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Validity of ADHD Symptoms in Toddlers

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by

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ABSTRACT

VALIDITY OF ADHD SYMPTOMS IN TODDLERS

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Attention deficit/hyperactivity disorder (ADHD) is one of the most common child neurodevelopmental disorders. The disorder is typically diagnosed in elementary school, but there is growing evidence for the validity of ADHD in preschoolers, and symptoms likely emerge even earlier than preschool years. Research suggests that ADHD symptoms can be evident in toddlers beyond developmentally appropriate behavior, and symptoms in toddlers are predictive of later impairment. However, few studies have examined the validity of Diagnostic and Statistical Manual of Mental Disorders (DSM) ADHD symptoms in this younger population. The present study examined the 18 DSM ADHD symptoms in a community sample of 2-year-old children by recruiting parents ($N = 321$) online through Amazon's Mechanical Turk. Results showed that ADHD symptoms were fairly common in 2-year-old children; a substantial minority (22%) of children met symptom criteria for ADHD. ADHD showed similar construct validity and symptom utility to older children, with the exception of verbal hyperactive-impulsive symptoms. Similar to school-age children, a two-factor model of ADHD, was the best fit. ADHD symptoms showed convergent and divergent validity with a temperament questionnaire; symptoms were related to similar traits such as motor activation and inhibitory control, and not related to traits

such as cuddliness or fear. Finally, item response theory analyses showed that items besides verbal symptoms discriminated well between toddlers high and low on ADHD. Results suggest that ADHD symptoms, with the exception of verbal symptoms, demonstrate good validity in 2-year-old children, and provide support for conducting prospective studies to determine whether 2-year-old children showing high levels of ADHD symptoms are at high risk for the development of ADHD.

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CHAPTER 1

INTRODUCTION

ADHD is characterized by impairing symptoms of inattention and/or hyperactivity/impulsivity and includes three distinct presentations: predominantly hyperactive/impulsive presentation, predominantly inattentive presentation, or combined presentation (American Psychiatric Association; APA, 2013). As one of the most common child neurodevelopmental disorders, ADHD affects 7-10% of children and adolescents in the United States (Thomas, Sanders, Doust, Beller & Glasziou, 2015; Vande Voort, He, Jameson & Merikangas, 2014). ADHD is typically diagnosed in middle childhood, but there is growing evidence for the validity of ADHD in preschoolers (e.g., Berger & Nevo, 2011) and, accordingly, the American Academy of Pediatrics recently extended guidelines for diagnosis down to age 4 (Wolraich et al., 2011). Past research has demonstrated an onset of ADHD symptoms in children even as young as toddlers (e.g., Galéra et al., 2011; Leblanc et al., 2008). However, little research has examined the DSM symptoms in children under 3 years of age. The present study aims to fill this research gap by examining the validity of DSM ADHD symptoms at age 2, as well as the utility of individual ADHD symptoms in discriminating 2-year-old children who show high and low levels of ADHD symptoms. A better understanding of how the DSM symptoms of ADHD function in toddlers will contribute to our understanding of the early emergence of the disorder, and can potentially facilitate earlier identification and intervention of at-risk children.

1.1 Early Development of ADHD

Until recently, ADHD was primarily diagnosed in school-aged children and most ADHD research has focused on middle childhood. There is now growing recognition that ADHD begins in early development and continues across the lifespan. Symptoms of ADHD have been identified in young children (e.g., Keenan & Wakschlag, 2000; Lavigne et al., 1996) and these symptoms often continue across childhood and adolescence (e.g., Lahey et al., 2004; Pierce, Ewing, & Campbell, 1999). In turn, some children with ADHD in childhood and adolescence continue to show clinical or subclinical ADHD symptoms in adulthood (e.g., Biederman, Petty, Evans, Small, & Faraone, 2010; Faraone, Biederman, & Mick, 2006). Thus, symptoms are no longer only considered in the context of middle childhood, and research is growing in the areas of adult and early childhood ADHD. This view of ADHD as a lifelong disorder is consistent with evidence that ADHD is a highly heritable, genetic disorder (e.g., Faraone et al., 2005; Faraone & Khan, 2006) that involves neurological delays and abnormalities (e.g., Castellanos et al., 2002; Shaw et al., 2006, 2007). ADHD can thus be conceptualized as a chronic neurodevelopmental disorder, the symptoms of which may appear early and continue throughout the life span. Consistent with this conceptualization, there has been a burgeoning body of research on adult ADHD (e.g., Davidson, 2008; Faraone et al., 2000; Kessler et al., 2006), and changes in ADHD criteria from DSM-IV to DSM-5 focused largely on making the criteria more relevant for adult ADHD.

Although considerably smaller than the adult ADHD literature, the body of research on preschool ADHD has also grown. ADHD has been increasingly

diagnosed and treated in preschoolers (Healey, Miller, Castelli, Marks, & Halperin, 2008; Zito et al., 2000) and a growing body of research supports the validity of ADHD in this population. Preschoolers with ADHD are similar to school-age children with ADHD. The disorder in preschoolers reportedly exists in rates similar to those in older children (Gimpel & Kuhn, 2000; Keenan, Shaw, Walsh, Delliquadri, & Giovanelli, 1997; Lavigne et al., 1996), though rates range across studies from approximately 2 to 13% (Egger, Kondo, & Angold, 2006; Lavigne, LeBailly, Hopkins, Gouze, & Binns, 2009). Preschoolers with ADHD show rates of psychiatric comorbidity similar to those in school-age children (e.g., Posner et al., 2007; Wilens et al., 2002) and are socially, academically, and behaviorally impaired relative to controls (Byrne, DeWolfe, & Bawden, 1998; DuPaul, McGoey, Eckert, & Van Brakle 2001; Lahey et al., 1998, 2004). Further, for most children, ADHD symptoms in preschool years are not simply a developmental phase. ADHD in preschoolers is predictive of later impairment and diagnosis, particularly in older preschoolers (Tandon, Si, & Luby, 2011); rates of preschoolers identified with ADHD who continue to meet criteria over several years range from approximately 75 to 89% (Harvey, Youngwirth, Thakar, & Errazuriz, 2009; Lahey et al., 2004; Riddle et al., 2013). Similarly, trajectory-based studies have found that some children may show increases or remittance of symptoms across the preschool years, but there are stable, high symptom trajectories (e.g., Harvey, Lugo-Candelas, & Breaux, 2015; Willoughby, Pek, Greenberg, & Family Life Project Investigators, 2012). In sum, these studies suggest that some children remain chronically impaired across the

preschool and early school-age years and that we can fairly reliably identify impaired preschoolers at risk for continuing to meet criteria for ADHD.

1.2 ADHD Symptoms in Toddlers

In contrast to the growing literature on preschoolers, less research has focused on ADHD symptoms under age 3. This may be due in part to the fact that symptoms commonly associated with externalizing disorders (e.g., overactivity, defiance, tantrums) are thought to be developmentally normative for toddlers (Campbell, 1990) and often naturally abate as children age (e.g, Owens & Shaw, 2003). Research and health professionals are understandably leery of overpathologizing normative behavior (McClellan & Speltz, 2003), as distinguishing between the 'terrible twos' and clinical impairment is not completely clear. However, there is evidence that a portion of children as young as 2 years of age may show clinically significant levels of ADHD symptoms (e.g., Keenan & Wakschlag, 2000; Lavigne et al., 1996; Rappley et al., 1999), suggesting that there are some toddlers who display ADHD symptoms beyond what might be developmentally appropriate.

1.2.1 Developmental course of symptoms.

A handful of longitudinal studies of community samples have examined ADHD symptoms starting in toddlerhood and have identified distinct developmental trajectories of hyperactivity and inattention (Galéra et al., 2011; Huijbregts, Séguin, Zoccolillo, Boivin, & Tremblay, 2007; Leblanc et al., 2008; Palfrey, Lavigne, Walker, & Sullivan, 1985; Romano, Tremblay, Farhat, & Côté, 2006; Salla et al., 2016; Shaw, Lacourse, & Nagin, 2005). These studies suggest that some children's symptoms remit, but that there are children who show stable high or moderate levels

of symptoms across early childhood, similar to findings in preschoolers. Retrospective research lends further support to these prospective studies. Although the average reported age of onset of impairing ADHD symptoms in the DSM-IV field trials was 4.2 years for the hyperactive/impulsive type and 6.1 years for the inattentive type, a substantial minority of parents reported that impairing symptoms first appeared before age 3 (Applegate et al., 1997). This small body of research suggests that for a portion of children, impairing ADHD symptoms emerge as early as toddlerhood and continue over time.

Although research on the course of ADHD symptoms in toddlers is sparse, the developmental continuity of externalizing symptoms in general is well established. Seminal work by Campbell and colleagues in the 1980s found that about half of parent-referred 2- to 3-year-olds identified as having more externalizing symptoms relative to controls (Campbell, Szumowski, Ewing, Gluck, & Breaux, 1982) continued to display significant problems with attention, impulsivity, and oppositionality across early childhood (Campbell, Breaux, Ewing, & Szumowski, 1986) and even into middle childhood (Campbell & Ewing, 1990) and adolescence (Pierce et al., 1999). Later research has similarly found that toddlers with severe or pervasive externalizing difficulties (e.g, Shaw, Owens, Giovanelli, & Winslow, 2001) or diagnoses (e.g, Lavigne et al., 1998) are at risk for later meeting criteria for externalizing disorders. Further, a large number of trajectory-based studies have determined that a portion of children as young as age 1 or 2 display stable, high levels of externalizing symptoms, including aggression and conduct problems, across early childhood (e.g., Côté, Vaillancourt, Leblanc, Nagin, & Tremblay, 2006; Huijbregtset

al., 2007; Petitclerc, Boivin, Dionne, Zoccolillo, & Tremblay, 2009; Shaw, Gilliom, Ingolsby, & Nagin, 2003; Shaw, et al., 2005; Tremblay et al., 2004). These studies suggest that externalizing problems can be identified as young as toddlerhood, particularly for children with severe symptoms.

In addition, although ADHD is less commonly studied in toddlers, temperament traits that are closely linked with ADHD symptoms have been commonly studied in this age range. Some temperament traits, such as inhibition and activity level, represent constructs very similar to ADHD symptoms. Despite some age-related changes in domains of temperament, such as natural increases in effortful control, temperament is fairly stable starting from infancy and toddlerhood (Campbell, 1990; Goldsmith, 1996; Lemery, Goldsmith, Klinnert, & Mrazek, 1999; Putnam, Gartstein, & Rothbart, 2006; Vaughn, Kopp, & Krakow, 1984). In particular, by age 2, effortful control (i.e., self-regulation and attention control) is a fairly stable characteristic, both across tasks and over time (Kochanska & Knaack, 2003). Given this stability, toddlers who show ADHD-like temperament traits (i.e., high activity level, low inhibition) are likely to continue to display these traits across childhood. Indeed, temperament in early childhood, in particular high reactivity and low effortful control, is associated with risk of psychopathology generally (see Muris & Ollendick, 2005) and specifically with later ADHD symptoms (Willoughby, Gottfredson, Stifter, & Family Life Project Investigators, 2016). Early deficits of effortful control in toddlers predict externalizing symptoms and behavior problems in preschool years (Kochanska & Knaack, 2003; Murray & Kochanska, 2002). Conversely, older children with ADHD show evidence of having had difficult temperament early in life.

In retrospective studies, school-age children with ADHD are reported to have been overactive and persistent in demands in early development (Barkley, DuPaul, & McMurray, 1990) and more restless, irritable, frustrated, nervous, and unable to delay gratification at ages 9 and 18 months (Gurevitz, Geva, Varon, & Leitner, 2014) relative to controls, suggesting that impairment may have been evident from an early age. Thus, a handful of studies of ADHD, and a larger body of research on externalizing symptoms and temperament in children under age 3 suggest that symptoms are not necessarily a common phase of development in toddlerhood, but may continue over time and predict later symptomatology.

1.2.2 Existing gaps in the literature

Though there is evidence that ADHD symptoms in toddlerhood may not always be just a developmentally normative phase, there are some important limitations to these studies. First, measuring ADHD symptoms in toddlers is difficult given the limited availability of validated measures of ADHD symptoms at this age (Sciutto & Terjesen, 2000). As such, studies that have examined ADHD in children under age 3 vary widely in the measures they use, often using questionnaires that measure general externalizing behavior or a few specific ADHD symptoms from these broad measures. Second, studies of ADHD symptoms in toddlers often combine 2-year-old children with older preschoolers, limiting the conclusions we can draw about ADHD symptoms specifically in toddlers (e.g., Gimpel & Kuhn, 2000; Keenan & Wakschlag, 2000; Rappley et al., 1999). Third, studies have mainly focused on symptoms of hyperactivity/impulsivity instead of inattention, with a few exceptions (Galéra et al., 2011; Salla et al., 2016). It is difficult to consider whether toddlers at-

risk for ADHD can be identified without examining the inattentive domain further. Finally, research has been limited with regard to examination of the DSM symptoms in toddlers. Studies that have attempted to "diagnose" toddlers who would meet DSM criteria are limited by the lack of DSM-based measures for use at this age (Keenan & Wakschlag, 2000; Lavigne et al., 1996; Luby & Morgan, 1997) and have included small numbers of 2-year-old children (e.g., Gimpel & Kuhn, 2000). Further, studies that "diagnose" infants and toddlers vary widely in ADHD rates (1 to 46%; Frankel, Boyum, & Harmon, 2004). This discrepancy across studies underscores the difficulty of identifying very young children with ADHD. In sum, it is not yet clear whether the DSM symptoms utilized in older children and preschoolers apply to toddlers. This is a necessary step before attempting to identify toddlers at-risk for ADHD, and certainly crucial before considering whether diagnoses would be appropriate at this age. Further research is needed to examine how the conceptualization of ADHD in older children applies to toddlers, including examining the validity of symptoms and the factor structure of ADHD symptoms at this age. An item-level analysis of the DSM symptoms will also inform our understanding of the utility of specific symptoms for identifying toddlers with impairment.

