Examining Differences in Executive Functioning in ADHD and Anxiety in an ODD Sample

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ABSTRACT

Executive functioning (EF) has been gaining attention recently in the area of child psychopathology and EF deficits have been hypothesized to be present in a variety of these disorders. Children with Oppositional Defiant Disorder (ODD), Attention Deficit/Hyperactivity Disorder (ADHD), and anxiety disorders (AD) all experience difficulties at home, with friends, and at school, some of which may be related to deficits in EF. The proposed study is designed to determine whether specific EF deficits are associated with ADHD and AD when they are comorbid with ODD. Children recruited for an ODD treatment study completed an emotional Stroop task and their mothers completed the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000). The present study included 49 children with ODD who had comorbid ADHD (n = 22) or comorbid AD (n = 27), but not both. The ODD/ADHD group exhibited significantly more EF deficits on the MI than the ODD/AD group when gender and corresponding symptoms of ADHD and AD were controlled for. However, no significant differences were found on the emotional Stroop or the BRI scale of the BRIEF suggesting that EF deficits may not be clearly differentiated in samples of ADHD and AD youth who are also comorbid with ODD. It is recommended that future studies explore executive dysfunction in pure ODD, ADHD, and AD samples to better identify possible differences that might be useful in designing interventions for children who have EF deficits associated with these disorders.

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1.0 – Introduction

Although the causes of childhood disorders are complex and difficult to determine, researchers are investigating several areas that may be related to the underlying processes involved in the development of various child psychopathologies at this time. For instance, executive function (EF), defined in the cognitive literature as consisting of an individual's ability to mental set shift, update and monitor information, and inhibit prepotent responses, has been hypothesized to be deficient in a variety of disorders, including autism spectrum disorder, traumatic brain injury, Attention-Deficit/Hyperactivity Disorder (ADHD), Oppositional Defiant Disorder (ODD), and the anxiety disorders (AD) (Greene & Doyle, 1999; Miyake, Friedman, Emerson, Witzki, et al., 2000; Smith, Barkley & Shapiro, 2007; Toren, Sadeh, Wolmer, Eldar, et al., 2000). Executive function has many components but some of the most clinically important components include nonverbal working memory, verbal working memory, self-regulation of emotional states, and planning (Smith et al., 2007). Nonverbal working memory is the ability to maintain primarily visuospatial information in mind while performing motor tasks while verbal working memory is the ability to store and mentally rehearse auditory information in order to subsequently recall that information. Self-regulation of emotional states is defined as the ability to modulate emotions and motivation in order to initiate behaviors or to achieve goals. Finally, planning is the ability to incorporate previous experiences or concepts into a plan of action in solving problems (Smith et al., 2007).

1.1 – Executive Function Brain Processes

Executive function is thought to be controlled in the prefrontal cortex (PFC), where information from other parts of the brain such as the amygdala and limbic systems (emotion) are regulated through cognitive processes. Importantly, recent research has focused on the connection between executive function and emotion regulation. Specifically, executive functions and emotion regulation have similar underlying brain processes suggesting that they may be related to one another. For instance, the prefrontal cortex (PFC) has been shown to be involved not only with cognitive (executive function) and emotional processes (emotion regulation) but also with effortful attentional control (Calkins & Marcovitch, 2010). In addition, Bell and Wolfe (2004) proposed that the underlying neural processes involved in emotion and cognition may be the same, in that the anterior cingulate cortex (ACC) is responsible for processing both cognitive

and emotional information. The PFC and ACC are important in child development, with deficits in self-regulation possibly contributing to childhood disorders such as oppositional defiant disorder (ODD), ADHD, and the anxiety disorders (AD). Examining the differences in symptomatic presentations and executive function deficits are important in understanding the underlying psychopathology and in accurately diagnosing these disorders in children.

1.2 – EF Deficits in ODD

Children with oppositional defiant disorder (ODD), by definition, display behaviors such as losing their temper, being argumentative, defying or refusing to do what they are told, and being grouchy or easily annoyed (APA, 2000). Prevalence estimates for children with ODD range from 2% to 16%, with the wide variation due to ascertainment methods and inconsistent diagnostic criteria (Lahey, Miller, Gordon, & Riley, 1999; Nock, Kazdin, Hiripi, & Kessler, 2007). Children diagnosed with ODD are thought to have executive function deficits in that they have difficulty with self-regulation of their behaviors and emotions. For instance, studies with children with ODD or children evincing high rates of physical aggression have shown these children to have difficulties in the areas of attention, working memory, planning, and inhibition (Drabick, Gadow, & Loney, 2007; Seguin, Boulerice, Harden, Tremblay, & Pihl, 1999). In addition, it has been suggested that children with ODD may have difficulties with the executive function of shifting sets. That is, the children may not be able to shift efficiently from the rules and expectations of one situation to the rules and regulations in a different situation. These children are often inflexible and rigid when asked to adapt to new environments (e.g., from home to school or from recess activities to classroom instruction). This deficit in shifting sets in addition to deficits in working memory and planning can contribute to a child's development of ODD if the caregivers or teachers are intolerant of the delay in response to requests or demands (Greene & Ablon, 2006).

1.3 – EF Deficits in ADHD

Although children with ODD may experience difficulties with deficits in executive functioning, an equally important question concerns whether children with ODD who are comorbid with other disorders experience similar or different deficits. The prevalence of comorbidity between ODD and ADHD is estimated to be close to 35% (Nock, Kazdin, Hiripi, & Kessler, 2007). Children with ADHD experience difficulties sustaining attention in everyday

activities and in inhibiting impulsive or overly active behaviors when it is necessary to do so. Researchers have begun to investigate executive function deficits in comorbid ADHD/ODD youth. For example, Qian et al. (2010) found in a study of Han Chinese children that children with comorbid ADHD/ODD showed more severe executive dysfunction in everyday life than children with ADHD alone. More specifically, parents rated children diagnosed with both ADHD and ODD as worse on inhibition, shifting, and emotional control than parents of children diagnosed with only ADHD on the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000). In addition, Oosterlaan and colleagues (2005) measured verbal fluency, working memory, and planning ability in children with ADHD, ODD/CD, and comorbid ADHD+ODD/CD. They found that ADHD was associated with added deficits in planning and working memory but not verbal fluency. Although results of their study indicated that ADHD, ODD/CD, or the comorbid ADHD+ODD/CD diagnoses did not help explain performance differences on the verbal fluency tasks, they showed that the presence of ADHD was responsible for executive function deficits in children with comorbid ADHD and ODD/CD.

1.4 – EF Deficits in Anxiety Disorders (AD)

In addition to children with comorbid ODD and ADHD, children with comorbid ODD and the anxiety disorders (AD) also experience difficulties related to deficits in executive functioning. The comorbidity of ODD and AD is estimated to be close to 60% (Nock et al., 2007). Research has also investigated specific deficits in the area of anxiety comorbid with ODD. For instance, Drabick, Ollendick, and Bubier (2010) have suggested two possible models for executive functions in children with comorbid AD and ODD; they suggest that AD can either mitigate or exacerbate the symptom presentation in children with ODD. They suggest that the possible underlying neural substrate of either outcome resides within the child's prefrontal cortex (PFC) and limbic system, in that children may have difficulties in self-monitoring, emotion control, and selection of appropriate behaviors if the PFC fails to regulate the limbic system's functioning (Drabick et al., 2010).

While these proposed ODD plus AD models are useful conceptually, few studies have attempted to test them empirically within comorbid ODD/AD samples. However, some research has been done regarding executive function deficits in children with anxiety disorders only. For

instance, Thorell and colleagues (2004) investigated the area of inhibition in relation to the development of social anxiety and found that high levels of inhibition significantly predicted social anxiety in children. In addition, Toren and colleagues (Toren, Sadeh, Wolmer, Eldar, et al., 2000) investigated possible deficits in working memory, shifting, and organizational abilities in children with anxiety compared to normal children. They found that the children with AD had more perseverative responses on the Wisconsin Card Sorting Task (WCST) following negative feedback, suggesting that they have more difficulty in shifting their attention and focus away from the negative feedback.

