RISK-TAKING IN ATTENTION-

DEFICIT/HYPERACTIVITY DISORDER: A META-

ANALYTIC REVIEW OF BEHAVIORAL TASKS AND

SELF-REPORT MEASURES

By

DELANIE K. ROBERTS

Bachelor of Arts in Psychology and Social Behavior

University of California, Irvine

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Thesis Approved:

R. Matt Alderson

Thesis Adviser
John M. Chaney, Ph.D.

Thad R. Leffingwell, Ph.D.

Name: DELANIE ROBERTS

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Abstract: Given characteristic features of ADHD that include behavioral disinhibition (Barkley, 1997), impulsivity (Patros et al., 2016), and increased reward and novelty seeking behaviors (Donfrancesco et al., 2015), it is not surprising that the disorder is also associated with increased risk-taking (Drechsler et al., 2008). The current study used meta-analytic methods to examine group differences in risk-taking between children and adults with and without ADHD, while accounting for the limitations of previous reviews. The present study expands on previous reviews by including a comparison of behavioral tasks and self-report measures of risk taking, and by examining potential methodological and sample moderator variables that were not examined in previous systematic (Groen et al., 2013) and meta-analytic (Dekkers et al., 2016) reviews. Thirty-eight behavioral task studies (ADHDN = 1,197, TDN = 1,178), twenty-nine self-report measure studies (ADHDN = 3,991, TDN = 3,292), and eight virtual reality studies (ADHDN = 214, TDN = 205) provided sufficient data to compute overall between-group effect sizes for risk-taking. Overall, studies using behavioral tasks (Hedges' g = .32, p < .001), self-report measures (Hedges' g = .39, p < .01), and virtual reality simulators (Hedges' g = .63, p = .04) yielded significant medium-magnitude effects, suggesting that children and adults with ADHD exhibited more risk-taking across all task domains, compared to children and adults without ADHD. Two meta-regressions were subsequently analyzed for potential moderating variables in behavioral tasks and self-report measures. Potential sample moderator variables examined in both meta-regressions included age, percentage of females, diagnostic grouping method, comorbid disruptive behavior disorders (DBD), ADHD subtype, and medication use. Potential methodological moderator variables included probabilistic descriptions, choice set size, reward type, and feedback for behavioral tasks, and response format and assessment type for self-report measures. All variables were found to be non-significant moderators in effect size variability. Collectively, these findings suggest that ADHD is associated with moderately greater risk-taking behavior, regardless of task type. Moreover, results suggest virtual reality simulators reality simulators may allow for a more accurate representation of risk-taking behavior exhibited in children and adults with ADHD, compared to laboratory-based behavioral tasks and self-report measures, and findings support the utility of virtual reality simulations in the examination of risk-taking.

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CHAPTER I

INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common

neurodevelopmental disorder of childhood (Perou et al., 2013), with an estimated worldwide

prevalence ranging from 3 to 7% (Polanczyk et al., 2014; Thomas et al., 2015) and approximately

6.1 million children and adolescents in the United States with a current diagnosis (Danielson et

al., 2018). ADHD is characterized by persistent and pervasive hyperactivity, inattention, and/or

impulsivity that leads to functional impairment in multiple settings (American Psychiatric

Association [APA], 2013) and is associated with adverse outcomes that significantly affect

children and adults throughout the lifespan (Seidman, 2006; Shaw et al., 2012; Spencer,

Biederman, & Mick, 2007). A diagnosis of ADHD often incurs impairments that affect multiple

areas of functioning, such as academic underachievement (Daley & Birchwood, 2010; Frazier et

al., 2007), social difficulties (Frederick & Olmi, 1994; Kofler et al., 2011; Maedgen & Carlson,

2000), emotion dysregulation (Graziano & Garcia, 2016; Tarle et al., 2019), and increased risk-

taking among affected children and adults (Groen et al., Dekkers et al., 2016, Mowinckel et al.,

2015).

Risk-taking refers to involvement in behaviors that compromise an individual's health

and well-being, or involve making decisions when the outcome is unknown (Trimpop, 1994). An

abundance of existing research suggests that ADHD-related symptoms of inattention and

hyperactivity are significantly correlated with specific risk behaviors, such as risky driving

(Barkley & Cox, 2007; Jerome et al., 2006; Richards et al., 2002), substance use and abuse

(Charach et al., 2011; Lee et al., 2011; Nigg et al., 2006), risky sexual behavior (White & Buehler, 2012), and criminal activities (Pratt et al., 2002). Moreover, converging evidence from laboratory-based studies that have examined between-group differences in risk-taking among ADHD and control groups suggest that children and adults with ADHD experience greater loss of reward (Garon et., 2006; Malloy-Diniz et al., 2007), choose unfavorable outcomes more frequently (DeVito et al., 2008; Matthies, Philipsen, & Svaldi, 2012), and exhibit poorer risk adjustment (DeVito et al., 2008; Sørensen et al., 2017) on gambling tasks.

There are several plausible explanations for frequent risk-taking among children and adults with ADHD. One possible explanation involves ADHD-related deficits in attentional processes, such that risk-taking may be influenced by the impaired ability to focus and shift one's attention to efficiently reflect possible alternatives (Kühberger, 1998; Tversky & Kahneman, 1981; Solanto et al., 2007; Young, Morris, Toone, & Tyson, 2007). Another explanation proposes that ADHD-related deficits in behavioral inhibition (Barkley, 1997) may lead to deficits in other executive functions, such as working memory, self-regulation, and arousal, which consequently contributes to less rational decision-making and behavioral control (Barkley, 1997; Groen, et al., 2013). Alternatively, an aversion to delays (i.e., delay aversion - the motivation to escape or avoid delay; Sonuga-Barke, 1994, 2003, 2005) in children and adults with ADHD may increase their propensity to make decisions based on the immediacy of outcomes, rather than reflecting on long-term alternatives (Marco et al., 2009; Paloyelis et al., 2010; Solanto et al., 2001). Finally, a growing body of literature suggests that ADHD is associated with moderate to large magnitude working memory deficits in children (Alderson et al., 2010; Kasper et al., 2012; Kofler et al., 2010; Martinussen et al., 2005; Rapport et al., 2008; Rapport et al., 2009) and adults (Alderson et al., 2013; Alderson et al., 2013; Hervey et a., 2004; Hudec et al., 2014) that underlie other executive functions relevant to risk taking behavior, such as inhibition (Alderson, Rapport, Hudec, Sarver, & Kofler, 2010; Alderson et al., 2017; Raiker et al., 2012; Tarle et al., 2019) and decision-making (Bechara & Martin, 2004; Patros et al., 2015).

Although empirical research and theory provide support for increased risk-taking in ADHD, findings from extant reviews have been relatively equivocal. For example, a systematic review of risk-taking on gambling tasks in ADHD found that only 27% of studies reported greater risk-taking in adults with ADHD, and only 50% of studies reported greater risk-taking in children with the disorder (Groen et al., 2013). Moreover, several studies included in Groen and colleague's (2013) review found less risk-taking among children with ADHD, relative to child without ADHD (Humphreys et al., 2016; Kroyzer, Gross-Tsur, & Pollak, 2014; Pollak & Shoham, 2015). Inferences that may be drawn from this review are limited, however, since meta-analytic methods were not used, and consequently, the magnitude of between-group differences across studies is not provided. Moreover, conclusions are based on traditional box-score counts of studies that vary with respect to sample sizes and methodology.

A subsequent meta-analysis reviewed studies that examined risky decision-making in adults with and without ADHD using the Iowa Gambling Task (Mowinckel, et al., 2015). Although findings indicated that adults with ADHD committed more risky decisions (i.e. chose disadvantageous options more frequently), relative to adults without the disorder, the magnitude of this effect was relatively small (Hedges' $g = .23$, $p = .02$). Further, generalizability of these findings is limited due to the meta-analytic review's small sample that only included fourteen effect sizes from 9 studies. Small samples of this type are vulnerable to inaccurate estimations of effect size confidence intervals, limit heterogeneity within the effect size distribution, and often preclude examination of potential moderators due to insufficient power. Generalization of findings from Mowinckel and colleagues' (2015) review is also limited due to the authors' decision to exclude studies of children. Indeed, extant research has demonstrated that between-group (ADHD vs non-ADHD) differences tend to be larger in studies of children and adolescent, relative to adult studies (Groen et al., 2013), suggesting a downward bias of the overall estimated effect-size magnitude is likely to the extent that any inferences are made about risk taking in children and adolescents with ADHD.

A more recent meta-analytic review examined risky decision-making in adults and children with and without ADHD using laboratory-based gambling tasks (Dekkers et al., 2016). Thirty-seven studies (52 effect sizes) yielded a medium-magnitude effect size ($d = .36$, $p < .001$), suggesting that ADHD groups exhibit moderately more risky decision-making compared to control groups (Dekkers et al., 2016). Notably, the magnitude of this effect was larger than that of Mowinckel and colleagues' (2015) review. This finding may be explained by the addition of children and suggests a formal examination of the effect of age on risk-taking effect sizes is needed. To that end, Dekkers and colleagues' (2016) review also examined several potential moderators, including the percentage of participants with comorbid disruptive behavior disorders in the ADHD group, the percentage of participants with comorbid internalizing disorders in the ADHD group, average age in years of both the ADHD and control group, and the explicitness of gambling tasks (i.e., whether the consequence of response options were given to the participants or if they have to be learned).

Findings indicated that a higher percentage of participants with comorbid disruptive behavior disorders (i.e., oppositional defiant disorder, conduct disorder, antisocial personality disorder) in the ADHD group was associated with larger between-group risky decision-making effect sizes, whereas all other potential moderating variables were not significant. Dekkers et al.'s review was the first to include children and adults in a meta-analytic examination of potential moderators and between-group differences in risk-taking between ADHD and non-ADHD groups. The meta-analytic review, however, unnecessarily excluded studies that did not provide means and standard deviations of outcome measures, consequently yielding a less-comprehensive and potentially biased review of the literature. Although the use of means and standard deviations to calculate effect sizes is generally preferred and tends to yield the most precise effect size estimates (Lipsey & Wilson, 2001), other metrics such as sample size and p values, t-statistics, F-statistics, or group frequency rates may also be used to estimate effect sizes (Rosnow &

Rosenthal, 2008). Therefore, an updated review of the literature that is inclusive of all studies with sufficient data for effect size estimation is warranted.

Collectively, extant findings of risk-taking in ADHD have proven to be equivocal, and findings from previous systematic and meta-analytic reviews suggest a need for examination of moderating factors that may explain discrepancies in effect size estimates of risk-taking in ADHD. While Dekkers and colleagues' (2016) inclusion of several potential moderators is a step towards advancement in the literature, further research is needed to examine additional potential moderators that may contribute to heterogeneity in between-group differences across studies. For example, several alternate explanatory factors, including gambling task type, comorbidities, ADHD subtype, medication use, reward type, and demographic variables, were suggested in Groen et al.'s (2013) systematic review but have not been examined via meta-analytic procedures (e.g., meta-regression).

It is also notable that previous systematic (i.e., Groen et al., 2013) and meta-analytic (i.e., Dekkers et al.2016; Mowinckel et al., 2015) findings are exclusively derived from studies that used laboratory-based behavioral tasks, which in turn obscures a comprehensive understanding of the risk-taking construct in ADHD. Examples of common behavioral tasks used to examine ADHD-related risk-taking include the Iowa Gambling Task (IGT; Bechara et al., 1994), the Cambridge Gambling Task (CGT; Rogers et al., 1999), the Card Playing Task (CPT; Newman, Patterson, & Kosson, 1987), and the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). These tasks are thought to provide a metric of risky behavior because they measure a participants' choice between several options that differ in the probability of reward or punishment (Dekkers et al., 2016; Groen et al., 2013). Laboratory-based behavioral tasks are likely preferred over self-report measures due to their ability to provide an objective measure of behavior in a controlled environment that yields strong internal validity (Dang et al., 2020; Lejuez et al., 2002; Reynolds et al., 2006), however, they pose several limitations that warrant consideration. For example, behavioral tasks often narrowly measure a specific domain of risk-taking behavioral processes

(e.g., reward sensitivity), and consequently limit inferences that may be made about more general risk-taking behavior. In addition, the external and ecological validity of laboratory-based behavioral tasks may vary considerably, as they often require participants to exhibit simple, irrelevant actions (e.g., clicking a computer mouse) that are tied to reinforcement/punishment contingencies with relatively low potency or magnitude, relative to risk-taking outcomes that occur in real-world settings (de-Juan-Ripoll, 2018).

Self-report measures of risk-taking behaviors are a common alternative method to laboratory-based behavioral tasks that allow for measurement of more "naturalistic" risk-taking behavior, including driving behavior, sexual behavior, and substance use. Due to significant associations between ADHD and naturally occurring risk-taking behaviors (Shoham et al., 2016), standardized ratings scales of risky behaviors, such as the Personal Drinking Habits Questionnaire (PDHQ; Vogel-Sprott, 1992) and the Alcohol Use Disorders Identification Test (AUDIT; Babor, de la Fuente, Saunders, & Grant, 1992), arguably provide greater ecological and external validity relative to laboratory-based metrics. Moreover, compared to behavioral tasks, self-report measures often provide a measure of domain-specific behavior over an extended period of time, rather than a measure of optimal performance of a specific behavior in a controlled environment (Barkley & Fischer, 2011; Barkley & Murphy, 2010; Holst & Thorell, 2019; van Duijvenvoorde et al., 2016). Nevertheless, self-report measures of risk-taking have several limitations that largely mirror the strengths of laboratory-based behavioral tasks. For instance, self-report measures are inherently vulnerable to validity and reliability problems, as they often rely on participants' self-perceptions of their behavior and are more susceptible to personal biases and the effects of social desirability (Owens et al. 2007; Wang et al., 2015). Self-report measures may also be unreliable due to variable interpretations of the wording of items (Lanyon and Goodstein, 1997) or lapses in participants' memory (Schwarz & Oyserman, 2001), particularly among children and adolescents with ADHD.

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Recently, there has been an increase in the use of virtual reality simulators in studies of ADHD-related risk-taking. Virtual reality simulators provide simulations of the real-world in a high-resolution 3D virtual environment and consequently allow participants to act and react naturally to various hazards that may elicit risk taking (de-Juan-Ripoll, 2018). For example, a virtual simulation of driving behavior may involve driving through various virtual environments (e.g., highway, country, and city) while following verbal directions (e.g., "Take your next right turn") provided by the simulator and responding appropriately to unexpected events in the virtual environment (e.g., car suddenly pulls out into participant's path; Knouse et al., 2005). Virtual reality simulators encompass the strengths of both behavioral tasks and self-report measures, by allowing for careful experimental control while also having strong external validity. Initial findings from this emerging methodology have shown that children and adults with ADHD engage in more risk behavior, such as driving longer distances while speeding (Groom, 2015), being involved in more vehicle collisions (Knouse, 2003), and completing more unsafe road crossings (Clancy, 2006). Despite the growing popularity of virtual reality in research and its ability to provide an objective measure while still allowing for flexibility in participants' responding, the utility of virtual reality simulators in research on risk-taking in ADHD is less established, compared to other metrics of risk-taking. To date, no previous systematic or meta-analytic reviews have examined studies of risk-taking via virtual reality simulators.

Collectively, findings from previous reviews of risk-taking in ADHD have been equivocal, which may be explained by study-wise variability in sample and task characteristics and the unnecessary exclusion of relevant studies. The current study, therefore, aimed to account for limitations of previous reviews by including an updated and more comprehensive meta-analytic review of published studies that was all-inclusive of participant ages, risk-taking measures (i.e., both behavioral task, self-report, and virtual reality metrics), and effect size computation procedures. Moreover, the current study provides the first review of examinations of ADHD-related risk taking via virtual reality simulators. Finally, the present study expanded upon

previously examined moderators with the addition of several potential methodological and sample moderator variables that were not examined in previous reviews. Two separate meta-regressions were completed to examine potential moderator variables of effect size heterogeneity across behavioral tasks and self-report measures. Potential sample moderator variables examined in both meta-regressions included age, percentage of females, diagnostic grouping method, comorbid disruptive behavior disorders, ADHD subtype, and medication use. Potential methodological moderator variables included probabilistic descriptions, choice set size, reward type, feedback for behavioral tasks, and response format and assessment type for self-report measures.

CHAPTER II

METHODOLOGY

Literature Searches

Literature searches were conducted using the Web of Science, PubMed, and PsychInfo databases and included articles published through July, 2019. All possible combinations of the following keywords were searched in each of the databases: attention deficit hyperactivity disorder (i.e., behav* disorder, externalizing disorder, attention, ADD, ADHD, hyper*), risk-taking (i.e., risk tak*, risk* behave*, risk seek*), risk-taking tasks (e.g., Iowa Gambling, Cambridge Gambling Task, Door Opening Task), and risk taking behaviors (e.g., driving, sexual behavior, substance use, alcohol use. A root word followed by an asterisk indicated a search for any derivative of that root word (e.g., risk* behav* = risk behavior, risk behaviors, risky behavior, and risky behaviors). The Social Science Citation Index was used to conduct a forward search, and an examination of citations in included studies was used to conduct a backward search.

Inclusion Criteria

Studies included in the current meta-analysis compared risk-taking in children and adults with and without ADHD using either behavioral tasks, self-report measures, or virtual reality simulators. Behavioral measures of risk-taking included laboratory-based behavioral tasks that required participants to select between two or more options, with at

least one option being disadvantageous. Examples include the Iowa Gambling Task (IGT; Bechara et al., 1994), the Cambridge Gambling Task (CGT; Rogers et al., 1999), the Card Playing Task (CPT; Newman, Patterson, & Kosson, 1987), and the the BART (Lejuez et al., 2002). Outcome variables of behavioral tasks reflected participants' choices when provided two or more options that differed in the magnitude and/or probability of gains or losses (e.g., number of cards drawn from a "disadvantageous" deck compared to an "advantageous" deck).

Studies that utilized virtual reality tasks were examined separately from studies that used non-virtual reality behavioral tasks, as risk-taking paradigms presented in virtual reality simulators are qualitatively different from those presented in traditional laboratory-based behavioral tasks (de-Juan Ripoll et al., 2018). Moreover, no previous reviews have examined risk-taking in virtual reality, which constituted the need to examine virtual reality studies independently. Virtual reality simulators of risk-taking involved simulations of driving, biking, or crossing the street. Outcome variables of virtual reality tasks reflected behavioral decisions made in the face of risk, such as the number of virtual collisions, the distance driven while speeding, and the number of unsafe crossings across the street.

Self-report measures of risk-taking required participants to self-report, via a questionnaire or interview, information about behaviors that place them in a potentially disadvantageous situation. Examples included gambling, driving behavior, sexual behavior, and substance use or abuse (but not substance disorders). Outcome variables of self-report measures reflected a total count of real-world risky behaviors, such as the number of driving tickets received (e.g., Barkley, 2002; Knouse, 2005; Rosenbloom,

2011), the number of sexual partners (e.g., Hetchman, 2018; Olazagasti), or the frequency rates of engaging in a particular behavior, such as the frequency of substance use (Lambert, 2005; Molina, 2003; Rooney, 2012). Notably, when studies reported occurrence rates of a particular behavior over several timeframes (e.g., *lifetime use* of drugs and *drug use within the past 30 days*), the longest timeframe was included (e.g., *lifetime use* of drugs was included instead of *drug use within the past 30 days*; Pollak, 2018). Additionally, when a study reported occurrence rates of a particular behavior for several frequency ranges (e.g., 0-5, 6-10, 11-25, or 26+ sexual partners), the most risky option was included (e.g., 26+ sexual partners; Olazagatasi, 2013).

Additional inclusion criteria required that studies a) were peer-reviewed, published articles, b) were written in English, c) provided sufficient data to compute between-group effect sizes, d) included samples with an average IQ greater than 80, e) included children and adults who received a diagnosis of ADHD based on professional opinion (e.g., pediatric evaluation), clinical interviews, and/or rating scales, and f) included a comparison control group.

The initial search yielded 14,018 articles. After an initial review of abstracts, 78 studies were retained based on the inclusion criteria outlined above. Of the remaining 78 studies, one study could not be located (i.e., Zhao-hong et al., 2011), one study did not provide group data for each comparison group (i.e., Humphreys, 2018), one study used a non-laboratory based behavioral task (i.e., in-the-moment driving behavior; Merkel, 2016), and seven studies included a sample examined in a more recently published studies (i.e., Barkley, 1990; Hoza et al., 2013; Molina & Pelham, 2003; Murphy &

Barkley, 1996; Pollak et al., 2015; Skogli et al., 2014; Thompson et al., 2007). See *Figure 1* for PRISMA flow diagram.

Several of the remaining 68 studies required additional considerations. When a single study produced multiple effect sizes, only one effect size per each independent sample was used to avoid violation of the assumption of statistical independence (Lipsey & Wilson, 2001). Several studies (i.e., Biederman & Faraone, 2006; Dunne, 2014; Egan, 2017; Hechtman, 2018; Huggins, 2015; Lambert, 2005; Luman, 2008; Molina, 2003; Nikolas, 2016; Odell, 2017; Olazagasti, 2013; Pollak, 2018; Rooney, 2012; Valero, 2017) reported multiple outcome variables of risky substance use (e.g., use of alcohol, marijuana, and illicit drugs; Rooney, 2012), multiple risky driving behaviors (e.g., collisions and near collisions; Nikolas, 2016), or unrelated behaviors across several risk domains (e.g., sex partners and police contact; Hetchman, 2018). In such cases, data provided for each outcome variable reported by a given study was aggregated to calculate a single effect size. When a single sample produced sufficient data to calculate effect sizes for two or more measurement modalities (i.e., behavioral tasks, self-report measures, and virtual reality simulators), one effect size was calculated for each modality since behavioral tasks, virtual reality simulators, and self-report measures were examined separately (i.e., Barkley, 1996; Dai, 2016; Pollak, Oz, Neventsal, Rabi, Kitrossky, & Maeir, 2016; Weafer, 2011; Groom, 2015; Knouse, 2005; Reimer, 2010). Finally, four studies compared risk-taking in samples of medicated participants and non-medicated participants (i.e., Abouzari, 2015; Agay, Yechiam, Carmel, & Levkovitz, 2010; DeVito, 2008; Morell, 2019), in which case the non-medicated sample was used to calculate effect sizes.

A total of 75 independent effect sizes from 68 studies ($ADHD_N = 5,191$; $TD_N = 4,471$) were included in the review. Specifically, 75 effect sizes were examined across separate analyses for experimental tasks (38 effect sizes), self-report measures (29 effect sizes), and virtual reality simulators (8 effect sizes). The current review includes 47 studies previously unexamined via meta-analytic review, in addition to 19 studies from Groen et al.'s (2013) review, 9 studies from Mowinckel et al.'s (2015) review, and 26 studies from Dekkers et al.'s (2016) review.

Potential Moderators

Moderators Examined in Behavioral Tasks and Self-Report Measures

Age. Previous research has shown that children and adolescents, relative to adults, engage in disproportionately greater risk-taking (Boyer, 2006; Christakou et al., 2011; Groen et al., 2013; Steinberg, 2008). Age-related differences may be more pronounced in ADHD, given that symptoms of hyperactivity and impulsivity tend to attenuate from childhood into adulthood (Biederman et al., 2000; Ingram et al., 1999), and associated ontological improvements in cognitive functioning may reduce the propensity to engage in risk-taking behaviors (Groen et al., 2013). The present study, therefore, expected to find larger effect sizes among studies with a lower mean-age sample (coded continuously as years), compared to studies with a higher mean-age sample.

Percentage of Females. Research has consistently indicated that, compared to females, males are more likely to engage in risk-taking behaviors, including risky sexual behaviors (Dir et al., 2014), risky financial investments (Charness & Gneezy, 2012), and risky driving (Turner & McClure, 2003). The present study, therefore, expected to find a significant moderating effect of sex on risk-taking in children and adults with and without

ADHD, whereby studies with a lower percentage of females (coded continuously) would be associated wtih larger effect sizes than studies with a higher percentage of females.

Diagnostic Grouping Method. Inclusion criteria for diagnostic groupings often vary across studies. For example, some studies rely on narrow-band rating scales provided by a single informant (e.g., parent *or* teacher), while others use a more comprehensive approach including a combination of rating scales provided by multiple informants (e.g., parent *and* teacher) and/or clinical interviews. Diagnostic methods that rely exclusively on a single source of information are vulnerable to validity threats with respect to grouping participants with and without ADHD, given the non-pathognomonic nature of ADHD symptoms (Evans et al., 2010; Ford-Jones, 2015). Cross-contamination of children and adults without ADHD in an ADHD group, and/or children and adults with ADHD in a control group, is likely to increase both within-group heterogeneity and between-group homogeneity. The current study, therefore, expected to find larger between-group effect sizes among studies that utilized comprehensive diagnostic procedures (coded as 1) with multiple measures and/or multiple informants, compared to studies that utilized narrow diagnostic procedures with a single measure and/or informant (coded as 0).