1.3 ADHD Factor Structure

Many studies have examined the factor structure of ADHD symptoms in older children, but the structure of ADHD has not been explored in toddlers. Shifts in the DSM definition of the disorder are aligned with different factor models in older children, including a three-factor model of inattention, hyperactivity, and impulsivity in DSM-III (APA, 1980), a single factor (unidimensional model) in DSM III-R (APA,

1987), and two factors (bidimensional) of inattention and hyperactivity/impulsivity in DSM-IV and subsequent editions (APA, 1994; 2000; 2013). Factor analyses of parent and teacher ratings of ADHD in school-age children generally converge to support the two-factor model with separate inattentive and hyperactive/impulsive factors (Amador-Campos, Forns-Santacana, Martorelli-Balanzó, Guárdia-Olmos, & Peró-Cebollero, 2005; Bauermeister, Alegría, Bird, Rubio-Stipec, & Canino, 1992; DuPaul et al., 1997, 2016; Wolraich et al., 2003). In a review, Bauermeister, Canino, Polanczyk, and Rohde (2010) identified very few studies that supported other models. For example, Scholte, van Berckelaer-Omnes, and van der Ploeg (2001) found that the three-factor fit slightly better than the two-factor model. Muris and Meesters (2003) found that the one-, two-, and three-factor models all showed good fit, but a one-factor model was selected as more parsimonious. Studies have also examined models including a latent general ADHD factor. There is emerging evidence for a bifactor model in which the specific ADHD factors and the general ADHD factor each influence symptoms directly (e.g., Li, Reise, Chronis-Tuscano, Mikami, & Lee, 2015; Martel, von Eye, & Nigg, 2010; Normand, Flora, Toplak, & Tannock, 2012; Willoughby, Blanton, & Family Life Project Investigators, 2015). A second order factor model is hierarchically structured such that the general ADHD factor predicts the specific ADHD factors. Although the bifactor model has mostly been found to be a better fit than the second order factor model (e.g., Martel et al., 2010), one recent study found that a two-factor second order factor represents ADHD symptoms in adolescence (e.g., Nichols et al., 2017).

In samples of preschool children, the factor structure of ADHD is less clear. Hardy et al. (2007) found that two- and three-factor structures were marginally acceptable and McGoey et al. (2015) found support for a three-factor model. In a model of multiple disruptive behavior disorders, Burns, Boe, Walsh, Somers-Flanagan, and Teegarden (2001) found that ADHD demonstrates two distinct I and hyperactivity/impulsivity factors in children as young as age 3. In contrast, Arias, Ponce, Martínez-Molina, Arias, and Núñez (2016) found support for a bifactor model; in addition to three specific factors, there was a general ADHD factor. Finally, there is also support that ADHD is best represented by a single ADHD factor in preschoolers (Bauermeister, 1992; Willoughby et al., 2012). These studies of the factor structure of preschool ADHD all used different rating scales and varied slightly in the age of the sample, but given the small number of studies, it is difficult to determine whether these methodological differences may account for mixed findings.

Examining the structure of ADHD in toddlers will shed light on how ADHD symptoms at this age manifest. To our knowledge, no studies have examined the factor structure of DSM ADHD symptoms in toddlers. However, Deutscher and Fewel (2001) used an observational measure based on an 8-minute laboratory interaction to examine the factor structure of behaviors associated with ADHD in low-birthweight, premature 30-month-old children. They found evidence for three factors (overactivity, impulsivity, and inattention), which each explained a portion of variance in behavior. Scores on this measure were associated with parent- and teacher- reported symptoms 6 months later (Child Behavior Checklist; Achenbach, 1987), but the relation to DSM symptoms was not examined. Findings of this study

suggest that ADHD symptoms may exhibit the same structure as has been evident in at least some studies of older children, but the factor structure needs to be evaluated using DSM symptomatology in samples other than premature children.

Evaluating factors of ADHD in younger children may be challenging given the relative frequency of hyperactivity/impulsivity symptoms versus inattentive symptoms in young children. Inattentive symptoms generally emerge later than hyperactivity/impulsivity symptoms (Applegate et al., 1997; Berger & Nevo, 2011; Willoughby et al., 2012). In the DSM-IV field trials, children with the hyperactive/impulsive type of ADHD were generally younger and had an earlier age of onset of impairment than the combined type, both of whom were younger and impaired at an earlier age than children with the inattentive type (Applegate et al., 1997; Lahey et al., 1994). Similarly, Lahey et al. (1998) found that preschoolers were more likely to meet criteria for the hyperactive/impulsive or combined type and over time children initially identified as having the hyperactive/impulsive presentation often shift to the combined presentation due to increasing inattentive symptoms (Lahey, Pelham, Loney, Lee and Willcutt, 2005). Thus, the challenge of identifying a clear model for ADHD symptoms in younger children might be related to the appropriateness of symptoms at this age. While inattentive symptoms in preschoolers do distinguish children who will later meet criteria for ADHD (Harvey et al., 2015) these symptoms have poorer utility than hyperactivity/impulsivity symptoms at this age (Hardy et al., 2007; Harvey et al., 2015). Yet, we know that young children experience inattention. It is quite commonplace for young children to be distractible and have difficulty focusing and sustaining attention (e.g., Mahone & Schneider,

2012; Smidts & Oosterlan, 2007) Examining the utility of individual DSM symptoms in young children is important to identify which symptoms, particularly in the case of inattentive symptoms, may be more or less appropriate and reliably indicate impairment.

1.4 Item Response Theory

In order to examine the utility of individual DSM symptoms of ADHD for toddlers, a symptom-based analysis is necessary. Item Response Theory (IRT) can be used to examine the information that individual items or symptoms provide. IRT is a statistical method of examining how test item scores are related to underlying latent traits or abilities (see Hambleton, Swaminathan, & Rogers, 1991). In the context of ADHD, IRT can be used to examine how well particular symptoms of ADHD discriminate individuals who are high or low on ADHD, as well as how likely a particular symptom is to be endorsed based on an individual's underlying level of ADHD. IRT is particularly useful when conceptualizing the underlying trait as a continuous variable (i.e., number of inattention symptoms) instead of examining symptoms based on diagnostic status (i.e., ADHD or control). Multidimensional IRT can be used when there are multiple latent traits; this method is needed for ADHD given that hyperactivity/impulsivity and inattention are both underlying traits to examine. IRT can be applied to both dichotomous scales, where an item is endorsed or not, as well as to Likert scales with multiple options (polytomous data). Threshold parameters are generated to determine how much of a latent trait is necessary for the next highest level of an item to be endorsed. The severity of symptoms on ADHD rating scales may provide particularly useful information for differentiating which

children display more underlying ADHD, beyond the information provided by dichotomous symptom endorsement.

IRT has been used to examine polytomous ADHD symptoms in school-age children (e.g., Garcia Rosales et al., 2015; Gomez, 2008a; Gomez, 2008b; Li et al., 2015; Makransky & Bilenberg, 2014). These studies have generally found that DSM-IV and DSM-5 symptoms of ADHD all discriminate well between individuals with different levels of the latent ADHD trait. More of the latent trait is required for higher item endorsements and items provide less information at the extreme levels of the trait (Gomez, 2008a; Gomez, 2008b; Li et al., 2015). Further, Makransky and Bilenberg (2014) found some symptom discrimination differences from younger school-age children to adolescents; parents were more likely endorse certain items in older or younger children even with the same level of the latent trait. Thus, the utility of symptoms may differ depending on age.

IRT has also been used to examine ADHD symptoms in preschoolers (Purpura & Lonigan, 2009; Purpura, Wilson, & Lonigan, 2010). Using Graded Response Model IRT applied to the ADHD Rating Scale: School Checklist, Purpura et al. (2010) found that all of the ADHD items discriminated well between levels of the latent trait. Some items were identified as having particularly high discriminative ability, including: close attention to details, does not follow through, difficulty organizing tasks, loses things, leaves seat, runs about, difficulty playing quietly, and on the go. In contrast, some items were less useful for discriminating children with various levels of ADHD symptoms, including: talks excessively and blurts out answers. Interestingly, the inattentive items generally had higher discriminative

ability that the hyperactive/impulsive items. Pupura and Lonigan (2009) also evaluated an adapted Conners Teacher Rating Scale and identified the most discriminating items from each the inattentive and hyperactive/impulsive scales. Out of the 11 inattentive items, the five most discriminating items were: fails to finish things, easily distracted, forgets things, short attention span, and does not follow through. Out of the 19 hyperactive/impulsive items, the five best items were: restless in the squirmy sense, restless/always on the go, cannot remain still, runs about, and difficulty playing quietly. Across these two studies, common items with high discriminability included: runs about, difficulty playing quietly, and does not follow through. Generally, the results of these IRT studies suggest that in preschoolers and school-age children, some symptoms may be more useful for identifying children with differing levels of ADHD than others. Applying this methodology to ADHD ratings in toddlers is particularly important. Given that some symptoms of ADHD may commonly occur in toddlers, certain symptoms or severity levels of symptoms may better differentiate which children have more ADHD and are at risk to remain impaired across early childhood.

1.5 The Present Study

There is emerging evidence that ADHD symptoms are evident in toddlers and predictive of later impairment, but it is not clear whether the DSM symptoms of ADHD are valid in this younger population and could potentially be used to identify children at-risk for ADHD. To better understand the early emergence of ADHD symptoms, more research is needed to determine the validity of these symptoms. The present study will address this gap in the literature by examining parent-reported

ADHD symptoms in a community sample of 2-year-old children, and will examine the following research questions:

1) What is the construct validity of ADHD symptoms in toddlers?

a. Factor structure. The factor structure of ADHD symptoms in 2-year-old children will be examined. In school-age children, ADHD is most commonly represented with a two-factor model (see Bauermeister et al., 2010). Given mixed evidence for the structure of ADHD in preschoolers, it is possible that a two-factor model similar to school-age children will be evident in toddlers. However, it might also be the case that a single factor, three-factor, bifactor, or second order model of ADHD will be appropriate at this age. There was no specific hypothesis about which factor structure will fit best, given the mixed evidence in preschool samples, although at least some of the models were expected to show adequate fit.

b. Convergent and divergent validity. ADHD symptoms were expected to exhibit good convergent and divergent validity with subscales from the Early Childhood Behavior Questionnaire (ECBQ), a measure of temperament in toddlers. A large body of literature supports concurrent associations between temperament traits and ADHD symptoms in older children and preschoolers. In particular, lower effortful control and persistence, higher distractibility, higher surgency/extraversion (including traits related to approach and social behavior such as impulsivity, sociability, activity level, high intensity pleasure), and higher negative affect (i.e., anger, fear, sadness) have been associated with ADHD (Bell, Kellison, Garvan, & Bussing, 2010; Martel, Grimillion, & Roberts, 2012; Martel, Gremillion, Roberts, Zastrow, & Tacket, 2014; Martel & Nigg, 2006; McIntosh & Cole-Love, 1996).

Consistent with these findings, I expected that higher ADHD symptoms in toddlers would be related to higher Negative Affect and Surgency, and lower Effortful Control, which are the three domains of temperament on the ECBQ. Specific subscales of the ECBQ were expected to be more or less related to ADHD symptoms. Based on the conceptual overlap with symptoms of ADHD, ADHD symptoms were expected to be highly related to the following subscales: Activity Level, Attentional Focusing, Attentional Shifting, Impulsivity, Inhibitory Control, Motor Activation. ADHD symptoms were expected to be moderately related to the following subscales: Frustration, High Intensity Pleasure, Low Intensity Pleasure, Positive Anticipation, Shyness, Sociability, Soothability, Discomfort, Fear, & Sadness. ADHD symptoms were expected to be less related to the following subscales: Cuddliness, Perceptual Sensitivity.

2) How useful are individual symptoms for discriminating levels of ADHD among toddlers?

Item Response Theory. Using item response theory, I examined how well specific symptoms discriminate toddlers based on their underlying level of ADHD. This analysis was exploratory so there were no hypotheses about the utility of specific symptoms. However, it was expected that certain symptoms may provide less information either because they occur less often in toddlers or because they are extremely common. Some symptoms of ADHD are less contextually relevant for a 2-year-old child given that they are more cognitively complex, and may be more useful as children age (Harvey et al., 2015). For example, the symptoms "avoids tasks that require sustained mental effort," or "has difficulty organizing tasks" may become

more relevant as a child enters school and is given more responsibility. More verbally based symptoms such as “blurts out answers” or “talks excessively” may also be less relevant to toddlers who are limited in their verbal abilities. Thus, given normative toddler capabilities and behavior, nonverbal symptoms may be more useful at this age.