1.5 – EF Measures

As the area of executive function deficits becomes more clearly defined and implicated in the diagnosis of various disorders, consideration must also be extended to the measures used for such purposes. Oosterlaan and colleagues (2005) suggest that only tests that challenge the PFC should be included as measures of executive function as that is the area of the brain primarily associated with executive functions. Consequently, they used the Controlled Oral Word Association Test to measure verbal fluency, the Tower of London task to measure planning, and the Self-Ordered Pointing Task to measure working memory (Oosterlaan, Scheres, & Sergeant, 2005). In contrast, Qian et al. (2010) used the Behavior Rating Inventory of Executive Function (BRIEF), which is an ecologically valid test completed by parents or teachers that measures everyday executive function in children (Gioia, Isquith, Guy, & Kenworthy, 2000). The BRIEF has two subscales: the Behavioral Regulation Index (BRI) and the Metacognition Index (MI). The BRI represents a child's ability to shift cognitive sets and to display appropriate inhibitory control in modulating emotions and behavior. The MI represents the child's ability to initiate, plan, organize, and maintain future-oriented problem solving in working memory. As such, the BRIEF has proven to be useful in the assessment of ADHD (McCandless & O'Laughlin, 2007). Additionally, Qian et al. (2010) used the more commonly administered performance-based measures of executive function, such as the Stroop Color-Word Test, measuring inhibition; the Trail-Making Test, measuring shifting; the Digit span test from the Wechsler Intelligence Scale for Children (WISC), measuring verbal working memory; and the Tower of Hanoi task, measuring planning.

1.6 – Stroop Task

The Stroop task, specifically, has been used in a number of ADHD and AD studies, with responses being attributed to attention biases or cognitive processing biases (e.g., Macleod, 2005; Nightingale, Field, & Kindt, 2010; Qian et al., 2010; Schneider, Unnewehr, In-Albon, & Margraf, 2008; and Sideridis, 2009). The Stroop task varies from study to study, but the general concept is that children are required to read the names of colors in letters that are either congruent or incongruent with the color being named (e.g., reading "blue" written in blue ink or reading "blue" written in red ink). Children are observed to exhibit the Stroop interference effect if the amount of time it takes to name the incongruent color-word pair is longer than the congruent color-word pair (Macleod, 2005). A variation on this task is the emotional Stroop task where children are asked to respond to emotion words (e.g., sad) or neutral words (e.g., cat) and interference is observed on emotion words that are salient to the child (Nightingale, Field, & Kindt, 2010; Sideridis, 2009). The emotional Stroop task can be conceptualized as one that challenges a child's executive functions (i.e., inhibition) as well as emotion regulation abilities in order to show that cognitive interference (i.e., the Stroop effect; Stroop, 1935) occurs for children who have salient emotional reactions to the words or difficulties inhibiting responses (Nightingale et al., 2010).

1.7 – Current Study

As a result of the discrepancies in the literature regarding which aspects of executive functioning are associated with ADHD, AD, and ODD, there is a need to further examine these deficits in children with the single disorders as well as the comorbid diagnoses. Also missing from the literature is whether any executive function deficits are specific to one disorder or characteristic of all of them more broadly. In addition, no empirical studies have been conducted with children with comorbid ODD and AD that measure specific executive function deficits. In this way, the current study aims to investigate whether the deficits present in children with comorbid ODD/ADHD are different from the deficits in children with comorbid ODD/AD.

Based on previous research, children with ADHD seem to have more difficulty in the area of the traditional definition of executive function, concerning working memory, organization, planning, and monitoring (Oosterlaan et al., 2005). In addition, children with AD appear to have more difficulty with regulating emotions and shifting attention, especially in

situations with perceived threats (Drabick et al., 2010). Specifically, using the emotional Stroop task and the BRIEF (parent report) as performance-based and ecologically valid measures of executive function, it was predicted that children with ODD/ADHD would experience interference (i.e., slower response times) on words related to ADHD and ODD, while children with ODD/AD would experience interference on words related to anxiety and ODD. In addition, it was predicted that children with ODD/ADHD would have executive function deficits in the area of metacognition (initiate, working memory, plan/organize, organization of materials, monitor) whereas children with ODD/AD would have more pronounced deficits in the area of behavioral regulation (inhibit, shift, emotional control) on the BRIEF.

2.0 – Method

2.1 – Participants

The sample for the present study includes 49 children (a) who met diagnostic criteria for ODD and either ADHD (n = 22) or anxiety (n = 27) but not both, (b) who completed the Emotional Stroop Task with at least 80% valid responses, and (c) whose parents completed the Behavior Rating Inventory of Executive Function (BRIEF). In the total sample, the mean age was 10.09 years (*SD* = 1.81) with 30 males (61.2%) and 19 females (38.8%). Regarding ethnicity, 45 (91.8%) children were Caucasian, 2 (4.1%) were African American, 1 (2.0%) was Hispanic and 1 (2.0%) was classified as "Other." In the ODD/ADHD group, the mean age was 10.23 years (*SD* = 1.82) with 14 (63.6%) males and 8 (36.4%) females. This group had 20 (90.9%) children who were Caucasian and 2 (9.1%) children who were African American. In the ODD/AD group, the mean age was 9.98 years (*SD* = 1.82) with 16 (59.3%) males and 11 (40.7%) females. The ODD/AD group had 25 (92.6%) children who were Caucasian, 1 (3.7%) child who was Hispanic, and 1 (3.7%) child who was classified as "Other."

A power analysis was conducted for the proposed study using G*Power 3.1.2. When a power of 0.8, an alpha level of .05, and a large effect size were specified for a 2-group analysis of variance, a sample size of 42 (21 in each group) was indicated. Therefore, with the present sample of 49, there was sufficient power to detect only large effects. However, to detect medium effects, a sample size of 102 (51 in each group) would be needed. This number of participants was not available for the current study.

2.2 – Measures

2.2.1 – Anxiety Disorders Interview Schedule for DSM-IV (ADIS-IV)

The Anxiety Disorders Interview Schedule for DSM-IV, Child and Parent Versions (ADIS-C/P; Silverman & Albano, 1996) are semi-structured interviews designed for the diagnosis of most psychiatric disorders seen in childhood and adolescence. During the interview, the clinician assesses symptoms and obtains frequency, intensity, and interference ratings (0–8 scale). These symptoms and ratings are used by the clinician to identify diagnostic criteria and develop a clinician's severity rating (CSR). A CSR of 4 or above (0-8) indicates a diagnosable condition. It should be noted that the ADIS assesses for ADHD and AD in both schedules but only in the parent interview for CD and ODD.

Recent examination of the ADIS-C/P (for *DSM-IV*) has yielded acceptable to excellent 7 to 14-day test-retest reliability estimates regarding child (ages 7–16; κ = .61–.80) and parent (κ = .65–1.00) diagnoses for those diagnoses assessed on the ADIS (Silverman, Saavedra, & Pina, 2001). Interrater agreement analyses of earlier versions of the ADIS-C/P have shown some variability in video (κ = .45–.82; Rapee, Barrett, Dadds, & Evans, 1994) and live observer paradigms (κ = .35–1.00; Silverman & Nelles, 1988), but in general, acceptable interrater agreement has been established, again for all specific diagnoses assessed by the ADIS. Trained graduate-student clinicians with who were enrolled in an American Psychological Association-approved doctoral program in clinical psychology conducted the diagnostic interviews.

2.2.2 – Diagnostic Interview Schedule for Children – Version IV (DISC-IV)

The Diagnostic Interview Schedule for Children—Version IV (DISC–IV; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000), a comprehensive, structured diagnostic instrument that is based on the *Diagnostic and Statistical Manual–IV* (*DSM–IV;* American Psychiatric Association, 2000), was also administered. The interviewee provides yes/no answers to questions regarding symptoms of most psychological disorders observed in children and adolescents. Questions also explore how much the endorsed symptoms interfere in the child's life. Diagnoses are then derived from a structured algorithm that includes the symptom counts, interference levels, and other relevant *DSM–IV* criteria. The DISC–IV is one of the most extensively studied diagnostic interviews in child psychopathology research and is frequently used as a gold standard for providing concurrent validity to other diagnostic measures (e.g., Dewey, Kaplan, Crawford, & Fisher, 2001). In addition, Friman et al. (2000) provided external evidence of the validity of the Oppositional Defiant Disorder (ODD) module of the DISC–IV. Indeed, the DISC–IV is the most commonly used diagnostic tool in the diagnosis of ODD, CD, and ADHD among children and adolescents (Frick & McMahon, 2008; Johnston & Mah, 2008).