Comorbid Disruptive Behavior Disorders (DBD). Previous research suggest that ADHD-related risk taking behaviors may be attributed to the disorder's high comorbidity with disruptive behavior disorders, including Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD) in children, and antisocial personality disorder (APD) in adults (Garzon et al. 2008; Schwebel et al. 2002). To that end, longitudinal research has indicated that, among children with ADHD, those with comorbid DBD exhibit the

most risk-taking in adulthood (Biederman et al., 2008; Olazagasti et al., 2013). Further, compared to adults with only ADHD or DBD, adults with ADHD and comorbid DBD engage in more substance use (Barkley et al., 2004; Molina & Pelham, 2003; Sarver et al., 2014; Wilens et al., 2008), risky sexual behavior (Flory et al., 2006), and risky driving (Barkley et al., 1993). Experimental research has also indicated that performance on gambling tasks is the most impaired among children and adults with ADHD and comorbid DBD or APD, compared to children and adults with ADHD only (Groen et al., 2013). The present study, therefore, expected to find larger effect sizes among studies that included comorbid DBD diagnoses within the ADHD group. Studies were coded dichotomously to indicate whether participants with a comorbid DBD diagnosis (i.e., ODD, CD and/or APD) were excluded from the ADHD group. Studies that excluded participants from the ADHD group due to comorbid DBD diagnosis were coded as 1. Studies that included participants with comorbid DBD in the ADHD group, or did not specifically exclude comorbid DPD, were coded as 0.

ADHD Subtype. Existing research suggests important differences in risk-taking across ADHD subtypes, such that performance on risk-taking tasks has demonstrated more risky decision-making among adolescents with ADHD-C compared to ADHD-I (Skogli et al., 2014). Similarly, research has indicated a significant association between performance on risk-taking tasks and symptoms of hyperactivity and impulsivity among adults with ADHD, but not with symptoms of inattention (Lee & Hinshaw, 2006). In line with this findings, it was hypothesized that studies with samples of participants with ADHD-I would be associated with greater effect sizes relative to those that did not. Studies in the current review were coded dichotomously to indicate whether ADHD

predominantly inattentive subtype was included (coded as 1) or excluded (coded as 0) in the ADHD group.

Medication Use. Findings from non-experimental research on stimulant medication and risk-taking among adolescent and adults with ADHD suggests that methylphenidate use is associated with decreased real-world risky behaviors, such as drug abuse (Faraone et al., 2007) and risky sexual behaviors (Chen et al., 2018). In contrast, findings from experimental research have been mixed, such that nearly equal numbers of studies have provided evidence of decreased and increased risk taking following stimulant medication trials (Groen et al.'s (2013). Consequently, behavioral-task studies included in the current review were coded dichotomously to indicate whether participants with ADHD were medicated with a psychostimulant (e.g., methylphenidate; coded as 1) or not medicated with a psychostimulant (coded as 0) during task administration. Studies that included children or adults that discontinued stimulant medication use at least 24 hours prior to task administration were also coded as 0. Self-report studies were similarly coded dichotomously to indicate whether participants were prescribed stimulant medication for ADHD (coded as 1) or medication-naïve (coded as 0). Medication naïve participants included children and adults that had never used stimulant medication for treatment of ADHD.

Moderators Examined in Behavioral Tasks

Probabilistic Descriptions. Methodological variability in studies' descriptions of probabilistic outcomes (i.e., chances of winning or losing) may significantly affect patterns of risk-taking (Pollak & Shoham, 2015) and, consequently, effect size heterogeneity across studies. For example, *explicit* decision-making tasks elicit

"decisions under risk" by providing participants a priori knowledge of probabilistic outcomes, which in turn allows for a rational determination of the risks and benefits of each choice alternative (Brand, Labudda, & Markowitsch, 2006). *Implicit* decision-making tasks, in contrast, elicit "decisions under ambiguity" by requiring participants to learn about outcomes and probabilities through experience (Bechara, 2004). As such, implicit tasks place higher demands on executive functioning by requiring individuals to remember previous experiences (e.g., working memory; Cui et al., 2015; Hinson et al. 2002; Jameson et al., 2004) and update their existing knowledge of outcomes and probabilities accordingly (e.g., updating; Brand et al., 2007). Given the large body of research the provides reliable evidence of moderate to large magnitude executive function deficits in children (Alderson et al. 2007; Kasper et al. 2012; Lijffijt et al. 2005; Martinussen et al. 2005; Willcutt & Taylor, 2005) and adults (Adler et al., 2017; Barkley, 1997; Barkley et al., 2008; Brown, 2005) with ADHD, therefore, studies in the current review that utilized an implicit behavioral task, were expected to be associated with larger effect sizes, relative to studies that utilized an explicit task. To examine this hypothesis, studies included in the current review were coded as providing explicit probabilistic descriptions (i.e., described the outcome of each option, such as in the Cambridge Gambling Task; coded as 1), or implicit probabilistic descriptions (i.e., required learning about the outcome of each option through experience of gains and losses, such as in the Iowa Gambling Task; coded as 0).

Choice Set Size. Previous research has demonstrated that the likelihood of selecting risky alternatives increases as the choice set size (i.e., number of choice alternatives) increases (Hills et al., 2013; Noguchi & Hills, 2016). Research in ADHD,

however, has evidenced equivocal findings and suggest that a greater number of response options increases the potential for response variability among children and adults with ADHD, rather than increasing the likelihood for poorer decision-making. For example, Patros, Alderson, Lea, Tarle (2015) found that, overall, boys with ADHD exhibited more impaired performance on a decision-making task when compared to typically-developing boys. However, as the choice set size increased from two to five choices, boys with ADHD performed more similarly to boys without ADHD and between-group differences became non-significant. Coinciding with this finding, the current study predicted that smaller effect sizes would be associated with a larger number of choice alternatives. The choice set size used in behavioral tasks was coded continuously to indicate the total number of response options provided to participants. For example, if a participant was required to choose a card from one of four decks, such as in the Iowa Gambling Task (IGT; Bechara et al., 1994), the study was coded as having a choice set size of four. Examples of tasks with a choice set size of two included the Balloon Analogue Risk Task (i.e., choose to pump the balloon or not; BART, Lejuez et al. 2002) and the Card Playing Task (i.e., choose to continue playing or not; CPT, Newman, Patterson, & Kosson, 1987).

Reward Type. Although tangible (e.g., monetary incentives) and hypothetical rewards (e.g., points) are commonly used as reinforcers in research on risk-taking, the extent to which each reward type affects risk-taking behaviors is widely debated. For example, a subset of basic-cognitive research has found similar risky behavior responses to both tangible and hypothetical rewards (Bowman & Turnbull, 2003; Johnson & Bickel, 2002; Lagorio & Madden, 2005; Locey, Jones, & Rachlin, 2011; Madden et al., 2004; Matusiewicz et al., 2013), while other studies have indicated that children (Xu, Fang, &

Rao, 2013) and adults (Hinvest & Anderson, 2010; Lane et al., 2003) exhibit greater risk

aversion when presented with tangible rewards. Similar findings have been observed

among children and adults with ADHD. Although previous research suggests that

tangible rewards, relative to hypothetical rewards, elicit more risk-taking behaviors in

children with ADHD (Scheres Lee, & Sumiya, 2008), more recent findings suggest

tangible and hypothetical reward tasks elicit equal responses (Pollak et al., 2016).

Overall, it is unclear whether risk-taking behavior is differentially affected by the use of

tangible rewards compared to hypothetical rewards, which warrants a meta-analytic

examination of reward type as a moderating variable of risk-taking. Studies were coded

dichotomously to indicate whether they provided tangible rewards (e.g., such as money,

stickers, or toys; coded as 1) or hypothetical rewards (e.g., points or fictive money coded

as 0) based on task performance. It is noted that several studies allowed participants to

trade in their non-tangible task earnings for tangible reward after task completion (e.g.,

$.01 for every fictive $1.00 earned during game; Ernst, 2003), in which case, they were

coded as a tangible reward study.

  Feedback. Adolescents with ADHD appear to demonstrate less risk-taking

behavior on experimental gambling tasks when compared to adolescents without ADHD,

but only under conditions when feedback is provided (Pollak and Shoham, 2015).

Moreover, children without ADHD use feedback to update context information and adapt

responses accordingly, whereas children with ADHD are deficient in this ability and have

a propensity to risk smaller bets in the absence of feedback (Pollak & Shoham, 2015).

These findings suggest that, when feedback is provided to children with ADHD, they

may respond more conservatively and exhibit impaired performance, compared to when

feedback is not provided. As such, studies that provided feedback during tasks were

expected to be associated with larger effect sizes. Feedback was coded dichotomously to

indicate whether studies provided immediate feedback (i.e., provided information on

gains and/or losses following each individual trial; coded as 1) or delayed feedback (i.e.,

provided information about total gains and/or losses after each block of trials; coded as

0).

Moderators Examined in Self-Report Measures

Response Format. Self-report measures that utilize dichotomous forced-choice

items (e.g., "Do you use recreational drugs?") require minimal cognitive effort to

accurately recall the occurrence of a behavior (Schwarz & Oyserman, 2001). In contrast,

Likert scales, semantic differential scales, and open-ended questions (e.g., "How often do

you use recreational drugs?") draw upon more cognitive resources to both accurately

recall the occurrence of a behavior and the extent to which it occurs (Schwarz &

Oyserman, 2001). Given that impairment in the ability to recall and manipulate

information (i.e., working memory) has been well-documented in children (Alderson et

al., 2010; Kasper et al., 2012; Kofler et al., 2010; Martinussen et al., 2005; Rapport et al.,

2008; Rapport et al., 2009) and adults (Alderson, Hudec, Patros, & Kasper, 2013;

Alderson, Kasper, Hudec, & Patros, 2013; Hervey, Epstein, & Curry, 2004; Hudec,

Alderson, Patros, & Kasper, 2014) with ADHD, reducing cognitive demands through use

of dichotomous response formats would likely increase the validity of responses provided

by the ADHD group. The present study, therefore predicted that studies using

dichotomous self-report formats would be associated with greater between-group

differences (i.e., larger effect sizes) in risk-taking, compared to non-dichotomous self-

report formats. Studies that used self-report measures were coded to indicate whether the response format was dichotomous (coded as 0) or non-dichotomous (coded as 1). When studies utilized a combination of dichotomous and non-dichotomous responses, they were coded as non-dichotomous.

Assessment Type. Inaccurate self-reports of externalizing behavior and associated difficulties have been well-documented in ADHD literature (Owens et al., 2007; Pelham et al. 2005; Wolraich et al. 2004). Specifically, characteristic symptoms of ADHD, such as inattention and impulsivity, may lead to careless mistakes, difficulty following instructions, or failure to complete items when filling out self-report questionnaires. Interview-style questioning that requires participants to verbally respond to questions are expected to minimize inaccurate responses by allowing for clarification of answers and questions, and by having another person present (e.g., the examiner) to increase on-task behavior. Accordingly, the current study expected to find larger effect sizes associated with studies that required participants to report on risky behaviors via interviews (coded as 1) compared to self-report questionnaires (e.g., via paper/pencil or computer; coded as 0).

Data Analytic Strategy

Estimation of Effect Sizes

Effect sizes were computed using Comprehensive Meta-Analysis Version 3 (CMA-3; Borenstein, Hedges, Higgins, & Rothstein, 2014) software. Hedges' *g* effect sizes were calculated (Hedges' *g*; Hedges & Olkin, 1985) to correct for positive bias in small study samples by weighting effect sizes based on their standard error (i.e., the standard deviation of the sampling distribution), such that effect sizes of large-sample

studies were given more weight than small-sample studies; Lipsey & Wilson, 2001; Viechtbauer, 2010). Random effects models were utilized to adjust for variability in effect sizes that is assumed to be randomly distributed (i.e., between-study variability), in addition to subject-level sampling error.

Means and standard deviations were used to calculate effect sizes for 50 studies (35 behavioral task studies, 11 self-report studies, and 4 virtual reality studies). Twenty-five studies did not provide means and/or standard deviations, and therefore, effect sizes were estimated using other metrics, such as sample size and t statistics, sample size and F statistics, sample size and frequency rates, or odds ratios and confidence intervals. Positive effect sizes indicated higher mean scores (i.e., greater risk-taking) for the ADHD group relative to the control group. Several studies reported a mean number of advantageous choices as a dependent variable, and consequently, larger means reflected greater risk taking. To ensure consistent comparisons, these outcome variables were recoded so that higher mean scores reflect more risk-taking. For example, an overall mean of 10.4 was reversed to -10.4 (i.e., Garon, 2006) to reflect fewer advantageous choices (i.e., more risk-taking). Effect sizes were classified as small (ES ≤ 0.30), medium (0.31 ≤ ES ≥ 0.66), or large (ES ≥ 0.67), and effect sizes equal to zero indicated no difference between group means (Cohen, 1992).

Publication Bias

Several methods were used to assess potential publication bias. First, funnel plots were visually inspected for symmetry of the distribution of effect sizes across studies, where an asymmetrical distribution would suggest the possibility of publication bias. Next, Egger's test was used to examine the symmetry of the funnel plot using a regression

analysis, where greater *y* intercept values suggest an increased likelihood of publication bias (Egger et al., 1997). Finally, a *Fail-safe N* analysis was conducted to estimate the number of unpublished studies that would be needed to reduce the confidence interval of an effect size to include zero (i.e., non-significant between-group differences).

Homogeneity Analysis

Two independent *Q* tests were performed to examine the effect size distribution across all behavioral tasks and self-report measures. A significant *Q* indicated that the assumption of homogeneity was rejected and examination of potential moderator effects was supported (Lipsey & Wilson, 2001).

Moderator Analyses

Random effects meta-regressions were conducted to provide a measure of overall fit (Q_R) and an error/residual term (Q_E) for behavioral task studies and self-report studies. Whereas a significant Q_R indicates that the model accounts for significant variability among effect sizes, a significant Q_E indicates that residual variance is greater than what is expected from random study-level sampling error (Lipsey & Wilson, 2001). Because effect size estimates do not necessarily fall on a normal distribution in meta-analysis, beta-weights from each regression were converted to *z* scores and compared to a *z*-distribution that reflected a standardized difference between values (Lipsey & Wilson, 2001).

CHAPTER IV

RESULTS

Behavioral Task Analyses

Thirty-eight studies, consisting of 2,375 participants ($ADHD_N = 1,197$, $TD_N = 1,178$), provided sufficient data to calculate an overall effect size for studies that used behavioral tasks (see *Table 1*). A statistically significant, medium-magnitude effect size of 0.32 (95% CI [0.17, 0.47], $p < .001$) indicated that the ADHD group exhibited moderately more risk-taking on behavioral tasks, compared to the non-ADHD group (see *Figure 2*). A visual inspection of the funnel plot indicated a symmetrical distribution of effect sizes across studies and Egger's regression intercept of 2.25 (95% CI [0.01, 4.50], $p = .05$) suggested no evidence of publication bias. In addition, the *Fail-safe N* analysis revealed that an unlikely 460 unpublished studies with null effects would be needed to change the confidence interval to include zero.

A significant Q test, $Q(37) = 113.31$, $p < .001$, $I^2 = 67.35$, indicated that the assumption of homogeneity across effect sizes (Hedges' g range from -0.65 to 1.38) was rejected and examination of potential moderator effects using meta-regression was supported (see *Table 4*). Four effect sizes (i.e., Antonini, 2015; Humphreys, 2011; Matthys, 1998; van Goozen, 2004) were identified as outliers, but were retained in analyses based on previous research that suggests outliers may reveal important patterns

related to study characteristics (Viechtbauer & Cheung, 2010). The mixed-effects meta-regression model did not explain a significant proportion of effect size variability ($Q_R = 0.89$, $df = 6$, $p = .99$), suggesting that the included moderators (i.e., *age, percentage of females, diagnostic grouping method, probabilistic descriptions*, *choice set size,* and *reward type*) could not explain significant heterogeneity in the effect size distribution. Not surprisingly, the significant sum-of-squares residual ($Q_E = 113.31$, $df = 37$, $p < .001$) indicated residual variance in the model beyond study-level sampling error. This finding suggests that there are likely moderators other than those considered in this review that affect between-group differences in risk-taking in ADHD and healthy-control groups.

Self-Report Measure Analyses

Twenty-nine studies, consisting of 7,283 participants ($\text{ADHD}_N = 3,991$, $\text{TD}_N = 3,292$), provided sufficient data to calculate effect sizes for studies that used self-report measures (see *Table 2*). A statistically significant, medium-magnitude effect size of 0.39 (95% CI [0.27, 0.51], $p < .01$) indicated that children and adults with ADHD exhibited more risk-taking on self-report measures, compared to healthy-control children and adults (see *Figure 3*). A visual inspection of the funnel plot indicated a symmetrical distribution of effect sizes across studies and Egger's regression intercept of 1.48 (95% CI [-0.47, 4.43], $p = .13$) suggest no evidence of publication bias. In addition, the *Fail-safe N* analysis revealed that an unlikely 1,372 unpublished studies with null effects would be needed to change the confidence interval to include zero.

A significant Q test, $Q(13) = 147.05$, $p < .001$, $I^2 = 80.96$, indicated that the assumption of homogeneity across effect sizes (Hedges' g range from -0.28 to 1.22) was rejected and examination of potential moderator effects using meta-regression was

supported (see *Table 4*). Two effect sizes (i.e., Flory, 2006; Groom, 2015) were identified as outliers, but were retained in analyses. The mixed-effects meta-regression model did not explain a significant proportion of effect size variability ($Q_R = 3.00$, $df = 6$, $p = .81$), suggesting that the included moderators (i.e., *age, percentage of females, diagnostic grouping method, response format* and *assessment type*) could not explain significant heterogeneity in the effect size distribution. In addition, a significant sum-of-squares residual ($Q_E = 147.05$, $df = 28$, $p < .001$) indicated residual variance in the model beyond study-level sampling error.

Virtual Reality Task Analyses

Eight studies, consisting of 419 participants ($ADHD_N = 214$, $TD_N = 205$), utilized virtual reality simulations in their examinations of risk taking and provided sufficient data to calculate effect sizes (see *Table 3*). A significant medium-magnitude effect size of 0.63 (95% CI [-0.04, 1.22], $p = .04$) indicated that children and adults with ADHD exhibited significantly more risk-taking on behavioral tasks presented in virtual reality, compared to children and adults without ADHD (see *Figure 4*). A visual inspection of the funnel plot indicated a symmetrical distribution of effect sizes across studies and Egger's regression intercept of 1.57 (95% CI [-4.34, 7.47], $p = .53$) suggest no evidence of publication bias. However, the *Fail-safe N* analysis revealed that only 7 unpublished studies with null effects would be needed to change the confidence interval to include zero. A significant Q test, $Q(6) = 48.15$, $p < .001$, $I^2 = 87.54$, indicated that the assumption of homogeneity across effect sizes (Hedges' g range from -0.41 to 2.69) was rejected and examination of potential moderator effects using meta-regression was

supported (see *Table 4*). However, due to the small sample size of included studies, meta-regressions were not completed and potential moderators were not examined statistically.

Excluded Moderators

Several additional variables were considered as potential moderators of effect size variability, but were not examined using meta-regression procedures due to insufficient data reporting or limited variability across studies. However, these potential moderators were examined post hoc via a hybrid of meta-analytic and traditional methods common to systematic reviews.

Only 64% of all behavioral task studies and 34% of all self-report studies were coded for ADHD subtype because the remaining studies did not report sample characteristics with regard to ADHD subtype. Twenty behavioral task studies ($n_{ADHD} = 786$, $n_{TD} = 654$) included heterogeneous samples of ADHD that included ADHD-I (Hedges' $g = .25$, $p = .01$), while only 5 studies ($n_{ADHD} = 118$, $n_{TD} = 145$) included samples of only ADHD-C and/or ADHD-H (Hedges' $g = .49$, $p = .001$). Across self-report studies, only 6 studies ($n_{ADHD} = 304$, $n_{TD} = 295$) included heterogeneous samples with ADHD-I (Hedges' $g = .54$, $p < .001$), and 4 studies ($n_{ADHD} = 802$, $n_{TD} = 494$) included homogenous samples of ADHD-C and/or ADHD-H (Hedges' $g = .44$, $p < .001$).

Eight behavioral task studies ($n_{ADHD} = 183$, $n_{TD} = 214$) excluded comorbid DBD diagnoses from their ADHD sample (Hedges' $g = .29$, $p = .06$), while 30 studies ($n_{ADHD} = 1,014$, $n_{TD} = 964$) did not exclude comorbid DBD diagnoses (Hedges' $g = .33$, $p < .01$). Within self-report studies, only 5 studies ($n_{ADHD} = 613$, $n_{TD} = 586$) excluded comorbid DBD diagnoses from their ADHD sample (Hedges' $g = .56$, $p < .001$), while 24 studies

(n_{ADHD} = 3,378, n_{TD} = 2,706) did not exclude comorbid DBD diagnoses (Hedges' g = .35, p < .001).

An examination of medication use across behavioral tasks indicated that 32 studies (n_{ADHD} = 1,034, n_{TD} = 947) included ADHD groups not on medication at the time of task administration (Hedges' g = .32, p < .001), while only 4 studies (n_{ADHD} = 119, n_{TD} = 155) included ADHD groups on medication at the time of task administration (Hedges' g = .08, p = .65). Only 62% of self-report studies provided information about medication use of participants, with all 18 studies (n_{ADHD} = 1,780, n_{TD} = 1,534) including ADHD participants with an active prescription for stimulant medication (Hedges' g = .41, p < .001).

Finally, only one behavioral task study (n_{ADHD} = 37, n_{TD} = 35) did not provide trial-by-trial feedback and the effect size (Hedges' g = .43, p = .07) was not significant. The remaining 37 studies (n_{ADHD} = 1,160, n_{TD} = 1,143) provided trial-by-trial feedback (Hedges' g = .32, p < .001).

CHAPTER V

DISCUSSION

The current study updates previous systematic (Groen et al., 2013) and meta-analytic (Dekkers et al., 2016; Mowinckel et al., 2015) reviews of risk-taking in children and adolescents with and without ADHD. Findings from previous reviews have been equivocal and suggest a need for examination of moderating factors that may explain heterogeneity across studies. As such, the current study provides a unique examination of potential methodological and sample moderator variables, while comparing effect size estimates across behavioral task studies. The current review also provides the first comprehensive examination of self-report measures across several risk-taking domains (e.g., substance use, risky driving, and risky sexual behavior), as well as a review of the nascent body of literature that has examined ADHD-related risk taking via virtual reality.

Thirty-nine laboratory-based behavioral task studies, including 10 studies that were not examined in previous meta-analytic reviews, and 29 self-report studies were included in the current review. Overall, the aggregated effect size of behavioral task and self-report studies of ADHD-related risk-taking yielded medium-magnitude effects (Hedges' g = .33 and 39, respectively), indicating that children and adults with ADHD exhibited moderately more risk-taking, compared to children and adults without ADHD. Contrary to expectations, these findings suggest performance on behavioral tasks parallel findings from self-report measures of risk-taking that are arguably more ecologically

valid (Barkley & Fischer, 2011; Barkley & Murphy, 2010; Dang et al., 2020; Holst & Thorell, 2019), and corroborate previous correlational research suggesting that performance on behavioral tasks is correlated with self-report measures of behavior (Kirby et al., 1999, Richards et al., 1999, Swann et al., 2002). Although the magnitude of effects were consistent with Dekkers and colleagues' (2016) previous meta-analysis (d = .36), they are larger than the small-magnitude effect size reported by Mowinckel and colleagues (2015; Hedges' g = .23). The discrepancy in effect size magnitudes may reflect the effect of age on risk-taking, and specifically, the examination of adults in Mowinckel et al.'s review, compared to the examination of adults and children in the current review. Alternatively, the difference in magnitude between effect sizes across reviews may reflect differences in the diversity of tasks included in each review. That is, Mowinckel et. al.'s review only included studies that used the IGT task, whereas the present review included any laboratory-based gambling tasks or self-report measure that assessed for risk-taking behavior. This finding implies that the IGT is associated with smaller effects, relative to other metrics.

Eight studies that examined risk-taking via virtual reality simulators yielded an aggregated medium-magnitude effect (Hedges' g = .63), indicating that children and adults with ADHD exhibited more risk-taking on virtual reality simulators, compared to children and adults without ADHD. Consistent with expectations, the magnitude of the between-group effect size of virtual reality simulators is 49% and 38% larger than the magnitude of between-group effect sizes of behavioral tasks and self-report measures, respectively. This findings suggests that virtual reality simulators may be more sensitive to group differences in risk-taking between ADHD and non-ADHD groups, compared to

behavioral tasks and self-report measures, and indicates that virtual reality metrics provide enhanced ecological validity of the evaluation of behavioral and cognitive responses (Parsey & Schmitter-Edgecombe, 2013). Of note, however, the small sample size of virtual reality studies and the possibility of publication bias suggest these finding should be considered with caution.

In addition to overall between-group differences in risk-taking among ADHD and non-ADHD groups, our findings indicated significant heterogeneity across effect sizes within each task domain. Specifically, 66%, 81%, and 88% of variability across behavioral tasks, self-report measures, and virtual reality simulators, respectively, was accounted for by intra-study variability, rather than by chance. The significant variability and sufficient sample size of behavioral task and self-report measure studies warranted the examination of potential moderator variables.

Surprisingly, age was not a significant moderator of effect size variability across studies that used behavioral tasks or self-report measures. That is, unlike reliable and well-documented findings that evince a reduction in ADHD-related impairment that corresponds with ontological development (Bedard et al. 2002; Biederman, Mick, & Faraone, 2000; Shaw et al., 2007; Hudec et al., 2014), as well as previous findings of a linear decrease in risky decision-making from childhood to adolescent (Crone & van der Molen, 2007; Hooper et al., 2004), and from adolescence to adulthood (Crone & van der Molen, 2007; Mitchell et al., 2008; van Duijvenvoorde et al., 2012) in individuals without ADHD, risk-taking does not appear to follow a similar trajectory in ADHD. Other empirical studies, however, have indicated findings consistent with our null results (Cauffman et al., 2010 ; Overman et al., 2004), which suggest that risk-taking in ADHD

may have more continuity across the lifespan than previous expectations, and that adults with ADHD engage in risk-taking at proportionate rates compared to children with ADHD. Although it was initially suggested that, the larger effect size found in the present review compared to Mowinckel et al.'s (2015) review may be explained by our inclusion of children, these findings indicate that a more probable explanation is likely and the discrepancy in effect sizes cannot be explained by age-related differences.