CHAPTER 2

METHOD

2.1 Participants

Parents (N = 321) of 2-year-old children (178 boys, M = 29.32 months, SD = 3.45) were recruited online through Amazon's Mechanical Turk (MTurk) system to complete a survey about their child. MTurk is an online recruitment tool shown to yield reliable data from large, diverse samples (Buhrmester, Kwang, & Gosling, 2011). Demographics were fairly similar to the US census, with slightly higher representation of college-educated and White individuals. Parents were 251 (78.2%) biological mothers, 63 (19.6%) biological fathers, 3 (.9%) step or adoptive mother, 1 (.3%) grandmother, and 3 (.9%) step or adoptive fathers. A majority (N = 271, 84.4%) of parents identified as White, with 31 (9.7%) identifying as Black or African American, 21 (6.5%) as Hispanic or Latino, 13 (4.0 %) as Asian, 8 (2.5%) as American Indian, and 1 (.3%) as Pacific Islander. Of these parents, 21 (6.5%) identified with multiple races/ethnicities. Most parents (N = 248, 77.3%) were married; others were cohabiting (N = 39, 12.1%), single (N = 17, 5.3%), divorced or separated (N = 14, 2.5%), engaged (N = 2, .6%), or in a committed relationship (N = 1, .3%). Just under half (N = 140, 43.6%) of the sample was not employed, 137 (N = 42.7%) were employed full-time, and 44 (13.7%) were employed part-time. Eighty percent of the sample reported household incomes of less than $80,000 (39.6% reported $0 to $39,999 and 40.1% fell between $40,000 and $79,999), 21.2% fell between $80,000 and $119,999, and 9% reported incomes of at least $120,000. A

majority of parents (99.4%) had at least a high school degree, with 51.1% having achieved at least a Bachelor's degree.

The majority of parents (N = 281, 87.5%) identified their 2-year-old child as White, with 38 (11.8%) identified as Black or African American, 38 (11.8%) as Hispanic or Latino, 15 (4.7%) as Asian, 2 (.6%) as Pacific Islander, 14 (4.4%) as American Indian, and 1 (.3%) as Middle Eastern. Of these children, 63 (19.6%) were reported as belonging to multiple races/ethnicities. A small portion of parents (N = 19, 5.9%) reported that their child had been evaluated for learning, emotional, or behavioral issues. Three children (.9%) were diagnosed and 7 children (2.1%) had suspected developmental or verbal delays. Only 14 (4.4%) parents reported that they suspected that their child may have ADHD. However, a substantial portion of parents (N = 122, 38%) reported concern or possible concern about their child's behavior in one or more domains; 19.9% of parents reported concerns about hyperactivity, 17.5% reported concerns about attention problems, 21.5% about defiance, and 15.6% about aggression.

2.2 Procedure

Data were collected from two cohorts; data from cohort 1 were collected from October 2015 to February 2016 and data from cohort 2 were collected from June 2016 to December 2016. For both cohorts, a link to a survey for parents of young children was posted on MTurk. Interested MTurk workers were directed to a Qualtrics survey where they confirmed their parental status and US residency and indicated the ages of all of their children in the age range. This brief screening procedure was set to minimize the number of MTurk workers who might falsely

claim that they had a 2-year-old child. To reach the final sample, 4835 MTurk workers were screened and received 2 cents for completing this screen. Of those screened, 805 (16.6%) were parents of 2-year-old children who were invited to complete the full survey; 727 of those completed the survey.

The full survey consisted of several questionnaires, including the ADHD Rating Scale – IV Preschool Version, Early Childhood Behavior Questionnaire, and a Demographics/Family History Questionnaire. Several test questions scattered throughout the survey asked participants to select a certain response to ensure participants were reading the questions and not selecting responses randomly. Participants were also asked to indicate their children's birth month and year twice throughout the survey to check for consistent responding. Once participants completed the screen or survey, they were given a unique code to enter into the MTurk system and they were paid $1.50 through MTurk.

For cohort 1, workers who indicated they had a 2-year-old child were immediately directed to the full survey. For cohort 2, workers were invited two weeks later to complete the full survey. This change in procedure was put in place because during the 6-month follow-up from cohort 1 that was part of a larger study, some participants (16.7% of those who initially deemed eligible) indicated different birthdays for their children than they reported in the original survey. With a two-week delay between the screen and survey, we could identify workers with consistent responding before inviting them for the 6-month follow up. Only parents who reported matching birthdays at two time points (6 months apart for cohort 1 or 2 weeks apart for cohort 2) were included in the final sample.

Of parents who participated, 55.8% were excluded for the following reasons: did not complete a follow-up to be able to match birthdays (N = 126), not US residents (N = 19), invalid survey responses (e.g., inconsistent birthdays, response patterns; N = 121); incomplete surveys not submitted for payment (N = 35); not answering >25% of one of the measures used for analysis in the present study (N = 5); diagnosis of or suspected autism, intellectual disability, cerebral palsy, Down syndrome (N = 48).

2.3 Measures

2.3.1 ADHD symptoms

Parents completed the ADHD Rating Scale-IV Preschool Version (see Appendix). This 18-item scale is a modified version of DuPaul, Power, Anastopoulos, & Reid's (1998) ADHD Rating Scale – IV (McGoey, DuPaul, Haley, & Shelton, 2007). The symptoms of this rating scale are based on the 18 DSM-IV-TR items. The DSM-5 has nearly identical symptoms, with specific examples added for some symptoms. As such, the ADHD Rating Scale-IV, Preschool Version statements are very similar to the DSM-5 symptoms, with some adaptations of examples for preschoolers. Parents indicated how frequently each of the 18 symptoms occurs on a 4-point Likert scale ranging from 0 (*never*) to 3 (*very often*). With preschool samples, the measure has shown good internal consistency (Inattention α = .93, Hyperactivity/Impulsivity α = .92, and Total α = .95), test-retest reliability (Inattention α = .85, Hyperactivity/Impulsivity α = .80, and Total α = .87), and concurrent validity with the Conners Rating Scales – Revised (Conners, Sitarenios, Parker, & Epstein, 1998), with values ranging from .54 to .96 (McGoey et al., 2007).

In the present study, the measure showed good internal consistency (Inattention α = .85, Hyperactivity/Impulsivity α = .81, Total α = .90).

2.3.2 Temperament

The Early Childhood Behavior Questionnaire – Short Form (Putnam, Jacobs, Gartstein, & Rothbart, 2010) is a 107-item questionnaire that measures temperament in children ages 18 months to 36 months. This measure was used to examine convergent and divergent validity of the ADHD Rating Scale-IV, Preschool Version. The scale measures 18 temperament traits that cluster into three factors. Items are averaged to determine a subscale score, and subscales are averaged to determine a factor score. Thus, only individuals who skipped all items corresponding to a particular subscale are missing scores for that scale. Negative Affect is comprised of the subscales: discomfort, fear, motor activation, sadness, perceptual sensitivity, shyness, soothability, and frustration. Surgency/Extraversion is comprised of the subscales: impulsivity, activity level/energy, high intensity pleasure, sociability, and positive anticipation. Effortful Control is comprised of the subscales: inhibitory control, attentional shifting, low intensity pleasure, cuddliness, and attentional focusing. Parents indicate how frequently each of the items occur on a 7-point Likert scale ranging from 1 (*never*) to 7 (*always*). This measure has shown internal consistency scores ranging from .65 to .83 (M = .74) and shows stability over 6-month (.58), 12-month (.53), and 18-month (.46) periods (Putnam et al., 2010). The present sample showed good overall internal consistency (α = .86), with individual subscales ranging from α = .66 to α = .84. Of the three broad scales, surgency showed

lower internal consistency (α = .54) than effortful control (α = .75) and negative affect (α = .68).

2.3.3 Demographics and Family History

Parents were asked to complete demographic questions about their child and household. They were asked to indicate diagnosed or suspected psychiatric or medical disorders and identify concerns or possible concerns about hyperactivity, aggression, defiance, and/or attention.

2.4 Analytic Plan

SPSS version 23 was used to conduct descriptive analyses and evaluate for normality and outliers. Frequencies of each response level (0 to 3) of ADHD symptoms were examined. Additionally, frequencies of symptom endorsements were calculated based on dichotomized items; items with a score of 0 (*never)* or 1 (*sometimes*) were considered not endorsed, and items with scores of 2 (*often*) or 3 (*very often*) were considered endorsed. Skipped items were considered not endorsed in total symptom counts. Using dichotomized endorsements, symptom-based prevalence of ADHD subtypes were calculated.

Main analyses were conducted in MPlus (Muthén & Muthén, 2010). Using Confirmatory Factor Analysis, several models were tested. A three-factor model was tested in which there are three separate, correlated hyperactivity, impulsivity, and inattention factors. A two-factor model was tested, consisting of separate, correlated hyperactive/impulsive and inattention factors. A one-factor model was tested and in order to allow for model comparison, the one-factor model was tested by setting the correlation of the two factors to one, so that the one-factor and two-factor models

were nested. A bifactor model was tested (consisting of hyperactive/impulsive and inattention factors and a general ADHD factor, which were all orthogonal), and a second order factor model (the two latent factors load onto a general ADHD factor). Model fit was assessed using model χ^2 (χ^2 /df between 2.0 and 5.0 indicates acceptable fit, with smaller values better; Hooper, Coughlan, & Mullen, 2008), the comparative fit index (CFI >.90 indicates good fit; Hu & Bentler, 1999), standardized root mean residuals (SRMR <.08 is acceptable fit; Hu & Bentler, 1999), the root mean square error of approximation (RMSEA <.08 is acceptable fit, and closer to .06 is considered a better cutoff; Hooper, Coughlan, & Mullen, 2008; Hu & Bentler, 1999), as well as the Akaike and Bayesian Information Criteria (AIC and BIC; smaller values are associated with better fit). The nested one- and two-factor models were compared with a $\Delta\chi^2$ test. The final model was tested for gender invariance.

To test the convergent and divergent validity of the ADHD Rating Scale, two structural regression models were evaluated, using the factor structure determined to be the best fit. The ADHD factors were each regressed onto the three temperament domains (first model), or the 18 temperament subscales (second model). No error variances were allowed to covary. Both models were tested for gender invariance.

Multidimensional IRT analysis (see Hambleton et al., 1991) in MPlus was used to calculate item parameters for the ADHD Rating Scale. Polytomous scoring was used given that there are four response options for each item and past studies (e.g., Purpura et al., 2010) have utilized polytomous over dichotomous scoring. The threshold parameters measure how much of an underlying trait is necessary for an individual to be more likely to endorse the next highest response (Hays, Morales, &

Reise, 2007). Threshold and difficulty values are comparable and represent severity (Cappelleri, Lundy, & Hays, 2015). Each item generates three threshold values representing the amount of underlying trait (inattention or hyperactivity/impulsivity) necessary for an individual to be more likely rated as a 1 versus a 0 (b1); 2 versus 1 (b2) or 3 versus 2 (b3). The threshold values should increase, indicating that more of the underlying trait is required to endorse the item at a higher value on the Likert scale. The discrimination parameter indicates how well an item differentiates among levels of the trait below and above the thresholds for that item. IRT analyses also generate theta values for each individual. The theta value is the amount of the latent trait at which the individual would be more likely to endorse items that have a threshold value lower than the theta value and less likely to endorse items that have difficulty values above the theta value. These parameters were used to generate an Item Characteristic Curve (ICC) for each item, which indicates how likely an item is to be endorsed based on theta. ICCs and related values were examined, including the discrimination and threshold values, to determine which symptoms were most useful. Additionally, the Item Information Functions (IIFs) were examined for each symptom to compare how much information individual symptoms provided and at which point among the latent trait information was highest. Higher information values indicate lower measurement error at that point along the latent trait (Hambleton et al., 1991; Purpura et al., 2010).

Though there is no clear method for calculating power for an IRT (Embretson & Reise, 2000), our sample size provides adequate power (.8) to detect effects using structural equation modeling, based on Wolf, Harrington, Clark, and Miller's (2013)

Monte Carlo analysis. They found that the required sample size to have power of .8 decreased both when the number of indicators and the factor loadings increased. One and two-factor models with six or eight indicators with factor loadings of .5 require minimum sample sizes of less than 200; there are more indicators for the present study which should decrease the required sample size, so our sample is more than adequate.

CHAPTER 3

RESULTS

3.1 Descriptive Statistics

3.1.1 ADHD Rating Scale

There was a small portion of missing responses for the ADHD Rating Scale (items 3, 10, 15, 16, 18 missing 1 response; items 11 and 13 missing 2 responses; item 4 missing 3 responses; item 14 missing 4 responses; item 17 missing 9 responses). Frequencies of item responses and symptom endorsements are presented in Table 1. ADHD total symptom counts ranged from 0 to 18 (M = 5.43, SD = 4.17) and number of symptoms showed a small positive skew, although the skew coefficient was small (skewness coefficient = .66). The number of ADHD symptoms endorsed for boys (M = 5.81, SD = 4.16) and girls (M = 4.95, SD = 4.14) was not significantly different, t (319) = 1.84, p = .07. Parents endorsed an average of 3.21 (SD = 2.31) hyperactive symptoms and 2.21 (SD = 2.27) inattentive symptoms. There was not a significant difference in the number of inattentive symptoms endorsed for boys (M = 2.38, SD = 2.29) and girls (M = 2.01, SD = 2.22), t (319) = 1.48, p = .141, nor in the number of hyperactive symptoms endorsed for boys (M = 3.43, SD = 2.26) and girls (M = 2.94, SD = 2.35), t (319) = 1.87, p = .062. Inattentive symptoms appeared to have a small positive skew (skewness coefficient = .92), and hyperactive/impulsive symptoms appeared to have a minimal positive skew (skewness coefficient = .33). Most items had a modal response of 1, indicating that the symptom occurred “sometimes.” Based on endorsements of items, 32 (10%) children would meet symptom criteria for ADHD hyperactive/impulsive presentation,

10 (3.1%) children would meet symptom criteria for ADHD inattentive presentation, and 27 (8.4%) children would meet symptom criteria for ADHD combined presentation. See Figure 1 for histograms of symptom counts.

3.1.2 ECBQ

The means and standard deviations of temperament subscales and factors are listed in Table 2. Three participants had missing data on all of the items for a subscale (2 for sociability, 1 for positive anticipation) and thus their subscale score could not be calculated. For analyses utilizing subscale scores, these participants were removed using list-wise deletion. The three broadband scales and most subscales appeared normally distributed. Sociability showed a small negative skew (skewness coefficient = -1.28).