The parent version of the DISC–IV can be administered to parents of children between the ages of 6 and 17 years old. The DISC–IV provides a tally of endorsed symptoms, as well as frequency estimates as endorsed by the parents. In addition, the DISC–IV also includes items that ask parents to determine how much the child's symptoms interfere with family activities, friendships, and the child's academic performance. Scoring the DISC–IV and assigning diagnoses are accomplished by following guidelines provided by the diagnostic algorithm, which

incorporates the number of symptoms endorsed with the duration and frequency of the symptoms. It is noteworthy that the algorithm does not utilize the impairment items; however, the instructions for scoring the DISC–IV do include suggestions for different ways to include this additional information.

2.2.3 – Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4)

The Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4) is a measure of receptive language ability and a screener of verbal ability (Dunn & Dunn, 2007). Children are shown four pictures and asked to identify which one corresponds to a specific word read by the examiner. The test yields raw scores, standard scores, and age equivalents. More than 5,500 individuals were tested in the standardization process, with data from 4,000 used for the normative scores. The remaining data were used in validation studies. The norm sample matches the current U.S. population in terms of sex, race/ethnicity, geographic region, socioeconomic status (SES), and clinical diagnosis or special-education placement. The PPVT-4 was used as a proxy for intelligence.

2.2.4 – Behavior Rating Inventory of Executive Function (BRIEF)

The Behavior Rating Inventory of Executive Function (BRIEF) is an ecologically valid measure of executive function (Gioia et al., 2000). The BRIEF is an 86-item parent and teacher rating scale of executive functioning skills in children ages 5 to 18. The measure produces two summary index scores (Behavior Regulation Index, Metacognition Index) composed of eight scales measuring the basic components of executive functioning and an overall executive composite score (Global Executive Composite). Higher scores on the BRIEF indicate greater executive dysfunction, with T scores at or above 65 having potential clinical significance. The Behavioral Regulation Index (BRI) represents a child's ability to shift cognitive sets and to display appropriate inhibitory control in modulating emotions and behavior. The BRI is composed of the following subscales: Inhibit, Shift, and Emotional Control. The Inhibit scale is designed to assess the child's ability to stop behaviors at appropriate times. Shift assesses the child's ability to move from one situation or activity to another as circumstances require. Emotional Control is designed to measure the child's ability to regulate emotional responses. In addition, the Metacognition Index (MI) represents the child's ability to "cognitively self-manage tasks, monitor his or her performance [and] actively problem solve in a variety of contexts"

(Gioia et al., 2000). It includes the subscales of Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor. Initiate measures the child's ability to begin tasks independently or generate ideas or problem-solving strategies. Working Memory is designed to assess the child's ability to hold information in mind in order to accomplish a task. Plan/Organize measures the child's ability to manage current and future-oriented task demands. Organization of Materials assesses the child's ability to keep work and play spaces organized. Monitor assesses whether a child checks over work for accuracy after completing a task. Finally, the Global Executive Composite Score (GEC) is a summary score that incorporates all eight clinical scales of the BRIEF. Higher ratings on the BRIEF are indicative of greater perceived impairment of the child's executive functioning. Gioia et al. (2000) report test-retest reliability of .79 to .88 over a 2-week period. Internal consistency is reported to range from .80 to .98.

2.2.5 – Emotional Stroop Task

The Emotional Stroop task was presented on either a Dell Optiplex GX270 computer (15" screen) or a Dell Latitude C540 laptop (14.1" screen). Both computers used Windows XP as the operating system. Each computer's keyboard was used to record color-naming response latency and accuracy. Stickers with the colors red, blue, green, and yellow were attached to the V, B, N, and M keys, respectively. Negative disorder-specific words were generated by the research team. Four disorder domains were selected: attention-deficit/hyperactivity disorder (ADHD), depression, anxiety, and oppositional/conduct problems; however, only three disorder domains were examined in this study: ADHD, anxiety, and oppositional/conduct problems. Six negative disorder-specific words were selected for each problem area. Control words were generated using The American Heritage Word Frequency Book (Carroll, Davies, & Richman, 1971) and were matched to the negative disorder specific words on the number of syllables, the number of letters, and the frequency in which the words appeared in 3rd - 5th grade level reading materials. Control words were selected with the theme of animal names in an attempt to choose a word type with a neutral valence. The final word list contained 24 negative disorder-specific words (e.g., sad and crying for depression; anxious and nervous for anxiety) and 24 matched control words (e.g., rabbit, butterfly, monkey). (See Appendix A for a list of the words used in this study.)

Color (i.e., red, blue, green, or yellow) was randomly matched to each of the 48 words, so each child viewed the same color-word combination during the task. The order of each color-word combination was randomized for each presentation period (i.e., practice and actual task). First, the Stroop software presented ten randomly selected practice words until the child clearly understood the task. All children viewed the same set of practice words. The computer then presented the 48 negative disorder-specific and control words in random order. Following the color-naming task, the computer program repeated the presentation of the stimulus words in random order but without color variation (i.e., all words were in white letters on a black background). Children read the words aloud and pressed the space bar after he or she read each word. The experimenter recorded whether the child was able to read the word accurately.

Color-naming times were excluded from the analyses if the response latency for color naming was less than 100 ms or greater than 3000 ms (see Segal et al., 1995). Also, children who had invalid responses on over 20% of their trials were excluded from analyses. The interference scores for negative disorder-specific words were calculated by subtracting each child's response time for the control words from the negative disorder-specific words.

2.3 – Procedure

Children included in the present study were recruited from the New River and Roanoke Valleys for a larger treatment study for children with ODD (Ollendick & Greene, 2007). The children ranged in age from 7-13 years old and met diagnostic criteria for ODD as measured by the Anxiety Disorders Interview Schedule for DSM-IV (ADIS-IV) and the Diagnostic Interview Schedule for Children (DISC-IV), both of which were administered during a pre-treatment assessment. Children who were diagnosed with mental retardation or pervasive developmental disorders as well as children with psychotic symptoms or suicidal ideations were excluded from the study.

2.4 – Data Analysis

To test the first hypothesis regarding Stroop interference effects for the ODD/ADHD group on ADHD words and the ODD/AD group on anxiety words, analyses of variance (ANOVAs) were conducted. The interference scores for negative disorder-specific words were calculated by subtracting each child's response time for the control words from the negative disorder-specific words. That is, the mean reaction time for the ADHD control words were

subtracted from the mean reaction time for the ADHD words, and the same calculation was conducted for the anxiety words and ODD words. A positive interference score represents color-naming interference where response times were greater for the disorder words than those produced by the neutral control words. A negative interference score indicates that the control words created more color-naming interference than the experimental words.

The second hypothesis stated that children with ODD/ADHD would have executive function deficits primarily in the area of metacognition (initiate, working memory, plan/organize, organization of materials, monitor) whereas children with ODD/AD would have deficits primarily in the area of behavioral regulation (inhibit, shift, emotional control) on the BRIEF. This hypothesis was tested by conducting a multivariate analysis of variance (MANOVA) with the two subscales on the BRIEF to determine any significant group differences on this measure.

3.0 – Results

Means and standard deviations for the study variables are presented in Table 1 for the full sample as well as for the ODD/ADHD and ODD/AD groups separately. First, one-way ANOVAs were used to compare the two groups on age and PPVT standard scores. Additionally a Chi Square test was computed to determine if gender differed across the two groups. Next, a MANOVA was used to compare the groups on the MI and BRI from the BRIEF and ANOVAs were used for the three Stroop interference scores.