Contrary to expectations, the percentage of females included in studies did not significantly moderate between-group effects sizes in behavioral-task or self-reported risk-taking. In hindsight, the absence of this effect may be explained by contextual factors associated with sex-related differences in risk-taking. A previous meta-analysis that investigated sex differences in risk-taking among healthy children and adults demonstrated that differences in risk-taking exhibited by males and females may be moderated by several other context-related variables, including biological maturation, cognitive ability, self-perceptions; perceptions of others, personal values, risk perception, and characteristics of peer groups (Byrnes et al., 1999). Although this poses an interesting theory for our examination of sex-differences in risk-taking among children and adults with ADHD, this investigation is beyond the scope of this meta-analysis and should be considered for future research.

Diagnostic grouping method was surprisingly not a significant moderator of effect size variability in risk-taking. Although comprehensive diagnostic procedures typically increase sensitivity and specificity for diagnostic groupings, unexpected findings with respect to diagnostic grouping methods are not unprecedented. For example, previous meta-analytic studies have reported findings of smaller effect sizes associated with more

comprehensive assessment procedures (Alderson et al., 2007; Kofler et al., 2008).

Authors of these paradoxical effects suggested they may be an artifact of the calculation of standardized effect size metrics (i.e., a mean difference divided by its pooled standard deviation). That is, due to the high rates of intra- and inter-individual variability evidenced in children with ADHD (Buzy et al., 2009; Kofler et al., 2013; Russell et al., 2006; Uebel et al., 2010), an increase in the homogeneity of groups would likely result in greater within-in group variation, a corresponding increase in the denominator of Hedge's *g* effect size calculations, and a relatively smaller effect size estimates. Given the present study's null effect, however, it may be the case that grouping method matters for executive functions that serve as core features of ADHD (e.g., working memory, inhibition), but not for tertiary features such as risk-taking.

The choice set-size of behavioral tasks did not significantly moderate effect size heterogeneity. A plausible explanation for this unexpected null finding is that the effect of choice set-size is confounded by the amount of risk, or expected value, attributed to each choice rather than the number of choices themselves. That is, laboratory-based behavioral tasks may confound risk-seeking behavior with suboptimal decision-making by providing risky alternatives that are also less optimal based on their expected value (Shoham et al., 2016). To that end, research has demonstrated that ADHD and control groups perform similarly when participants are presented with risky and safe alternatives that are equal in expected value on a gambling task (Pollak et al. 2016). It is therefore unclear whether selection of risky alternatives is a result of increased risk-taking or poorer decision-making, or whether risk-taking in ADHD may be more reflective of a reification error due to an impaired ability to compare probabilistic outcomes, which then

impairs choice selection (e.g., making a risky decision). Future studies should examine between-group differences in risk-taking elicited on tasks with equal expected value to explore mechanisms of risk taking (e.g., risky decision making vs. suboptimal decision making) associated with ADHD.

The present study found several additional moderators to be non-significant. For instance, methodological variability in the use of explicit or implicit behavioral tasks (i.e., probabilistic descriptions) did not significantly moderate effect size variability in risk-taking across behavioral-task studies, similar to findings demonstrated in Dekkers et al.'s (2016) meta-analysis. Although implicit tasks may increase risk-taking by placing higher demands on executive functions (Brand et al., 2007; Cui et al., 2015; Hinson et al. 2002; Jameson et al., 2004), our finding suggests it is equally plausible that implicit tasks may also increase conservative responding by impairing decision-making processes (Pollak & Shoham, 2015). The type of reward provided to participants did not significantly moderate effect size variability in risk-taking. Our null findings coincide with extant findings that have indicated similar responses to tangible or hypothetical rewards in children with ADHD (Pollak et al., 2016). Considering the growing body of research on aberrant reward process in ADHD (Luman et al. 2010; Sonuga-Barke et al. 2008; Tripp & Wickens, 2009), however, further investigation on the effects of risk-taking in ADHD is warranted. Future research should examine different characteristics of reward, such reward schedules and levels of reward. The type of response format used for self-report measures, surprisingly, did not significantly moderate effect size variability in risk-taking between ADHD and control groups. Our null finding may be explained by the tendency for children and adults with ADHD to underreport the frequency and severity of their

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symptoms (Hemmingsson et al., 2017; Kooij et al., 2008; Sibley et al., 2010; Sibley et al., 2012). Although non-dichotomous response formats present the opportunity to obtain more variable information regarding behavior, compared to dichotomous formats, underreporting in ADHD may produce underestimations of risk-taking behavior. The type of assessment used for self-report measures was not a significant moderator in effect size variability in risk-taking. This unexpected finding may be explained by less valid responding associated with self-report questionnaires due to ADHD-related impairments (e.g., making careless mistakes, difficulty with understanding instructions, or failure to complete items; Huizinga & Elliott, 1986; Shaffer et al. 2000) that parallels with less valid responding associated with the increased tendency to respond in a socially desirable way or a decreased sense of privacy in the presence of an interviewer (Huizinga & Elliot, 186).

Several variables were considered as potential moderators (i.e., *ADHD subtype*, *comorbid DBD*, *medication use*, and *feedback* on behavioral tasks), but were not examined via meta-regression due to lack of variability and/or insufficient reporting across studies. A hybrid meta-analytic/systematic review approach indicated that the effect size of behavioral task studies with ADHD samples that included ADHD-I were, on average, 51% smaller than studies with homogenous samples of ADHD-C and/or ADHD-H. Not surprisingly, this finding suggests that children and adults with ADHD-I exhibit less risk-taking on behavioral tasks, compared to children and adults with ADHD-C or ADHD-H. Across self-report studies, however, studies with ADHD samples that included ADHD-I were, on average, 19% larger than studies with homogenous samples of ADHD-C and/or ADHD-H. These seemingly paradoxical findings between behavioral

task and self-report studies may indicate that ADHD-related inattention is associated with less self-awareness on self-report measures of risk-taking, which is consistent with previous research demonstrating that adolescents and young adults lack insight into their own behavior (Barkley, 2006; Wolraich et al. 2005).

In addition, the exclusion of participants with comorbid DBD from the ADHD group in behavioral task studies was not associated with significant between-group differences. Studies that did not exclude comorbid DBD from the ADHD group, on the other hand, were associated with significantly greater risk-taking in ADHD groups, compared to non-ADHD groups. Significant effect sizes of roughly equal magnitude were found across behavioral and self-report studies, regardless of whether or not they included or excluded participants with comorbid DBD. As expected, behavioral task studies that excluded participants on medication were associated with moderate-magnitude group differences, whereas the aggregated effect size from studies that included groups on medication was not significant. There was no variability in medication use across self-report studies, and therefore, no inferences could be made. Nevertheless, the finding from laboratory-based behavioral studies appears to suggest that medication use may reduce risky behavior in children and adults with ADHD. Finally, the absence of trial-by-trial feedback was associated with a non-significant between-group difference, whereas studies that provided trial-by-trial feedback were associated with a moderate-magnitude effect size. It is noted, however, that only one study did not provide trial-by-trial feedback and this finding should therefore be considered with caution.

Limitations

The present study is the first to review risk-taking in ADHD across behavioral, self-report, and virtual reality metrics and provides a unique contribution due to its examination of potential sample and methodological moderator variables. Nevertheless, a few potential limitations warrant consideration. For instance, our findings suggest a strong potential for publication bias among studies that utilized virtual reality simulators. Although this bias likely reflects the small sample size of only eight effect sizes, rather than true publication bias, caution is warranted. In addition, the small sample size of virtual reality studies inhibited our ability to examine potential moderators and reduces the reliability and external validity of our results, which warrants consideration of the current study's findings. Future studies on risk-taking in ADHD should aim to include measures of risk-taking in virtual environments to further inform the utility of virtual reality simulations in research.

Finally, although the present study expanded upon prior reviews with the inclusion of several additional moderators that were not previously investigated, not all potential moderators could be examined within the scope of the current study. In part, our inclusion of potential moderators was limited due to insufficient reporting. Several other potential moderators (e.g., ADHD subtype, medication use, feedback), however, were not examined due to a lack of variability across studies. Future studies of risk-taking in ADHD should aim to examine and report these variables so that updated meta-analytic reviews can examine their potential moderating effects. Likewise, as the growing body of literature continues to advance, future studies should consider incorporating additional moderating variables in their analyses, such as schedules of reinforcement, reward

sensitivity, and presentation of feedback (e.g., visual, verbal, social), to discern variables

that significantly affect between-group differences in risk-taking among ADHD and non-

ADHD groups.

CHAPTER VI

CONCLUSION

The current study aimed to elucidate differences in risk-taking among children and adults with and without ADHD through meta-analytic methods, while accounting for limitations of previous reviews. Results revealed that, when compared to children and adults without ADHD, ADHD was associated with greater risk-taking behavior across task domains. The present study also examined potential moderator variables of behavioral task and self-report studies and found non-significant effects, despite the finding that there was significant heterogeneity across behavioral task studies and self-report studies. Future research is needed to investigate additional potential moderators that may deepen our understanding of risk-taking in ADHD. Taken together, our findings suggest that children and adults exhibit reliably greater risk-taking behavior, compared to children and adults without ADHD, and supports convergent validity across risk-taking task domains. However, findings of the present study indicate that the careful experimental control and strong external validity provided by virtual reality simulators may allow for a more accurate representation of risk-taking behavior exhibited in children and adults with ADHD. Future research is needed to expand on these findings, however, the utility of virtual reality simulators in risk-taking research is promising.

REFERENCES

Abikoff, H. B., Jensen, P. S., Arnold, L. E., Hoza, B., Hechtman, L., Pollack, S., ... & Vitiello, B. (2002). Observed classroom behavior of children with ADHD: Relationship to gender and comorbidity. Journal of abnormal child psychology, 30(4), 349-359.

Abouzari, M., Oberg, S., Gruber, A., & Tata, M. (2015). Interactions among attention-deficit hyperactivity disorder (ADHD) and problem gambling in a probabilistic reward-learning task. *Behavioural Brain Research*, 291, 237-243.

Adler, L. A., Faraone, S. V., Spencer, T. J., Berglund, P., Alperin, S., & Kessler, R. C. (2017). The structure of adult ADHD. *International journal of methods in psychiatric research*, *26*(1), e1555.

Agay, N., Yechiam, E., Carmel, Z., & Levkovitz, Y. (2010). Non-specific effects of methylphenidate (Ritalin) on cognitive ability and decision-making of ADHD and healthy adults. Psychopharmacology, 210(4), 511-519.

Alderson, R. M., Hudec, K. L., Patros, C. H., & Kasper, L. J. (2013). Working memory deficits in adults with attention-deficit/hyperactivity disorder (ADHD): An examination of central executive and storage/rehearsal processes. *Journal of abnormal psychology*, *122*(2), 532.

Alderson, R. M., Kasper, L. J., Hudec, K. L., & Patros, C. H. (2013). Attention-deficit/hyperactivity disorder (ADHD) and working memory in adults: A meta-analytic review. *Neuropsychology*, *27*(3), 287.

Alderson, R. M., Patros, C. H., Tarle, S. J., Hudec, K. L., Kasper, L. J., & Lea, S. E. (2017). Working memory and behavioral inhibition in boys with ADHD: An experimental examination of competing models. *Child Neuropsychology*, *23*(3), 255-272.

Alderson, R. M., Rapport, M. D., & Kofler, M. J. (2007). Attention-deficit/hyperactivity disorder and behavioral inhibition: a meta-analytic review of the stop-signal paradigm. *Journal of abnormal child psychology*, *35*(5), 745-758.

Alderson, R. M., Rapport, M. D., Hudec, K. L., Sarver, D. E., & Kofler, M. J. (2010). Competing core processes in attention-deficit/hyperactivity disorder (ADHD): Do working memory deficiencies underlie behavioral inhibition deficits? *Journal of Abnormal Child Psychology, 38*(4), 497-507. doi:10.1007/s10802-010-9387-0

Amador-Campos, J. A., Forns-Santacana, M., Guàrdia-Olmos, J., & Peró-Cebollero, M. (2006). DSM-IV attention deficit hyperactivity disorder symptoms: Agreement between informants in prevalence and factor structure at different ages. Journal of Psychopathology and Behavioral Assessment, 28(1), 23-32.

American Psychiatric Association (1980). *Diagnostic and statistical manual of mental disorders* (3rd ed.). Arlington, VA: American Psychiatric Association.

American Psychiatric Association (1983). *Diagnostic and statistical manual of mental disorders,* (3rd ed., revised). Washington, DC: American Psychiatric Publishing.

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

American Psychiatric Association. (1968). *Diagnostic and statistical manual of mental disorders* (2nd ed.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, D.C.: American Psychiatric Publishing.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Antonini, T. N., Becker, S. P., Tamm, L., & Epstein, J. N. (2015). Hot and cool executive functions in children with attention-deficit/hyperactivity disorder and comorbid oppositional defiant disorder. *Journal of the International Neuropsychological Society*, 21(8), 584-595.

Asherson, P., Akehurst, R., Kooij, J. S., Huss, M., Beusterien, K., Sasané, R., ... & Hodgkins, P. (2012). Under diagnosis of adult ADHD: cultural influences and societal burden. Journal of Attention Disorders, 16(5_suppl), 20S-38S.

August, G. J., Winters, K. C., Realmuto, G. M., Fahnhorst, T., Botzet, A., & Lee, S. (2006). Prospective study of adolescent drug use among community samples of ADHD and non-ADHD participants. *Journal of the American Academy of Child & Adolescent Psychiatry*, 45(7), 824-832.

Babinski, L. M., Hartsough, C. S., & Lambert, N. M. (1999). Childhood conduct problems, hyperactivity-impulsivity, and inattention as predictors of adult

criminal activity. The Journal of Child Psychology and Psychiatry and Allied Disciplines, 40(3), 347-355.

Babor, T. F., de la Fuente, J. R., Saunders, J., & Grant, M. (1992). AUDIT: The alcohol use disorders identification test: Guidelines for use in primary health care. In *AUDIT: The alcohol use disorders identification test: Guidelines for use in primary health care*. World Health Organization.

Baddeley, A. (2000). The episodic buffer: a new component of working memory?. Trends in cognitive sciences, 4(11), 417-423.

Bagwell, C. L., Molina, B. S., Pelham Jr, W. E., & Hoza, B. (2001). Attention-deficit hyperactivity disorder and problems in peer relations: Predictions from childhood to adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*(11), 1285-1292.

Barbaresi, W. J., Colligan, R. C., Weaver, A. L., Voigt, R. G., Killian, J. M., & Katusic, S. K. (2013). Mortality, ADHD, and psychosocial adversity in adults with childhood ADHD: a prospective study. Pediatrics, 131(4), 637-644.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. Psychological bulletin, 121(1), 65.

Barkley, R. A. (1998). Attention-deficit hyperactivity disorder. Scientific American, 279(3), 66-71.

Barkley, R. A. (2002). Major life activity and health outcomes associated with attention-deficit/hyperactivity disorder. The Journal of clinical psychiatry.

Barkley, R. A. (2006). Primary symptoms, diagnostic criteria, prevalence, and gender

    differences. Attention-deficit hyperactivity disorder: A handbook for diagnosis

    and treatment, 3, 76-121.

Barkley, R. A. (2011). The importance of emotion in ADHD. Journal of ADHD and

    related disorders, 1(2), 5-37.

Barkley, R. A., & Cox, D. (2007). A review of driving risks and impairments associated

    with attention-deficit/hyperactivity disorder and the effects of stimulant

    medication on driving performance. *Journal of safety research*, *38*(1), 113-128.

Barkley, R. A., & Fischer, M. (2011). Predicting impairment in major life activities and

    occupational functioning in hyperactive children as adults: Self-reported

    executive function (EF) deficits versus EF tests. *Developmental*

    neuropsychology, *36*(2), 137-161.

Barkley, R. A., & Murphy, K. R. (2010). Impairment in occupational functioning and

    adult ADHD: the predictive utility of executive function (EF) ratings versus EF

    tests. *Archives of clinical neuropsychology*, *25*(3), 157-173.

Barkley, R. A., DuPaul, G. J., & McMurray, M. B. (1990). Comprehensive evaluation of

    attention deficit disorder with and without hyperactivity as defined by resear

Barkley, R. A., Fischer, M., Smallish, L., & Fletcher, K. (2004). Young adult follow-up

    of hyperactive children: antisocial activities and drug use. Journal of child

    psychology and psychiatry, 45(2), 195-211.

Barkley, R. A., Fischer, M., Smallish, L., & Fletcher, K. (2006). Young adult outcome of

    hyperactive children: adaptive functioning in major life activities. Journal of the

    American Academy of Child & Adolescent Psychiatry, 45(2), 192-202.

Barkley, R. A., Guevremont, D. C., Anastopoulos, A. D., DuPaul, G. J., & Shelton, T. L. (1993). Driving-related risks and outcomes of attention deficit hyperactivity disorder in adolescents and young adults: a 3-to 5-year follow-up survey. *Pediatrics*, *92*(2), 212-218.

Barkley, R. A., Murphy, K. R., & Fischer, M. (2008). ADHD in adults: What the science says. Guilford Press.

Barkley, R. A., Murphy, K. R., & Kwasnik, D. (1996). Motor vehicle driving competencies and risks in teens and young adults with attention deficit hyperactivity disorder. Pediatrics, 98(6), 1089-1095.

Barkley, R. A., Murphy, K. R., Dupaul, G. J., & Bush, T. (2002). Driving in young adults with attention deficit hyperactivity disorder: knowledge, performance, adverse outcomes, and the role of executive functioning. *Journal of the International Neuropsychological Society*, 8(5), 655-672.

Bechara, A. (2004). The role of emotion in decision-making: Evidence from neurological patients with orbitofrontal damage. Brain and cognition, 55(1), 30-40.

Bechara, A., & Martin, E. M. (2004). Impaired decision making related to working memory deficits in individuals with substance addictions. *Neuropsychology*, *18*(1), 152.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, 50(1-3), 7–15.

Bedard, A. C., Nichols, S., Barbosa, J. A., Schachar, R., Logan, G. D., & Tannock, R. (2002). The development of selective inhibitory control across the life span. *Developmental neuropsychology*, *21*(1), 93-111.

Berry, C. A., Shaywitz, S. E., & Shaywitz, B. A. (1985). Girls with attention deficit disorder: a silent minority? A report on behavioral and cognitive characteristics. Pediatrics, 76(5), 801-809.

Biederman, J., & Faraone, S. V. (2006). The effects of attention-deficit/hyperactivity disorder on employment and household income. Medscape General Medicine, 8(3), 12.

Biederman, J., Faraone, S. V., Weber, W., Russell, R. L., Rater, M., & Park, K. S. (1997). Correspondence between DSM-III-R and DSM-IV attention-deficit/hyperactivity disorder. Journal of the American Academy of Child & Adolescent Psychiatry, 36(12), 1682-1687.

Biederman, J., Mick, E., & Faraone, S. V. (2000). Age-dependent decline of symptoms of attention deficit hyperactivity disorder: impact of remission definition and symptom type. *American journal of psychiatry*, *157*(5), 816-818.

Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., ... & Johnson, M. A. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. *American Journal of psychiatry*, *159*(1), 36-42.

Biederman, J., Newcorn, J., & Sprich, S. (1991). Comorbidity of attention deficit hyperactivity disorder. American journal of psychiatry, 148(5), 564-577.

Biederman, J., Petty, C. R., Dolan, C., Hughes, S., Mick, E., Monuteaux, M. C., &
Faraone, S. V. (2008). The long-term longitudinal course of oppositional defiant
disorder and conduct disorder in ADHD boys: findings from a controlled 10-year
prospective longitudinal follow-up study. *Psychological medicine*, *38*(7), 1027.

Bird, H. R. (2002). The diagnostic classification, epidemiology and cross-cultural validity
of ADHD. Attention deficit hyperactivity disorder: State of the science, 12-1.

Blachman, D. R., & Hinshaw, S. P. (2002). Patterns of friendship among girls with and
without attention-deficit/hyperactivity disorder. *Journal of Abnormal Child
Psychology*, *30*(6), 625-640.

Borenstein, M., Hedges, L., Higgins, J., & Rothstein, H. (2014). Comprehensive meta-
analysis version 3.3. 070. *Englewood, NJ: Biostat*, *104*.

Bowman, C. H., & Turnbull, O. H. (2003). Real versus facsimile reinforcers on the Iowa
Gambling Task. Brain and cognition, 53(2), 207-210.

Boyer, T. W. (2006). The development of risk-taking: A multi-perspective review.
Developmental review, 26(3), 291-345.

Brand, M., Labudda, K., & Markowitsch, H. J. (2006). Neuropsychological correlates of
decision-making in ambiguous and risky situations. Neural Networks, 19(8),
1266-1276.

Brand, M., Recknor, E. C., Grabenhorst, F., & Bechara, A. (2007). Decisions under
ambiguity and decisions under risk: correlations with executive functions and
comparisons of two different gambling tasks with implicit and explicit
rules. *Journal of Clinical and Experimental Neuropsychology*, *29*(1), 86-99.

Breyer, J. L., Botzet, A. M., Winters, K. C., Stinchfield, R. D., August, G., & Realmuto, G. (2009). Young adult gambling behaviors and their relationship with the persistence of ADHD. *Journal of Gambling Studies*, 25(2), 227-238.

Brown, T. E. (2005). *Attention deficit disorder: The unfocused mind in children and adults*. Yale University Press.

Bunford, N., Evans, S. W., Becker, S. P., & Langberg, J. M. (2015). Attention-deficit/hyperactivity disorder and social skills in youth: A moderated mediation model of emotion dysregulation and depression. Journal of abnormal child psychology, 43(2), 283-296.

Bussing, R., Schoenberg, N. E., & Perwien, A. R. (1998). Knowledge and information about ADHD: evidence of cultural differences among African-American and white parents. Social science & medicine, 46(7), 919-928.

Bussing, R., Schoenberg, N. E., Rogers, K. M., Zima, B. T., & Angus, S. (1998). Explanatory models of ADHD: do they differ by ethnicity, child gender, or treatment status?. Journal of Emotional and Behavioral Disorders, 6(4), 233-242.

Buzy, W. M., Medoff, D. R., & Schweitzer, J. B. (2009). Intra-individual variability among children with ADHD on a working memory task: an ex-Gaussian approach. *Child Neuropsychology*, *15*(5), 441-459.

Byrnes, J. P., Miller, D. C., & Schafer, W. D. (1999). Gender differences in risk taking: A meta-analysis. Psychological Bulletin, 125(3), 367–383.

Canino, G., & Guarnaccia, P. (1997). Methodological challenges in the assessment of Hispanic children and adolescents. Applied Developmental Science, 1(3), 124-134.

Cauffman, E., Shulman, E. P., Steinberg, L., Claus, E., Banich, M. T., Graham, S., & Woolard, J. (2010). Age differences in affective decision making as indexed by performance on the Iowa Gambling Task. *Developmental psychology*, *46*(1), 193.

Cervantes, P. E., Matson, J. L., Adams, H. L., Williams, L. W., Goldin, R. L., & Jang, J. (2013). Comparing social skill profiles of children with autism spectrum disorders versus children with attention deficit hyperactivity disorder: Where the deficits lie. Research in Autism Spectrum Disorders, 7(9), 1104-1110.

Charach, A., Yeung, E., Climans, T., & Lillie, E. (2011). Childhood attention-deficit/hyperactivity disorder and future substance use disorders: comparative meta-analyses. *Journal of the American Academy of Child & Adolescent Psychiatry*, *50*(1), 9-21.

Charness, G., & Gneezy, U. (2012). Strong evidence for gender differences in risk taking. *Journal of Economic Behavior & Organization*, *83*(1), 50-58.

Chen, M. H., Hsu, J. W., Huang, K. L., Bai, Y. M., Ko, N. Y., Su, T. P., ... & Chang, W. H. (2018). Sexually transmitted infection among adolescents and young adults with attention-deficit/hyperactivity disorder: a nationwide longitudinal study. Journal of the American Academy of Child & Adolescent Psychiatry, 57(1), 48-53.

Christakou, A., Brammer, M., & Rubia, K. (2011). Maturation of limbic corticostriatal activation and connectivity associated with developmental changes in temporal discounting. Neuroimage, 54(2), 1344-1354.

Clancy, T. A., Rucklidge, J. J., & Owen, D. (2006). Road-crossing safety in virtual

    reality: A comparison of adolescents with and without ADHD. *Journal of Clinical*

    Child & Adolescent Psychology, 35(2), 203-215.

Clark, L., Blackwell, A. D., Aron, A. R., Turner, D. C., Dowson, J., Robbins, T. W., &

    Sahakian, B. J. (2007). Association between response inhibition and working

    memory in adult ADHD: a link to right frontal cortex pathology?. Biological

    psychiatry, 61(12), 1395-1401.

Classen, S., & Monahan, M. (2013). Evidence-based review on interventions and

    determinants of driving performance in teens with attention deficit hyperactivity

    disorder or autism spectrum disorder. *Traffic Injury Prevention*, 14(2), 188-193.