3.2 Factor Structure

Goodness-of-fit statistics for all CFA models appear in Table 3. The second order factor model did not show adequate fit on any of the fit statistics, and showed the highest AIC and BIC, indicating poorer fit. The χ^2/df value was above the range indicating adequate fit (2 to 5). The bifactor model showed poor fit on the RMSEA and CFI, although the SRMR value was adequate (< .08) and the χ^2/df value fell within acceptable limits. The one-, two-, and three-factor models without a general ADHD latent factor all showed better fit than both the second order and bifactor models. The one-factor model showed adequate RMSEA, SRMR, and χ^2/df, but the χ^2/df was highest of the one-, two-, and three-factor models. Additionally, the CFI value was not adequate, since it was below .90. The two-factor model showed adequate SRMR and RMSEA, as well as a low χ^2/df value, but the CFI was also

below .90. The two-factor model showed significantly better fit than the one-factor model, $\Delta\chi^2(1) = 16.75$, $p < .001$. The three-factor model showed comparable fit to the two-factor model, although the models could not be compared with a $\Delta\chi^2$ test because they were not nested. The RMSEA and SRMR values were similar, and the CFI value was only .1 higher, still below the cutoff for adequate fit. The χ^2/df value for the three-factor model was slightly smaller than for the two-factor model. Additionally, the three-factor AIC was smaller, but the BIC was larger than the two-factor model. In both the two- and three-factor models, the indicator-factor correlations of the three verbally-based hyperactive/impulsive symptoms were low. In the three-factor model, the symptom *blurts out answers* (symptom 14) loaded poorly on the impulsivity factor ($r = .38$, $SE = .06$), and there were only two other impulsivity items. Given that the impulsivity factor only had two items with high loadings and the overall fit of the three-factor model was similar to the two-factor model, the more parsimonious two-factor model was selected as a better fit.

In the two-factor model, the latent factors were highly correlated ($r = .93$, $SE = .02$). Factor loadings for inattention ranged from .61 to .72 and for hyperactivity/impulsivity ranged from .31 to .69. As noted above, three hyperactive/impulsive items showed poor reliability (ranging from .09 to .26) and relatively low indicator-factor correlations: *difficulty playing quietly* (symptom 8; $r = .51$, $SE = .05$), *talks excessively* (symptom 12; $r = .31$, $SE = .05$), and *blurts out answers* (symptom 14; $r = .37$, $SE = .05$). All of these items are verbally-based items, and may be less likely to be present in young children with limited verbal ability, and indeed showed low levels of endorsements in the present sample. Therefore, these

verbal items were removed from the model and a two-factor model without these verbal items was tested. This model showed better fit on all fit statistics compared to the 4 other models, and was the only model with a CFI above .90. Individual factor loadings were high, and the two factors were highly correlated (r = .92, SE = .02). Most items showed low to moderate reliability (ranging from .31 to .53), although reliability scores of the factors were better than those of individual items (inattention = .50, hyperactivity = .53). This model is not nested in another model, so a $\Delta\chi^2$ test could not be used to compare models. The two-factor model without verbal items was selected as the final model (see Table 4 and Figure 2).

Gender invariance of this two-factor model without verbal items was tested. Two models were estimated in Mplus, one in which factor loadings and the factor correlation were set to be equal for boys and girls, and one in which these parameters were allowed to vary across gender. The gender variant model did not show significantly better fit than the gender invariant model, $\Delta\chi^2(16) = 11.88$, p = .753, suggesting that the factor structure is similar for boys and girls.

3.3 Convergent and Divergent Validity

To test the convergent and divergent validity, a structural regression model was tested using the two-factor solution without verbal items (see Table 5 and Figure 3). Given the large number of estimated correlations in the model, alpha was set to .01 to limit Type 1 error. First, each of the three temperament domains were regressed on each of the latent ADHD factors. All three temperament domains were related to each ADHD subscale in the expected direction, controlling for the other temperament

domains[1]. Greater surgency was associated with more inattentive symptoms and higher hyperactive/impulsive symptoms. Higher effortful control was associated with fewer inattentive symptoms and fewer hyperactive/impulsive symptoms. Finally, higher negative affect was associated with higher hyperactivity/impulsivity and showed a trending relation with higher inattention. Gender invariance of this model was tested by comparing a model in which regression paths for girls were set to be equal to these paths for boys, and one in which these paths were freely estimated for both genders. The factor loadings were held invariant across gender in both models, given that gender invariance of the factor loadings was previously established. The gender variant model was not a significantly better fit than the gender invariant model, $\Delta\chi^2(7) = 2.63$, $p = .917$, suggesting that the relations between temperament and ADHD factors were similar for boys and girls.

In a separate model, all 18 temperament subscales were regressed onto each of the latent factors (see Table 6 for all estimates and see Figure 4). As expected, several temperament subscales that were expected to have a strong relation with ADHD symptoms were associated with one or both domains of ADHD. Lower inhibitory control and higher activity level were associated with higher hyperactive/impulsive symptoms and lower attentional focus was associated with higher inattentive symptoms. Higher motor activation was associated with both higher inattention and hyperactivity/impulsivity. Somewhat consistent with expectations, several temperament traits that were expected to show low to moderate associations with

[1] Several items on the temperament scale that are highly similar to ADHD symptoms were removed (items 12, 75, 76, 78, 95, 44, 45) and analyses were repeated. Results were highly similar, with all 3 temperament domains showing significant relations with ADHD symptoms in the expected direction

ADHD were found to either have marginally significant relations with small effect-sizes or no significant relation with ADHD symptoms. Specifically, higher sociability and lower perceptual sensitivity showed a marginally significant small-sized association with higher inattention and hyperactivity/impulsivity. Higher frustration showed a trending small-sized association with higher hyperactivity/impulsivity. Temperament traits that did not show significant associations with ADHD symptoms included: high intensity pleasure, low intensity pleasure, positive anticipation, shyness, soothability, discomfort, fear, sadness, and cuddliness. In contrast to expectations, some subscales that were expected to show strong relations with ADHD showed no relations or trending relations. Higher inhibitory control and attention shifting each showed a trending relation with lower inattentive symptoms, and attentional focus showed a trending association with lower hyperactive/impulsive symptoms. Impulsivity was not associated with either domain of ADHD[2]. Gender invariance of this model was tested by comparing a model in which regression paths for girls were set to be equal to these paths for boys, and one in which these paths were freely estimated for both genders. The factor loadings were held invariant across gender in both models, given that gender invariance of the factor loadings was previously established. The gender variant model was not a significantly better fit than the gender invariant model, $\Delta\chi^2(38) = 39.94$, $p = .384$, suggesting that the

[2] Several items on the temperament scale that are highly similar to ADHD symptoms were removed (items 12, 75, 76, 78, 95, 44, 45) and analyses were repeated. Results were similar. Most temperament subscales showed the same relation with ADHD symptoms, with few exceptions: Higher High Intensity Pleasure was now significantly related to hyperactivity ($b = .09$, $SE = .034$, $p = .006$) and attentional focusing was no longer trending in relation to hyperactive symptoms ($b = -.064$, $SE = .038$, $p = .089$).

correlations between temperament subscales and ADHD factors were similar for boys and girls.

3.4 Item Response Theory Parameters

3.4.1 Inattention

Parameters for all ADHD symptoms are presented in Table 7. All nine inattention symptoms showed adequate discrimination parameters, ranging from 1.33 to 2.22. Symptoms with the highest discrimination values were the symptoms *easily distracted* (symptom 15) and *difficulty sustaining attention* (symptoms 3). Threshold values were examined and revealed shifts between response levels for each item such that more of the latent trait (inattention) was required to endorse a higher response option. Further, there was heterogeneity across item thresholds suggesting that the same response is not equally likely across symptoms. The amount of theta required to shift from a response of 0 to 1 (b_1) ranged from -3.48 to .63, from 1 to 2 (b_2) ranged from .51 to 2.72, and from 2 to 3 (b_3) ranged from 2.46 to 3.87. Symptoms that required a relatively large amount of the latent trait to endorse a response of 1 over a response of 0 were symptoms *avoids sustained effort* (symptom 11), *forgetful* (symptom 17), and *loses things* (symptom 13). Several items required much less of the inattention trait to endorse a 1 over a 0, including symptoms *easily distracted* (symptom 15) and *fails to attend to detail*s (symptom 1). Item characteristic curves (see Figure 7), which reflect both the discrimination and threshold parameters, revealed that most inattentive symptoms showed distinct shifts between response options. However, several symptoms appeared to show less distinction between response options 2 (often) and 3 (very often), including symptom *does not follow*

through (symptom 7), *avoids sustained effort* (symptom 11), and *forgetful* (symptom 17).

Item information functions are presented in Figure 5 and information values across a range of theta values are presented in Table 8. Overall, items showing higher information values (about .6 to .8) across about +/- 2 standard deviations (SDs) above and below the mean of the latent trait were symptoms *fails to attend to details* (symptom 1), *difficulty sustaining attention* (3), and *difficulty organizing* (symptom 9). The symptom *easily distracted* (15) provided slightly more information (values closer to 1) across a similar range of the latent trait. The symptoms *avoids sustained effort* (11) and *forgetful* (17) showed moderate information (around .6) in a smaller range of about 1 *SD* above and below the mean. Other inattentive symptoms showed lower information (around .4) across a broad range (+/- 2 *SD*s above and below the mean) of the latent trait (*does not listen* [5], *does not follow through* [7]) or a narrow range of +/- 1 *SD* above and below the mean (*loses things* [13]). The sum of all symptoms provided the most information (approximately 6.15) at a theta value of approximately 0.6 and showed moderate information values around .4 to .6 across a range of about 1.5 *SD*s above and below the mean.

3.4.2 Hyperactivity/impulsivity

Most hyperactive/impulsive symptoms showed adequate discrimination parameters, ranging from 0.61 to 1.93, generally lower than inattention symptoms. Two symptoms showed low discrimination ability: *talks excessively* (symptom 12) and *blurts out answers* (symptom 14). Symptoms with the highest discrimination values were the symptoms *runs about* (symptom 6) and *interrupts/intrudes* (symptom

18). Threshold values were examined and revealed shifts between response levels for each item such that more hyperactivity/impulsivity was required to endorse a higher response option. Further, there was heterogeneity across item thresholds suggesting that the same response is not equally likely across symptoms. The amount of theta required to shift from a response of 0 to 1 (b_1) ranged from -2.64 to 1.19, from 1 to 2 (b_2) ranged from -0.64 to 3.028, and from 2 to 3 (b_3) ranged from 1.16 to 4.48. The symptom *blurts out answers* (14) required the largest amount of the latent hyperactivity/impulsivity trait to endorse higher responses. Two other verbal items required the most latent trait to shift from a response of 0 to 1: *difficulty playing quietly* (symptom 8) and *talks excessively* (symptom 12). Item characteristic curves (see Figure 8) showed that some symptoms had distinct shifts between response options. Several items did not show distinct shifts across all response options, including all three verbal symptoms: *difficulty playing quietly* (symptom 8), *talks excessively* (symptom 12), and *blurts out answers* (symptom 14). Additionally, *fidgets* (symptom 2) showed little distinction between responses of 2 and 3.

Item information functions are presented in Figure 6 and information values across a range of theta values are presented in Table 8. Most symptoms provided a moderate to high amount of information (information value peaks around .6 to .8) across a range of about 1.5 *SD*s above and below the average latent trait including *fidgets* (2), *leaves seat* (4), *runs about* (6), *difficulty waiting turn* (16), *interrupts/intrudes* (18), and *on the go* (10). The three verbal items provided less information. *Difficulty playing quietly* (8) provided information values of about .4 across a range from 1 *SD* below the mean to 2 *SD*s above the mean. The symptoms

talks excessively (12) and *blurts out answers* (14) provided little information (values around .06 to .2) across the range of the latent trait. The sum of all hyperactive/impulsive symptoms provided the most information at a theta value of approximately 0.4 (information = 4.98) and showed good information (between 4 and 5) within 2 *SD*s above and below the mean.

CHAPTER 4

DISCUSSION

The present study aimed to examine the validity of ADHD symptoms in toddlers. In a community sample of 2-year-old children, there was generally strong support for the validity of parent-rated ADHD symptoms, with the exception of verbally-based symptoms. Consistent with studies of school-age children (see Bauermeister et al., 2010), a two-factor model consisting of an inattention factor and hyperactivity/impulsivity factor demonstrated good fit and was slightly better than a one-factor or three-factor model. However, unlike results of studies with older children, verbal hyperactivity/impulsive symptoms did not load well on the hyperactive/impulsive factor. Evidence also emerged supporting the convergent and divergent validity of the symptoms; ADHD symptoms were related to conceptually similar temperament traits, and not related to traits that are less conceptually similar. Item response theory analyses revealed that, with the exception of verbal symptoms, symptoms of inattention and hyperactivity/impulsivity showed good utility in discriminating 2-year-old children with varying levels of ADHD symptoms.

4.1 Prevalence of ADHD Symptoms in 2-year-old Children

A substantial portion (21.5%) of 2-year-old children met symptom criteria for ADHD (> 6 symptoms in one or both domains) based on the ADHD Rating Scale. This is larger than the number of preschool children who met criteria based on a similar ADHD scale (11%; Arias et al., 2016) and much higher than the overall rate of ADHD diagnoses in childhood (7 – 10%). However, the majority of 2-year-old children did not exhibit elevated levels of inattention or hyperactivity/impulsivity and

the average number of inattentive and hyperactive/symptoms was lower than in previous studies with the ADHD Rating Scale with older children (e.g., DuPaul et al., 2015; McGoey et al., 2007). Notably, in these previous studies, there was a much larger gender difference, with girls showing lower symptomatology than boys across domains; in the present study, ratings were comparable across boys and girls in both ADHD domains. Thus, although toddlers, and particularly boys, are often thought to be highly active, impulsive, and distractible, most toddlers appear to show low levels of ADHD symptoms. Additionally, most individual symptoms did not occur in the majority of the sample at such high or low frequencies to suggest symptoms are not useful at this age, with two exceptions. The symptom *blurts out answers* (symptom 14) was only present above the symptom threshold in 5% of the sample, and the symptom *on the go* (symptom 10) was reported to occur above the symptom threshold in 60% of the sample. These symptoms were, respectively, highly uncommon and highly common, suggesting that they each may be less useful at this age.