The ANOVA and MANOVA analyses did not reveal any significant group differences on the study variables. However, there was a trend for group differences on the MI between the ODD/ADHD group and the ODD/AD group such that the ODD/ADHD group had a higher mean score than the ODD/AD group indicating greater dysfunction. Further, results of the Chi Square analyses revealed that the groups did not differ by gender χ^2 (1, N = 49) = 0.98, p = .75. However, given some gender differences in ADHD, AD, and ODD in the literature, gender comparisons were made on the study variables. These analyses revealed significant gender effects for PPVT and MI, with females scoring lower on the PPVT than males but scoring higher on the MI than males. Because these gender effects were present, ANCOVAs were conducted controlling for gender. When controlling for gender, a significant main effect for group status was obtained on the MI $F(1, 48) = 4.89$, $p < .05$, with the ODD/ADHD group having significantly higher MI scores than the ODD/AD group (adjusted means noted in Table 1).

Table 3 presents data from the Stroop task, with mean reaction times (MRT) in milliseconds (ms) for the disorder words and the control words. Additionally, the table presents an overall MRT for the disorder words and the control words which was calculated by taking the mean of the anxiety, ADHD, and ODD disorder and control words, respectively. There were no significant group differences on the emotional Stroop task.

Table 4 presents the bivariate correlations for the full sample. In the full sample, it was found that the PPVT standard score was significantly and negatively correlated with the behavioral regulation index (BRI) T-score $r(47) = -.33$, $p < .05$. The MI T-score was significantly and positively correlated with the BRI T-score $r(47) = .53$, $p < .01$ and negatively correlated with the ODD Stroop interference score $r(47) = -.32$, $p < .05$. The anxiety Stroop

interference score was significantly and negatively correlated with the ADHD Stroop interference score $r(47) = -.32$, $p < .05$.

3.1 – Additional Analyses

Due to the lack of group differences in the original analyses, it was thought that overlap of anxiety and attentional symptoms between the ODD/ADHD group and the ODD/AD group might be responsible for these non-significant effects. Additionally, since both groups had ODD, it was thought that controlling for ODD symptoms might better reveal EF deficits specific to ADHD or AD, if they were present. Therefore, ANCOVAs were conducted to control for anxiety symptoms in the ODD/ADHD group and ADHD symptoms in the ODD/AD group as well as to control for ODD symptoms in both groups. The parent report on the Behavior Assessment System for Children – 2nd Edition (BASC-2; Reynolds & Kamphaus, 1992) was used to control for such symptoms. Specifically, the anxiety, attention problems, hyperactivity, and aggression scales were used to control for the respective symptoms in the ANCOVA analyses. The means of the attention problems and hyperactivity T-scores were used to determine an overall ADHD symptom score, which was used for the ODD/AD group to control for ADHD symptoms. Table 5 presents the means of the BASC-2 scales used in these analyses.

When controlling for aggression, no significant group differences emerged on either the BRIEF or emotional Stroop task (see Table 6). However, when controlling for anxiety symptoms in the ODD/ADHD group and ADHD symptoms in the ODD/AD group, significant group differences emerged on the BRIEF scales but not on the emotional Stroop task. Specifically, the ODD/ADHD group had significantly higher scores on the MI $F(1, 48) = 8.44$, $p < .01$ and the BRI $F(1, 48) = 7.18$, $p < .05$ than the ODD/AD group (see Table 7).

4.0 – Discussion

The primary purpose of the present study was to examine executive functioning (EF) differences in children with either comorbid ODD/ADHD or ODD/AD. It was expected that children with ODD/ADHD would show more executive dysfunction in the area of metacognition whereas children with ODD/AD would show more executive dysfunction in the area of behavioral regulation. Additionally, it was hypothesized that these children would show interference, that is, longer response times, on an emotional Stroop task on disorder words that corresponded directly to their respective disorders (e.g., restless and focus for ADHD; nervous and afraid for AD). The findings from this study partially support the hypotheses. That is, significant group differences were found on the MI, in the expected direction, when gender and corresponding symptoms of ADHD and AD were controlled for. In these analyses, the ODD/ADHD group exhibited more EF deficits on the BRIEF than the ODD/AD group. Additionally, there were significant group differences on the BRI when corresponding symptoms of ADHD and AD were controlled for; however, the difference was not in the hypothesized direction. Specifically, it was hypothesized that the ODD/AD group would exhibit more EF deficits in this area than the ODD/ADHD group, but the ODD/ADHD group actually had more EF deficits on the BRI than the ODD/AD group. On the other hand, no significant group differences emerged on the emotional Stroop task. It is important to note that this is the first study to explore EF differences in comorbid ODD/ADHD and comorbid ODD/AD samples. That is, much of the research investigating executive dysfunction is done with relatively pure disorders such as ODD/CD, ADHD, or AD (e.g., Barkley, 1997; Hobson, Scott, & Rubia, 2011; Qian et al., 2010; Toren et al., 2000; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), but there are few studies that have examined the effect of comorbid disorders on possible EF deficits (e.g., Oosterlaan et al., 2005).

In examining the EF deficits on the BRIEF scales, it is interesting to note that the behavioral regulation index (BRI) scores were clinically significant (>65) for both groups, suggesting that the presence of ODD may have obscured potential differences associated with comorbid ADHD or AD. For example, the Inhibit component of the BRI, measuring the ability to appropriately modulate behavior, may be clinically significant for children with ODD, independent of its comorbidity with ADHD or AD. This is consistent with Hobson et al.'s

(2011) findings that ODD/CD, independent of ADHD, was related to slower inhibitory responding but not associated with cognitive flexibility, another component of the BRI (i.e., Shift). Therefore, since the BRI was clinically significant for both groups, it may be generally related to a diagnosis of ODD and not useful in differentiating ADHD from AD.

However, the metacognition index (MI) scale was only clinically significant (>65) for the ADHD group. Moreover, this was the only scale that reached significance between the two groups, when controlling for gender and corresponding symptoms, supporting the hypothesis about the ADHD group having more dysfunction on the MI than the AD group . This is consistent with theories of ADHD independent of ODD, such that the components of the MI including initiate, working memory, plan/organize, organization of materials, and monitor are found to contribute to the difficulties these children experience (Barkley, 1997; Beck et al., 2010; Klorman, Hazel-Fernandez, Shaywitz, Fletcher, et al., 1999; Sergeant, Geurts, & Oosterlaan, 2002).

On the other hand, the emotional Stroop task results are more difficult to interpret. For instance, the anxious interference scores were positive, regardless of group status, and the ADHD and ODD interference scores were negative, regardless of group status. As stated earlier, a positive interference score represents color-naming interference that is greater than that produced by the neutral control words. In this study, the anxious words were associated with interference regardless of diagnostic group, demonstrating the emotional Stroop effect (i.e., longer latencies for disorder words than control words) for both groups. This finding does not comport with other studies using the emotional Stroop task which show a differential effect for anxious versus non-anxious participants. For example, Martin, Horder, and Jones (1992) showed that children who were phobic of spiders exhibited longer latencies to name colors, that is, interference, on the spider-related words than neutral words. However, this interference was specific to the children who were fearful of spiders - the non-phobic children did not show the same effect. In reconciling these differences, MacLeod (2005) suggests that such non-specific results may be due to increased overall emotional negativity rather than personal relevance of the emotion stimuli. Therefore, it is possible that an ODD sample may have increased emotional negativity overall and that the anxious words may not have had particular personal relevance to

either the ADHD or AD group, thus accounting for the positive interference on the anxious words for both groups.

As noted, the ADHD and ODD interference scores were negative for both groups. As a reminder, a negative interference score indicates that the control words created more color-naming interference than did the experimental or disorder-specific words. These results, namely the color words creating more interference than experimental words, are unusual but not unprecedented. For instance, Chajut, Mama, Levy, and Algom (2010) found that the responses of some individuals on an emotional Stroop task were faster than control words (like the present findings), which they attributed to approach-avoidance tendencies. Specifically, they speculated that the interference found on the emotional Stroop task was a threat- or emotion- related phenomenon, not an attention phenomenon (Chajut et al., 2010). However, even though there is some evidence for faster response times on the disorder words than for the control words, it is more difficult to explain why there was negative interference for both comorbid groups. That is, the study by Chajut and colleagues was conducted with an anxious sample, which does not explain why both ODD/ADHD and ODD/AD groups responded faster to words associated with ODD and ADHD in the current sample. As a result, overall, it seems possible that the two groups (both of whom had clinical diagnoses of ODD) were more alike than different when examining the findings from the emotional Stroop task; however, the findings on this measure are largely uninterpretable due to the conflicting positive and negative interference scores across both groups with no clear pattern.

