592**	.228	.267	.027	.280	.058	.736**	__							
9.	Shift	.572**	.078	.100	-.088	.210	-.036	.827**	.497**	__						
10.	Emot. Control	.465**	.046	.094	-.045	.110	-.041	.664**	.512**	.809**	__					
11.	Initiate	.580**	-.132	-.215	-.329	.208	-.126	.859**	.543**	.645**	.442**	__				
12.	WM	.642**	.127	.010	-.144	.433*	.009	.876**	.543**	.579**	.307	.839**	__			
13.	Plan/Organize	.567**	.092	.011	-.172	.393*	-.026	.852**	.484**	.603**	.299	.783**	.878**	__		
14.	Org. Materials	.353	.325	.217	.092	.493*	.157	.608**	.408*	.374*	.110	.529**	.664**	.587**	__	
15.	Monitor	.779**	.106	.125	-.123	.256	-.036	.867**	.575**	.648**	.473**	.711**	.808**	.798**	.473**	__
Mean		62.97	54.59	54.44	54.96	54.25	53.30	52.26	59.17	59.08	57.22	60.56	66.03	63.58	60.19	59.47
Standard Deviation		8.54	12.10	12.89	12.33	11.58	11.46	12.29	14.54	15.14	16.25	12.36	13.55	12.86	8.66	14.19

Note. ADHD Problems = The Child Behavior Checklist (CBCL) Attention Deficit/Hyperactivity Problems *T* score Depression Total = The Children's Depression Inventory (CDI2) Total *T* score; Emot. Control = BRIEF Emotional Control *T* score; Global EF Deficits = BRIEF Global Executive Composite (GEC); Ineffectiveness = CDI Ineffectiveness *T* score; Inhibit = BRIEF Inhibit *T* score; Initiate = BRIEF Initiate *T* score; IntPersonal Prob. = CDI Interpersonal Problems *T* score; Monitor = BRIEF Monitor *T* score; Neg. Mood/Phys. Symp. = CDI Negative Mood/ Physical Symptoms *T* score; Neg. Self Esteem = CDI Negative Self Esteem *T* score; Org. Materials = BRIEF Organization of Materials *T* score; Plan/Organize = BRIEF Plan/Organize *T* score; Shift = BRIEF Shift *T* score; WM = BRIEF Working Memory *T* score. $^{**}p<.001$ $^{*}p<.05$.

Discussion

In this study, we examined the relations among ADHD symptoms, depression symptoms, and EFs. While many studies have focused largely on either the relation between ADHD and depression or the relation between EFs and both depression and ADHD, very few studies have investigated the relation between EFs, ADHD symptoms, and depression symptoms together. We aimed to gain insight into the similarities and differences of executive function in relation to both ADHD symptoms and depression symptoms in hopes of informing diagnosis of both disorders as well as ADHD with comorbid depression.

Our findings suggest a nonsignificant relation between depression symptoms and ADHD symptoms in the present study. This finding is inconsistent with the literature. A meta-analysis of diagnostic comorbidity by Angold et al. (1999) found depression and ADHD to be related. Larson et al. (2011) found that only 1% of children without ADHD had depression, while 14% of children with ADHD had depression. A study by Roy et al. (2017) found that 37.5% of the sample that was diagnosed with ADHD at T1 had developed depression by T4, about 8 years later. It is possible that the use of a non-clinical sample contributed to the non-significance of the relationship in the present study. Only 5 out of the 27 (18.5%) participants had a *T* score in the "Elevated" or "Highly Elevated" range, and only 6 out of the 27 (22.2%) participants had a *T* score in the clinical range. The relationship between ADHD symptoms and depression symptoms is likely stronger for samples with more severe symptoms. The non-significant finding could also be due to our small sample size. A total of 27 participants are included in the sample. This small sample size causes decreased statistical power, meaning the analysis is less likely to find a

statistically significant relationship than an analysis with a larger sample size. The small sample size also makes it more difficult to detect relationships with smaller effect sizes.

Additionally, our preliminary analysis found that depression symptoms were not related to global EF deficits. This finding is inconsistent with existing literature. Han et al. (2016), for example, found that adolescents with higher levels of global EF deficits had significantly more depressive symptoms. Wante et al. (2017) found that EF impairment (measured by the BRIEF) was positively correlated with depressive symptoms (measured by the CDI). Our findings may be due to the use of a small sample size. Future research should examine the relation among depression symptoms and EF deficits with a larger sample. While we did not document a relation between EF defined broadly and depression, we documented that ineffectiveness was significantly related to working memory, planning/organization, and organization of materials. Ineffectiveness is measured by asking children to choose the sentence that describes them best in the past two weeks, with three choices for each question. The sentences that indicate ineffectiveness are “I do everything wrong”, “Nothing will ever work out for me”, “I have to push myself all the time to do my schoolwork”, “I do very badly in subjects I used to be good at”, and “I can never be as good as other kids” (Kovacs, 2011). Franova et al. (2008) found that ineffectiveness had the highest correlation of CDI subscales with school performance (r = 0.29). Working memory, planning/organization, and organization of materials have been found to be related to poor academic performance (Gathercole et al., 2008; Kroesbergen et al., 2003; Langberg et al., 2011; Mahone et al., 2002). It is possible that deficits in working memory, planning/organization, and organization of materials leads to poor academic performance which in turn leads to ineffectiveness. Future research should further investigate this possibility.

Our preliminary analysis found that ADHD symptoms were related to overall EF deficits. This finding is consistent with existing literature. This finding is consistent with the literature. Toplak et al. (2008) found that the executive function deficit was significantly higher for participants with ADHD than for participants without ADHD. Semrud-Clikeman et al. (2010) found a significant relationship between ADHD symptoms and overall EF deficits. The relationship found in the present study between ADHD symptoms and EF deficits is unique because we used a non-clinical sample. The strong effect and strong significance of this relationship in a community sample provides evidence for the pervasiveness of this relationship.

It is important to improve our understanding of the relation between ADHD and depression so that we may increase proper diagnosis of comorbid ADHD/MDD and decrease misdiagnosis of ADHD as depression or depression as ADHD. Children with comorbid ADHD/MDD, for example, may require different treatment than children with either disorder alone. Sobanski and Alm (2007) found that adults with ADHD and depression symptoms benefitted significantly less than adults with ADHD without depression symptoms from the treatment of the stimulant medication, methylphenidate. Hornig-Rohan and Amsterdam (2002) found that 80% of their patients with comorbid ADHD/MDD who were treated with both an antidepressant and a stimulant saw reduced ADHD and MDD symptoms, whereas only 33% of the patients with comorbid ADHD/MDD who were treated with stimulant medication alone saw reduced ADHD and MDD symptoms. Many parents believe their child may have ADHD because of poor school performance which is related to both ADHD and depression (Frojd et al, 2008; Loe & Feldman, 2007). Because restlessness and inattention can be symptoms of both ADHD and depression, it can sometimes be difficult to determine if the child has ADHD, depression, or both (American Psychiatric Association, 2013). Examining executive function

deficits may help providers with diagnoses. If the child only has deficits in Working Memory, Planning and Organization, and Organization of Materials, but not in any other executive function, this may be a sign that the symptoms are due to depression and not ADHD. Future research should compare differences in EF deficits of children/adolescents with ADHD, depression, and comorbid ADHD.

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