4.2 Construct Validity

This study found support for the construct validity of ADHD symptoms in toddlers. The present findings showed that the best overall structure of ADHD symptoms in 2-year-old children is two highly correlated but separate domains, without three verbally-based items (*difficulty playing quietly, talks excessively, blurts out answers*) that showed low reliability and low loadings on the hyperactivity/impulsivity factor. Other tested models did not show adequate fit, including a bifactor and second order model, or showed adequate fit but were

determined to not be the best fit for the data (one-factor, three-factor, and a two-factor model that included the verbal items). The findings are somewhat similar to those found with school-age children, in which a two-factor structure has been most commonly supported (see Bauermeister et al., 2010). The more limited findings with preschoolers have been mixed, with studies finding support for a one-factor model (Willoughby et al., 2012), two-factor model (Hardy et al., 2007), a three-factor model (Hardy et al., 2007; McGoey et al., 2015), and a bifactor model (Arias et al., 2016). To our knowledge, the only prior study examining the factor structure of ADHD in toddlers used an observational measure that was not DSM-based (Deutscher & Fewel; 2001). Although they found three factors, the present study found two factors, which may be related to the use of a DSM-based questionnaire that includes questions aimed to reflect two domains. Although the two-factor model in the present study is similar to findings in school-age children, fit of the final model was slightly worse than that found in studies with older children (Amador-Campos et al., 2005; Arias et al., 2016); Du Paul et al., 2007, 2016; Hardy et al., 2007; Willoughby et al., 2012). Thus, model fit was less robust in toddlers and verbal symptoms were not as good, but the overall construct of ADHD manifests similarly in toddlers based on the factor structure. In contrast to studies with older children, verbal items occurred at a lower frequency than other items, which could partially account for their poor loadings because verbal skills may be limited at this age. It is likely that verbal impulsivity does not represent ADHD symptomatology at this age, but rather, is related to developmental skill. Since younger children have fewer verbal skills, this may account for the poor fit of verbal items.

Examining the relation between ADHD symptoms and conceptually similar temperament traits showed some support for the convergent and divergent validity of ADHD. As expected and consistent with previous findings in older children (e.g., Martel & Nigg, 2006; Martel et al., 2012; Martel et al., 2014), both domains of ADHD were found to be related to higher surgency and lower effortful control, and hyperactivity/impulsivity was associated with higher negative affect. Inattentive symptoms showed a trending relationship with higher negative affect. Past studies mostly examined convergent validity with broad temperament domains and not specific subscales or traits, with few exceptions; Bell et al. (2010) found that children's report of activity level was related to parents' reported ADHD symptoms. The present study examined specific subscales and found that the relation between ADHD symptoms and more specific temperament dimensions provided support for the validity of ADHD at this age. In particular, inattention was related to motor activation and attentional focus, and hyperactivity/impulsivity was related to motor activation, inhibitory control, and activity level. Traits that were expected to be related less strongly to ADHD did not show significant relations, including perceptual sensitivity, sociability, frustration, discomfort, fear, sadness, shyness, soothability, cuddliness, low intensity pleasure, high intensity pleasure, and positive anticipation. The only findings that failed to support convergent validity of ADHD symptoms was a lack of significant relations between ADHD symptoms and temperamental traits of impulsivity and attentional shifting. Like previous studies (e.g., Lemery, Essex, & Smider, 2002) results suggest that the observed relation between scales may not simply be due to overlapping items.

The observed relation between ADHD symptoms and temperament may reflect a number of possible underlying mechanisms. For instance, certain temperament traits may confer risk for psychopathology (vulnerability model), or temperament traits and psychopathology may be dimensionally related due to common etiologies (spectrum model; see Tackett, 2006). It is also possible that certain temperamental traits and ADHD symptoms are simply different terms for the same underlying construct. For example, temperamental traits of low inhibitory control, low attentional focus, and high activity level are highly similar to the ADHD symptoms of impulsivity, inattention, and hyperactivity. Although we may conceptualize temperament traits as reflecting individual differences and ADHD symptoms as psychopathology, the same processes may underlie both constructs. Historically, high levels of inattention, hyperactivity, and impulsivity have been conceptualized as reflecting "difficult" temperament in toddlers, but are typically considered psychopathology in older children; it remains unclear whether this distinction reflects true developmental shifts in the processes underlying these behaviors or simply a shift in our conceptual framework.

4.3 Symptom Utility

IRT analyses found that most symptoms, with the exception of verbal hyperactive/impulsive ones, showed adequate utility for discriminating children with differing levels of underlying ADHD. However, discrimination and information values were smaller than those in studies with older children (e.g., Gomez et al., 2008a, Li et al., 2015, Purpura et al., 2010), suggesting that symptoms have less utility in toddlers compared to older children. Generally, inattentive symptoms

provided more information across a broader range and showed higher discriminability than hyperactive/impulsive symptoms, similar to past IRT studies with preschoolers (e.g., Li et al., 2015; Purpura et al., 2010). However, this is somewhat in contrast to some past studies that did not use IRT and showed that in preschoolers, inattentive symptoms are less useful than hyperactive/impulsive symptoms (e.g., Hardy et al., 2007; Harvey et al., 2015). Although inattentive symptoms were overall less common than hyperactive/impulsive symptoms (besides the three verbal symptoms), they appeared to have more utility for discriminating children's levels of ADHD; perhaps hyperactive/impulsive symptoms are less useful because they are more developmentally normative and not as likely to be related to underlying psychopathology. In the present study, all inattentive symptoms showed adequate discrimination parameters, but several inattentive symptoms were consistently best across all IRT parameters, including symptoms *easily distracted* (symptom 15), *difficulty sustaining attention* (symptom 3), and *fails to attend to details* (symptom 1). These symptoms also required less of the latent trait for parents to endorse a value above "never occurs" compared to other symptoms, suggesting that they are more common among toddlers. Several inattentive symptoms showed less distinction across the range of responses, including symptoms *does not follow through* (7), *avoids sustained effort* (11), and *forgetful* (17); generally, these symptoms required more of the trait to endorse, and they occurred less commonly.

Most symptoms of hyperactive/impulsive showed good discriminability and distinct shifts across the latent trait, with the exception of the three verbal symptoms (*difficulty playing quietly* [8], *talks excessively* [12], and *blurts out answers* [14]),

which showed poor discriminability and little distinction across response options. These verbal symptoms also provided much less information than other symptoms, likely related to their low frequency compared to other symptoms. Some past studies have shown a similar pattern of some or all verbal symptoms having worse discriminability compared to other symptoms (e.g., Li et al., 2015, Purpura et al., 2010). As noted above, verbal symptoms may be less useful since they are less common in toddlers due to limited verbal skills. However, overall, given that most symptoms showed clear distinct shifts across responses and adequate discriminability, there is evidence that the symptoms besides the three verbal ones can be useful for toddlers, albeit less so than in older children.

4.4 Limitations

The study has several limitations. First, although the sample provided adequate power for the analyses conducted, it is important to replicate the factor analyses with a larger sample to have better estimates of the population and be able to test invariance across a variety of demographic characteristics. Second, although the sample was fairly representative of the United States, there was not enough racial/ethnic diversity among children to examine whether models varied across ethnicity. There were also not enough fathers to examine whether models differed as a function of parent gender. Third, the same parent/guardian completed all measures for the present study, so shared method variance may account for some of the observed relations between temperament and ADHD. Although past studies have used similar methodology to examine the relation between temperament and ADHD (e.g., Martel et al., 2012; Martel et al., 2014), it will be important to extend these

studies to other measures of temperament, including observation and other raters, especially given some evidence that observational measures and parent reports may show low correlations (e.g., Gagne, Van Hulle, Askan, Essex, & Goldsmith, 2011). Fourth, the data were collected anonymously online, so participants may have been less truthful or paid less attention than in an in-person study. However, procedures were in place to minimize this, and previous researchers have found online data collection and MTurk specifically to be reliable and similar to in-person collection (e.g., Buhrmester et al., 2011; Gosling, Vazire, Srivastava, & John, 2004).

4.5 Clinical Implications and Future Directions

Despite these limitations, this study was the first to analyze the validity of DSM symptoms of ADHD in 2-year-old children. The results generally provided support for the validity of ADHD symptoms in toddlers, but found that verbal symptoms were less useful at this age. Screening at-risk toddlers for ADHD may need to involve less attention to those verbal hyperactive/impulsive symptoms and more focus on inattentive symptoms. Longitudinal studies examining the utility of symptoms over time will be an important next step. Past research suggests that early childhood temperament predicts later ADHD and externalizing behavior (e.g., Kochanska & Knaack, 2003; Willoughby et al., 2016), and ADHD symptoms have been shown to be relatively stable beginning in the toddler years (e.g., Galéra et al., 2011; Romano et al., 2006). However, the stability of DSM ADHD symptoms beginning in the toddler years has not been evaluated. Further, examining the stability of the construct validity and IRT parameters over time may help us to better create measures for identifying at-risk toddlers, and examine when exactly particular

symptoms (e.g., verbal symptoms) become more useful. The present study lends support for using most DSM symptoms with 2-year-old children, and suggests further longitudinal studies to identify toddlers at-risk for ADHD are warranted.

Table 1
ADHD Rating Scale–IV Preschool Version: Item Frequencies

Item Number	*M (SD)*	Never (%)	Sometimes (%)	Often (%)	Very Often (%)	Symptom Present (%)
Inattentive						
Item 1 – Fails to attend to details	1.32 (.92)	53 (16.5)	**159 (49.5)**	61 (19.0)	48 (15.0)	109 (34.0)
Item 3 – Difficulty sustaining attention	1.14 (.91)	80 (24.9)	**148 (46.1)**	60 (18.7)	32 (10.0)	92 (28.7)
Item 5 – Does not listen	1.20 (.86)	63 (19.6)	**163 (50.8)**	64 (19.9)	31 (9.7)	95 (29.6)
Item 7 – Does not follow through	1.09 (.84)	72 (22.4)	**174 (54.2)**	48 (15.0)	27 (8.4)	75 (23.4)
Item 9 – Difficulty organizing	0.92 (.88)	115 (35.8)	**137 (42.7)**	48 (15.0)	21 (6.5)	69 (21.5)
Item 11 – Avoids sustained effort	0.57 (85)	**195 (60.7)**	85 (26.5)	21 (6.5)	18 (5.6)	39 (12.1)
Item 13 – Loses things	0.79 (.89)	**146 (45.5)**	113 (35.2)	40 (12.5)	20 (6.2)	60 (18.7)
Item 15 – Easily distracted	1.48 (.89)	35 (10.9)	**150 (46.7)**	83 (25.9)	52 (16.2)	135 (42.1)
Item 17 – Forgetful	0.66 (.82)	**158 (49.2)**	117 (36.4)	21 (6.5)	16 (5.0)	37 (11.5)
Hyperactivity/Impulsivity						
Item 2 – Fidgets	1.39 (1.06)	75 (23.4)	**114 (35.5)**	64 (19.9)	68 (21.2)	132 (41.1)
Item 4 – Leaves seat	1.50 (1.04)	61 (19.0)	**107 (33.3)**	79 (24.6)	71 (22.1)	95 (29.6)
Item 6 – Runs about	1.35 (.99)	67 (20.9)	**128 (39.9)**	72 (22.4)	54 (16.8)	126 (39.3)
Item 8 – Difficulty playing quietly	0.67 (.79)	**159 (49.5)**	122 (38.0)	28 (8.7)	12 (3.7)	40 (12.5)
Item 10 – On the go	1.78 (1.03)	43 (13.4)	82 (25.5)	96 (29.9)	**99 (30.8)**	195 (60.7)
Item 12 – Talks excessively	1.14 (.97)	92 (28.7)	**130 (40.5)**	61 (19.0)	38 (11.8)	99 (30.8)
Item 14 – Blurts out answers	0.33 (.64)	**236 (73.5)**	62 (19.3)	14 (4.4)	5 (1.6)	19 (5.9)
Item 16 – Difficulty waiting turn	1.53 (.96)	43 (13.4)	**129 (40.2)**	84 (26.2)	64 (19.9)	148 (46.1)
Item 18 – Interrupts/intrudes	1.38 (.96)	54 (16.8)	**144 (44.9)**	68 (21.2)	54 (16.8)	122 (38.0)

Note. Scale is from 0 = *Never* to 3 = *Very Often*. Modal response is bolded. A symptom is considered present if it occurs often or very often.

Table 2
Early Childhood Behavior Questionnaire Scores

Subscale	*M*	*SD*
Negative Affect	3.16	0.58
Discomfort	2.49	0.99
Fear	2.32	0.87
Motor Activation	2.45	0.92
Sadness	3.04	0.92
Perceptual Sensitivity	4.18	1.19
Shyness	3.65	1.31
Soothability	4.84	0.89
Frustration	4.06	1.14
Effortful Control	4.68	0.67
Inhibitory Control	3.92	0.98
Attentional Shifting	4.79	0.77
Attentional Focusing	4.84	0.89
Cuddliness	5.06	1.03
Low Intensity Pleasure	4.78	1.01
Surgency/Extraversion	5.15	0.59
Impulsivity	4.48	1.10
Activity level	4.90	0.82
High Intensity Pleasure	5.01	1.03
Sociability	5.74	0.98
Positive Anticipation	5.60	1.07

Note. Scale is from 1 = Never to 7 = Always.