One issue that needs to be addressed is the face validity of the Stroop task in this and other studies. That is, the task has been used in some studies to measure inhibition, a component of EF, and attention bias, specifically, attention to threat. In this study it was used as a measure of executive function; however, the emotional Stroop task is fundamentally different than the standard Stroop task. Specifically, the emotional Stroop task was designed as a measure of attention bias toward threat (i.e., disorder) words and versions of the emotional Stroop task are often used in anxious samples to measure selective information processing of emotional stimuli (Chajut et al., 2010; Nightingale et al., 2010; Schneider et al., 2008). The expectation in the emotional Stroop task is for the child to show interference on words that are emotionally salient – words that are specific to the disorder the child has.

Alternatively, the standard Stroop color-word task is a measure of attention; specifically, it assesses if the person is able to inhibit responding to the color of a word that is incongruent with the name of the word (MacLeod, 1991). For the standard Stroop task, the expectation is that the person will show interference naming the color word on the color-incongruent words due to increased time it takes to inhibit a dominant response for a competing, subdominant response (Barkley, 1997; MacLeod, 1991; MacLeod, 2005). Therefore, since the present study used an emotional Stroop task, differences might have been more validly attributed to attention bias rather than EF deficits between the ODD/ADHD and ODD/AD groups.

Furthermore, much of the literature investigating processes involved in externalizing disorders focus on executive function, including self-regulation, whereas studies with internalizing disorders examine emotion regulation. Although both of these concepts involve cognition more broadly, it is difficult to compare these underlying processes without determining a clearer definition of the constructs believed to be involved in both externalizing and internalizing disorders. That is, the measures used to measure EF in the present study may not be capturing the constructs underlying the processes involved in AD as well as those involved in ADHD and ODD, considering the slightly varying conceptualizations of self-regulation compared to emotion regulation. Furthermore, Sorensen and colleagues (2011) suggested that children with ADHD or anxiety may both have emotional dysregulation. However, the process by which the children have difficulty regulating their emotions may follow different routes. Children with ADHD might have an impaired ability to inhibit their responses, therefore causing emotional dysregulation; on the other hand, children with anxiety may have difficulty regulating their emotions that cause problems with over-inhibiting responses and shifting their attention (Sorensen, Plessen, Nicholas, & Lundervold, 2011).

Additionally, self-regulation is defined as an individual's capacity to regulate arousal in the service of goal-oriented action (Greene & Doyle, 1999). Self-regulation is theorized to be involved in the processes underlying disorders such as ADHD and ODD (see Greene & Doyle, 1999, for a review). Emotion regulation, on the other hand, is defined as the ability to modulate emotions in response to environmental demands (Suveg, Sood, Comer, & Kendall, 2009). Although conceptualized as separate constructs, they both appear to measure arousal processes. It seems that the main difference between self-regulation, a component of executive function,

and emotion regulation is that self-regulation is goal-oriented, whereas emotion regulation may not always be so. However, Hoeksma, Oosterlaan, and Schipper (2004) investigated the process of emotion regulation where it was conceptualized as the ability to modulate or inhibit emotions when the individual's current emotional state is discrepant from one's goals, suggesting that there is some goal-oriented executive process involved in emotion regulation as well. Therefore, the broad concept of self-regulation, which includes the concept of arousal, may be the best overall construct to compare externalizing disorders with internalizing disorders.

Additionally, the results of this study suggest that there may be EF differences not only in the area of metacognition between ADHD and anxiety, but also in the area of behavioral regulation. Furthremore, EF deficits may be more similar than they are different. That is, underlying EF processes involved in the difficulties of children with ODD comorbid with ADHD or AD may obscure differences between these disorders, especially in the areas of emotional control. Hence, it may be helpful to consider the interplay of emotion and cognition in the development of both ADHD and anxiety, since it is suggested that both involve arousal at the most basic level (Pfaff, 2006). Additionally, Brown (2009) proposed that the interaction between emotion and executive functions is bidirectional in that "executive functions are activated and sustained by emotion but also are involved in modulating emotion and in managing its effect on behavior." Therefore, these underlying executive function and emotion processes should be investigated further to either distinguish ADHD from AD or identify similarities between them.

4.1 – Limitations

There are a number of limitations that should be considered when interpreting the results of this study. First, this study used data that were collected as part of a larger treatment study for ODD and, as such, analyses were limited to the measures that were administered to parents and children in that study. The measures used (i.e., BRIEF and emotional Stroop task) in this study might not have been the best measures of executive function (EF) to examine our hypotheses. Although the BRIEF is considered an ecologically valid measure of EF, this study only used the parent report to assess EF deficits (Gioia et al., 2000; Qian et al., 2010). It would have been additionally informative to have an assessment from the child's teacher to confirm the validity of the parent BRIEF results. Additionally, the emotional Stroop task used in this study has not been standardized nor has it shown evidence for construct validity despite evidence in the literature

suggesting that it is a good measure of cognitive interference in disordered populations (e.g., Chajut et al., 2010; Kaur, Butow, Thewes, 2011; Sideridis, 2009). In the current study, it was designed by the researchers and was exploratory in nature. Second, this study did not use a non-clinical control group. It may be the case that these two comorbid ODD groups are not highly differentiated when examining EF, which is difficult to determine without a comparison group. Finally, the current study lacked power to detect small to medium effect sizes due to the relatively small number of participants. That is, increasing the number of subjects may have been able to show medium to small effects between the ODD/ADHD and ODD/AD group. This might especially be so in as much as differences on the MI between the two groups approached significance ($p = .055$) and were in the predicted direction.

4.2 – Future Directions

Future research should explore EF differences in pure ADHD and AD samples to avoid the possible contribution ODD has in such deficits and to compare these clinical samples to a non-clinical group. In examining the EF differences between these two disorders, it would be useful to first identify the overall construct of interest, whether that is inhibition, attention, self-regulation, or emotion regulation. Clearly defining the variable of interest will help to inform which measures are best suited for such a comparison. Additionally, it is recommended that studies use more comprehensive neuropsychological evaluations of EF such as the Wisconsin Card Sorting Task, measuring set shifting, or the Tower of Hanoi, measuring planning, to determine if differences indicated on a self-report measure are consistent with the child's performance (Oosterlaan, Scheres, & Sergeant, 2005; Qian et al., 2010). It may also be useful to determine if there are common underlying processes that contribute to the development of ADHD, AD, and/or ODD. That is, research has suggested that EF deficits may overlap between ADHD and ODD (e.g., Greene & Doyle, 1999; Oosterlaan, Scheres, & Sergeant, 2005; Qian et al., 2010), but there may be common processes involved in development of AD and ODD (e.g., difficulties regulating negative emotions; see Drabick et al., 2010), as well as AD and ADHD (e.g., attention, inhibition, shifting). Future research in this area may prove useful in designing interventions for children who have EF deficits associated with such disorders.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text revision). Washington, DC.

Barkley, R. A. (1997). Behavioral Inhibition, Sustained Attention, and Executive Functions: Constructing a Unifying Theory of ADHD. *Psychological Bulletin, 121(1),* 65-94. doi: 10.1037/0033-2909.121.1.65

Beck, S. J., Hanson, C. A., Puffenberger, S. A., Benninger, K. L., & Benninger, W. B. (2010). A Controlled Trial of Working Memory Training for Children and Adolescents with ADHD. *Journal of Clinical Child and Adolescent Psychology, 39(6)*, 825-836. doi: 10.1080/15374416.2010.517162

Bell, M. A. & Wolfe, C. D. (2004). Emotion and Cognition: An Intricately Bound Developmental Process. *Child Development, 75(2)*, 366-370. doi: 10.1111/j.1467-8624.2004.00679.x

Brown, T. E. (2009). Developmental Complexities of Attentional Disorders. In T. E. Brown (Ed.), *ADHD Comorbidities: Handbook for ADHD Complications in Children and Adults* (pp. 3-22). Arlington, VA: American Psychiatric Publishing, Inc.