Coghill, D. R., Seth, S., & Matthews, K. (2014). A comprehensive assessment of

    memory, delay aversion, timing, inhibition, decision making and variability in

    attention deficit hyperactivity disorder: advancing beyond the three-pathway

    models. *Psychological Medicine*, 44(9), 1989-2001.

Coghill, D. R., Seth, S., Pedroso, S., Usala, T., Currie, J., & Gagliano, A. (2014). Effects

    of methylphenidate on cognitive functions in children and adolescents with

    attention-deficit/hyperactivity disorder: evidence from a systematic review and a

    meta-analysis. Biological psychiatry, 76(8), 603-615.

Cohen, J. (1992). A power primer. Psychological bulletin, 112(1), 155.

Coll, C. G., Akerman, A., & Cicchetti, D. (2000). Cultural influences on developmental

    processes and outcomes: Implications for the study of development and

    psychopathology. Development and psychopathology, 12(3), 333-356.

Conners, C. K. (2000). Attention-deficit/hyperactivity disorder—historical development and overview. Journal of Attention Disorders.

Corr, P. J. (2004). Reinforcement sensitivity theory and personality. Neuroscience & Biobehavioral Reviews, 28(3), 317-332.

Crichton, A. (1798). On attention and its diseases. An inquiry into the nature and origin of mental derangement, 1, 254-290.

Crone, E. A., & Van Der Molen, M. W. (2007). Development of decision making in school-aged children and adolescents: Evidence from heart rate and skin conductance analysis. *Child development*, *78*(4), 1288-1301.

Cuffe, S. P., Moore, C. G., & McKeown, R. E. (2005). Prevalence and correlates of ADHD symptoms in the national health interview survey. Journal of attention disorders, 9(2), 392-401.

Cui, J. F., Wang, Y., Shi, H. S., Liu, L. L., Chen, X. J., & Chen, Y. H. (2015). Effects of working memory load on uncertain decision-making: evidence from the Iowa Gambling Task. *Frontiers in Psychology*, *6*, 162.

Cunningham, C. E., Siegel, L. S., & Offord, D. R. (1985). A developmental dose-response analysis of the effects of methylphenidate on the peer interactions of attention deficit disordered boys. Journal of Child Psychology and Psychiatry, 26(6), 955-971.

Dai, Z., Harrow, S. E., Song, X., Rucklidge, J. J., & Grace, R. C. (2016). Gambling, delay, and probability discounting in adults with and without ADHD. *Journal of Attention Disorders*, 20(11), 968-978.

Daley, D., & Birchwood, J. (2010). ADHD and academic performance: why does ADHD impact on academic performance and what can be done to support ADHD children in the classroom?. *Child: Care, Health and Development*, 36(4), 455-464.

Dang, J., King, K. M., & Inzlicht, M. (2020). Why are self-report and behavioral measures weakly correlated?. *Trends in Cognitive Sciences*, *24*(4), 267-269.

Danielson, M. L., Bitsko, R. H., Ghandour, R. M., Holbrook, J. R., Kogan, M. D., & Blumberg, S. J. (2018). Prevalence of parent-reported ADHD diagnosis and associated treatment among US children and adolescents, 2016. Journal of Clinical Child & Adolescent Psychology, 47(2), 199-212.

Davidson, M. A. (2008). Literature review: ADHD in adults: a review of the literature. *Journal of Attention Disorders*, 11(6), 628-641.

De Los Reyes, A., & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: a critical review, theoretical framework, and recommendations for further study. *Psychological Bulletin*, 131(4), 483.

de-Juan-Ripoll, C., Soler-Domínguez, J. L., Guixeres, J., Contero, M., Álvarez Gutiérrez, N., & Alcañiz, M. (2018). Virtual reality as a new approach for risk taking assessment. *Frontiers in psychology*, *9*, 2532.

Dekkers, T. J., Popma, A., van Rentergem, J. A. A., Bexkens, A., & Huizenga, H. M. (2016). Risky decision making in attention-deficit/hyperactivity disorder: A meta-regression analysis. *Clinical psychology review*, *45*, 1-16.

DeVito, E. E., Blackwell, A. D., Kent, L., Ersche, K. D., Clark, L., Salmond, C. H., ... & Sahakian, B. J. (2008). The effects of methylphenidate on decision making in attention-deficit/hyperactivity disorder. Biological psychiatry, 64(7), 636-639.

Dir, A. L., Coskunpinar, A., & Cyders, M. A. (2014). A meta-analytic review of the relationship between adolescent risky sexual behavior and impulsivity across gender, age, and race. *Clinical Psychology Review*, 34(7), 551–562.

Donfrancesco, R., Di Trani, M., Porfirio, M. C., Giana, G., Miano, S., & Andriola, E. (2015). Might the temperament be a bias in clinical study on attention-deficit hyperactivity disorder (ADHD)?: Novelty seeking dimension as a core feature of ADHD. *Psychiatry Research*, 227(2-3), 333-338.

Douglas, V. I. (1972). Stop, look and listen: The problem of sustained attention and impulse control in hyperactive and normal children. Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement, 4(4), 259.

Drechsler, R., Rizzo, P., & Steinhausen, H. C. (2008). Decision-making on an explicit risk-taking task in preadolescents with attention-deficit/hyperactivity disorder. *Journal of Neural Transmission*, 115(2), 201-209.

Dunne, E. M., Hearn, L. E., Rose, J. J., & Latimer, W. W. (2014). ADHD as a risk factor for early onset and heightened adult problem severity of illicit substance use: An accelerated gateway model. *Addictive Behaviors*, 39(12), 1755-1758.

DuPaul, G. J., Gormley, M. J., & Laracy, S. D. (2013). Comorbidity of LD and ADHD: Implications of DSM-5 for assessment and treatment. Journal of learning disabilities, 46(1), 43-51.

DuPaul, G. J., Power, T. J., Anastopoulos, A. D., & Reid, R. (1998). ADHD Rating

    Scale—IV: Checklists, norms, and clinical interpretation. Guilford Press.

DuPaul, G. J., Schaughency, E. A., Weyandt, L. L., Tripp, G., Kiesner, J., Ota, K., &

    Stanish, H. (2001). Self-report of ADHD symptoms in university students: Cross-

    gender and cross-national prevalence. Journal of learning disabilities, 34(4), 370-

    379.

Egan, T. E., Dawson, A. E., & Wymbs, B. T. (2017). Substance use in undergraduate

    students with histories of attention-deficit/hyperactivity disorder (ADHD): the

    role of impulsivity. *Substance Use & Misuse*, 52(10), 1375-1386.

Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis

    detected by a simple, graphical test. Bmj, 315(7109), 629-634.

Ernst, M., Grant, S. J., London, E. D., Contoreggi, C. S., Kimes, A. S., & Spurgeon, L.

    (2003). Decision making in adolescents with behavior disorders and adults with

    substance abuse. *American Journal of Psychiatry*, *160*(1), 33-40.

Evans, W. N., Morrill, M. S., & Parente, S. T. (2010). Measuring inappropriate medical

    diagnosis and treatment in survey data: The case of ADHD among school-age

    children. *Journal of health economics*, *29*(5), 657-673.

Faraone, S. V., Biederman, J., Lehman, B. K., Spencer, T., Norman, D., Seidman, L. J.,

    ... & Tsuang, M. T. (1993). Intellectual performance and school failure in children

    with attention deficit hyperactivity disorder and in their siblings. Journal of

    abnormal psychology, 102(4), 616.

Faraone, S. V., Biederman, J., Spencer, T., Wilens, T., Seidman, L. J., Mick, E., & Doyle,

    A. E. (2000). Attention-deficit/hyperactivity disorder in adults: an overview.

    Biological psychiatry, 48(1), 9-20.

Faraone, S. V., Biederman, J., Wilens, T. E., & Adamson, J. (2007). A naturalistic study

    of the effects of pharmacotherapy on substance use disorders among ADHD

    adults. Psychological medicine, 37(12), 1743-1752.

Fayyad, J., De Graaf, R., Kessler, R., Alonso, J., Angermeyer, M., Demyttenaere, K., ...

    & Lepine, J. P. (2007). Cross-national prevalence and correlates of adult

    attention-deficit hyperactivity disorder. The British Journal of Psychiatry, 190(5),

    402-409.

Flory, K., Molina, B. S., Pelham Jr, W. E., Gnagy, E., & Smith, B. (2007). ADHD and

    risky sexual behavior. The ADHD Report, 15(3), 1-4.

Flory, K., Molina, B. S., Pelham, Jr, W. E., Gnagy, E., & Smith, B. (2006). Childhood

    ADHD predicts risky sexual behavior in young adulthood. *Journal of Clinical

    Child and Adolescent Psychology*, 35(4), 571-577.

Ford-Jones, P. C. (2015). Misdiagnosis of attention deficit hyperactivity

    disorder:'Normal behaviour'and relative maturity. *Paediatrics & Child

    Health*, *20*(4), 200-202.

Frazier, T. W., Youngstrom, E. A., Glutting, J. J., & Watkins, M. W. (2007). ADHD and

    achievement: Meta-analysis of the child, adolescent, and adult literatures and a

    concomitant study with college students. Journal of learning disabilities, 40(1),

    49-65.

Frederick, B. P., & Olmi, D. J. (1994). Children with attention-deficit/hyperactivity disorder: A review of the literature on social skills deficits. Psychology in the Schools, 31(4), 288-296.

Froehlich, T. E., Lanphear, B. P., Epstein, J. N., Barbaresi, W. J., Katusic, S. K., & Kahn, R. S. (2007). Prevalence, recognition, and treatment of attention-deficit/hyperactivity disorder in a national sample of US children. Archives of pediatrics & adolescent medicine, 161(9), 857-864.

Fuster, J. M. (1989). The prefrontal cortex: Anatomy, physiology, and neuropsychology of the frontal lobe . nueva York. Raven Press.(Original work published 1980). dents. Dissertation Abstracts International: The Science and Engineering, 60(11-B), 5802.

Garon, N., Moore, C., & Waschbusch, D. A. (2006). Decision making in children with ADHD only, ADHD-anxious/depressed, and control children using a child version of the Iowa Gambling Task. Journal of Attention Disorders, 9(4), 607-619.

Garzon, D. L., Huang, H., & Todd, R. D. (2008). Do attention deficit/hyperactivity disorder and oppositional defiant disorder influence preschool unintentional injury risk?. *Archives of Psychiatric Nursing*, 22(5), 288-296.

Gaub, M., & Carlson, C. L. (1997). Gender differences in ADHD: a meta-analysis and critical review. Journal of the American Academy of Child & Adolescent Psychiatry, 36(8), 1036-1045.

Gershon, J. (2002). Gender differences in ADHD. The ADHD Report, 10(4), 8-16.

Gershon, J., & Gershon, J. (2002). A meta-analytic review of gender differences in

  ADHD. *Journal of attention disorders*, *5*(3), 143-154.

Getahun, D., Jacobsen, S. J., Fassett, M. J., Chen, W., Demissie, K., & Rhoads, G. G.

  (2013). Recent trends in childhood attention-deficit/hyperactivity disorder. JAMA

  pediatrics, 167(3), 282-288.

Geurts, H. M., Van der Oord, S., & Crone, E. A. (2006). Hot and cool aspects of

  cognitive control in children with ADHD: decision-making and inhibition.

  Journal of Abnormal Child Psychology, 34(6), 811-822.

Gonzalez-Gadea, M. L., Baez, S., Torralva, T., Castellanos, F. X., Rattazzi, A., Bein, V.,

  ... & Ibanez, A. (2013). Cognitive variability in adults with ADHD and AS:

  disentangling the roles of executive functions and social cognition. *Research in*

  Developmental Disabilities, 34(2), 817-830.

Gray, J. A. (1987). *The psychology of fear and stress*. Cambridge: Cambridge University

  Press

Gray, J. A. (1991). The neuropsychology of temperament. In Explorations in

  temperament (pp. 105-128). Springer, Boston, MA.

Graziano, P. A., & Garcia, A. (2016). Attention-deficit hyperactivity disorder and

  children's emotion dysregulation: A meta-analysis. *Clinical psychology*

  review, *46*, 106-123.

Groen, Y., Gaastra, G. F., Lewis-Evans, B., & Tucha, O. (2013). Risky behavior in

  gambling tasks in individuals with ADHD–a systematic literature review. *PLoS*

  One, *8*(9), e74909.

Groom, M. J., Van Loon, E., Daley, D., Chapman, P., & Hollis, C. (2015). Driving
behaviour in adults with attention deficit/hyperactivity disorder. *BMC Psychiatry*,
15(1), 175.

Guevremont, D. C., & Dumas, M. C. (1994). Peer relationship problems and disruptive
behavior disorders. Journal of Emotional and Behavioral Disorders, 2(3), 164-
172.

Halperin, J. M., & Schulz, K. P. (2006). Revisiting the role of the prefrontal cortex in the
pathophysiology of attention-deficit/hyperactivity disorder. Psychological
bulletin, 132(4), 560.

Harpin, V. A. (2005). The effect of ADHD on the life of an individual, their family, and
community from preschool to adult life. Archives of disease in childhood,
90(suppl 1), i2-i7.

Hechtman, L., Swanson, J. M., Sibley, M. H., Stehli, A., Owens, E. B., Mitchell, J. T., ...
& Abikoff, H. B. (2016). Functional adult outcomes 16 years after childhood
diagnosis of attention-deficit/hyperactivity disorder: MTA results. *Journal of the
American Academy of Child & Adolescent Psychiatry*, 55(11), 945-952.

Hedges, L. V., & Olkin, I. (1985). Statistical methods for meta.

Hemmingsson, H., Ólafsdóttir, L. B., & Egilson, S. T. (2017). Agreements and
disagreements between children and their parents in health-related assessments.
Disability and rehabilitation, 39(11), 1059-1072.

Hervey, A. S., Epstein, J. N., & Curry, J. F. (2004). Neuropsychology of adults with
attention-deficit/hyperactivity disorder: a meta-analytic
review. *Neuropsychology*, *18*(3), 485.

Hills, T. T., Noguchi, T., & Gibbert, M. (2013). Information overload or search-amplified

    risk? Set size and order effects on decisions from experience. Psychonomic

    Bulletin & Review, 20, 1023–1031.

Hinshaw, S. P. (1992). Externalizing behavior problems and academic underachievement

    in childhood and adolescence: causal relationships and underlying mechanisms.

    Psychological bulletin, 111(1), 127.

Hinshaw, S. P. (1994). Attention deficits and hyperactivity in children (Vol. 29). Sage.

Hinshaw, S. P., & Melnick, S. M. (1995). Peer relationships in boys with attention-deficit

    hyperactivity disorder with and without comorbid aggression. *Development and*

    psychopathology, *7*(4), 627-647.

Hinson, J. M., Jameson, T. L., & Whitney, P. (2002). Somatic markers, working memory,

    and decision making. *Cognitive, Affective, & Behavioral Neuroscience*, *2*(4), 341-

    353.

Hinvest, N. S., & Anderson, I. M. (2010). The effects of real versus hypothetical reward

    on delay and probability discounting. The Quarterly journal of experimental

    psychology, 63(6), 1072-1084.

Hobson, C. W., Scott, S., & Rubia, K. (2011). Investigation of cool and hot executive

    function in ODD/CD independently of ADHD. *Journal of Child Psychology and*

    Psychiatry, 52(10), 1035-1043.

Hoffman, H. (1865). *Die Geschichte vom Zappel-Philipp[Fidgetty Phil].* In

    H.Hoffman,Der Struwwelpeter [Shockheaded Peter]. Erlangen, Germany:

    Pestalozzi-Verlag.

Holst, Y., & Thorell, L. B. (2019). Functional impairments among adults with ADHD: a comparison with adults with other psychiatric disorders and links to executive deficits. *Applied Neuropsychology: Adult*.

Hooper, C. J., Luciana, M., Conklin, H. M., & Yarger, R. S. (2004). Adolescents' performance on the Iowa Gambling Task: implications for the development of decision making and ventromedial prefrontal cortex. *Developmental psychology*, *40*(6), 1148.

Hovik, K. T., Plessen, K. J., Cavanna, A. E., Skogli, E. W., Andersen, P. N., & Øie, M. (2015). Cognition, emotion and behavior in children with Tourette's syndrome and children with ADHD-combined subtype—A two-year follow-up study. *PloS one*, 10(12).

Hoza, B. (2007). Peer functioning in children with ADHD. *Journal of pediatric psychology*, *32*(6), 655-663.

Hoza, B., McQuade, J. D., Murray-Close, D., Shoulberg, E., Molina, B. S., Arnold, L. E., ... & Hechtman, L. (2013). Does childhood positive self-perceptual bias mediate adolescent risky behavior in youth from the MTA study?. *Journal of consulting and clinical psychology*, *81*(5), 846.ch criteria. *Journal of consulting and clinical psychology*, *58*(6), 775.

Hoza, B., Mrug, S., Gerdes, A. C., Hinshaw, S. P., Bukowski, W. M., Gold, J. A., ... & Arnold, L. E. (2005). What aspects of peer relationships are impaired in children with attention-deficit/hyperactivity disorder?. *Journal of consulting and clinical psychology*, *73*(3), 411.

Hudec, K. L., Alderson, R. M., Kasper, L. J., & Patros, C. H. (2014). Working memory

    contributes to elevated motor activity in adults with ADHD: An examination of

    the role of central executive and storage/rehearsal processes. *Journal of attention*

    disorders, *18*(4), 357-368.

Hudec, K. L., Alderson, R. M., Patros, C. H., Lea, S. E., Tarle, S. J., & Kasper, L. J.

    (2015). Hyperactivity in boys with attention-deficit/hyperactivity disorder

    (ADHD): The role of executive and non-executive functions. Research in

    developmental disabilities, 45, 103-109.

Huggins, S. P., Rooney, M. E., & Chronis-Tuscano, A. (2015). Risky sexual behavior

    among college students with ADHD: Is the mother–child relationship protective?.

    Journal of Attention Disorders, 19(3), 240-250.

Huizinga, D., & Elliott, D. S. (1986). Reassessing the reliability and validity of self-

    report delinquency measures. *Journal of quantitative criminology*, *2*(4), 293-327.

Humphreys, K. L., & Lee, S. S. (2011). Risk taking and sensitivity to punishment in

    children with ADHD, ODD, ADHD+ ODD, and controls. Journal of

    Psychopathology and Behavioral Assessment, 33(3), 299-307.

Humphreys, K. L., Telzer, E. H., Flannery, J., Goff, B., Gabard-Durnam, L., Gee, D. G.,

    … Tottenham, N. (2016). Risky decision making from childhood through

    adulthood: Contributions of learning and sensitivity to negative feedback.

    Emotion, 16(1), 101–109.

Humphreys, K. L., Tottenham, N., & Lee, S. S. (2018). Risky decision-making in

    children with and without ADHD: a prospective study. *Child*

    neuropsychology, *24*(2), 261-276.

Ibanez, A., Cetkovich, M., Petroni, A., Urquina, H., Baez, S., Gonzalez-Gadea, M. L., ... & Teitelbaum, J. (2012). The neural basis of decision-making and reward processing in adults with euthymic bipolar disorder or attention-deficit/hyperactivity disorder (ADHD). *PloS one*, 7(5).

Ingram, S., Hechtman, L., & Morgenstern, G. (1999). Outcome issues in ADHD: Adolescent and adult long-term outcome. *Mental retardation and developmental disabilities research reviews*, *5*(3), 243-250.

Jameson, T. L., Hinson, J. M., & Whitney, P. (2004). Components of working memory and somatic markers in decision making. *Psychonomic Bulletin & Review*, *11*(3), 515-520.

Jensen, P. S., Martin, D., & Cantwell, D. P. (1997). Comorbidity in ADHD: implications for research, practice, and DSM-V. Journal of the American Academy of Child & Adolescent Psychiatry, 36(8), 1065-1079.

Jerome, L., Segal, A., & Habinski, L. (2006). What we know about ADHD and driving risk: a literature review, meta-analysis and critique. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *15*(3), 105.

Johnson, M. W., & Bickel, W. K. (2002). Within-subject comparison of real and hypothetical money rewards in delay discounting. Journal of the experimental analysis of behavior, 77(2), 129-146.

Kasper, L. J., Alderson, R. M., & Hudec, K. L. (2012). Moderators of working memory deficits in children with attention-deficit/hyperactivity disorder (ADHD): a meta-analytic review. *Clinical psychology review*, *32*(7), 605-617.

Keown, L. J., & Woodward, L. J. (2006). Preschool boys with pervasive hyperactivity: Early peer functioning and mother–child relationship influences. Social Development, 15(1), 23-45.

Kessler, J. W. (1980). History of minimal brain dysfunctions. Handbook of minimal brain dysfunctions: A critical view, 18-52.

King, S. M., Iacono, W. G., & McGue, M. (2004). Childhood externalizing and internalizing psychopathology in the prediction of early substance use. Addiction, 99(12), 1548-1559.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental psychology: general*, *128*(1), 78.

Klassen, L. J., Katzman, M. A., & Chokka, P. (2010). Adult ADHD and its comorbidities, with a focus on bipolar disorder. Journal of affective disorders, 124(1-2), 1-8.

Knouse, L. E., Bagwell, C. L., Barkley, R. A., & Murphy, K. R. (2005). Accuracy of self-evaluation in adults with ADHD: Evidence from a driving study. *Journal of Attention Disorders*, 8(4), 221-234.

Kofler, M. J., Rapport, M. D., & Matt Alderson, R. (2008). Quantifying ADHD classroom inattentiveness, its moderators, and variability: a meta-analytic review. *Journal of Child Psychology and Psychiatry*, *49*(1), 59-69.

Kofler, M. J., Rapport, M. D., Bolden, J., Sarver, D. E., & Raiker, J. S. (2010). ADHD and working memory: the impact of central executive deficits and exceeding

storage/rehearsal capacity on observed inattentive behavior. Journal of abnormal child psychology, 38(2), 149-161.

Kofler, M. J., Rapport, M. D., Bolden, J., Sarver, D. E., Raiker, J. S., & Alderson, R. M. (2011). Working memory deficits and social problems in children with ADHD. *Journal of Abnormal Child psychology*, *39*(6), 805-817.

Kofler, M. J., Rapport, M. D., Sarver, D. E., Raiker, J. S., Orban, S. A., Friedman, L. M., & Kolomeyer, E. G. (2013). Reaction time variability in ADHD: a meta-analytic review of 319 studies. *Clinical psychology review*, *33*(6), 795-811.

Kooij, S. J., Marije Boonstra, A., Swinkels, S. H. N., Bekker, E. M., De Noord, I., & Buitelaar, J. K. (2008). Reliability, validity, and utility of instruments for self-report and informant report concerning symptoms of ADHD in adult patients. *Journal of Attention Disorders*, *11*(4), 445-458.

Kramer, F., & Pollnow, H. (1932). Uber eine hyperkinetische Erkrankung im Kindesalter. Aus der Psychiatrischen und Nerven-Klinik der Charité in Berlin (Direktor: Geh. Med.-Rat Prof. Dr. Bonhoeffer). Mschr Psychiat Neurol, 82, 21-40.

Kroyzer, N., Gross-Tsur, V., & Pollak, Y. (2014). Risk taking in adolescents with attention deficit hyperactivity disorder on a probabilistic choice task. Journal of Nervous and Mental Disease, 202(3), 247–252.

Kühberger, A. (1998). The influence of framing on risky decisions: A meta-analysis. Organizational behavior and human decision processes, 75(1), 23-55.

Kuntsi, J., Stevenson, J., Oosterlaan, J., & Sonuga-Barke, E. J. (2001). Test-retest reliability of a new delay aversion task and executive function measures. British Journal of Developmental Psychology, 19(3), 339-348.

Lagorio, C. H., & Madden, G. J. (2005). Delay discounting of real and hypothetical

    rewards III: Steady-state assessments, forced-choice trials, and all real rewards.

    Behavioural processes, 69(2), 173-187.

Lahey, B. B., Applegate, B., McBurnett, K., Biederman, J., Greenhill, L., Hynd, G. W., ...

    & Garfinkel, B. (1994). DMS-IV field trials for attention deficit hyperactivity

    disorder in children and adolescents. The American Journal of Psychiatry.

Lambert, N. (2005). The contribution of childhood ADHD, conduct problems, and

    stimulant treatment to adolescent and adult tobacco and psychoactive substance

    abuse. *Ethical Human Psychology and Psychiatry*, 7(3), 197-221.

Lambert, N. M., & Hartsough, C. S. (1998). Prospective study of tobacco smoking and

    substance dependencies among samples of ADHD and non-ADHD participants.

    Journal of Learning Disabilities, 31(6), 533-544.

Landau, S., & Milich, R. (1988). Social communication patterns of attention-deficit-

    disordered boys. Journal of abnormal child psychology, 16(1), 69-81.

Lane, S. D., Cherek, D. R., Rhoades, H. M., Pietras, C. J., & Tcheremissine, O. V.

    (2003). Relationships among laboratory and psychometric measures of

    impulsivity: Implications in substance abuse and dependence. Addictive

    Disorders & Their Treatment, 2(2), 33-40.

Langberg, J. M., Dvorsky, M. R., & Evans, S. W. (2013). What specific facets of

    executive function are associated with academic functioning in youth with

    attention-deficit/hyperactivity disorder?. Journal of Abnormal Child Psychology,

    41(7), 1145-1159.

Lange, K. W., Reichl, S., Lange, K. M., Tucha, L., & Tucha, O. (2010). The history of

attention deficit hyperactivity disorder. ADHD Attention Deficit and

Hyperactivity Disorders, 2(4), 241-255.