Table 3
Results of Factor Analyses

	AIC	BIC	CFI	RMSEA	SRMR	χ^2	df	χ^2/df
Second order	13814.49	14018.14	0.69	0.12	0.22	744.02	135	5.51
Bifactor	13512.53	13768.99	0.85	0.09	0.07	414.07	121	3.42
One-factor	13457.88	13661.53	0.87	0.08	0.05	387.41	135	2.87
Two-factor	13443.12	12650.55	0.88	0.07	0.05	370.66	134	2.77
Three-factor	13427.60	13642.57	0.89	0.07	0.05	351.14	132	2.66
Two-factor without verbal items	11312.32	11485.80	0.92	0.07	0.05	235.75	89	2.65

Note. All χ^2 had associated $p < .001$.

Table 4
Factor Loadings of Two-factor Structure (Without Verbal Items)

Item	Estimate *(SE)*	Correlation *(SE)*	Reliability
Inattention			.50
Item 1 – Fails to attend to details	1.00 (.00)	.64 (.04)	.41
Item 3 – Difficulty sustaining attention	1.08 (.10)	.70 (.03)	.49
Item 5 – Does not listen	0.83 (.09)	.56 (.04)	.32
Item 7 – Does not follow through	0.81 (.09)	.57 (.04)	.32
Item 9 – Difficulty organizing	0.95 (.10)	.64 (.04)	.41
Item 11 – Avoids sustained effort	0.86 (.09)	.60 (.04)	.36
Item 13 – Loses things	0.84 (.10)	.56 (.04)	.31
Item 15 – Easily distracted	1.11 (.10)	.73 (.03)	.53
Item 17 – Forgetful	0.84 (.09)	.60 (.04)	.36
Hyperactive/impulsive			.53
Item 2 – Fidgets	1.00 (.00)	.60 (.04)	.36
Item 4 – Leaves seat	1.00 (.11)	.62 (.04)	.38
Item 6 – Runs about	1.08 (.11)	.70 (.03)	.49
Item 10 – On the go	0.99 (.11)	.62 (.04)	.38
Item 16 – Difficulty waiting turn	0.99 (.11)	.66 (.04)	.44
Item 18 – Interrupts/intrudes	1.02 (.11)	.68 (.04)	.47

Table 5
Associations Between Temperament Domains and ADHD Symptoms

Temperament Trait	Inattention		Hyperactivity/impulsivity	
	Unstandardized (*SE*)	Standardized (*SE*)	Unstandardized (*SE*)	Standardized (*SE*)
Negative Affect	0.11 (.05)[a]	.11 (.05)[a]	0.18 (.06)*	.17 (.05)*
Effortful Control	-0.47 (.06)**	-.55 (.05)**	-0.48 (.06)**	-.50 (.05)**
Surgency/Extraversion	0.21 (.05)**	.21 (.05)**	0.39 (.06)**	.36 (.05)**

**$p < .001$; *$p < .01$; [a]$p \leq .05$

Table 6

Associations between Temperament Traits and ADHD Symptoms

Temperament Trait	Inattention		Hyperactivity/impulsivity	
	Unstandardized *(SE)*	Standardized *(SE)*	Unstandardized *(SE)*	Standardized *(SE)*
Negative Affect				
Discomfort	-0.00 (.04)	-.01 (.07)	0.01 (.04)	.01 (.06)
Fear	-0.05 (.04)	-.07 (.06)	-0.04 (.04)	-.05 (.06)
Motor Activation	0.11 (.04)*	.18 (.06)*	0.10 (.04)*	.15 (.05)*
Sadness	0.05 (.04)	.09 (.06)	0.04 (.04)	.06 (.06)
Perceptual sens	-0.06 (.03)[a]	-.13 (.05) [a]	-0.06 (.03)[a]	-.12 (.05) [a]
Shyness	0.01 (.02)	.01 (.05)	-0.01 (.03)	-.02 (.05)
Soothability	-0.05 (.04)	-.07 (.06)	-0.02 (.04)	-.02 (.06)
Frustration	0.001 (.03)	.003 (.07)	0.08 (.04)[a]	.14 (.06) [a]
Effortful Control				
Inhibitory Control	-0.07 (.04)[a]	-.13 (.06) [a]	-0.14 (.04)**	-.22 (.06)**
Attentional Focusing	-0.19 (.04)**	-.29 (.06)**	-0.09 (.04)[a]	-.12 (.06) [a]
Attentional Shifting	-0.11 (.05)[a]	-.14 (.06) [a]	-0.07 (.05)	-.09 (.06)
Cuddliness	-0.04 (.03)	-.07 (.06)	-0.04 (.03)	-.6 (.05)
Low Intensity Pleasure	-0.02 (.03)	-.04 (.06)	-0.04 (.03)	-.06 (.06)
Surgency/Extraversion				
Impulsivity	0.00 (.03)	.006 (.05)	-0.03 (.03)	-.05 (.05)
Activity Level	0.05 (.05)	.07 (.07)	0.14 (.05)*	.20 (.06)*
High Intens Pleasure	0.02 (.04)	.03 (.06)	0.06 (.04)	.09 (.06)
Sociability	0.07 (.03)[a]	.12 (05) [a]	0.07 (.03)[a]	.10 (.05) [a]
Positive Anticipation	0.02 (.03)	.03 (.05)	0.04 (.03)	.07 (.05)

**$p < .001$; *$p < .01$; [a]$p \leq .05$

Table 7
Item response Theory Parameters

Latent trait	Item	Discrimination (*SE*)	Threshold *b1* (*SE*)	Threshold *b2* (*SE*)	Threshold *b3* (*SE*)
Inattention					
	Item 1 – Fails to attend to details	1.69 (.20)	-2.37 (.24)	0.92 (.17)	2.46 (.23)
	Item 3 – Difficulty sustaining attention	2.04 (.23)	-1.79 (.22)	1.46 (.21)	3.43 (.31)
	Item 5 – Does not listen	1.38 (.18)	-1.84 (.19)	1.16 (.17)	2.87 (.24)
	Item 7 – Does not follow through	1.39 (.18)	-1.64 (.19)	1.57 (.18)	3.07 (.26)
	Item 9 – Difficulty organizing	1.75 (.20)	-0.88 (.18)	1.89 (.21)	3.75 (.31)
	Item 11 – Avoids sustained effort	1.67 (.22)	0.63 (.17)	2.72 (.24)	3.82 (.30)
	Item 13 – Loses things	1.33 (17)	-0.26 (.15)	1.82 (.18)	3.32 (.26)
	Item 15 – Easily distracted	2.22 (.26)	-3.48 (.33)	0.51 (.20)	2.71 (.27)
	Item 17 – Forgetful	1.67 (.25)	-0.05 (.17)	2.65 (.24)	3.87 (.34)
Hyperactive/ impulsive					
	Item 2 – Fidgets	1.51 (.18)	-1.68 (.19)	0.43 (.16)	1.77 (.18)
	Item 4 – Leaves seat	1.54 (.18)	-2.02 (.21)	0.14 (.16)	1.72 (.19)
	Item 6 – Runs about	1.92 (.22)	-2.03 (.22)	0.66 (.18)	2.47 (.23)
	Item 8 – Difficulty playing quietly	1.21 (.16)	-0.04 (.14)	2.43 (.21)	3.91 (.34)
	Item 10 – On the go	1.63 (.19)	-2.61 (.24)	-0.64 (.17)	1.16 (.18)
	Item 12 – Talks excessively	0.61 (.13)	-0.99 (.14)	0.86 (.13)	2.13 (.18)
	Item 14 – Blurts out answers	0.90 (.19)	1.19 (.15)	3.03 (.24)	4.48 (.45)
	Item 16 – Difficulty waiting turn	1.64 (.18)	-2.64 (.25)	0.18 (.16)	1.98 (.20)
	Item 18 – Interrupts/intrudes	1.93 (.23)	-2.45 (.25)	0.72 (.18)	2.43 (.24)

Table 8
Item Information Across Theta Values

Item	-3.0	-2.8	-2.4	-2.0	-1.6	-1.2	-0.8	-0.4	0	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.0
Inattention																	
Item 1 – Fails to attend to details	0.12	0.16	0.26	0.40	0.51	0.56	0.55	0.56	0.62	0.68	0.69	0.62	0.49	0.35	0.22	0.13	0.09
Item 3 – Difficulty sustaining attn.	0.04	0.06	0.13	0.26	0.47	0.72	0.86	0.84	0.81	0.88	0.91	0.81	0.64	0.45	0.27	0.14	0.10
Item 5 – Does not listen	0.12	0.15	0.22	0.30	0.37	0.41	0.42	0.42	0.43	0.45	0.47	0.45	0.41	0.34	0.27	0.20	0.16
Item 7 – Does not follow through	0.11	0.13	0.20	0.29	0.37	0.42	0.43	0.42	0.41	0.43	0.45	0.46	0.43	0.36	0.29	0.21	0.17
Item 9 – Difficulty organizing	0.03	0.04	0.09	0.16	0.29	0.46	0.63	0.72	0.71	0.68	0.67	0.63	0.55	0.44	0.32	0.21	0.16
Item 11 – Avoids sustained effort	0.01	0.01	0.02	0.05	0.09	0.16	0.28	0.44	0.61	0.72	0.71	0.64	0.54	0.43	0.32	0.21	0.17
Item 13 – Loses things	0.04	0.05	0.08	0.12	0.18	0.26	0.35	0.42	0.46	0.47	0.45	0.42	0.38	0.32	0.26	0.20	0.17
Item 15 – Easily distracted	0.11	0.17	0.34	0.60	0.78	0.76	0.70	0.81	1.05	1.15	1.06	0.86	0.60	0.33	0.16	0.07	0.05
Item 17 – Forgetful	0.02	0.02	0.05	0.09	0.16	0.28	0.44	0.61	0.70	0.69	0.62	0.56	0.51	0.43	0.32	0.22	0.17
Hyperactive/Impulsive																	
Item 2 – Fidgets	0.08	0.11	0.17	0.27	0.37	0.47	0.53	0.57	0.59	0.59	0.55	0.47	0.37	0.26	0.16	0.10	0.08
Item 4 – Leaves seat	0.09	0.12	0.20	0.30	0.40	0.49	0.55	0.59	0.62	0.62	0.57	0.48	0.37	0.26	0.16	0.10	0.07
Item 6 – Runs about	0.06	0.08	0.16	0.30	0.49	0.67	0.76	0.79	0.85	0.88	0.83	0.70	0.52	0.33	0.18	0.09	0.07
Item 8 – Difficulty playing quietly	0.04	0.04	0.07	0.10	0.15	0.22	0.28	0.34	0.37	0.38	0.36	0.34	0.32	0.29	0.26	0.22	0.20
Item 10 – On the go	0.11	0.15	0.24	0.35	0.45	0.54	0.62	0.67	0.69	0.66	0.58	0.45	0.31	0.19	0.11	0.06	0.04
Item 12 – Talks excessively	0.07	0.07	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.08
Item 14 – Blurts out answers	0.02	0.02	0.03	0.04	0.05	0.07	0.09	0.12	0.14	0.17	0.19	0.21	0.21	0.21	0.19	0.18	0.17
Item 16 – Difficulty waiting turn	0.13	0.17	0.28	0.39	0.47	0.51	0.55	0.61	0.66	0.68	0.63	0.54	0.42	0.29	0.18	0.10	0.08
Item 18 – Interrupts	0.08	0.11	0.22	0.39	0.58	0.70	0.71	0.73	0.82	0.90	0.86	0.72	0.52	0.32	0.18	0.09	0.06