Calkins, S. D. & Marcovitch, S. (2010). Emotion Regulation and Executive Functioning in Early Development: Integrated Mechanisms of Control Supporting Adaptive Functioning. In S. D. Calkins & M. A. Bell (Eds.), *Child Development at the Intersection of Emotion and Cognition, Human Brain Development* (pp. 37-57). Washington, DC: American Psychological Association, doi: 10.1037/12059-003

Carroll, J. B., Davies, P., & Richman, B. (1971). *The American Heritage Word Frequency Book*. Boston: Houghton Mifflin.

Chajut, E., Mama, Y., Levy, L., & Algom, D. (2010). Avoiding the Approach Trap: A Response Bias Theory of the Emotional Stroop Effect. *Journal of Experimental Psychology, 36(6)*, 1567-1572. doi: 10.1037/a0020710

Dewey, D., Kaplan, B. J., Crawford, S. G., & Fisher, G. C. (2001). Predictive Accuracy of the Wide Range Assessment of Memory and Learning in Children with Attention Deficit Hyperactivity Disorder and Reading Difficulties. *Developmental Neuropsychology, 19(2)*, 173-189. doi: 10.1207/S15326942DN1902_3

Drabick, D. A., Gadow, K. D., & Loney, J. (2007). Source-Specific Oppositional Defiant Disorder: Comorbidity and Risk Factors in Referred Elementary Schoolboys. *Journal of the American Academy of Child & Adolescent Psychiatry, 46(1)*, 92-101. doi: 10.1097/01.chi.0000242245.00174.90

Drabick, D. A., Ollendick, T. H. & Bubier, J. (2010). Co-occurring ODD and anxiety: Shared processes and evidence for a dual-pathway model. *Clinical Psychology: Science and Practice, 17*, 307-318. doi: 10.1111/j.1468-2850.2010.01222.x

Dunn, L. M. & Dunn D. M. (2007). *PPVT-4 Manual*. Bloomington, MN: NCS Pearson, Inc.

Frick, P. J. & McMahon, R. J. (2008). Child and adolescent conduct problems. In J. Hunsley & E. J. Mash (Eds.), *A guide to assessments that work, Oxford series in clinical psychology* (pp. 41-66). New York: Oxford University Press.

Friman, P. C., Handwerk, M. L., Smith, G. L., Larzelere, R. E., Lucas, C. P., & Shaffer, D. M. (2000). External Validity of Conduct and Oppositional Defiant Disorders Determined by the NIMH Diagnostic Interview Schedule for Children. *Journal of Abnormal Child Psychology, 28(3)*, 277-286. doi: 10.1023/A:1005148404980

Gioia, G., Isquith, P., Guy, S. C., & Kenworth, L. (2000). *Behavior Rating Inventory of Executive Function: Professional Manual*. Lutz, FL: Psychological Assessment Resources.

Greene, R. W. & Ablon, J. S. (2006). *The Explosive Child*. New York: The Guilford Press.

Greene, R. W. & Doyle, A. E. (1999). Toward a Transactional Conceptualization of Oppositional Defiant Disorder: Implications for Assessment and Treatment. *Clinical Child and Family Psychology Review, 2(3)*, 129-148. doi: 10.1023/A:1021850921476

Hobson, C. W., Scott, S., & Rubia, K. (2011). Investigation of cool and hot executive function in ODD/CD independent of ADHD. *Journal of Child Psychology and Psychiatry, 52(10)*, 1035-1043. doi: 10.111/j.1469-7610.2011.02454.x

Hoeksma, J. B., Oosterlaan, J., & Schipper, E. M. (2004). Emotion Regulation and the Dynamics of Feelings: A Conceptual and Methodological Framework. *Child Development, 75(2)*, 354-360. doi: 10.1111/j.1467-8624.2004.00677.x

Johnston, C. J. & Mah, J. W. T. (2008). Child Attention-Deficit/Hyperactivity Disorder. In J. Hunsley & E. J. Mash (Eds.), *A guide to assessments that work, Oxford series in clinical psychology* (pp. 17-40). New York: Oxford University Press.

Kaur, A., Butow, P., & Thewes, B. (2011). Do Metacognitions Predict Attentional Bias in Health Anxiety? *Cognitive Therapy and Research, 35(6)*, 575-580. doi: 10.1007/s10608-011-9387-6

Klorman, R., Hazel-Fernandez, L. A., Shaywitz, S. E., Fletcher, J. M., Marchione, K. E., Holahan, J. M., Stuebing, K. K., & Shaywitz, B. A. (1999). Executive Functioning Deficits in Attention-Deficit/Hyperactivity Disorder are Independent of Oppositional Defiant or Reading Disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 38(9)*, 1148-1155. doi: 10.1097/00004583-199909000-00020

Lahey, B. B., Miller, T. L., Gordon, R. A., & Riley, A. W. (1999). Developmental epidemiology of the disruptive behavior disorders. In H. C. Quay & A. E. Hogan (Eds.), *Handbook of the disruptive behavior disorders* (pp 23-48). New York: Plenum.

MacLeod, C. (1991). Half a Century of Research on the Stroop Effect: An Integrative Review. *Psychological Bulletin, 109(2)*, 163-203. doi: 10.1037/0033-2909.109.2.163

MacLeod, C. (2005). The Stroop Task in Clinical Research. In A. Wenzel & D. Rubin (Eds.), *Cognitive methods and their application to clinical research* (pp. 41-62). Washington, DC: American Psychological Association. doi: 10.1037/10870-003

Martin, M., Horder, P., & Jones, G. V. (1992). Integral bias in naming of phobia-related words. *Cognition and Emotion, 6(6)*, 479-486. doi: 10.1080/02699939208409700

McCandless, S. & O'Laughlin, L. (2007). The clinical utility of the Behavior Rating Inventory of Executive Function (BRIEF) in the diagnosis of ADHD. *Journal of Attention Disorders, 10(4)*, 381-389. doi: 10.1177/1087054706292115

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis. *Cognitive Psychology, 41*, 49-100. doi: 10.1006/cogp.1999.0734

Nightingale, Z. C., Field, A. P., & Kindt, M. (2010). The Emotional Stroop Task in Anxious Children. In J. A. Hadwin & A. P. Field (Eds.), *Information Processing Biases and Anxiety: A Developmental Perspective* (pp. 47-75). Hoboken, NJ: Wiley-Blackwell. doi: 10.1002/9780470661468.ch3

Nock, M. K., Kazdin, A. E., Hiripi, E., & Kessler, R. C. (2007). Lifetime prevalence, correlates, and persistence of oppositional defiant disorder: results from the National Comorbidity Survey Replication. *Journal of Child Psychology and Psychiatry, 48(7)*, 703-713. doi: 10.1111/j.1469-7610.2007.01733.x

Ollendick, T. H. & Greene, R. W. (2007). Mediators, Moderators, and Treatment Efficacy of Two Forms of Psychosocial Treatment for Oppositional Children. Blacksburg, USA: Virginia Polytechnic Institute and State University. Child Study Center. NIMH Grant.

Oosterlaan, J., Scheres, A., & Sergeant, J. A. (2005). Which Executive Functioning Deficits Are Associated With AD/HD, ODD/CD, and Comorbid AD/HD+ODD/CD? *Journal of Abnormal Child Psychology, 33*, 69-85. doi: 10.1007/s10802-005-0935-y

Pfaff, D. (2006). *Brain Arousal and Information Theory: Neural and Genetic Mechanisms*. Cambridge, MA: Harvard University Press.