Lanyon, R. I., & Goodstein, L. D. (1997). *Personality assessment*. John Wiley & Sons.

Lee, D. H., Oakland, T., Jackson, G., & Glutting, J. (2008). Estimated prevalence of

attention-deficit/hyperactivity disorder symptoms among college freshmen:

gender, race, and rater effects. Journal of Learning Disabilities, 41(4), 371-384.

Lee, S. S., & Hinshaw, S. P. (2006). Predictors of adolescent functioning in girls with

attention deficit hyperactivity disorder (ADHD): the role of childhood ADHD,

conduct problems, and peer status. *Journal of Clinical Child and Adolescent

Psychology*, *35*(3), 356-368.

Lee, S. S., Humphreys, K. L., Flory, K., Liu, R., & Glass, K. (2011). Prospective

association of childhood attention-deficit/hyperactivity disorder (ADHD) and

substance use and abuse/dependence: a meta-analytic review. *Clinical psychology

review*, *31*(3), 328-341.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., ...

& Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: the

Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology:

Applied*, *8*(2), 75.

Lijffijt, M., Kenemans, J. L., Verbaten, M. N., & van Engeland, H. (2005). A meta-

analytic review of stopping performance in attention-deficit/hyperactivity

disorder: deficient inhibitory motor control?. *Journal of abnormal

psychology*, *114*(2), 216.

Lipsey, M. W., & Wilson, D. B. (2001). Practical meta-analysis. SAGE publications, Inc.

Locey, M. L., Jones, B. A., & Rachlin, H. (2011). Real and hypothetical rewards. Judgment and decision making, 6(6), 552.

Logan, G. D., Cowan, W. B., & Davis, K. A. (1984). On the ability to inhibit simple and choice reaction time responses: a model and a method. Journal of Experimental Psychology: Human Perception and Performance, 10(2), 276.

Lopez, S. R., & Guarnaccia, P. J. (2000). Cultural psychopathology: Uncovering the social world of mental illness. Annual review of psychology, 51(1), 571-598.

Luman, M., Oosterlaan, J., & Sergeant, J. A. (2005). The impact of reinforcement contingencies on AD/HD: a review and theoretical appraisal. Clinical psychology review, 25(2), 183-213.

Luman, M., Oosterlaan, J., Knol, D. L., & Sergeant, J. A. (2008). Decision-making in ADHD: sensitive to frequency but blind to the magnitude of penalty?. *Journal of Child Psychology and Psychiatry*, *49*(7), 712-722.

Luman, M., Tripp, G., & Scheres, A. (2010). Identifying the neurobiology of altered reinforcement sensitivity in ADHD: a review and research agenda. *Neuroscience & Biobehavioral Reviews*, *34*(5), 744-754.

MacCoon, D. G., Wallace, J. F., & Newman, J. P. (2004). Self-regulation: Context-appropriate balanced attention. In K. D. Vohs, & R. F. Baumeister (Eds.) Handbook of self-regulation: Research, theory, and applications (pp. 422–444). New York, NY: Guilford Press.

Madden, G. J., Raiff, B. R., Lagorio, C. H., Begotka, A. M., Mueller, A. M., Hehli, D. J., & Wegener, A. A. (2004). Delay Discounting of Potentially Real and

Hypothetical Rewards: II Between- and Within-Subject Comparisons. Experimental and Clinical Psychopharmacology, 12(4), 251–261.

Maedgen, J. W., & Carlson, C. L. (2000). Social functioning and emotional regulation in the attention deficit hyperactivity disorder.. Journal of Clinical Child Psychology, 29(1), 30.

Makransky, G., & Bilenberg, N. (2014). Psychometric properties of the parent and teacher ADHD Rating Scale (ADHD-RS) measurement invariance across gender, age, and informant. Assessment, 21(6), 694-705.

Malloy-Diniz, L. F., Leite, W. B., Moraes, P. H. P. D., Correa, H., Bechara, A., & Fuentes, D. (2008). Brazilian Portuguese version of the Iowa Gambling Task: transcultural adaptation and discriminant validity. *Brazilian Journal of Psychiatry*, 30(2), 144-148.

Malloy-Diniz, L., Fuentes, D., Leite, W. B., Correa, H., & Bechara, A. (2007). Impulsive behavior in adults with attention deficit/hyperactivity disorder: characterization of attentional, motor and cognitive impulsiveness. Journal of the International Neuropsychological Society, 13(4), 693-698.

Mannuzza, S., Klein, R. G., & Moulton III, J. L. (2008). Lifetime criminality among boys with attention deficit hyperactivity disorder: a prospective follow-up study into adulthood using official arrest records. Psychiatry research, 160(3), 237-246.

Mannuzza, S., Klein, R. G., Bessler, A., Malloy, P., & LaPadula, M. (1993). Adult outcome of hyperactive boys: Educational achievement, occupational rank, and psychiatric status. Archives of general psychiatry, 50(7), 565-576.

Mannuzza, S., Klein, R. G., Bessler, A., Malloy, P., & LaPadula, M. (1998). Adult

    psychiatric status of hyperactive boys grown up. American journal of psychiatry,

    155(4), 493-498.

Mäntylä, T., Still, J., Gullberg, S., & Del Missier, F. (2012). Decision making in adults

    with ADHD. Journal of attention disorders, 16(2), 164-173.

Mäntylä, T., Still, J., Gullberg, S., & Del Missier, F. (2012). Decision making in adults

    with ADHD. *Journal of attention disorders*, 16(2), 164-173.

Marco, R., Miranda, A., Schlotz, W., Melia, A., Mulligan, A., Müller, U., ... & Medad, S.

    (2009). Delay and reward choice in ADHD: an experimental test of the role of

    delay aversion. *Neuropsychology*, *23*(3), 367.

Mariani, M. A., & Barkley, R. A. (1997). Neuropsychological and academic functioning

    in preschool boys with attention deficit hyperactivity disorder. Developmental

    neuropsychology, 13(1), 111-129.

Marshal, M. P., Molina, B. S., & Pelham Jr, W. E. (2003). Childhood ADHD and

    adolescent substance use: an examination of deviant peer group affiliation as a

    risk factor. Psychology of addictive behaviors, 17(4), 293.

Marshall, R. M., Hynd, G. W., Handwerk, M. J., & Hall, J. (1997). Academic

    underachievement in ADHD subtypes. Journal of Learning Disabilities, 30(6),

    635-642.

Martel, M. M., Von Eye, A., & Nigg, J. T. (2010). Revisiting the latent structure of

    ADHD: is there a 'g'factor?. Journal of Child Psychology and Psychiatry, 51(8),

    905-914.

Martinussen, R., Hayden, J., Hogg-Johnson, S., & Tannock, R. (2005). A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. *Journal of the American academy of child & adolescent psychiatry*, *44*(4), 377-384.

Mash, E. J., & Barkley, R. A. (2003). Childhood psychopathology.

Masunami, T., Okazaki, S., & Maekawa, H. (2009). Decision-making patterns and sensitivity to reward and punishment in children with attention-deficit hyperactivity disorder. *International Journal of Psychophysiology*, 72(3), 283-288.

Matthies, S., Philipsen, A., & Svaldi, J. (2012). Risky decision making in adults with ADHD. Journal of behavior therapy and experimental psychiatry, 43(3), 938-946.

Matthys, W., Van Goozen, S. H., De Vries, H., Cohen-Kettenis, P. T., & Van Engeland, H. (1998). The dominance of behavioural activation over behavioural inhibition in conduct disordered boys with or without attention deficit hyperactivity disorder. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, 39(5), 643-651.

Matusiewicz, A. K., Carter, A. E., Landes, R. D., & Yi, R. (2013). Statistical equivalence and test–retest reliability of delay and probability discounting using real and hypothetical rewards. Behavioural Processes, 100, 116-122.

McBurnett, K., Harris, S. M., Swanson, J. M., Pfiffner, L. J., Tamm, L., & Freeland, D. (1993). Neuropsychological and Psychophyiosological Differentiation of Inattention/Overactivty and Aggression/Defiance Symptom Groups. Journal of Clinical Child Psychology, 22(2), 165-171.

McLean, A., Dowson, J., Toone, B., Young, S., Bazanis, E., Robbins, T. W., & Sahakian, B. J. (2004). Characteristic neurocognitive profile associated with adult attention-deficit/hyperactivity disorder. Psychological medicine, 34(4), 681-692.

Melnick, S. M., & Hinshaw, S. P. (2000). Emotion regulation and parenting in AD/HD and comparison boys: Linkages with social behaviors and peer preference. Journal of abnormal child psychology, 28(1), 73-86.

Merkel Jr, R. L., Nichols, J. Q., Fellers, J. C., Hidalgo, P., Martinez, L. A., Putziger, I., ... & Cox, D. J. (2016). Comparison of on-road driving between young adults with and without ADHD. *Journal of attention disorders*, *20*(3), 260-269.

Mesrobian, S. K., Villa, A. E., Bader, M., Götte, L., & Lintas, A. (2018). Event-Related Potentials during a Gambling Task in Young Adults with Attention-Deficit/Hyperactivity Disorder. *Frontiers in Human Neuroscience*, 12, 79.

Miller, M., Sheridan, M., Cardoos, S. L., & Hinshaw, S. P. (2013). Impaired decision-making as a young adult outcome of girls diagnosed with attention-deficit/hyperactivity disorder in childhood. *Journal of the International Neuropsychological Society*, 19(1), 110-114.

Mitchell, S. H., Schoel, C., & Stevens, A. A. (2008). Mechanisms underlying heightened risk taking in adolescents as compared with adults. *Psychonomic bulletin & review*, *15*(2), 272-277.

Mitsis, E. M., McKay, K. E., Schulz, K. P., Newcorn, J. H., & Halperin, J. M. (2000). Parent–teacher concordance for DSM-IV attention-deficit/hyperactivity disorder in a clinic-referred sample. Journal of the American Academy of Child & Adolescent Psychiatry, 39(3), 308-313.

Molina, B. S., & Pelham Jr, W. E. (2003). Childhood predictors of adolescent substance
use in a longitudinal study of children with ADHD. Journal of abnormal
psychology, 112(3), 497.

Molina, B. S., Hinshaw, S. P., Swanson, J. M., Arnold, L. E., Vitiello, B., Jensen, P. S., ...
& Elliott, G. R. (2009). The MTA at 8 years: prospective follow-up of children
treated for combined-type ADHD in a multisite study. Journal of the American
Academy of Child & Adolescent Psychiatry, 48(5), 484-500.

Morell, B.R., & Expósito, S.H. (2019). Differential long-term medication impact on
executive function and delay aversion in ADHD. *Applied Neuropsychology:
Child*, 8(2), 140-157.

Murphy, K., & Barkley, R. A. (1996). Attention deficit hyperactivity disorder adults:
comorbidities and adaptive impairments. Comprehensive psychiatry, 37(6), 393-
401.

Newman, J. P., & Wallace, J. F. (1993). Diverse pathways to deficient self-regulation:
Implications for disinhibitory psychopathology in children. Clinical Psychology
Review, 13(8), 699-720.

Newman, J. P., Patterson, C. M., & Kosson, D. S. (1987). Response perseveration in
psychopaths. *Journal of abnormal psychology*, *96*(2), 145.

Nigg, J. T., Wong, M. M., Martel, M. M., Jester, J. M., Puttler, L. I., Glass, J. M., ... &
Zucker, R. A. (2006). Poor response inhibition as a predictor of problem drinking
and illicit drug use in adolescents at risk for alcoholism and other substance use
disorders. *Journal of the American Academy of Child & Adolescent
Psychiatry*, *45*(4), 468-475.

Nikolas, M. A., Elmore, A. L., Franzen, L., O'Neal, E., Kearney, J. K., & Plumert, J. M.
(2016). Risky bicycling behavior among youth with and without attention-deficit
hyperactivity disorder. *Journal of Child Psychology and Psychiatry*, 57(2), 141-
148.

Noguchi, T., & Hills, T. T. (2016). Experience-based decisions favor riskier alternatives
in large sets. Journal of Behavioral Decision Making, 29(5), 489-498.

Norwalk, K., Norvilitis, J. M., & MacLean, M. G. (2009). ADHD symptomatology and
its relationship to factors associated with college adjustment. Journal of Attention
Disorders, 13(3), 251-258.

O'Brien, B. S., & Frick, P. J. (1996). Reward dominance: Associations with anxiety,
conduct problems, and psychopathy in children. *Journal of Abnormal Child
Psychology*, 24(2), 223-240.

Odell, A., Reynolds, G. L., Fisher, D. G., Huckabay, L. M., Pedersen, W. C., Xandre, P.,
& Miočević, M. (2017). Attention Deficit Hyperactivity Disorder and Trait
Displaced Aggression. *The Journal of Nervous and Mental Disease*, 205(5), 372.

Olazagasti, M. A. R., Klein, R. G., Mannuzza, S., Belsky, E. R., Hutchison, J. A.,
Lashua-Shriftman, E. C., & Castellanos, F. X. (2013). Does childhood attention-
deficit/hyperactivity disorder predict risk-taking and medical illnesses in
adulthood?. *Journal of the American Academy of Child & Adolescent Psychiatry*,
52(2), 153-162.

Overman, W. H., Frassrand, K., Ansel, S., Trawalter, S., Bies, B., & Redmond, A.
(2004). Performance on the IOWA card task by adolescents and
adults. *Neuropsychologia*, *42*(13), 1838-1851.

Owens, J. A. (2005). The ADHD and sleep conundrum: a review. Journal of

    Developmental & Behavioral Pediatrics, 26(4), 312-322.

Owens, J. S., Goldfine, M. E., Evangelista, N. M., Hoza, B., & Kaiser, N. M. (2007). A

    critical review of self-perceptions and the positive illusory bias in children with

    ADHD. *Clinical child and family psychology review*, *10*(4), 335-351.

Paloyelis, Y., Asherson, P., Mehta, M. A., Faraone, S. V., & Kuntsi, J. (2010). DAT1 and

    COMT effects on delay discounting and trait impulsivity in male adolescents with

    attention deficit/hyperactivity disorder and healthy

    controls. *Neuropsychopharmacology*, *35*(12), 2414.

Parsey, C. M., & Schmitter-Edgecombe, M. (2013). Applications of technology in

    neuropsychological assessment. *The Clinical Neuropsychologist*, *27*(8), 1328-

    1361.

Pastor, P. N., & Reuben, C. A. (2005). Racial and ethnic differences in ADHD and LD in

    young school-age children: parental reports in the National Health Interview

    Survey. Public health reports, 120(4), 383-392.

Paterson, D., & Spence, J. C. (1921). The after-effects of epidemic encephalitis in

    children. *The Lancet*, *198*(5114), 491-493.

Patros, C. H., Alderson, R. M., Kasper, L. J., Tarle, S. J., Lea, S. E., & Hudec, K. L.

    (2016). Choice-impulsivity in children and adolescents with attention-

    deficit/hyperactivity disorder (ADHD): A meta-analytic review. *Clinical*

    Psychology Review, *43*, 162-174.

Patterson, C. M., & Newman, J. P. (1993). Reflectivity and learning from aversive events: Toward a psychological mechanism for the syndromes of disinhibition. Psychological review, 100(4), 716.

Pelham, Jr, W. E., Fabiano, G. A., & Massetti, G. M. (2005). Evidence-based assessment of attention deficit hyperactivity disorder in children and adolescents. *Journal of clinical child and adolescent psychology*, *34*(3), 449-476.

Pelham, W. E., Foster, E. M., & Robb, J. A. (2007). The economic impact of attention-deficit/hyperactivity disorder in children and adolescents. Journal of pediatric psychology, 32(6), 711-727.

Perou, R., Bitsko, R. H., Blumberg, S. J., Pastor, P., Ghandour, R. M., Gfroerer, J. C., & Huang, L. N. (2013). Mental health surveillance among children—United States, 2005–2011. *MMWR Suppl*, *62*(2), 1-35.

Phillips, L. H., Tunstall, M., & Channon, S. (2007). Exploring the role of working memory in dynamic social cue decoding using dual task methodology. Journal of Nonverbal Behavior, 31(2), 137-152.

Pickering, A. D., Corr, P. J., & Gray, J. A. (1999). Interactions and reinforcement sensitivity theory: A theoretical analysis of Rusting and Larsen (1997).

Polanczyk, G. V., Willcutt, E. G., Salum, G. A., Kieling, C., & Rohde, L. A. (2014). ADHD prevalence estimates across three decades: an updated systematic review and meta-regression analysis. *International journal of epidemiology*, *43*(2), 434-442.

Polanczyk, G., De Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The

worldwide prevalence of ADHD: a systematic review and metaregression

analysis. American journal of psychiatry, 164(6), 942-948.

Pollak, Y., & Shoham, R. (2015). Feedback may harm: Role of feedback in probabilistic

decision making of adolescents with ADHD. Journal of Abnormal Child

Psychology, 43(7), 1233–1242

Pollak, Y., Oz, A., Neventsal, O., Rabi, O., Kitrossky, L., & Maeir, A. (2016). Do

adolescents with attention-deficit/hyperactivity disorder show risk seeking?

Disentangling probabilistic decision making by equalizing the favorability of

alternatives. *Journal of Abnormal Psychology*, 125(3), 387.

Pollak, Y., Shalit, R., & Aran, A. (2018). Risk taking and adult attention

deficit/hyperactivity disorder: A gap between real life behavior and experimental

decision making. *Psychiatry Research*, 259, 56-62.

Power, T. J., Werba, B. E., Watkins, M. W., Angelucci, J. G., & Eiraldi, R. B. (2006).

Patterns of parent-reported homework problems among ADHD-referred and non-

referred children. School Psychology Quarterly, 21(1), 13.

Pratt, T. C., Cullen, F. T., Blevins, K. R., Daigle, L., & Unnever, J. D. (2002). The

relationship of attention deficit hyperactivity disorder to crime and delinquency:

A meta-analysis. *International Journal of Police Science & Management*, *4*(4),

344-360.

Quay, H. C. (1988). The behavioral reward and inhibition system in childhood behavior

disorder.

Quay, H. C. (1997). Inhibition and attention deficit hyperactivity disorder. Journal of
abnormal child psychology, 25(1), 7-13.

Quinn, P. O. (2008). Attention-deficit/hyperactivity disorder and its comorbidities in
women and girls: an evolving picture. Current Psychiatry Reports, 10(5), 419-
423.

Quinn, P. O., & Madhoo, M. (2014). A review of attention-deficit/hyperactivity disorder
in women and girls: uncovering this hidden diagnosis. The primary care
companion for CNS disorders, 16(3).

Quinn, P., & Wigal, S. (2004). Perceptions of girls and ADHD: results from a national
survey. Medscape general medicine, 6(2).

Rabiner, D. L., Murray, D. W., Rosen, L., Hardy, K., Skinner, A., & Underwood, M.
(2010). Instability in teacher ratings of children's inattentive symptoms:
Implications for the assessment of ADHD. Journal of developmental and
behavioral pediatrics: JDBP, 31(3), 175.

Raiker, J. S., Rapport, M. D., Kofler, M. J., & Sarver, D. E. (2012). Objectively-
measured impulsivity and attention-deficit/hyperactivity disorder (ADHD):
testing competing predictions from the working memory and behavioral inhibition
models of ADHD. *Journal of abnormal child psychology*, *40*(5), 699-713.

Rappley, M. D. (2005). Attention deficit–hyperactivity disorder. New England Journal of
Medicine, 352(2), 165-173.

Rapport, M. D., Alderson, R. M., Kofler, M. J., Sarver, D. E., Bolden, J., & Sims, V.
(2008). Working memory deficits in boys with attention-deficit/hyperactivity

disorder (ADHD): the contribution of central executive and subsystem

processes. *Journal of abnormal child psychology*, *36*(6), 825-837.

Rapport, M. D., Bolden, J., Kofler, M. J., Sarver, D. E., Raiker, J. S., & Alderson, R. M.

(2009). Hyperactivity in boys with attention-deficit/hyperactivity disorder

(ADHD): A ubiquitous core symptom or manifestation of working memory

deficits?. *Journal of Abnormal Child Psychology, 37*, 521-534. doi:

10.1007/s10802-008-9287-8

Rapport, M. D., Chung, K. M., Shore, G., & Isaacs, P. (2001). A conceptual model of

child psychopathology: Implications for understanding attention deficit

hyperactivity disorder and treatment efficacy. *Journal of Clinical Child

Psychology*, *30*(1), 48-58.

Rapport, M. D., Bolden, J., Kofler, M. J., Sarver, D. E., Raiker, J. S., & Alderson, R. M.

(2009). Hyperactivity in boys with attention-deficit/hyperactivity disorder

(ADHD): a ubiquitous core symptom or manifestation of working memory

deficits?. *Journal of Abnormal Child Psychology*, 37(4), 521-534.

Reimer, B., Mehler, B., D'Ambrosio, L. A., & Fried, R. (2010). The impact of

distractions on young adult drivers with attention deficit hyperactivity disorder

(ADHD). *Accident Analysis & Prevention*, 42(3), 842-851.

Resnick, R. J. (2005). Attention deficit hyperactivity disorder in teens and adults: They

don't all outgrow it. Journal of clinical psychology, 61(5), 529-533.

Reynolds, B. (2006). A review of delay-discounting research with humans: relations to

drug use and gambling. *Behavioural pharmacology*, *17*(8), 651-667.

Reynolds, B., Ortengren, A., Richards, J. B., & de Wit, H. (2006). Dimensions of

    impulsive behavior: Personality and behavioral measures. *Personality and*

    Individual Differences, *40*(2), 305-315.

Richards, T. L., Deffenbacher, J. L., & Rosen, L. A. (2002). Driving anger and other

    driving-related behaviors in high and low ADHD symptom college students.

    Journal of Attention Disorders, 6(1), 25-38.

Richards, T. L., Rosen, L. A., & Ramirez, C. A. (1999). Psychological functioning

    differences among college students with confirmed ADHD, ADHD by self-report

    only, and without ADHD. *Journal of College Student Development*.

Rogers, R. D., Everitt, B. J., Baldacchino, A., Blackshaw, A. J., Swainson, R., Wynne,

    K., ... & London, M. (1999). Dissociable deficits in the decision-making cognition

    of chronic amphetamine abusers, opiate abusers, patients with focal damage to

    prefrontal cortex, and tryptophan-depleted normal volunteers: evidence for

    monoaminergic mechanisms. *Neuropsychopharmacology*, 20(4), 322-339.

Rohde, L. A., Szobot, C., Polanczyk, G., Schmitz, M., Martins, S., & Tramontina, S.

    (2005). Attention-deficit/hyperactivity disorder in a diverse culture: do research

    and clinical findings support the notion of a cultural construct for the disorder?.

    Biological psychiatry, 57(11), 1436-1441.

Rooney, M., Chronis-Tuscano, A., & Yoon, Y. (2012). Substance use in college students

    with ADHD. *Journal of Attention Disorders*, 16(3), 221-234.

Rosenbloom, T., & Wultz, B. (2011). Thirty-day self-reported risky driving behaviors of

    ADHD and non-ADHD drivers. *Accident Analysis & Prevention*, 43(1), 128-133.

Rosnow, R. L., & Rosenthal, R. (2008). Assessing the effect size of outcome research.

Ross, D. M., & Ross, S. A. (1976). Hyperactivity: Research, theory, and action.

Rothenberger, A., & Neumärker, K. J. (2005). Wissenschaftsgeschichte der ADHS.
Kramer-Pollnow im Spiegel der Zeit, Steinkopff, Darmstadt.

Rucklidge, J. J. (2008). Gender differences in ADHD: implications for psychosocial
treatments. Expert Review of Neurotherapeutics, 8(4), 643-655.

Russell, H. F., Wallis, D., Mazzocco, M. M., Moshang, T., Zackai, E., Zinn, A. R., ... &
Muenke, M. (2006). Increased prevalence of ADHD in Turner syndrome with no
evidence of imprinting effects. *Journal of pediatric psychology*, *31*(9), 945-955.

Ryan, K. K., Dube, S. L., & Potter, A. S. (2013). Rate dependent effects of acute nicotine
on risk taking in young adults are not related to ADHD diagnosis. *Pharmacology
Biochemistry and Behavior*, 103(3), 652-658.

Sarver, D. E., McCart, M. R., Sheidow, A. J., & Letourneau, E. J. (2014). ADHD and
risky sexual behavior in adolescents: Conduct problems and substance use as
mediators of risk. *Journal of Child Psychology and Psychiatry*, *55*(12), 1345-
1353.

Scheres, A., Lee, A., & Sumiya, M. (2008). Temporal reward discounting and ADHD:
task and symptom specific effects. *Journal of neural transmission*, *115*(2), 221-
226.

Schwarz, N., & Oyserman, D. (2001). Asking questions about behavior: Cognition,
communication, and questionnaire construction. *American Journal of Evaluation*,
22(2), 127–160.

Sciutto, M. J., & Eisenberg, M. (2007). Evaluating the evidence for and against the
overdiagnosis of ADHD. Journal of attention disorders, 11(2), 106-113.

Schwebel, D. C., Speltz, M. L., Jones, K., & Bardina, P. (2002). Unintentional injury in

preschool boys with and without early onset of disruptive behavior. *Journal of

Pediatric Psychology*, 27(8), 727-737.

Seidman, L. J. (2006). Neuropsychological functioning in people with ADHD across the

lifespan. Clinical psychology review, 26(4), 466-485.

Sergeant, J. (2000). The cognitive-energetic model: an empirical approach to attention-

deficit hyperactivity disorder. Neuroscience & Biobehavioral Reviews, 24(1), 7-

12.