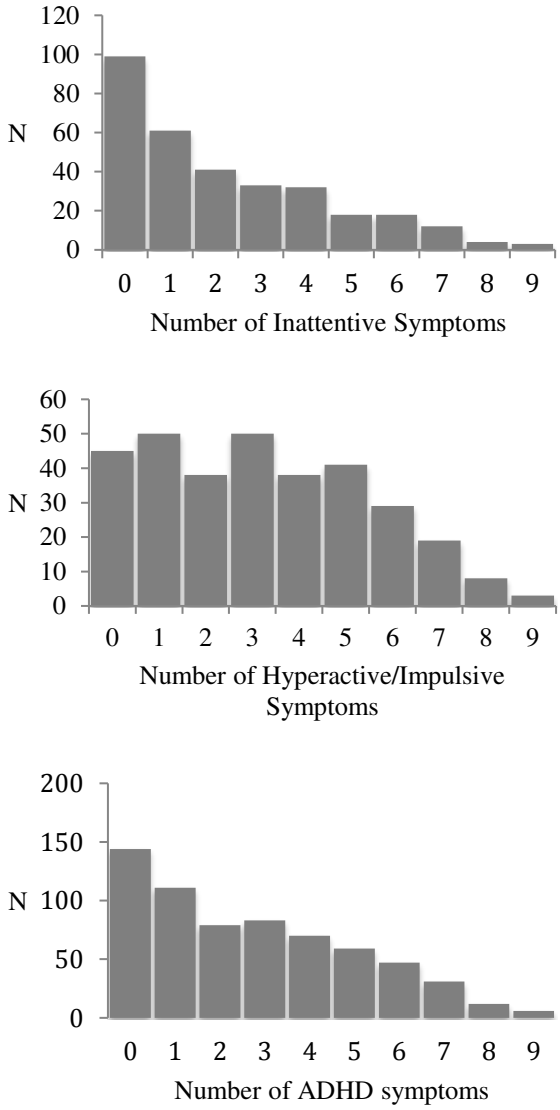

Figure 1. Histograms of ADHD symptom frequency by domain

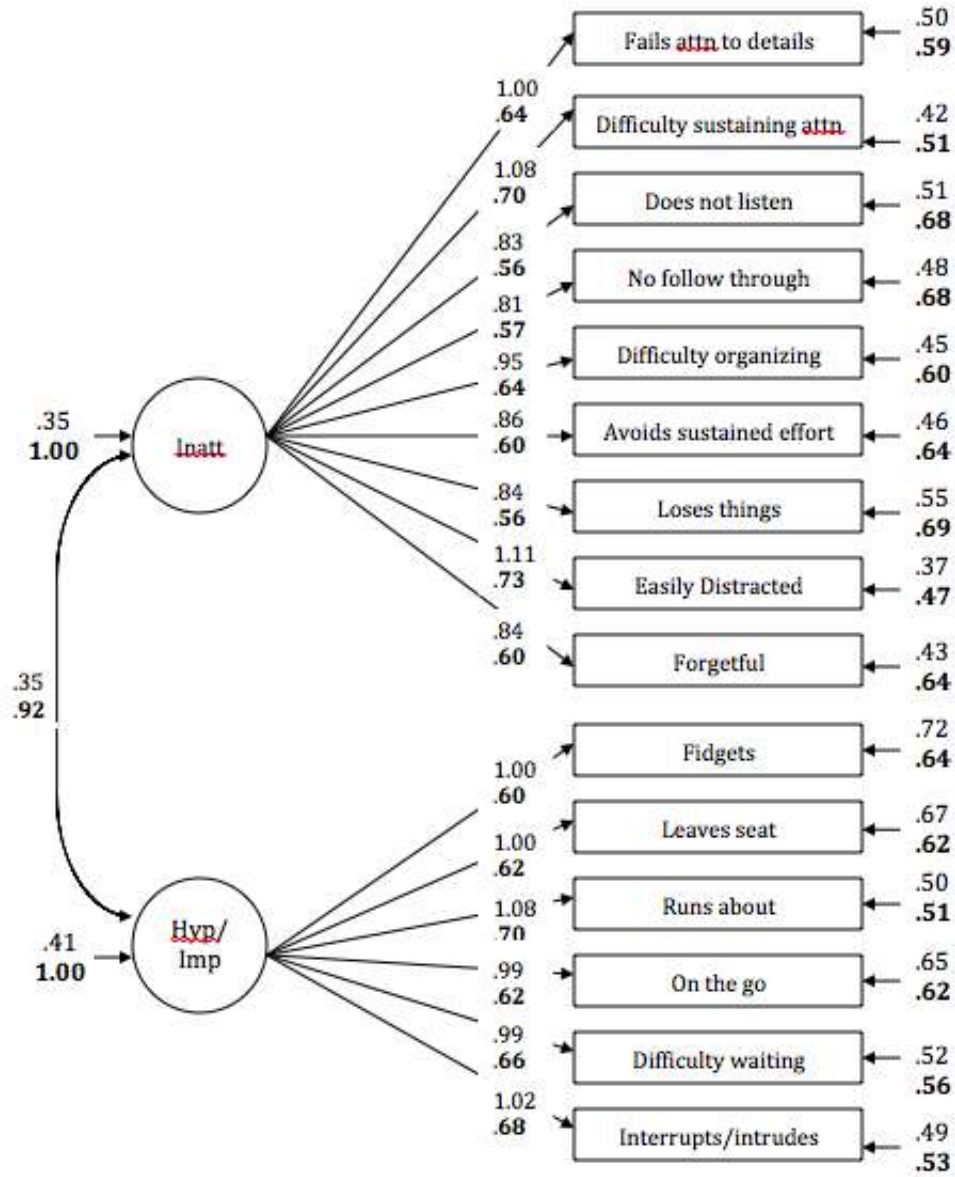

Figure 2. Two-factor model without verbal items. Standardized factor loadings are listed in bold below unstandardized factor loadings. Attn. = attention, Hyp/Imp = hyperactivity/impulsivity

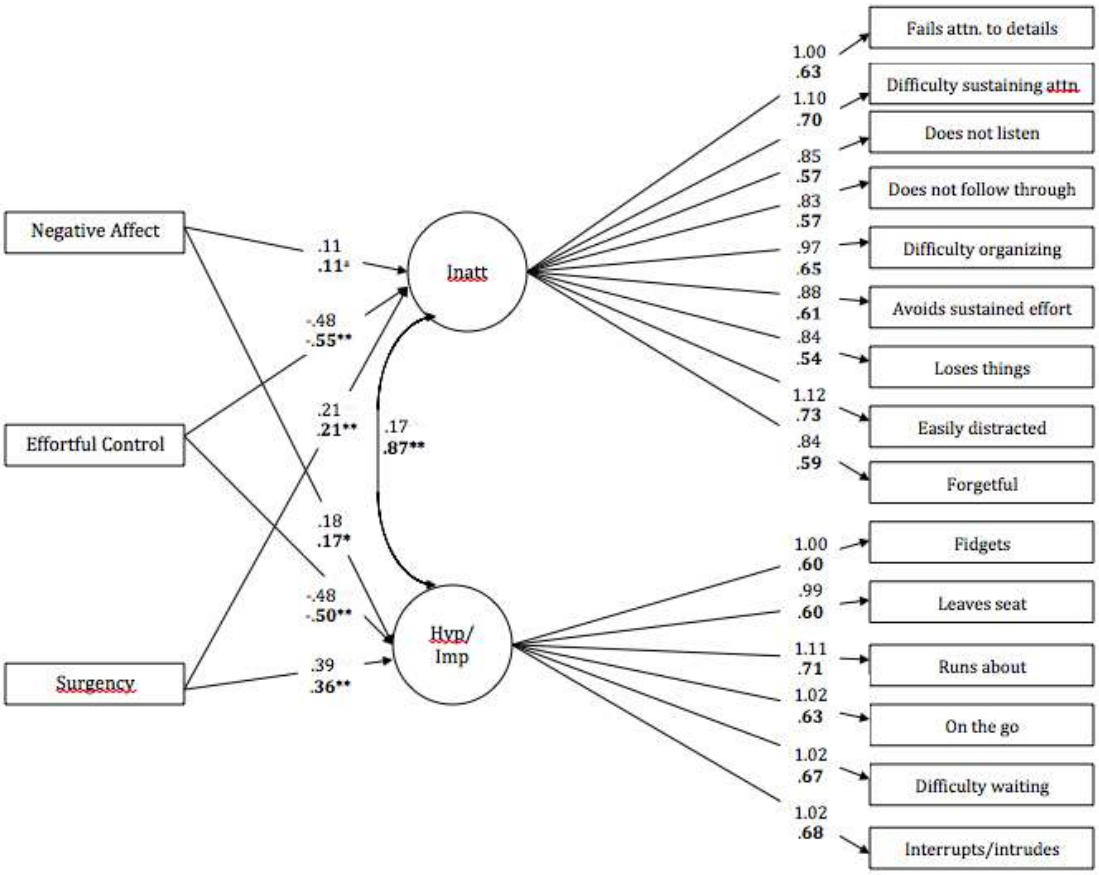

Figure 3. Structural regression model of temperament domains and ADHD symptoms. Standardized factor loadings are listed in bold below unstandardized factor loadings. Variances were estimated but not included here for ease of presentation. $^{**}p < .001$; $^{*}p < .01$; $^{a}p \leq .05$

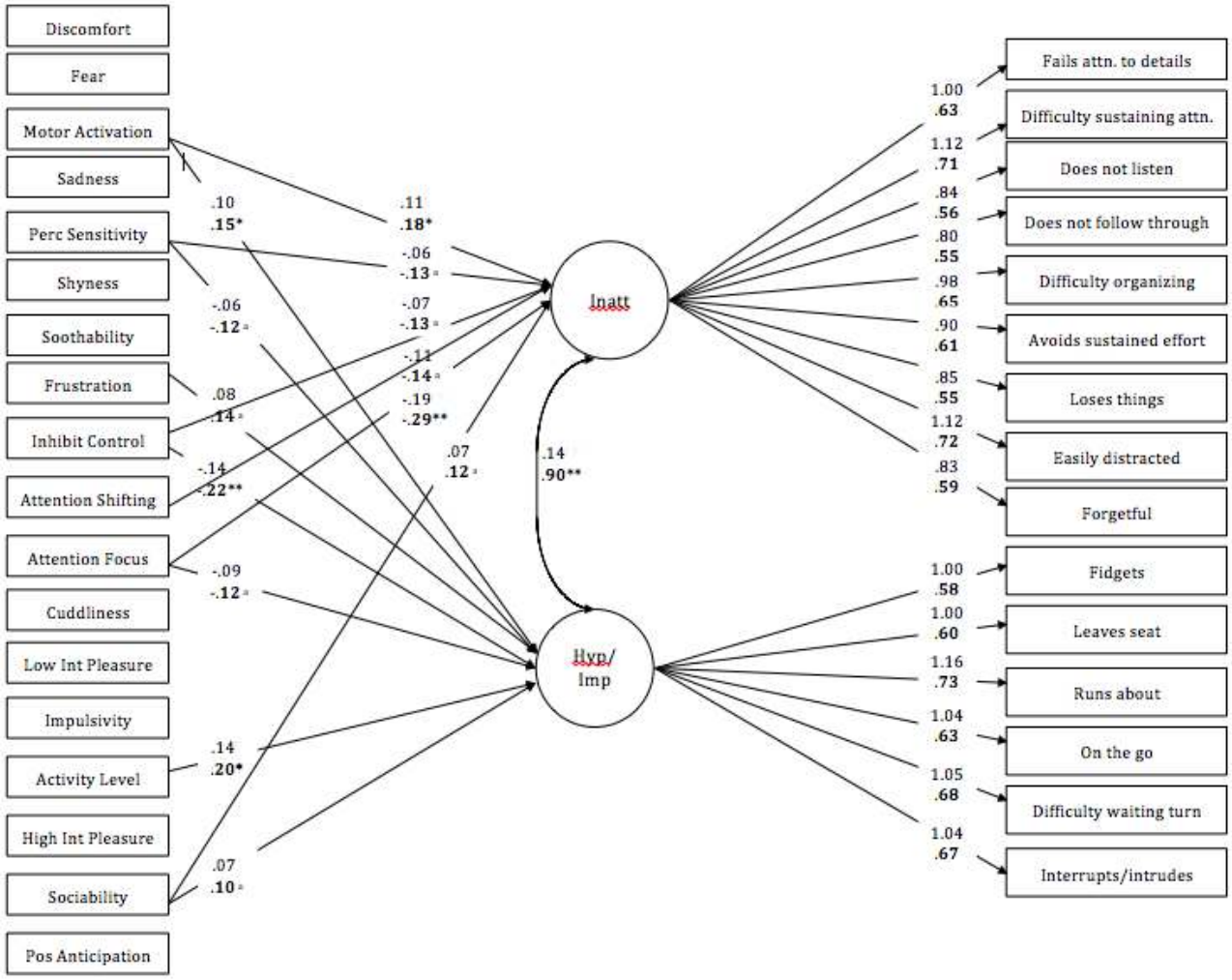

Figure 4. Structural regression model of temperament subscales and ADHD symptoms. Only significant or trending paths displayed. Unstandardized regression weights are listed in bold above standardized weights. Variances were estimated but not included here for ease of presentation. $^{**}p < .001$; $^{*}p < .01$; $^{a}p \leq .05$

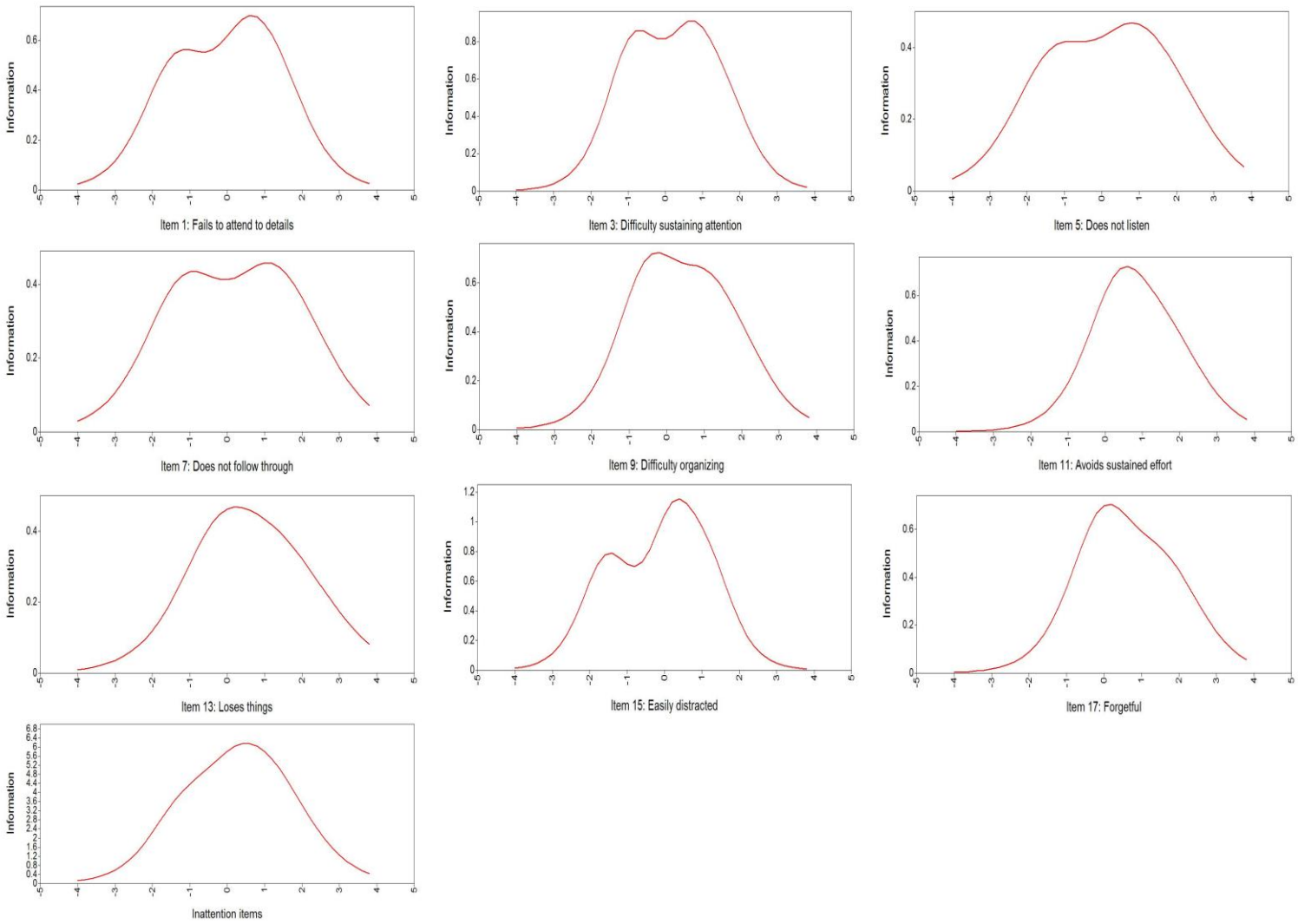

Figure 5. Information functions for inattentive symptoms.