Qian, Y., Lan, S., Qingjiu, C., Chan, R. C. K., & Wang, Y. (2010). Do executive function deficits differentiate between children with Attention Deficit Hyperactivity Disorder (ADHD) and ADHD comorbid with Oppositional Defiant Disorder? A cross-cultural study using performance-based tests and the Behavior Rating Inventory of Executive Function. *The Clinical Neuropsychologist, 24*, 793-810. doi: 10.1080/13854041003749342

Rapee, R. M., Barrett, P. M., Dadds, M. R., & Evans, L. (1994). Reliability of the *DSM-III-R* Childhood Anxiety Disorders Using Structured Interview: Interrater and Parent-Child Agreement. *Journal of the American Academy of Child and Adolescent Psychiatry, 33*, 984-992. doi: 10.1097/00004583-199409000-00008

Reynolds, C. R. & Kamphaus, R. W. (1992). *Behavior Assessment System for Children (2nd ed.)*. Circle Pines, MN: AGS.

Schneider, S., Unnewehr, S., In-Albon, T., & Margraf, J. (2008). Attention Bias in Children of Patients with Panic Disorder. *Psychopathology, 41*, 179-186. doi: 10.1159/000120986

Segal, Z. V., Gemar, M., Truchon, C., Guirguis, M., & Horowitz, L. M. (1995). A Priming Methodology for Studying Self-Representation in Major Depressive Disorder. *Journal of Abnormal Psychology, 104(1)*, 205-213. doi: 10.1037/0021-843X.104.1.205

Seguin, J. R., Boulerice, B., Harden, P. W., Tremblay, R. E., & Pihl, R. O. (1999). Executive Functions and Physical Aggression after Controlling for Attention Deficit Hyperactivity Disorder, General Memory, and IQ. *Journal of Child Psychology and Psychiatry, 40(8)*, 1197-1208. doi: 10.1111/1469-7610.00536

Sergeant, J. A., Geurts, H., & Oosterlaan, J. (2002). How specific is a deficit of executive functioning for Attention-Deficit/Hyperactivity Disorder? *Behavioural Brain Research, 130*, 3-28. doi: 10.1016/S0166-4328(01)00430-2

Shaffer, D., Fisher, P., Lucas, C. P., Dulcan, M. K., & Schwab-Stone, M. E. (2000). NIMH Diagnostic Interview Schedule for Children Version IV (NIMH DISC-IV): Description, Differences From Previous Versions, and Reliability of Some Common Diagnoses. *Journal of the American Academy of Child & Adolescent Psychiatry, 39(1)*, 28-38. doi: 10.1097/00004583-200001000-00014

Sideridis, G. D. (2009). Assessing Cognitive Interference Using the Emotional Stroop Task in Students with and Without Attention Problems. *European Journal of Psychological Assessment, 25(2)*, 99-106. doi: 10.1027/1015-5759.25.2.99

Silverman, W. K., & Albano, A. M. (1996). *The Anxiety Disorders Interview Schedule for DSM-IV---Child and Parent Versions*. San Antonio, TX: Graywind.

Silverman, W. K., & Nelles, W. B. (1988). The Anxiety Disorders Interview Schedule for Children. *Journal of the American Academy of Child and Adolescent Psychiatry, 27*, 772-778. doi: 10.1097/00004583-198811000-00019

Silverman, W. K., Saavedra, L. M., & Pina, A. A. (2001). Test-Retest Reliability of Anxiety Symptoms and Diagnoses With the Anxiety Disorders Interview Schedule for *DSM-IV*:

Child and Parent Versions. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*, 937-944. doi: 10.1097/00004583-200108000-00016

Smith, B. H., Barkley, R. A., & Shapiro, C. J. (2007). Attention-Deficit/Hyperactivity Disorder. In E. J. Mash & R. A. Barkley (Eds.), *Assessment of Childhood Disorders* (pp. 53-123). New York: The Guilford Press.

Sorensen, L., Plessen, K. J., Nicholas, J., & Lundervold, A. J. (2011). Is Behavioral Regulation in Children With ADHD Aggravated by Comorbid Anxiety Disorder? *Journal of Attention Disorders, 15(1)*, 56-66. doi: 10.1177/1087054709356931

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662.

Suveg, C., Sood, E., Comer, J. S., & Kendall, P. C. (2009). Changes in Emotion Regulation Following Cognitive-Behavioral Therapy for Anxious Youth. *Journal of Clinical Child & Adolescent Psychology, 38(3)*, 390-401. doi: 10.1080/15374410902851721

Thorell, L. B., Bohlin, G., & Rydell, A. (2004). Two types of inhibitory control: Predictive relations to social functioning. *International Journal of Behavioral Development, 28(3)*, 193-203. doi: 10.1080/01650250344000389

Toren, P., Sadeh, M., Wolmer, L., Eldar, S., Koren, S., Weizman, R., & Laor, N. (2000). Neurocognitive Correlates of Anxiety Disorders in Children: A Preliminary Report. *Journal of Anxiety Disorders, 14(3)*, 239-247. doi: 10.1016/S0887-6185(99)00036-5

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the Executive Function Theory of Attention-Deficity/Hyperactivity Disorder: A Meta-Analytic Review. *Biological Psychiatry, 57(11)*, 1336-1346. doi: 10.1016/j.biopsych.2005.02.006

Table 1

Means and Standard Deviations and Counts/Percentages for the Full Sample, ODD/ADHD group and ODD/AD group

	Full Sample (n = 49)	ODD/ADHD (n = 22)	ODD/AD (n = 27)	F/χ^2	p	η^2
Age	10.09 (1.81)	10.23 (1.82)	9.98 (1.82)	.22	.64	.01
Gender – M	30 (61.2%)	14 (63.6%)	16 (59.3%)	.98	.75	---
ODD CSR	5.82 (1.09)	6.00 (.93)	5.67 (1.21)	1.13	.29	.02
Comorbid CSR	---	5.77 (1.38)	4.93 (1.17)	---	---	---
PPVT	113.14 (14.68)	111.86 (14.97)	114.19 (14.64)	.30	.59	.01
PPVT, adjusted	---	111.65 (3.05)†	114.36 (2.75)†	.43	.51	.01
MI	66.43 (10.89)	69.73 (10.11)	63.74 (10.93)	3.89	.06	.08
MI, adjusted	---	69.91 (2.12)†	63.59 (1.92)†	4.89	.03*	.10
BRI	72.14 (10.82)	73.73 (9.41)	70.85 (11.86)	.85	.36	.02
Anx Interference[a]	42.61 (148.79)	33.65 (133.67)	49.92 (162.23)	.14	.71	.00
ADHD Interference[b]	-37.47 (134.70)	-45.74 (131.93)	-30.74 (139.04)	.15	.70	.00
ODD Interference[c]	-18.38 (156.99)	-40.57 (142.87)	-.31 (168.10)	.79	.38	.02

Note. Gender = Male (1) Female (2), ODD CSR = Clinician Severity Rating for ODD (0-8), Comorbid CSR = respective CSR for comorbid groups, PPVT = Peabody Picture Vocabulary Test, PPVT, adjusted = controlling for gender, MI = Metacognition Index, MI, adjusted = controlling for gender, BRI = Behavioral Regulation Index, Anx Interference = Anxiety Stroop words interference score, ADHD Interference = ADHD Stroop words interference score, ODD Interference = ODD Stroop words interference score.

[a] Interference scores ranged from -255.50 – 429.67

[b] Interference scores ranged from -397.33 – 240.33

[c] Interference scores ranged from -388.83 – 262.33

†Values in parentheses are standard errors

*$p < .05$

Table 2

Means and Standard Deviations for Males and Females

	Males (n = 30)	Females (n = 19)	t	p
PPVT	116.50 (16.65)	107.84 (8.94)	2.08	.04*
ODD CSR	5.60 (1.10)	6.16 (1.02)	-1.78	.08
MI	63.53 (10.99)	71.00 (9.23)	-2.46	.02*
BRI	69.83 (11.50)	75.79 (8.72)	-1.93	.06
Anx Interference	63.49 (159.54)	9.65 (127.11)	1.24	.22
ADHD Interference	-41.36 (129.87)	-31.33 (145.56)	-.25	.80
ODD Interference	-17.35 (167.86)	-20.02 (142.56)	.06	.96

Note. ODD CSR = Clinician Severity Rating for ODD (0-8), PPVT = Peabody Picture Vocabulary Test, MI = Metacognition Index, BRI = Behavioral Regulation Index, Anx Interference = Anxiety Stroop words interference score, ADHD Interference = ADHD Stroop words interference score, ODD Interference = ODD Stroop words interference score.