Sergeant, J. A. (2005). Modeling attention-deficit/hyperactivity disorder: a critical

appraisal of the cognitive-energetic model. Biological psychiatry, 57(11), 1248-

1255.

Shaffer, H. J., Eber, G. B., Hall, M. N., & Vander Bilt, J. (2000). Smoking behavior

among casino employees: Self-report validation using plasma cotinine. *Addictive

Behaviors*, *25*(5), 693-704.

Shaw, M., Hodgkins, P., Caci, H., Young, S., Kahle, J., Woods, A. G., & Arnold, L. E.

(2012). A systematic review and analysis of long-term outcomes in attention

deficit hyperactivity disorder: effects of treatment and non-treatment. *BMC

medicine*, *10*(1), 99.

Shaw, P., Eckstrand, K., Sharp, W., Blumenthal, J., Lerch, J. P., Greenstein, D. E. E. A.,

... & Rapoport, J. L. (2007). Attention-deficit/hyperactivity disorder is

characterized by a delay in cortical maturation. *Proceedings of the National

Academy of Sciences*, *104*(49), 19649-19654.

Shoham, R., Sonuga-Barke, E. J., Aloni, H., Yaniv, I., & Pollak, Y. (2016). ADHD-associated risk taking is linked to exaggerated views of the benefits of positive outcomes. Scientific reports, 6, 34833.

Sibley, M. H., Pelham Jr, W. E., Molina, B. S., Gnagy, E. M., Waxmonsky, J. G., Waschbusch, D. A., ... & Kuriyan, A. B. (2012). When diagnosing ADHD in young adults emphasize informant reports, DSM items, and impairment. Journal of consulting and clinical psychology, 80(6), 1052.

Sibley, M. H., Pelham, W. E., Molina, B. S., Waschbusch, D. A., Gnagy, E. M., Babinski, D. E., & Biswas, A. (2010). Inconsistent self-report of delinquency by adolescents and young adults with ADHD. Journal of abnormal child psychology, 38(5), 645-656.

Skogli, E. W., Andersen, P. N., Hovik, K. T., & Øie, M. (2017). Development of hot and cold executive function in boys and girls with ADHD: A 2-year longitudinal study. *Journal of Attention Disorders*, 21(4), 305-315.

Skogli, E. W., Egeland, J., Andersen, P. N., Hovik, K. T., & Øie, M. (2014). Few differences in hot and cold executive functions in children and adolescents with combined and inattentive subtypes of ADHD. *Child Neuropsychology*, *20*(2), 162-181.

Skogli, E. W., Teicher, M. H., Andersen, P. N., Hovik, K. T., & Øie, M. (2013). ADHD in girls and boys—Gender differences in co-existing symptoms and executive function measures. BMC *Psychiatry*, 13.

Slomkowski, C., Klein, R. G., & Mannuzza, S. (1995). Is self-esteem an important

    outcome in hyperactive children?. Journal of abnormal child psychology, 23(3),

    303-315.

Sobanski, E., Brüggemann, D., Alm, B., Kern, S., Philipsen, A., Schmalzried, H., ... &

    Rietschel, M. (2008). Subtype differences in adults with attention-

    deficit/hyperactivity disorder (ADHD) with regard to ADHD-symptoms,

    psychiatric comorbidity and psychosocial adjustment. European Psychiatry, 23(2),

    142-149.

Solanto, M. V., Abikoff, H., Sonuga-Barke, E., Schachar, R., Logan, G. D., Wigal, T., ...

    & Turkel, E. (2001). The ecological validity of delay aversion and response

    inhibition as measures of impulsivity in AD/HD: a supplement to the NIMH

    multimodal treatment study of AD/HD. *Journal of abnormal child*

    psychology, *29*(3), 215-228

Solanto, M. V., Gilbert, S. N., Raj, A., Zhu, J., Pope-Boyd, S., Stepak, B., ... & Newcorn,

    J. H. (2007). Neurocognitive functioning in AD/HD, predominantly inattentive

    and combined subtypes. Journal of abnormal child psychology, 35(5), 729-744.

Sonuga-Barke, E. J. (2002). Psychological heterogeneity in AD/HD—a dual pathway

    model of behaviour and cognition. *Behavioural brain research*, *130*(1-2), 29-36.

Sonuga-Barke, E. J. (2003). The dual pathway model of AD/HD: an elaboration of neuro-

    developmental characteristics. *Neuroscience & Biobehavioral Reviews*, *27*(7),

    593-604.

Sonuga-Barke, E. J. (2005). Causal models of attention-deficit/hyperactivity disorder: from common simple deficits to multiple developmental pathways. Biological psychiatry, 57(11), 1231-1238.

Sonuga-Barke, E. J. S., Houlberg, K., & Hall, M. (1994). When is "impulsiveness" not impulsive? The case of hyperactive children's cognitive style. Journal of Child Psychology and Psychiatry, 35(7), 1247-1253.

Sonuga-Barke, E. J. S., Taylor, E., Sembi, S., & Smith, J. (1992). Hyperactivity and delay aversion—I. The effect of delay on choice. *Journal of Child Psychology and Psychiatry*, *33*(2), 387-398.

Sonuga-Barke, E. J., Sergeant, J. A., Nigg, J., & Willcutt, E. (2008). Executive dysfunction and delay aversion in attention deficit hyperactivity disorder: nosologic and diagnostic implications. *Child and adolescent psychiatric clinics of North America*, *17*(2), 367-384.

Sonuga-Barke, E., Bitsakou, P., & Thompson, M. (2010). Beyond the dual pathway model: evidence for the dissociation of timing, inhibitory, and delay-related impairments in attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *49*(4), 345-355

Sørensen, L., Sonuga-Barke, E., Eichele, H., van Wageningen, H., Wollschlaeger, D., & Plessen, K. J. (2017). Suboptimal decision making by children with ADHD in the face of risk: Poor risk adjustment and delay aversion rather than general proneness to taking risks. Neuropsychology, 31(2), 119.

Spencer, T. J., Biederman, J., & Mick, E. (2007). Attention-deficit/hyperactivity disorder: diagnosis, lifespan, comorbidities, and neurobiology. Journal of pediatric psychology, 32(6), 631-642.

Stavrinos, D., Biasini, F. J., Fine, P. R., Hodgens, J. B., Khatri, S., Mrug, S., & Schwebel, D. C. (2011). Mediating factors associated with pedestrian injury in children with attention-deficit/hyperactivity disorder. *Pediatrics*, 128(2), 296-302.

Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental review*, *28*(1), 78-106.

Still, G. F. (1902). The Goulstonian Lectures. Some abnormal psychical conditions in children, 1008-1012.

Stryker, S. (1925). Encephalitis lethargica—The behavior residuals. Training School Bulletin, 22, 152-157.

Swann, A. C., Bjork, J. M., Moeller, F. G., & Dougherty, D. M. (2002). Two models of impulsivity: relationship to personality traits and psychopathology. *Biological psychiatry*, *51*(12), 988-994.

Swanson, J. M., Sergeant, J. A., Taylor, E., Sonuga-Barke, E. J. S., Jensen, P. S., & Cantwell, D. P. (1998). Attention-deficit hyperactivity disorder and hyperkinetic disorder. The Lancet, 351(9100), 429-433.

Tarle, S. J., Alderson, R. M., Arrington, E. F., & Roberts, D. K. (2019). Emotion regulation and children with attention-deficit/hyperactivity disorder: The effect of varying phonological working memory demands. *Journal of attention disorders*, 1087054719864636.

Thomas, R., Sanders, S., Doust, J., Beller, E., & Glasziou, P. (2015). Prevalence of

attention-deficit/hyperactivity disorder: a systematic review and meta-analysis.

Pediatrics, 135(4), e994-e1001.

Thompson, A. L., Molina, B. S., Pelham Jr, W., & Gnagy, E. M. (2007). Risky driving in

adolescents and young adults with childhood ADHD. *Journal of pediatric*

psychology, *32*(7), 745-759.

Toplak, M. E., Jain, U., & Tannock, R. (2005). Executive and motivational processes in

adolescents with Attention-Deficit-Hyperactivity Disorder (ADHD). *Behavioral*

and Brain Functions, *1*(1), 8.

Toplak, M. E., Sorge, G. B., Flora, D. B., Chen, W., Banaschewski, T., Buitelaar, J., ... &

Miranda, A. (2012). The hierarchical factor model of ADHD: invariant across age

and national groupings?. Journal of Child Psychology and Psychiatry, 53(3), 292-

303.

Trimpop, R. (1994). The psychology of risk taking behavior. Amsterdam: Elsevier

Science.

Tripp, G., & Wickens, J. R. (2009). Neurobiology of ADHD. Neuropharmacology, 57(7-

8), 579-589.

Turner, C., & McClure, R. (2003). Age and gender differences in risk-taking behaviour

as an explanation for high incidence of motor vehicle crashes as a driver in young

males. *Injury control and safety promotion*, *10*(3), 123-130.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of

choice. Science, 211(4481), 453-458.

Valero, S., Bosch, R., Corominas, M., Giannoni, A., Barrau, V., Ramos-Quiroga, J. A., &
Casas, M. (2017). Psychopathology and traffic violations in subjects who have
lost their driving license. *Comprehensive Psychiatry*, 76, 45-55.

Van Duijvenvoorde, A. C., Blankenstein, N. E., Crone, E. A., & Figner, B. (2016).
Towards a better understanding of adolescent risk-taking. *Individual Differences
in Judgement and Decision-Making: A Developmental Perspective*, 8.

Van Duijvenvoorde, A. C., Jansen, B. R., Bredman, J. C., & Huizenga, H. M. (2012).
Age-related changes in decision making: Comparing informed and noninformed
situations. *Developmental Psychology*, *48*(1), 192.

Van Goozen, S. H., Cohen-Kettenis, P. T., Snoek, H., Matthys, W., Swaab-Barneveld,
H., & Van Engeland, H. (2004). Executive functioning in children: a comparison
of hospitalised ODD and ODD/ADHD children and normal controls. *Journal of
Child Psychology and Psychiatry*, *45*(2), 284-292.

Viechtbauer, W., & Cheung, M. W. L. (2010). Outlier and influence diagnostics for
meta-analysis. Research synthesis methods, 1(2), 112-125.

Visser, S. N., Danielson, M. L., Bitsko, R. H., Holbrook, J. R., Kogan, M. D., Ghandour,
R. M., ... & Blumberg, S. J. (2014). Trends in the parent-report of health care
provider-diagnosed and medicated attention-deficit/hyperactivity disorder: United
States, 2003–2011. Journal of the American Academy of Child & Adolescent
Psychiatry, 53(1), 34-46.

Vogel-Sprott, M. (1992). *Alcohol tolerance and social drinking: Learning the
consequences*. Guilford Press.

Wang, M., Deng, Q., Armour, C., Bi, X., & Zeng, H. (2015). The psychometric
properties and factor structure of the antisocial process screening device self-
report version in chinese adolescents. *Journal of Psychopathology and Behavioral
Assessment*, 37(4), 553-562.

Weafer, J., Milich, R., & Fillmore, M. T. (2011). Behavioral components of impulsivity
predict alcohol consumption in adults with ADHD and healthy controls. *Drug and
Alcohol Dependence*, 113(2-3), 139-146.

Wehmeier, P. M., Schacht, A., & Barkley, R. A. (2010). Social and emotional
impairment in children and adolescents with ADHD and the impact on quality of
life. Journal of Adolescent health, 46(3), 209-217.

Weisler, R. H., & Goodman, D. W. (2008). Assessment and Diagnosis of Adult ADHD:
Clinical Challenges and Opportunities for Improving Patient Care. Primary
Psychiatry, 15(11).

Wheeler Maedgen, J., & Carlson, C. L. (2000). Social functioning and emotional
regulation in the attention deficit hyperactivity disorder subtypes. Journal of
clinical child psychology, 29(1), 30-42.

White, J. W., & Buehler, C. (2012). Adolescent sexual victimization, ADHD symptoms,
and risky sexual behavior. *Journal of Family Violence*, 27(2), 123-132.

Wiers, R. W., Gunning, W. B., & Sergeant, J. A. (1998). Is a mild deficit in executive
functions in boys related to childhood ADHD or to parental multigenerational
alcoholism?. *Journal of Abnormal Child Psychology*, *26*(6), 415-430.

Wilbertz, G., van Elst, L. T., Delgado, M. R., Maier, S., Feige, B., Philipsen, A., & Blechert, J. (2012). Orbitofrontal reward sensitivity and impulsivity in adult attention deficit hyperactivity disorder. *Neuroimage*, *60*(1), 353-361.

Wilens, T. E. (2004). Impact of ADHD and its treatment on substance abuse in adults. Journal of Clinical Psychiatry, 65, 38-45.

Wilens, T. E., Adamson, J., Sgambati, S., Whitley, J., Santry, A., Monuteaux, M. C., & Biederman, J. (2007). Do individuals with ADHD self-medicate with cigarettes and substances of abuse? Results from a controlled family study of ADHD. *American Journal on Addictions*, 16(sup1), 14-23.

Wilens, T. E., Adler, L. A., Adams, J., Sgambati, S., Rotrosen, J., Sawtelle, R., ... & Fusillo, S. (2008). Misuse and diversion of stimulants prescribed for ADHD: a systematic review of the literature. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*(1), 21-31.

Wilens, T. E., Biederman, J., Brown, S., Tanguay, S., Monuteaux, M. C., Blake, C., & Spencer, T. J. (2002). Psychiatric comorbidity and functioning in clinically referred preschool children and school-age youths with ADHD. Journal of the American Academy of Child & Adolescent Psychiatry, 41(3), 262-268.

Wilens, T. E., Biederman, J., Faraone, S. V., Martelon, M., Westerberg, D., & Spencer, T. J. (2009). Presenting ADHD symptoms, subtypes, and comorbid disorders in clinically referred adults with ADHD. The Journal of clinical psychiatry, 70(11), 1557.

Willcutt, E. G. (2012). The prevalence of DSM-IV attention-deficit/hyperactivity disorder: a meta-analytic review. Neurotherapeutics, 9(3), 490-499.

Williams, J., & Taylor, E. (2005). The evolution of hyperactivity, impulsivity and cognitive diversity. Journal of the Royal Society Interface, 3(8), 399-413.

Wolraich, M. L., Lambert, E. W., Bickman, L., Simmons, T., Doffing, M. A., & Worley, K. A. (2004). Assessing the impact of parent and teacher agreement on diagnosing attention-deficit hyperactivity disorder. Journal of Developmental & Behavioral Pediatrics, 25(1), 41-47.

Wymbs, B. T., Molina, B. S., Belendiuk, K. A., Pedersen, S. L., Walther, C. A., Cheong, J. W., ... & Pelham, W. E. (2013). Motorsports involvement among adolescents and young adults with childhood ADHD. *Journal of Clinical Child & Adolescent Psychology*, 42(2), 220-231.

Xu, S., Fang, Z., & Rao, H. (2013). Real or hypothetical monetary rewards modulates risk taking behavior. Acta Psychologica Sinica, 45(8), 874–886.

Young, S., Morris, R., Toone, B., & Tyson, C. (2007). Planning ability in adults with attention-deficit/hyperactivity disorder. Neuropsychology, 21(5), 581.

Zentall, S. S. (1993). Research on the educational implications of attention deficit hyperactivity disorder. Exceptional children, 60(2), 143-153.

Zhao-hong, Z., Yong-hui, W., & Ping, W. (2011). Performance of children with two subtypes of ADHD in roger's risk task. *Chinese Journal of Clinical Psychology*, 19(4), 479-482.

APPENDIX

.**Overview and Brief History of Attention-Deficit Hyperactivity Disorder**

Attention-Deficit/Hyperactivity Disorder (ADHD) is a childhood disorder

characterized by persistent and pervasive hyperactivity, inattention, and/or impulsivity

that leads to functional impairment in multiple settings (American Psychiatric

Association [APA], 2013). Coinciding with previous factor analytic studies suggesting

inattention and hyperactivity-impulsivity as being distinct factors of the disorder (DuPaul

et al.,1998; Willcutt, 2012), ADHD is categorized into domain-specific subtypes,

including ADHD-Predominantly Inattentive Presentation (ADHD-I), ADHD-

Predominantly Hyperactive-Impulsive Presentation (ADHD-H), and ADHD-Combined

Presentation (ADHD-C; APA, 2013). ADHD-I includes symptoms such as difficulty with

sustaining attention, forgetfulness, and distractibility, whereas ADHD-H includes

symptoms such as restlessness, talking excessively, and impulsivity. ADHD-C is

characterized by symptoms that meet criteria for both ADHD-I and ADHD-H. Although

the field's current understanding of ADHD is relatively neoteric, symptoms of

inattention, hyperactivity, and impulsivity have been observed in children and adults for

centuries (Lange et al., 2010; Rafalovich, 2001). Dating back to the 1800s, descriptions

of "morbid alterations" of attention (Crichton, 1798), such as being easily distracted and

having difficulty attending to a single object, began to define characteristics of what is

now operationalized as the inattention construct. Hyperactivity was first conceptualized in a commonly used allegory depicting motoric over-activity (Hoffmann, 1865), and was characterized by having the tendency to frequently interrupt and fidget. Despite a growing awareness of the defining characteristics of ADHD during the 1800s, less was known about its etiology. Initially, inattention and hyperactivity exhibited by children were considered residual effects of having a defect in moral control. These symptoms were defined as being characteristic of self-gratification, including qualities such as passionateness, spitefulness, lawlessness, and destructiveness (Still, 1902). Therefore, deficits in attention and hyperactivity were considered a behavioral disorder that could be managed with parental punishment and discipline.

Following the encephalitis epidemic in the early 1900s, etiological theories began to emphasize physiological abnormalities of the brain, rather than focusing on deficits of moral control. A proportion of affected children who survived the encephalitis outbreak developed significant emotional instability, cognitive deficits, and personality changes (Conners, 2000; Kessler, 1980; Rothenberger & Neumärker, 2005), producing problematic behaviors, such as hyperactivity, distractibility, and irritability (Paterson & Spence, 1921; Ross & Ross 1976; Stryker, 1925). This phenomenon became known as "postencephalitic behavior disorder" and spawned the conceptual connection between physiology and behavior in ADHD (Barkley, 2006; Rothenberger & Neumarker, 2005). Subsequently, an emergence of physiological research on behavior disorders indicated there was an association between brain damage and deviant behavior (Ross & Ross, 1976), suggesting hyperactivity was caused by "minimal brain damage" (Kessler, 1980). Critics argued, however, that not every child with abnormal behavior had brain damage

and, likewise, brain damage could not solely be inferred from signs of problematic

behavior. Later research suggested that brain dysfunction, rather than brain damage, was

the cause of problematic behaviors (Connors, 2000) and, as such, the term "minimal brain

damage" was replaced by "minimal brain dysfunction."

Despite many advances in the field and an increased understanding of the etiology

of inattentive and hyperactive symptoms, it was not until 1932, when German physicians

Franz Kramer and Hans Pollnow described observed symptoms of hyperactivity as a

"hyperkinetic disease" that was distinguishable from other brain dysfunctions with

similar symptoms, such as encephalitis and mental retardation (Kramer & Pollnow,

1932). The conceptualization of hyperkinetic disease as being a distinct disorder was the

first to closely resemble what is now referred to as ADHD (Lange et al., 2010).

ADHD was first recognized as a formal disorder in the DSM-II (APA, 1968) and

was initially termed "hyperkinetic reaction of childhood." The diagnostic criteria for

hyperkinetic reaction of childhood primarily included symptoms of excessive motor

activity, emphasizing that hyperactivity was viewed as the primary symptom of the

disorder, rather than brain dysfunction (Barkley, 2006; Lange et al., 2010). In the 1970s,

research findings indicated that inattention and impulsivity were also key features of

hyperkinetic reaction of childhood (Barkley, 2006; Douglas, 1972; Lange et al., 2010).

Therefore, the disorder was later re-conceptualized as including problems associated with

hyperactivity, inattention, and impulsivity, and was renamed Attention Deficit Disorder

(ADD) in the DSM-III (APA, 1980). Moreover, hyperactivity was no longer considered

the primary symptom of the disorder and, therefore, two subtypes emerged – ADD with

hyperactivity and ADD without hyperactivity. It was not until the publication of the

DSM-III-R (APA, 1983) that the moniker Attention Deficit/Hyperactivity Disorder was first introduced and the hyperactivity distinction was removed due to a lack of empirical evidence supporting the difference between children and adults with and without hyperactivity (Lange et al., 2010; McBurnett et al., 1993).

With the publication of the DSM-IV (APA, 1994), the disorder was again re-conceptualized to include three subtypes – predominantly inattentive subtype, predominantly hyperactive-impulsive subtype, and combined subtype. Empirical findings suggested the validity and reliability of the diagnostic criteria would improve with the restructuring of subtypes (Biederman et al., 1997; Lahey et al., 1994). For example, factor analytic research suggests two-factor models including inattention and hyperactivity-impulsivity represent the greatest model fit (DuPaul et al., 1998; Willcutt, 2012), and confirmatory factor analyses suggest the best model is represented using a single factor that encompasses both hyperactivity and impulsivity as a single symptom domain (Martel, von Eye, & Nigg, 2010; Toplak et al., 2012; Willcutt, 2012). As such, the use of subtypes was found to improve detection of the disorder among females, who primarily presented with the inattentive subtype, young children, who primarily presented with the hyperactive-impulsive subtype, and adults, who primarily exhibited symptoms associated with social and occupational impairment (APA, 1994; Lahey et al., 1994; Lange et al., 2010).

In the most recent update, the DSM-5 (APA, 2013), classifies ADHD as a neurodevelopmental disorder, rather than a disruptive behavior disorder. Although there were no substantial changes to the core symptom domains or symptomology of ADHD, minor revisions to the diagnostic criterion sets were included. For example, symptoms of

inattention, hyperactivity, and impulsivity listed in Criterion A were supplemented with examples that characterize symptoms that manifest in late adolescence and adulthood. Further, there was a reduction from six to five symptoms needed to meet diagnosis in older adolescents and adults. In Criterion B, the age of onset changed from before age seven to before age 12, and impairment at onset is no longer required. The pervasiveness requirement listed in Criterion C now requires evidence of symptoms in two or more settings, rather than evidence of impairment in multiple settings. Similarly, the impairment clause in Criterion D no longer requires that functional impairments be "clinically significant," but that only a reduction of *the quality of* social, academic or occupational functioning is necessary. Finally, Autism Spectrum Disorder was eliminated as an exclusionary condition listed in Criterion E.

Additional changes to the overall diagnostic classification of ADHD in the DSM-5 included a change in the terminology for ADHD subtypes and the addition of two modifiers for specification of the disorder. The alteration in the nomenclature of "subtypes" to "presentations" was included to better reflect possible changes in the manifestation of the disorder over time. Further, the inclusion of modifiers allows for better specification of the disorder, such as being able to indicate the severity (i.e., mild, moderate, or severe) and status (e.g., in partial remission) of the disorder.

Prevalence and Heterogeneity of ADHD

With an estimated worldwide prevalence of 7% (Thomas, Sanders, Doust, Beller, & Glasziou, 2015) and an approximated 11% of children aged 4 to 17 years diagnosed in the United States (Visser et al., 2014), ADHD is the most common neurodevelopmental disorder of childhood. Results of a recent epidemiological study suggests that

approximately 6.1 million children and adolescents in the United States have received an

ADHD diagnosis from a health care provider at some point in their lifetime, and 5.4

million children and adolescents have a current diagnosis (Danielson et al., 2018). In

addition to high prevalence rates, ADHD is often highly comorbid with several

psychiatric and medical conditions (Biederman, Newcorn, & Sprich, 1991; Jensen,

Martin, & Cantwell, 1997; Wilens et al., 2002). The National Survey of Children's

Health (2016) found that 64% of children with ADHD had at least one comorbid

disorder, with behavioral or conduct problems (52%) being the most common co-

occurring condition, followed by anxiety (33%), depression (17%), and autism spectrum

disorder (14%; Danielson et al., 2018). Other common comorbid conditions include

bipolar disorder (Klassen et al., 2010), learning disabilities (DuPaul, et al., 2013), sleep

disorders (Owens, 2005), and substance abuse (Wilens, 2004).

ADHD was initially conceptualized as a childhood disorder due to lower report of

prevalence in adults (3.4%; Fayyad et al., 2007), relative to children (5.9-7.1%; Willcutt,

2012). However, recent studies provide strong indication that ADHD persists into

adulthood for 35 to 70% of children and adolescents, with an overall prevalence of 4 to 5

% in the adult population (Weisler & Goodman, 2008). Whereas the most prevalent

subtype among children is ADHD-I (5.1%), followed by ADHD-C (3.3%) and ADHD-H

(2.9%; Willcutt, 2012), respectively, the most prevalent subtype among adults is ADHD-

C (62%), followed by ADHD-I (31%) and ADHD-H (7%; Wilens et al., 2009).

Conversely, ADHD-C is the most prevalent subtype among clinically referred children

(Gaub & Carlson, 1997). Although there has been a long withstanding belief that most

children will eventually outgrow the disorder, as symptoms tend to attenuate in adulthood

(Resnick, 2005), recent research suggests that ADHD often persists through adolescence and into adulthood (Barbaresi et al., 2013; Faraone et al., 2000). With a growing awareness of the chronicity of ADHD, recent updates of the DSM have broadened the definition of ADHD to account for symptoms and impairment observed in older adolescents and adults, and allow for greater diagnostic sensitivity into adulthood (APA, 2013).

Coinciding with recent amendments to the DSM, there has been a significant increase in the prevalence rates of ADHD. From 2003 to 2011, rates of diagnosed ADHD in the United States increased an average of 5% per year (Visser et al., 2014). Worldwide prevalence rates of ADHD have increased from 5.29% in 2007 (Polanczyk et al, 2007) to 7.2% in 2015 (Thomas et al., 2015). However, increases in prevalence may be partially explained by other factors, such as differences associated with sex, culture, and diagnostic procedures.

Sex differences and ADHD-related heterogeneity. Sex differences have been widely documented in ADHD literature. Boys are more often diagnosed with ADHD compared to girls (Biederman et al., 2002; Froehlich et al., 2007; Gaub & Carlson, 1997; Lee et al., 2008; Sciutto & Eisenberg, 2007; Quinn, 2008), with ratios ranging from 3:1 in community samples to 9:1 in clinical samples (Gaub & Carlson, 1997; Gershon, 2002). Research suggests differences in the expression of ADHD symptoms between males and females may produce variable prevalence estimates (APA, 2000; Gaub & Carlson, 1997; Gershon, 2002). While girls with ADHD typically exhibit greater internalizing symptoms (e.g., inattention) and receive diagnoses for inattentive presentation more often, boys with ADHD typically exhibit greater externalizing symptoms (e.g., hyperactivity) and receive

more diagnoses of the hyperactive presentation (APA, 2000; Biederman et al., 2002; Gershon & Gershon, 2002; Skogli et al., 2013). Compared to boys with ADHD, who often engage in more overt, disruptive behaviors, girls often exhibit symptoms that are less severe and are more frequently overlooked (Abikoff et al., 2002; Berry, Shaywitz, and Shaywitz, 1985). Consequently, ADHD in girls is often under-identified and underdiagnosed, relative to boys (Quinn & Madhoo, 2014; Quinn & Wigal, 2004). However, some researchers argue that males and females experience symptoms similarly, asserting that differences in prevalence rates are observed across sexes because only females with severe symptoms of ADHD are detected, while females with less severe symptomology are overlooked (Rucklidge, 2008).

   Cultural differences and ADHD-related heterogeneity. Differences in ADHD symptomology observed across cultures may also explain widely varying prevalence rates. Some argue that heterogeneity of the disorder is attributed to demographic factors that are associated with geographical differences (Rappley, 2005). Findings from recent epidemiological studies, for example, suggest prevalence rates in Africa and the Middle East are lower than in North America (Polanczyk et al., 2007). However, others argue that variable estimates of ADHD across cultures are better explained by access to health care, rather than true cultural differences, highlighting the difficulty in identifying and diagnosing ADHD among minorities (Bird, 2002; Rohde et al., 2005; Swanson, et al., 1998). Studies have shown that African-Americans with ADHD diagnoses are less likely to seek and receive treatment than Caucasians (Bussing, Schoenberg, & Perwien, 1998; Bussing et al., 1998), and parents of Hispanic and African American children are less

likely to report symptoms of ADHD (Cuffe, Moore, & McKeown, 2005; Pastor &

Rueben, 2005).

Cultural biases introduced during assessment and diagnosis also may affect

prevalence rates. For example, assessment instruments used during diagnostic procedures

are often highly influenced by Western culture and, therefore, lack cultural sensitivity

(Bauermeister, Berrios, Jimenez, Acevedo, & Gordon 1990; Canino & Guarnaccia, 1997;

Coll, Akerman, & Cicchetti, 2000; Lopez & Guarnaccia, 2000). Consequently, the

clinical use of Westernized assessment instruments may provide an underestimation of

prevalence rates in minorities (Barkley, 1998; Bird, 2002). Moreover, the application of

diagnostic criteria and assessment of impairment may be subjective to cultural influence,

producing inaccurate diagnoses that lead to invalid estimates of prevalence rates

(Polanczyk, De Lima, Horta, Biederman, & Rohde, 2007).

Other factors that affect ADHD-related heterogeneity. Additional explanations

of inconsistent prevalence rates of ADHD focus on method variance in diagnostic

procedures, regardless of culture. Specifically, diagnostic decisions are often reliant on

informant-based methods, such as rating scales and information obtained by single

informants (e.g., self-, parent- or teacher-report). However, these diagnostic methods are

often inaccurate and unreliable, especially when measuring symptoms over time (Rabiner

et al., 2010) and across sexes (Makransky & Bilenberg, 2014). For example, studies have

shown that adults with ADHD tend to under-report symptom frequency and severity

(Asherson et al., 2012; Davidson, 2008), while parents and teachers tend to over-report,

which may result in inaccurate prevalence rates (Getahun, Jacobsen, Fassett, Chen,

Demissie, & Rhoads, 2013). Even more, the use of multiple informants to inform

diagnostic decisions is not exempt from problems, as rater disagreement and the use of invalid or unreliable measures can complicate differential diagnoses (Amador-Campos et al., 2006; Antrop et al., 2002; Mitsis et al., 2000; De Los Reyes & Kazdin, 2005; Wolraich et al., 2004). Consequently, although informant-based methods may be proficient in identifying an individual's overall synopsis of their presenting problems, they may not accurately capture the full scope of ADHD-related symptoms, which likely influences prevalence rates (Getahun et al., 2013). As such, it is recommended that professional clinicians use the "gold standard," including several methods (e.g., interviews and questionnaires) and multiple informants (e.g., parent and teachers) when deriving diagnostic decisions.

Outcomes of ADHD

ADHD is recognized as a psychiatric condition associated with adverse outcomes that significantly affect children and adults throughout the lifespan (APA, 2013; Seidman, 2006; Shaw et al., 2012; Spencer, Biederman, & Mick, 2007). Children with ADHD often incur impairments that affect multiple areas, including academic (Daley & Birchwood, 2010; Frazier, Youngstrom, Glutting, & Watkins 2007), social (Frederick & Olmi, 1994; Kofler et al., 2011; Wheeler et al., 2000), and behavioral functioning (Barkley, 2006; DuPaul et al., 2001). Academic difficulties among children with ADHD have been extensively documented (Frazier, Youngstrom, Glutting, & Watkins 2007; Hinshaw, 1992; Hinshaw, 1994; Mash & Barkley, 2003; Zentall, 1993). Children and adolescents with ADHD often fail to complete and turn in their homework (Power, et al., 2006), develop poor study skills (Norwalk, Novilitis, & MacLean, 2009), and receive lower test grades than same-aged peers (Frazier, Youngstrom, Glutting, & Watkins

2007). With deficits beginning in the early stages of education and persisting through

college (Daley & Birchwood, 2010; Mariani & Barkley, 1997), ADHD is often

associated with a history of academic underachievement, learning disabilities, placements

in special education, and grade retentions (Barkley, 1998; Barkley, 2002; Faraone et al.,

1993; Hinshaw, 1992; Mannuzza et al.,1993; Marshall et al., 1997). Academic

impairments may also lead to social and behavioral problems in the school setting, such

as creating conflicts with peers and teachers, and engaging in disruptive behaviors in the

classroom (Hinshaw, 1992; Pelham, Foster, & Robb, 2007; Zentall, 1993).

Children with ADHD often experience more social functioning difficulties,

relative to typically-developing peers (Kofler et al., 2011; Maedgen & Carlson, 2000).

Compared to non-affected children, children with ADHD often experience more peer

rejection (Bagwell, Molina, Pelham, & Hoza, 2001; Hinshaw & Melnick, 1995; Hoza,

2007; Hoza et al., 2005), less stability in friendships (Blachman & Hinshaw, 2002), and

fewer dyadic friendships (Bagwell, Molina, Pelham, Hoza, 2001; Hoza et al., 2005).

Explanations for poor interpersonal relationships propose that symptoms of inattention

may limit the affected individual's ability to attend to social cues (Landau & Milich,

1988) and improve social skills through observational learning (Cunningham, Siegel, &

Offord, 1985), whereas symptoms of hyperactivity and impulsivity may promote socially

aversive behaviors (Cervantes et al., 2013; Guevremont & Dumas, 1994; Keown &

Woodard, 2006; Pelham, et al., 2007; Wehmeier et al., 2010). ADHD-related working

memory deficits have also been found to negatively impact social interactions by

impairing affected children's ability to participate in give-and-take interactions and

refrain from impulsive responding (Kofler et al., 2011; Langberg, Dvorsky, & Evans,

2013; Phillips, Tunstall, & Channon, 2007). Alternative explanations suggest that social functioning may be impaired due to emotional difficulties commonly associated with ADHD. Specifically, children with ADHD often exhibit poor emotion regulation, compared to non-affected children (Barkley, 2011; Bunford, Evans, Langberg, 2014; Maedgen & Carlson, 2000; Melnick & Hinshaw, 2000), and are more likely to have low self-esteem (Barkley et al., 2006; Mannuzza et al., 1998; Slomkowski, Klein, & Mannuzza, 1995; Sobanski et al., 2008), which may impair an individual's ability to obtain and maintain friendships.

Behavioral functioning also is often impaired due to ADHD-related symptoms (Barkley, 2006; DuPaul et al., 2001). Relative to typically-developing peers, children with ADHD are more likely to be defiant towards authority, often interrupt or intrude on others, have trouble waiting for their turn, fidget excessively, have difficulty staying seated, have difficulty paying attention, and often make careless mistakes (APA, 2013). Moreover, behavioral problems developed in childhood often persist and lead to negative outcomes as adolescents and adults (Barbaresi et al., 2013; Faraone et al., 2000; Murphy & Barkley, 1996). Maladaptive behaviors, such as frequent tardiness, making excessive mistakes, and having poor organizational and planning skills may result in lower occupational attainment (Barkley, Murphy, & Fischer, 2008; Harpin, 2005). Adults with ADHD often hold subordinate occupational positions (Barkley et al. 2008; Mannuzza et al. 1993), obtain lower incomes (Biederman & Faraone, 2006), and have greater difficulty sustaining full-time employment (Barkley et al., 2006), compared to non-affected adults. Lastly, frequent involvement in risky behaviors may increase the likelihood of automobile violations and accidents (Barkley, Murphy, & Kwasnik, 1996;

Murphy, & Barkley, 1996), criminal arrests (Babinski et al., 1999; Barkley et al. 2004; Mannuzza et al. 2008; Molina et al. 2009), risky sexual behaviors (Barkley at al., 2006; Flory, Molina, Pelham, Gnagy, & Smith, 2007; Harpin, 2005), and substance abuse (King, Iacono, & McGue, 2004; Marshal, Molina, & Pelham, 2003; Molina and Pelham 2003).

Risk-Taking in ADHD

Risk-taking refers to decisions or behaviors that compromise an individual's health and well-being, or involve making a selection when the outcome is unknown (Trimpop, 1994). Given that characteristic symptoms of ADHD include behavioral inhibition (Barkley, 1997), impulsivity (APA, 2013), and increased reward and novelty seeking behaviors (Donfrancesco et al., 2015), it is not surprising that the disorder has been found to be related to more risk-taking (Drechsler et al., 2008; Williams & Taylor, 2005; Barkley 2006). One possible explanation for frequent risk-taking among children and adults with ADHD involves deficits in attentional processes. For example, risk-taking may be influenced by the inability to focus and shift one's attention to efficiently reflect possible alternatives (Kühberger, 1998; Tversky & Kahneman, 1981; Solanto et al., 2007; Young, Morris, Toone, & Tyson, 2007). Another explanation proposes that children and adults with ADHD are more attracted to risk and novelty (Groen, Gaastra, Lewis-Evans, & Tucha, 2013), such that affected individuals tend to be risk-takers and thrill-seekers. Finally, research examining delay aversion (i.e., the motivation to escape or avoid delay; Sonuga-Barke, 1994, 2003, 2005) in ADHD provides another explanation for increased risk-taking by children with the disorder. Studies have shown that children and adolescents with ADHD, relative to non-affected children and adults, are more likely

to make decisions based on the immediacy of outcomes, rather than reflecting on long-term alternatives (Marco et al., 2009; Paloyelis, Asherson, Mehta, Faraone, & Kuntsi, 2010; Solanto et al., 2001).

Risk-Taking in Theoretical Models of ADHD

Cognitive-Energetic Model

Sergeant's (2000) cognitive-energetic model of ADHD posits that deficits associated with ADHD manifest according to three interdependent levels of information processing, including computational mechanisms of attention, energetic states, and management mechanisms. In the first level of information processing, computational mechanisms of attention include cognitive processes such as encoding, searching, decision-making, and motor organization (Sergeant, 2000). Energetic states in the second level of processing include effort, arousal, and activation, in which effort refers to the energy required to complete a task, arousal refers to responses influenced by stimulus intensity and novelty, and activation refers to an individual's physiological readiness to respond (Sergeant, 2005). Finally, the third level, comprised of management mechanisms, includes executive functions such as planning, monitoring, and the detection and correction of errors (Sergeant, 2000, 2005).

According to the cognitive-energetic model, deficits associated with ADHD occur at each level of information processing, such that attentional difficulties contribute to non-optimal energetic states, which result in poorer executive performance (Sergeant, 2005). Further, the model suggests that reinforcement (i.e., arousal) may activate the effort pool (i.e., activation), generating the required energy needed to meet task demands (i.e., effort; Sergeant, 2000; Luman, Oosterlaan, Sergeant, 2005). In line with this model,

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characteristics of ADHD, such as low levels of arousal, an underactive effort pool, and a limited capacity to activate cognitive resources explain the propensity for sensation-seeking and risky decisions. A child with ADHD that quickly grows bored in a classroom, for example, may find it difficult to attend to lecture and will therefore engage in disruptive, sensation-seeking behaviors in order to increase levels of arousal. A child without ADHD, however, may grow bored in the classroom but will likely have the cognitive resources to combat their boredom, attend to lecture, and refrain from sensation-seeking behaviors.

Neurodevelopmental Model

Halperin and Schulz's (2006) neurodevelopmental model of ADHD was developed in response to previous neuropsychological research that suggest symptoms of ADHD are associated with underdeveloped neural mechanisms in the prefrontal cortex. Contrary to previous models suggesting ADHD occurs due to abnormal development of the prefrontal cortex, Halperin and Schulz's neurodevelopmental model argues that ADHD occurs due to neurological dysfunction related to abnormalities of the prefrontal cortex that manifest early in development and remain static across the lifespan (Halperin & Schulz, 2006). In order to compensate for cognitive deficits, compensatory mechanisms and neural plasticity may occur in the prefrontal cortex, leading to the remission of ADHD-related symptoms in adulthood (Halperin & Schulz, 2006). Consistent with this model, research has indicated that ADHD-related risk-taking is associated with dysfunctions of the prefrontal cortex, including impairments in executive functions that are critical to response inhibition (Clark et al., 2007), and processes involved in modulating affective behavior and behavioral responses to reward (Tripp &

Wickens, 2009). Although Halperin and Schulz's (2006) model coincides with biological

underpinnings said to be involved in risk-taking, the model fails to address the

persistence of risk-taking behaviors across the lifespan among children and adults with

ADHD.

Functional Working Memory Model

The functional working memory model of ADHD (Rapport et al., 2001) is based

on Baddeley's (2000) multi-component model of working memory – consisting of a

domain-general system involved in executive cognitive processes (i.e., central executive)

and two subsidiary systems involved in the temporary storage and manipulation of

phonological (i.e., phonological loop) and visual (i.e., visuospatial sketchpad)

information – and hypothesizes that ADHD-related deficits in working memory give rise

to phenotypic features of the disorder, such as hyperactivity (Hudec et al., 2015; Rapport

et al., 2009) and inattention (Kofler et al., 2010). The model suggests that biological and

environmental influences are responsible for individual differences in the function of

neurobiological systems, which account for core cognitive and behavioral features of

ADHD (Rapport et al., 2009). Secondary features, such as hyperactivity and inattention,

and tertiary features, such as impairment in academic, social, and emotional functioning,

are therefore considered byproducts of ADHD-related working memory deficits (Rapport

et al., 2001).

Although the functional working memory model does not explicitly address risk

taking, it suggests that working memory deficits serve as a core feature of ADHD and

consequently underlie tertiary features commonly associated with the disorder. Moreover,

recent research suggests deficits in central executive functioning are associated with

difficulties in inhibition (Alderson, Rapport, Hudec, Sarver, & Kofler, 2010) and decision-making (Bechara & Martin, 2004), suggesting ADHD-related working memory deficits may contribute to increased frequency of risky decision-making among affected children and adults.

Reinforcement Model

Gray's Reinforcement Sensitivity Theory (RST; 1987) suggests that individual differences in behavior are related to two major neurobiological systems: the Behavioral Approach System (BAS) and the Behavioral Inhibition System (BIS). The BAS responds to cues of reward or relief from punishment, and is characterized by approach behaviors in response to reinforcement (Pickering, Corr, & Gray, 1999). Individuals with greater BAS sensitivity are hypothesized to have impaired abilities in self-regulation and tend to be more impulsive. Alternatively, the BIS responds to signals of punishment, frustrative non-reward, and novel stimuli (Gray, 1991). Individuals with greater BIS sensitivity are therefore hypothesized to be more sensitive to punishment and more prone to anxiety (Corr, 2004; Gray, 1991).

In applying Gray's RST to ADHD, researchers have highlighted poor behavioral inhibition (i.e., BIS; Quay, 1988, 1997) and overactive approach behaviors (i.e., BAS; Newman & Wallace, 1993; Nigg et al., 2006; Patterson & Newman, 1993) as being core features of ADHD. Specifically, this theory suggests that an underactive BIS in children and adults with ADHD is associated with difficulty inhibiting ongoing behavior and diminished sensitivity to punishment and non-reward (Corr, 2008), whereas an overactive BAS is associated with impulsivity and self-regulation difficulties (Ávila & Parcet 2000). Within this framework, risk-taking in ADHD is explained by a diminished sense of

caution (i.e., underactive BIS), and an increase in impulsivity and novelty-seeking (i.e., overactive BAS).

Behavioral Inhibition Model

Barkley's (1997) inhibition model of ADHD postulates that behavioral inhibition is the central-core deficit in children and adults with ADHD. Within this model, behavioral inhibition is defined as an executive function involved in inhibiting prepotent responses, delaying immediate, ongoing responses, and preventing extraneous information from interfering with response processes (Barkley, 1997; Fuster, 1989; Logan, Cowan, & Davis, 1984). Difficulties in behavioral inhibition are theorized to be upstream of deficits in other executive functions, including working memory, self-regulation, internalization of speech, arousal, and reconstitution, which lead to poor motor control (Barkley, 1997). This model also builds upon previous BAS/BIS theories (Gray, 1982, 1991; Quay, 1988) and suggests behavioral disinhibition results from an underactive BIS and an overactive BAS that essentially "overrides" the inhibition process of the BIS (MacCoon et al. 2004; Patterson & Newman, 1993). Thus, according to Barkley's (1997) behavioral inhibition model, ADHD-related deficits in behavioral inhibition may interfere with an individual's ability to perceive risk and may contribute to less rational decision-making and behavioral control in the face of risk.

Delay Aversion Models

According to Sonuga-Barke's delay aversion models, children and adults with ADHD are averse towards delay and typically favor smaller immediate rewards over larger delayed rewards (Kuntsi et al., 2001; Sonuga-Barke, 2002; Sonuga-Barke 2003; Sonuga-Barke, Bitsakou, & Thompson, 2010; Sonuga-Barke et al., 1992). Sonuga-

Barke's (2010) triple pathway model of ADHD describes three distinct pathways involved in the disorder – delay aversion, inhibitory control, and temporal processing. Whereas motivational deficits associated with ADHD correspond with atypical responses to reward and delay aversion, ADHD-related executive deficits are involved in impaired regulation of thought and action, and account for poor executive functioning and disinhibition in ADHD (Sonuga-Barke, 2002; 2003). Additional research has indicated further impairment in temporal processing, suggesting that children and adolescents with ADHD have difficulty estimating the passage of time (Solanto et al., 2001; Sonuga-Barke et al., 1994; Sonuga-Barke et al., 2010). The triple pathway model posits that sensitivity to delay and impairments in temporal processing lead to impulsiveness and excessive motor activity as a means of distraction from delay (Sonuga-Barke, 2010). Although different psychological processes modulate each pathway within this model, they are not conceptualized as competing theories. Sonuga-Barke (2010) proposes that each pathway shares a common neurobiological framework and the manifestation of ADHD involves deficits in one, two, or all three areas.

Collectively, the dual and triple pathway models suggest delay aversion is context-dependent and motivational attitudes are contingent on whether a delay can be avoided or not (Sonuga-Barke, 2010). When delay is unavoidable and an alternative option is not available, strategic attentional processes necessary for interpreting experiences of delay account for ADHD-related inattention and hyperactivity (Sonuga-Barke, 1994; Sonuga-Barke, De Houwer, De Ruiter, Ajzenstzen, & Holland, 2004). Within this framework, risk-taking in ADHD may be explained by delay aversion and the avoidance of choice alternatives that are only beneficial in the long term.

Table 1. Effect Sizes Across Behavioral Tasks

Study	ADHD Grouping	Control Grouping	ADHD Subtype	Medication Use	DBD Exclusion	Prob. Description	Choice Set Size	Tangible Reward	ADHD *n*	Control *n*	Age *M*	% Female	Effect Size (*g*)
Agay et al. (2010)	Comp	Comp	All	No	No	Implicit	2	Yes	13	16	32.8	45.5	-.65
Antonini et al. (2015)	Narrow	Comp	ADHD-I/C	No	NR	Implicit	4	No	67	30	9.0	28.5	-.43
Coghill et al. (2014)	Comp	Comp	All	No	No	Explicit	10	No	83	66	9.0	0.0	.36*
Dai et al. (2016)	Comp	Comp	All	No	Yes	Explicit	2	No	31	29	33.1	51.5	.25
DeVito et al. (2008)	Comp	Narrow	NR	No	No	Explicit	10	No	21	22	10.2	0.0	.25
Drechsler et al. (2008)	Comp	Comp	All	No	No	Explicit	14	No	23	24	12.1	6.5	.73*
Ernst et al. (2003)	Comp	Comp	ADHD-I/C	No	No	Implicit	4	Yes	10	12	29.4	50.0	.07
Garon et al. (2006)	Comp	Comp	ADHD-C	No	No	Implicit	4	Yes	21	21	9.8	19.0	.88**
Geurts et al. (2006)	Comp	Narrow	All	No	No	Implicit	4	No	20	22	10.0	83.5	-.04
Gonzalez-Gadea et al. (2013)	Comp	Narrow	NR	Yes	Yes	Implicit	4	No	22	21	36.8	58.0	.36
Hobson (2011)	Comp	Comp	All	No	No	Implicit	4	Yes	31	34	13.2	21.0	.68**
Hovik et al. (2015)	Comp	Comp	ADHD-C	No	No	Implicit	4	No	33	50	12.0	37.5	.21
Humphreys & Lee (2011)	Narrow	Narrow	NR	Yes	NR	Implicit	2	Yes	55	87	7.4	30.0	-.23
Ibanez et al. (2012)	Comp	Narrow	NR	No	Yes	Implicit	4	No	12	25	33.3	22.0	.46
Kroyzer et al. (2014)	Comp	Narrow	ADHD-I/C	No	No	Explicit	10	No	32	32	15.7	11.5	-.55*
Luman et al. (2008)[a]	Comp	Comp	All	No	No	Explicit	4	No	23	20	9.6	23.5	1.38***
Malloy-Diniz et al. (2007)	Narrow	Narrow	ADHD-I/C	No	No	Implicit	4	No	50	51	33.0	52.5	.78***
Malloy-Diniz et al. (2008)	Narrow	Narrow	ADHD-C	No	No	Implicit	4	No	25	25	32.0	50.0	.69*
Mantyla et al. (2012)	Narrow	Narrow	NR	Yes	No	Implicit	2	No	31	32	30.3	46.0	.10
Masunami et al. (2009)	Narrow	Narrow	ADHD-I/C	No	No	Implicit	4	No	14	11	11.6	26.0	.49
Matthies et al. (2012a)	Narrow	Narrow	NR	No	No	Explicit	3	No	15	16	35.3	48.5	.84*
Matthies et al. (2012b)	Narrow	Narrow	NR	No	No	Explicit	14	No	14	13	35.3	48.5	.30
Matthys et al. (1998)	Comp	Narrow	NR	No	No	Implicit	2	Yes	10	31	9.8	0.0	1.30***
McLean et al. (2004)	Comp	Narrow	All	No	No	Explicit	10	No	19	19	28.6	21.0	-.38
Mesrobian et al. (2018)	Narrow	Comp	All	No	Yes	Implicit	6	No	18	18	22.2	58.0	1.05**
Miller et al. (2013)	Comp	Comp	ADHD-I/C	No	No	Implicit	4	No	114	77	19.6	100.0	.28

Table 1. (continued)