*$p < .05$

Table 3

Means, Standard Deviations, and Ranges for the Emotional Stroop Task for the Full Sample, ODD/ADHD group and ODD/AD group

	Full Sample (n = 49)	ODD/ADHD (n = 22)	ODD/AD (n = 27)		
	M (*SD*)	*M* (*SD*)	*M* (*SD*)		
	Range	Range	Range	p	η^2
Anx	931.15 (260.64)	886.09 (273.81)	967.87 (248.48)	.279	.025
	491.00-1666.83	491.00-1412.60	648.00-1666.83		
Anx Con	888.53 (214.52)	852.44 (236.83)	917.95 (194.05)	.292	.024
	545.00-1594.50	545.00-1594.50	615.00-1351.83		
ADHD	894.05 (207.40)	858.85 (218.73)	922.72 (197.15)	.288	.024
	561.00-1488.33	561.00-1488.33	661.00-1293.33		
ADHD Con	931.52 (239.04)	904.60 (225.79)	953.46 (251.39)	.482	.011
	545.67-1674.17	545.67-1319.60	618.40-1674.17		
ODD	907.59 (199.30)	857.62 (193.85)	948.30 (197.85)	.114	.052
	532.33-1317.67	557.50-1277.17	532.33-1317.67		
ODD Con	925.97 (222.34)	898.19 (203.15)	948.61 (238.22)	.436	.013
	532.50-1445.33	532.50-1301.17	626.17-1445.33		
MRTDis	910.93 (205.08)	867.52 (207.61)	946.30 (199.84)	.184	.037
	553.17-1375.89	553.17-1257.67	653.22-1375.89		
MRTCon	915.34 (205.96)	885.07 (204.69)	940.01 (207.52)	.359	.018
	541.06-1490.44	541.06-1326.94	669.17-1490.44		
Anx Interference	42.61 (148.79)	33.65 (133.67)	49.92 (162.23)	.708	.003
	-255.50-429.67	-208.33-394.23	-255.50-429.67		
ADHD Interference	-37.47 (134.70)	-45.74 (131.93)	-30.74 (139.04)	.702	.003
	-397.33-240.33	-351.27-240.33	-397.33-158.57		
ODD Interference	-18.38 (156.99)	-40.57 (142.87)	-.31 (168.10)	.377	.017
	-388.83-262.33	-354.17-200.60	-388.83-262.33		

Note. MRT = mean reaction time (in milliseconds), Anx = anxious words, Anx Con = anxious control words, ADHD = ADHD words, ADHD Con = ADHD control words, ODD = ODD words, ODD Con = ODD control words, MRTDis = overall mean reaction time for disorder words, MRTCon = overall mean reaction time for control words.

Table 4

Bivariate Correlations of Study Variables for the Full Sample (N = 49)

Measure	1	2	3	4	5	6	7
1. Age	1						
2. PPVT	-.145	1					
3. MI	.156	-.197	1				
4. BRI	.258	-.327*	.526**	1			
5. Anx Interference	-.276	-.116	-.046	.075	1		
6. ADHD Interference	.148	-.021	.150	-.078	-.320*	1	
7. ODD Interference	.199	-.043	-.322*	-.086	.058	.046	1

Note. PPVT = Peabody Picture Vocabulary Test, MI = Metacognition Index, BRI = Behavioral Regulation Index, Anx Interference = Anxiety Stroop words interference score, ADHD Interference = ADHD Stroop words interference score, ODD Interference = ODD Stroop words interference score.

*$p < .05$, **$p < .01$

Table 5

Means table for BASC-2 subscales

	Full Sample ($n = 49$)	ODD+ADHD ($n = 22$)	ODD+AD ($n = 27$)	F	p	η^2
Anxiety	53.53 (12.52)	51.45 (13.08)	55.22 (12.03)	1.10	.30	.02
Attention Problems	63.69 (7.66)	67.64 (6.86)	60.48 (6.82)	13.27	.00**	.22
Hyperactivity	67.78 (11.70)	73.55 (9.85)	63.07 (11.10)	11.92	.00**	.20
ADHD score	65.73 (9.05)	70.59 (7.54)	61.78 (8.31)	14.81	.00**	.24
Aggression	70.67 (11.40)	69.95 (11.65)	71.26 (11.38)	.16	.70	.00

Note. ADHD score was calculated by taking the mean of the attention problems and hyperactivity scales.

**$p < .01$

Table 6

Adjusted Mean Differences for BRIEF scales and Emotional Stroop Task (controlling for Aggression)

	ODD/ADHD (n = 22)	ODD/AD (n = 27)	F	p	η^2
MI	69.73 (2.28)	63.74 (2.06)	3.79	.06	.08
BRI	73.89 (2.27)	70.72 (2.05)	1.08	.31	.02
Anx Interference	46.42 (33.98)	39.51 (30.34)	.02	.89	.00
ADHD Interference	-52.92 (31.01)	-24.89 (27.69)	.41	.53	.01
ODD Interference	-43.02 (36.06)	1.69 (32.20)	.77	.38	.02

Note. MI = Metacognition Index, BRI = Behavioral Regulation Index, Anx Interference = Anxiety Stroop words interference score, ADHD Interference = ADHD Stroop words interference score, ODD Interference = ODD Stroop words interference score.

Table 7

Adjusted Mean Differences for BRIEF scales and Emotional Stroop Task (controlling for Anxiety symptoms in the ODD/ADHD group and ADHD symptoms in the ODD/AD group)

	ODD/ADHD (n = 22)	ODD/AD (n = 27)	F	p	η^2
MI	71.59 (2.29)	62.22 (2.04)	8.44	.01**	.16
BRI	76.62 (2.15)	68.50 (1.92)	7.18	.01*	.14
Anx Interference	46.42 (33.98)	39.51 (30.34)	.02	.89	.00
ADHD Interference	-52.92 (31.01)	-24.89 (27.69)	.41	.52	.01
ODD Interference	-43.02 (36.06)	1.69 (32.20)	.77	.38	.02

Note. MI = Metacognition Index, BRI = Behavioral Regulation Index, Anx Interference = Anxiety Stroop words interference score, ADHD Interference = ADHD Stroop words interference score, ODD Interference = ODD Stroop words interference score.

*$p < .05$, **$p < .01$

Appendix A

Emotional Stroop Disorder and Control Words

Anxiety	Anxiety Control
nervous	penguin
scared	goat
worried	chicken
tense	camel
afraid	cattle
fear	duck

ADHD	ADHD Control
restless	reindeer
focus	panda
active	beaver
moving	cat
listen	horse
attention	buffalo

ODD/CD	ODD/CD Control
lie	owl
angry	sheep
argue	llama
blame	moose
fight	whale
disobey	gorilla

Appendix B

IRB Approval Letter

VirginiaTech

Office of Research Compliance
Institutional Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24060
540/231-4606 Fax 540/231-0959
e-mail irb@vt.edu
Website: www.irb.vt.edu

MEMORANDUM

DATE: May 9, 2011

TO: Thomas H. Ollendick, Kristin Austin

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires October 26, 2013)

PROTOCOL TITLE: Examining Differences in Executive Function and Emotion Regulation in ADHD and Anxiety in an ODD Sample

IRB NUMBER: 11-431

Effective May 9, 2011, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the new protocol for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at http://www.irb.vt.edu/pages/responsibilities.htm (please review before the commencement of your research).

PROTOCOL INFORMATION:
Approved as: **Exempt, under 45 CFR 46.101(b) category(ies) 4**
Protocol Approval Date: **5/9/2011**
Protocol Expiration Date: **NA**
Continuing Review Due Date*: **NA**
*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:
Per federally regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.