Study	ADHD Grouping	Control Grouping	ADHD Subtype	Medication Use	DBD Exclusion	Prob. Description	Choice Set Size	Tangible Reward	ADHD *n*	Control *n*	Age *M*	% Female	Effect Size (*g*)
Morell & Exposito (2019)	Comp	Narrow	NR	No	Yes	Explicit	10	No	26	19	10.4	37.0	1.06***
O'Brien & Frick (1996)	Comp	Comp	NR	NR	Yes	Implicit	2	Yes	18	40	8.9	10.0	.06
Pollak et al. (2016)	Narrow	Narrow	All	No	No	Explicit	2	No	37	35	15.6	36.0	.43
Pollak et al. (2018)	Narrow	Narrow	ADHD-I/C	No	No	Explicit	10	No	31	31	15.0	56.5	.17
Ryan et al. (2013)	Narrow	Narrow	ADHD-C	Yes	No	Implicit	2	No	11	15	19.9	60.0	.46
Skogli et al. (2017)	Comp	Narrow	ADHD-I/C	No	No	Implicit	2	No	75	47	13.7	43.0	-.08
Sørensen et al. (2017)	Narrow	Narrow	All	No	No	Explicit	4	No	36	34	10.1	37.5	.00
Toplak et al. (2005)	Comp	Comp	All	No	No	Implicit	10	Yes	44	34	9.2	36.5	.41
van Goozen et al. (2004)	Narrow	Narrow	NR	NR	No	Implicit	4	Yes	26	36	15.5	36.5	1.25***
Weafer et al. (2011)	Comp	Narrow	All	No	No	Implicit	2	Yes	30	21	9.4	47.5	.14
Wiers et al. (1998)	Comp	Narrow	ADHD-H/C	No	Yes	Implicit	2	Yes	28	34	9.1	0.0	.18
Wilbertz et al. (2012)	Comp	Narrow	ADHD-I/C	No	Yes	Explicit	2	Yes	28	28	36.9	0.0	-.17
											Overall Effect Size		.32***

Note. Comp = Comprehensive; NR = not reported; ADHD-C = ADHD Combined Presentation; ADHD-I = ADHD Predominantly Inattentive Presentation; ADHD-H = Predominantly Hyperactive-Impulsive Presentation

[a] effect size calculated using aggregated scores

* *p* < .05; ** *p* < .01; ** *p* ≤ .001

Table 2. Effect Sizes Across Self-Report Measures

Study	ADHD Grouping	Control Grouping	ADHD Subtype	Medication Use	DBD Exclusion	Response Format	Assessment Type	ADHD *n*	Control *n*	Age *M*	% Female	Effect Size (*g*)
Abouzari et al. (2015)	Comp	Comp	NR	Yes	No	Dichotomous	Questionnaire	23	16	22.49	49	-.28
August et al. (2006)	Comp	Comp	NR	NR	Yes	Non-Dich	Questionnaire	30	98	18.00	27	-.05
Barkley et al. (1996)	Comp	Narrow	NR	Yes	No	Non-Dich	Interview	25	23	22.50	38	.75*
Barkley et al. (2002)	Comp	Comp	All	Yes	No	Non-Dich	Interview	105	64	21.20	28	.49**
Barkley et al. (2004)	Comp	Comp	ADHD-H/C	Yes	No	Dichotomous	Interview	147	73	20.80	90	.38*
Biederman & Faraone (2006)[a]	Narrow	Narrow	NR	NR	No	Dichotomous	Interview	500	501	32.65	51	.41***
Breyer et al. (2009)	Comp	Comp	NR	NR	No	Dichotomous	Questionnaire	47	93	19.95	23	.42*
Dai et al. (2016)	Comp	Comp	All	Yes	Yes	Dichotomous	Questionnaire	31	29	33.13	52	.75**
Dunne et al. (2014)[a]	Narrow	Narrow	NR	NR	No	Dichotomous	Interview	817	124	34.15	50	.25***
Egan et al. (2017)[a]	Narrow	Narrow	NR	Yes	No	Dichotomous	Questionnaire	24	173	18.91	58	.63***
Flory et al. (2006)	Comp	Comp	NR	NR	Yes	Dichotomous	Questionnaire	364	240	17.46	11	.86***
Groom et al. (2015)	Comp	Comp	NR	Yes	No	Non-Dich	Questionnaire	22	21	32.70	21	1.22***
Hechtman et al. (2016)[a]	Comp	Narrow	ADHD-C	Yes	No	Non-Dich	Questionnaire	476	241	24.70	10	-.22***
Huggins et al. (2015)[a]	Comp	Comp	All	NR	No	Non-Dich	Questionnaire	44	48	19.64	57	.34
Knouse et al. (2005)	Comp	Narrow	ADHD-C	Yes	No	Non-Dich	Questionnaire	44	44	31.93	29	.58**
Lambert & Hartsough (1998)	Comp	Narrow	NR	Yes	No	Non-Dich	Interview	169	142	21.95	24	.57***
Lambert (2005)[a]	Comp	Narrow	NR	Yes	No	Non-Dich	Interview	176	223	26.00	22	.24***
Molina et al. (2003)[a]	Comp	Narrow	NR	NR	No	Non-Dich	Questionnaire	142	100	15.18	6	.24**
Odell et al. (2017)[a]	Narrow	Narrow	NR	NR	No	Dichotomous	Interview	131	265	40.96	25	.42***
Olazagasti et al. (2013)[a]	Comp	Comp	ADHD-C	Yes	Yes	Non-Dich	Interview	135	136	41.45	0	.45***
Pollak et al. (2016)	Narrow	Narrow	ADHD-I/C	Yes	No	Non-Dich	Questionnaire	40	40	15.03	35	.60**
Pollak et al. (2018)[a]	Narrow	Narrow	ADHD-I/C	Yes	No	Non-Dich	Interview	31	31	24.83	57	.54***
Reimer et al. (2010)	Narrow	Narrow	NR	Yes	No	Dichotomous	Questionnaire	25	35	20.56	40	.05
Rooney et al. (2012)[a]	Comp	Comp	All	Yes	Yes	Non-Dich	Questionnaire	53	83	19.87	50	.72***
Rosenbloom & Wultz (2011)	Narrow	Narrow	NR	NR	No	Non-Dich	Questionnaire	19	19	25.50	47	.48

Table 2. (continued)

Study	ADHD Grouping	Control Grouping	ADHD Subtype	Medication Use	DBD Exclusion	Response Format	Assessment Type	ADHD n	Control n	Age M	% Female	Effect Size (g)
Valero et al. (2017)[a]	Narrow	Narrow	NR	NR	No	Non-Dich	Interview	55	207	36.00	13	.57***
Weafer et al. (2011)	Comp	Narrow	NR	Yes	No	Non-Dich	Questionnaire	33	21	21.70	48	-.28
Wilens et al. (2007)	Comp	Comp	NR	NR	No	Non-Dich	Questionnaire	62	63	19.45	45	-.09
Wymbs et al. (2013)	Comp	Comp	NR	Yes	No	Non-Dich	Questionnaire	221	139	19.01	0	.31**
											Overall Effect Size	.39***

Note. Comp = Comprehensive; NR = not reported; ADHD-C = ADHD Combined Presentation; ADHD-I = ADHD Predominantly Inattentive Presentation; ADHD-H = Predominantly Hyperactive-Impulsive Presentation; Non-Dich = Non-Dichotomous

[a] effect size calculated using aggregated scores

* $p < .05$; ** $p \leq .01$; ** $p \leq .001$

Table 3. Effect Sizes Across Virtual Reality Simulators

Study	ADHD *n*	Control *n*	Age *M*	% Female	Effect Size (*g)*
Barkley et al. (1996)	25	23	22.5	37.5	.46**
Clancy et al. (2006)	24	24	14.96	50	.12
Classen et al. (2013)	9	22	14.66	37.1	1.23*
Groom et al. (2015)[a]	22	21	32.7	20.5	2.69**
Knouse et al. (2005)	44	4	31.93	28.5	.20
Nikolas et al. (2016)[a]	26	37	12	16.35	.44
Reimer et al. (2010)	25	35	20.56	39.5	.52**
Stavrinos et al. (2011)	39	39	9.16	29	-.40
				Overall Effect Size	.60*

* p ≤ .01; ** *p* ≤ .001

[a] effect size calculated using aggregated scores

Table 4. Regression model and moderating variable for behavioral measures and self-report measures

	Behavioral Measures				Self-Report Measures			
	Q	*df*	*p*		*Q*	*df*	*p*	
Regression	.88	7	1.00		3.00	6	.81	
Residual	110.09	30	< .001		89.73	22	<.001	
R^2	<.001				.15			

Moderator variables	*B*	*SEB*	*z*	*p*	*B*	*SEB*	*z*	*p*
Age	-.002	.009	-.24	.81	<.001	.01	.03	.98
% Female	-.001	.004	-.18	.86	-.001	.003	-.38	.70
ADHD grouping	-.15	.20	-.78	.44	-.211	.18	-1.14	.25
Control grouping	.12	.19	.60	.55	-.005	.15	1.39	.16
Probabilistic description[a]	-.02	.48	-.09	.93				
Choice set size[a]	<.001	.03	.00	1.00				
Reward[a]	-.02	.24	-.09	.93				
Response format[b]					-.005	.14	-.03	.97
Assessment type[b]					.08	.15	.57	.57

Note. B = Regression coefficients; *df* = degrees of freedom; *SEB* = standard error of the regression coefficients; *Q* = chi-square value; R^2 = variance accounted for by the model

[a] not included as moderator in self-report measures meta-regression

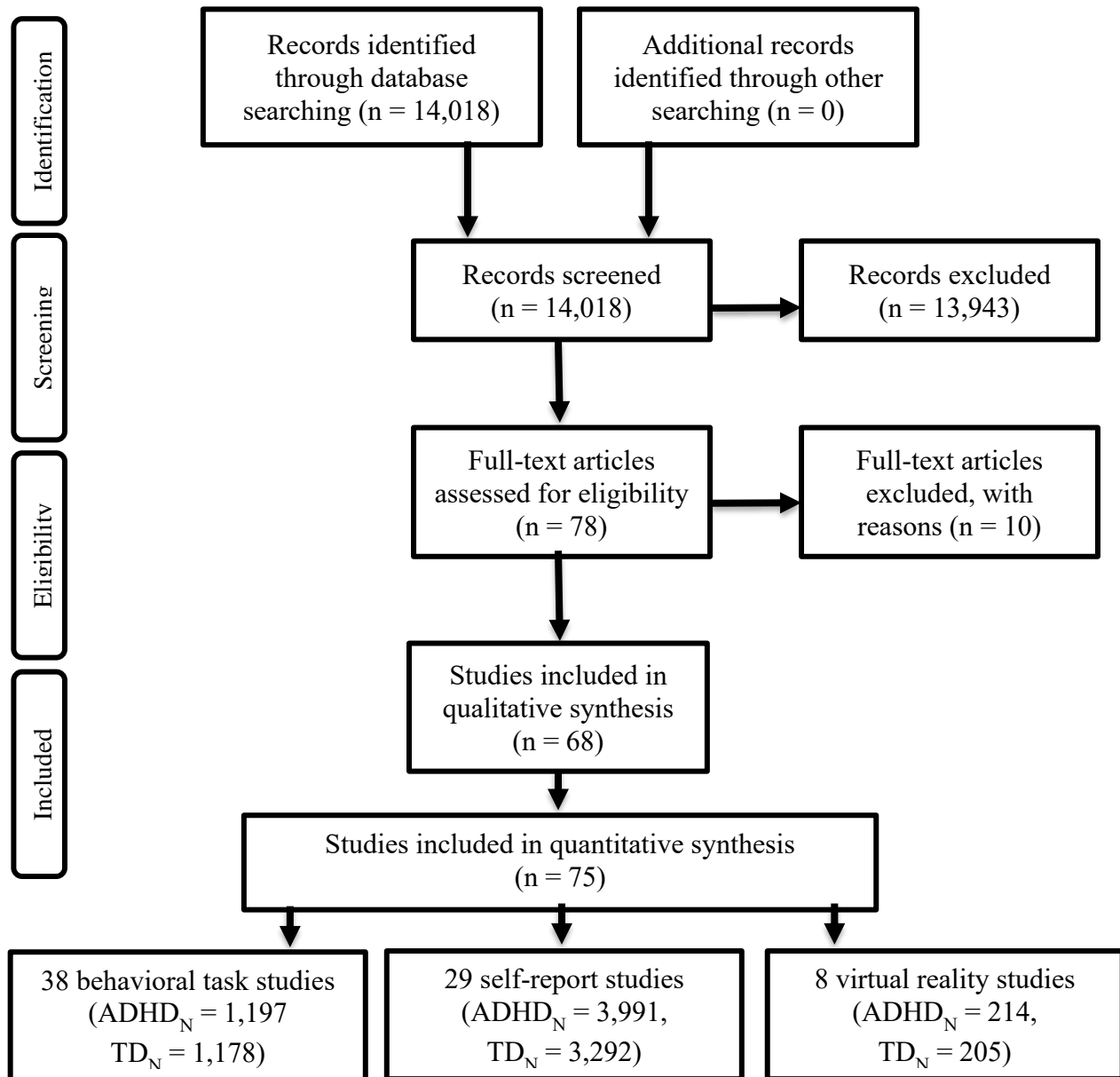[b] not included as a moderator behavioral tasks meta-regression

Figure 1. PRISMA Flow Diagram of Included Studies

Study	Effect Sizes

Agay et al. (2010)
Antonini et al. (2015)
Coghill et al. (2014)
Dai et al. (2016)
DeVito et al. (2008)
Drechsler et al. (2008)
Ernst et al. (2003)
Garon et al. (2006)
Geurts et al. (2006)
Gonzalez-Gadea et al. (2013)
Hobson (2011)
Hovik et al. (2015)
Humphreys & Lee (2011)
Ibanez et al. (2012)
Kroyzer et al. (2014)
Luman et al. (2008)
Malloy-Diniz et al. (2007)
Malloy-Diniz et al. (2008)
Mantyla et al. (2012)
Masunami et al. (2009)
Matthies et al. (2012): Study 1
Matthies et al. (2012): Study 2
Matthys et al. (1998)
McLean et al. (2004)
Mesrobian et al. (2018)
Miller et al. (2013)
Morell & Exposito (2019)
O'Brien & Frick (1996)
Pollak et al. (2016)
Pollak et al. (2018)
Ryan et al. (2013)
Skogli et al. (2017)
Sørensen et al. (2017)
Toplak et al. (2005)
van Goozen et al. (2004)
Weafer et al. (2011)
Wiers et al. (1998)
Wilbertz et al. (2012)

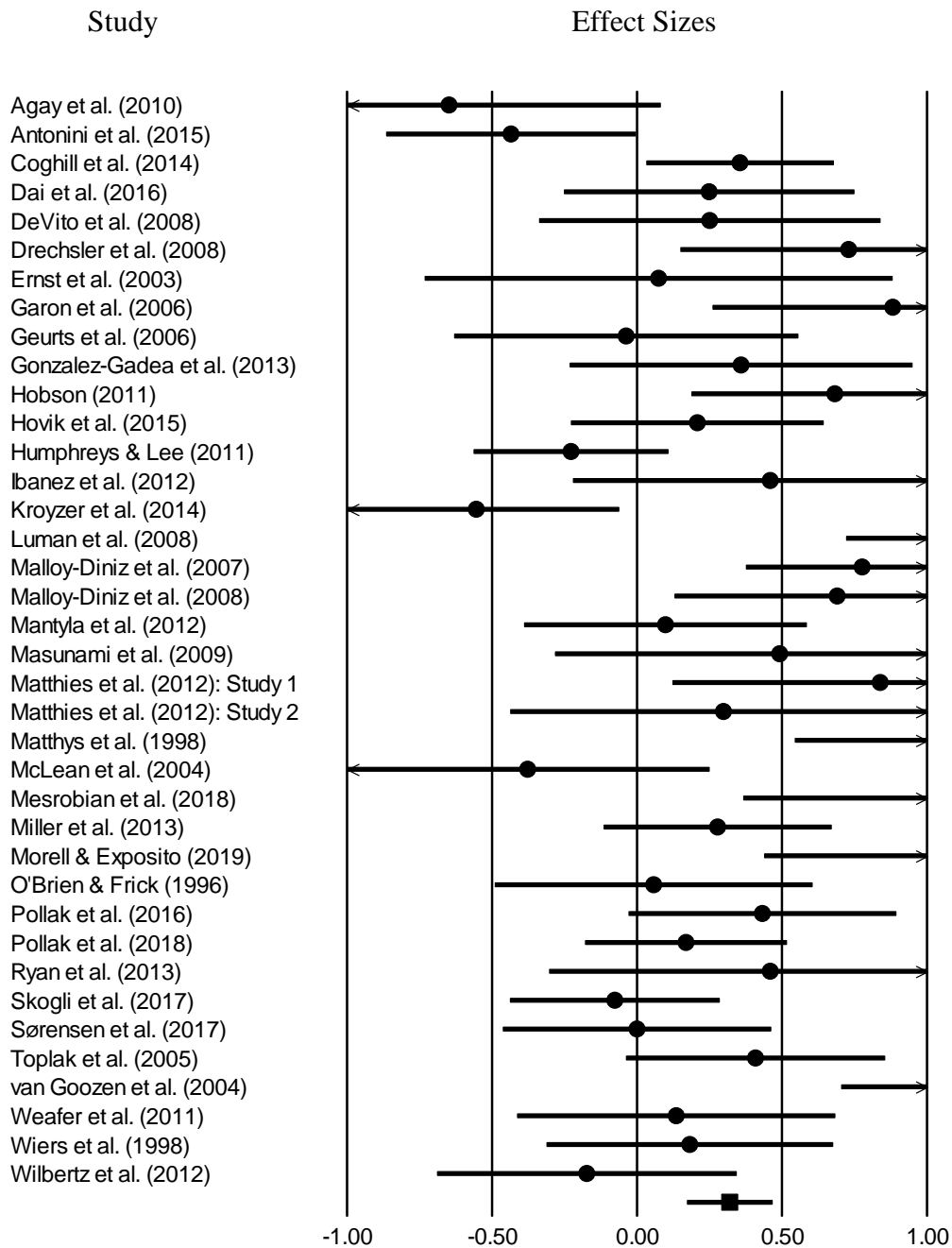-1.00   -0.50   0.00   0.50   1.00

Figure 2. Forest plot of behavioral task effect sizes. Circles indicate Hedge's g effect sizes for individual studies, whereas the square represents the overall Hedge's g effect size across studies. Horizontal lines represent lower and upper bounds for the effect sizes.
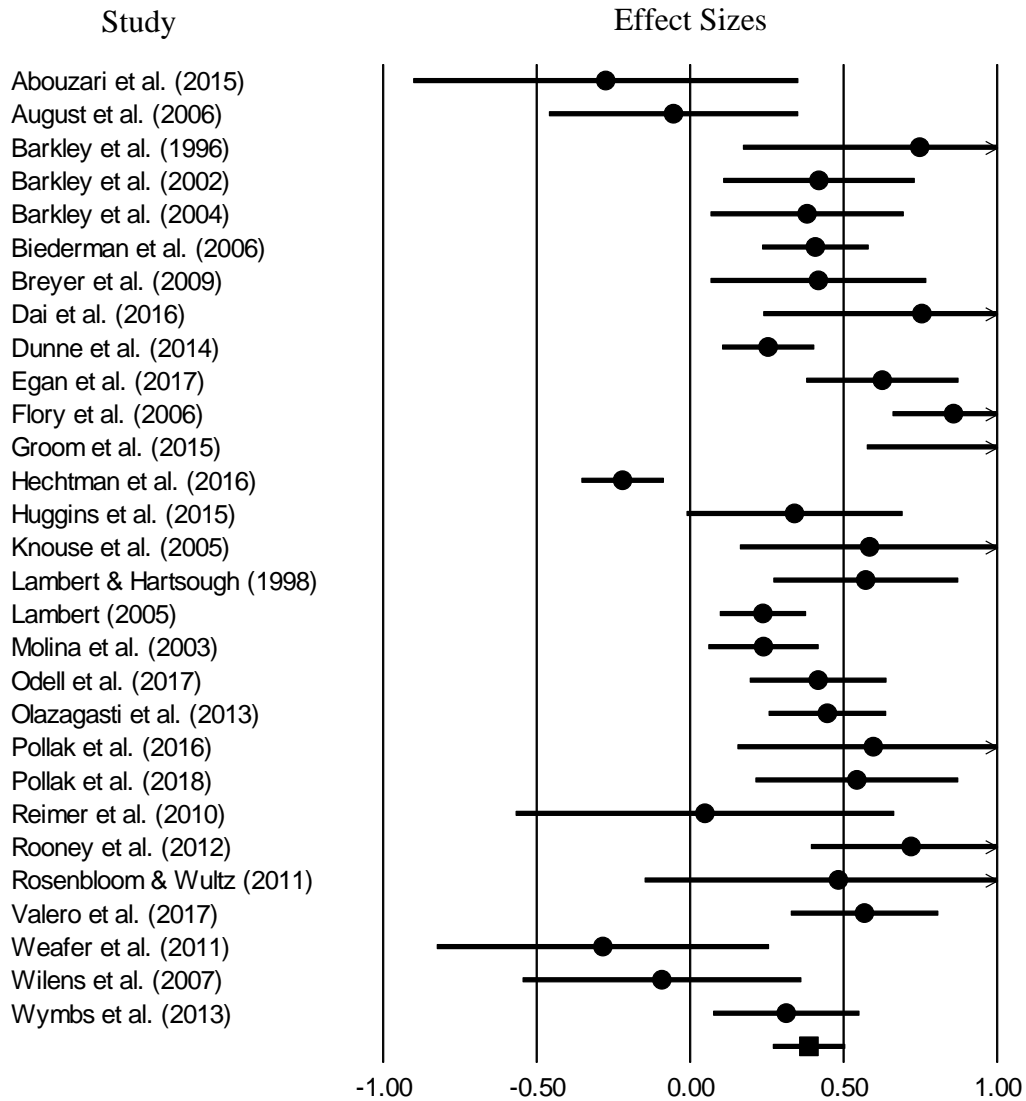
Figure 3. Forest plot of self-report effect sizes. Circles indicate Hedge's g effect sizes for individual studies, whereas the square represents the overall Hedge's g effect size across studies. Horizontal lines represent lower and upper bounds for the effect sizes.
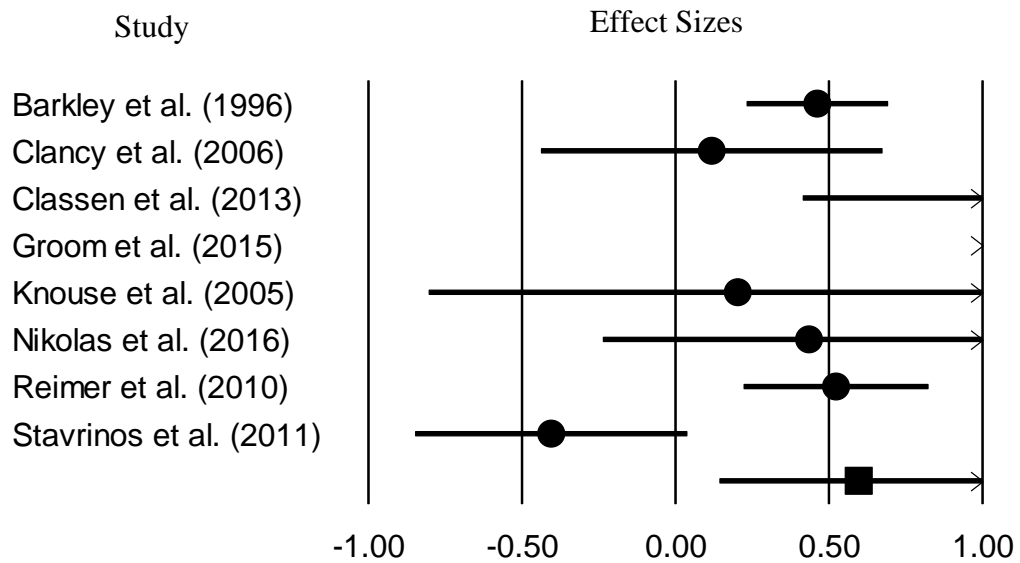
Figure 4. Forest plot of virtual reality effect sizes. Circles indicate Hedge's g effect sizes for individual studies, whereas the square represents the overall Hedge's g effect size across studies. Horizontal lines represent lower and upper bounds for the effect sizes.

VITA

Delanie K. Roberts

Candidate for the Degree of

Master of Science

Thesis: RISK-TAKING IN ATTENTION-DEFICIT/HYPERACTIVITY DISORDER: A META-ANALYTIC REVIEW OF BEHAVIORAL TASKS AND SELF-REPORT MEASURES

Major Field: Clinical Psychology

Biographical:

    Education:
        Completed the requirements for the Master of Science in Clinical Psychology at Oklahoma State University, Stillwater, Oklahoma in May, 2021.
        Completed the requirements for the Bachelor of Arts in Psychology at University of California, Irvine, Irvine, California in May 2015.

    Experience:
        Center for Research of Attention and Behavior – Graduate Student Research Assistant

    Professional Memberships:
        American Psychological Association (APA)
        Association for Behavioral and Cognitive Therapies (ABCT)

    Publications:
        Roberts, D. K., Betancourt J. L., & Alderson R. M. (2020). Inhibition. In *Encyclopedia of Evolutionary Psychological Science*. Springer, Cham
        Tarle, S. J., Alderson, R. M., Arrington, E. F., & **Roberts, D. K.** (2019). Emotion regulation and children with Attention-Deficit/Hyperactivity Disorder (ADHD): The effect of varying phonological working memory demands. *Journal of Attention Disorders.*
        Tarle, S. J., Alderson, R. M., Patros, C. H., Arrington, E. F., & **Roberts, D. K.** (2018). Working memory and behavioral inhibition in children with attention-deficit/hyperactivity disorder (ADHD): an examination of varied central executive demands, construct overlap, and task impurity. *Child Neuropsychology*, 1-24.
        Li, J. J., & **Roberts, D. K.** (2017). Genetic influences on executive functions across the lifespan. In M. A. Bell & D. Kirby (Eds.), *Executive functions: development across the life span*. New York: Taylor & Francis.