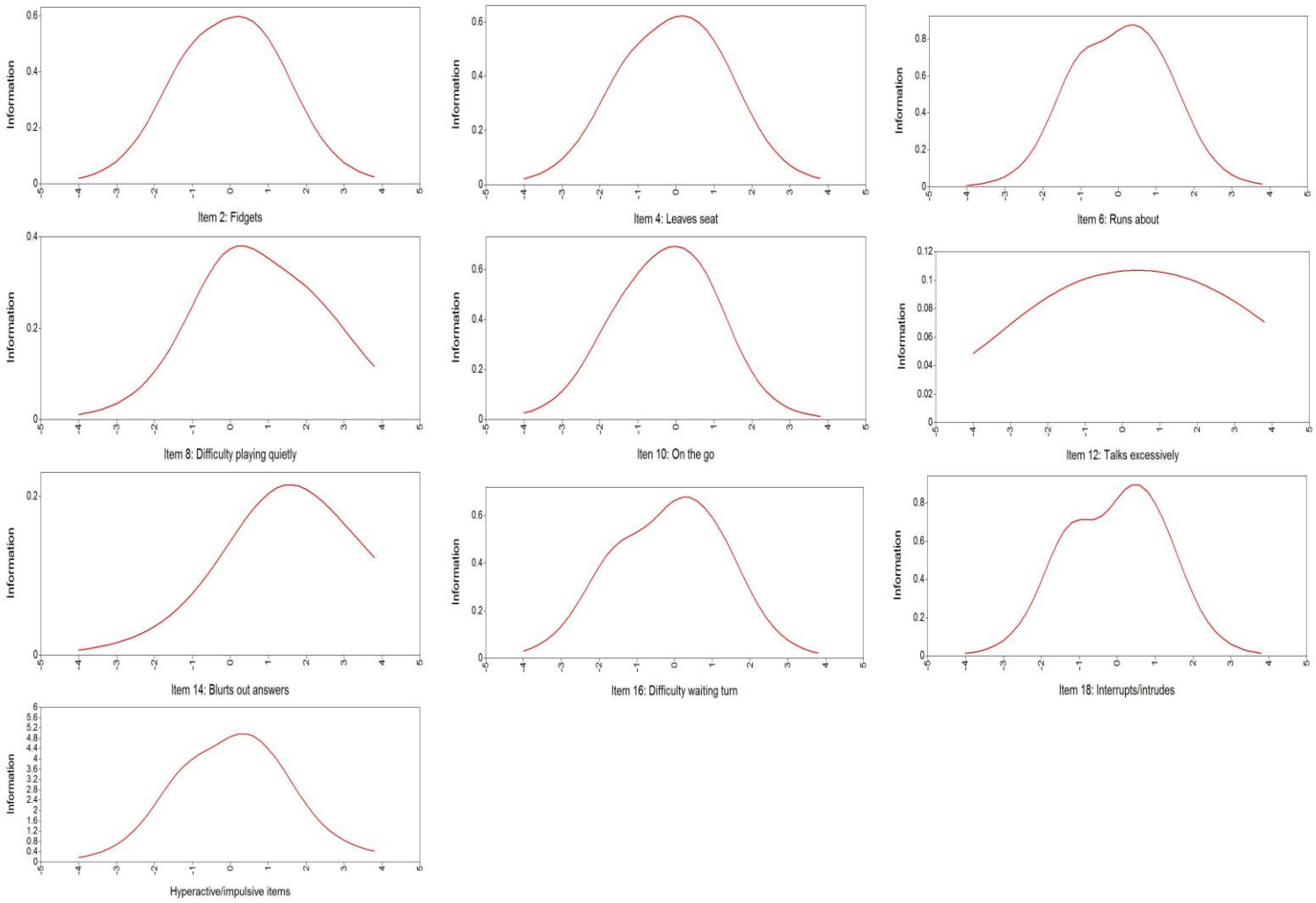

Figure 6. Information functions for hyperactive/impulsive symptoms.

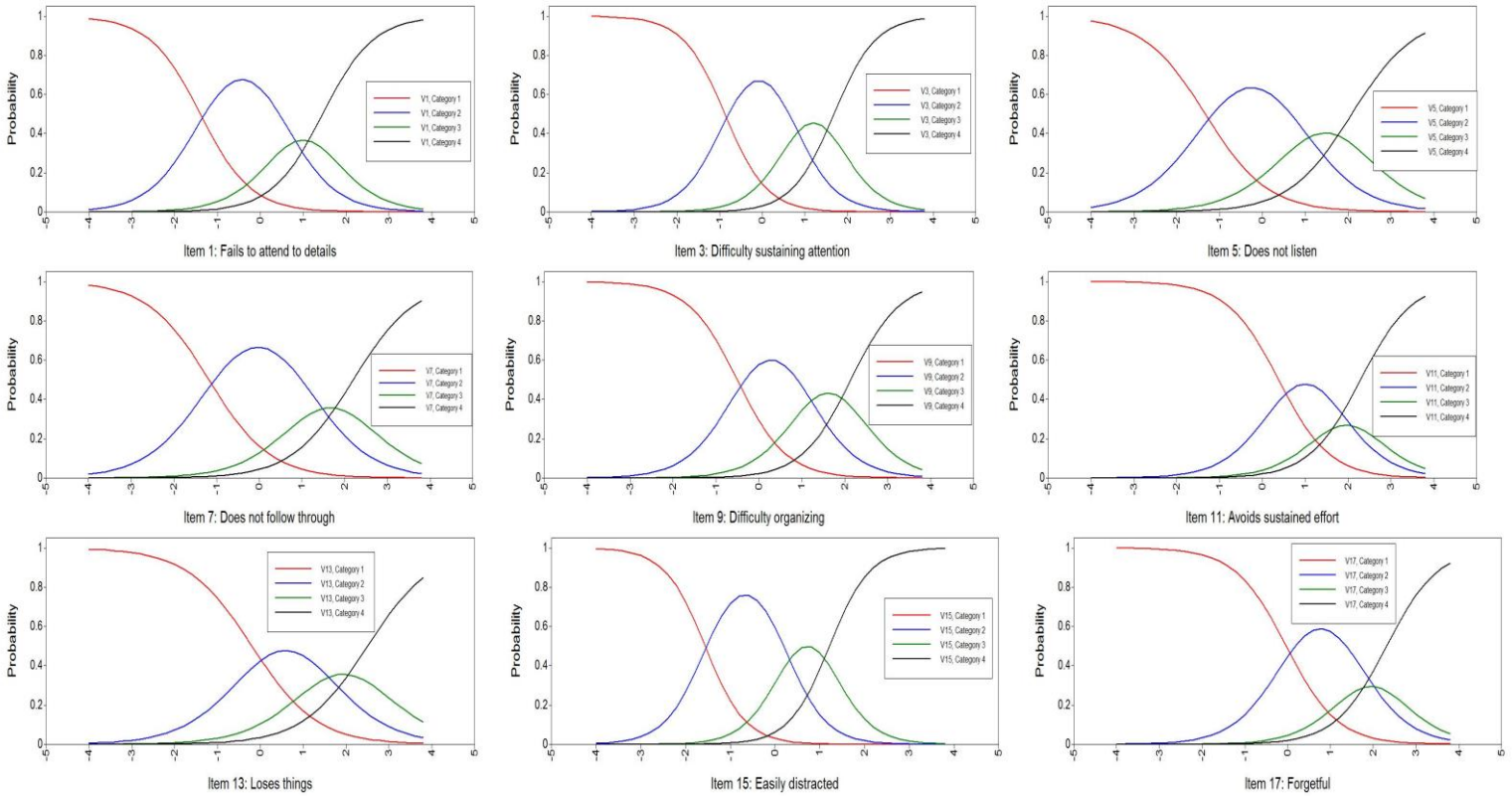

Figure 7. Item Characteristic Curves for Inattentive Items

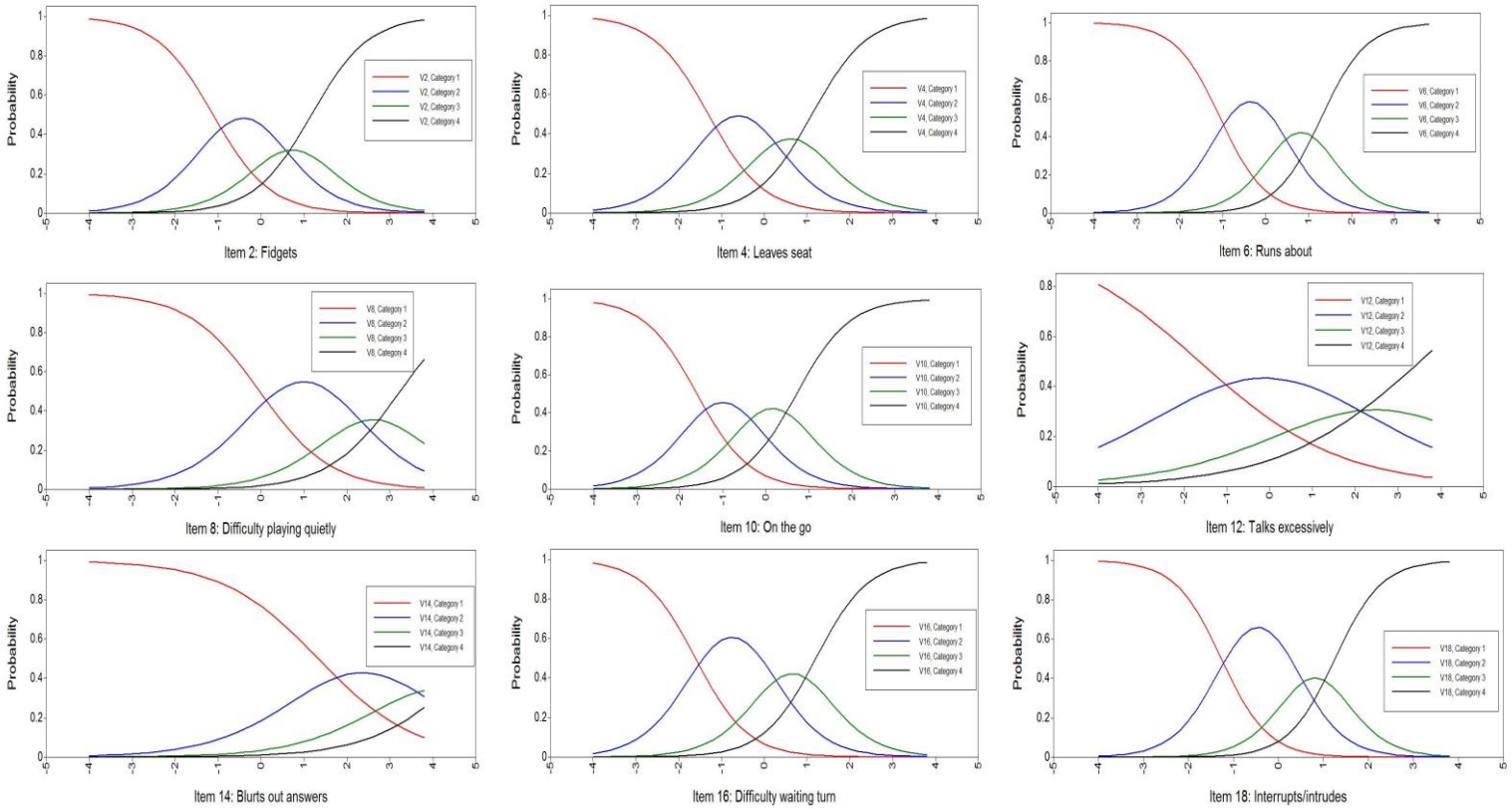

Figure 8. Item Characteristic Curves for Hyperactive/Impulsive Items

APPENDIX
ADHD RATING SCALE – IV, PRESCHOOL VERSION (McGoey et al., 2007)

Circle the number that **best describes** the child's behavior over the past 6 months.

	never or rarely	sometimes	often	very often
1. Fails to give close attention to details (i.e. rushes through activities, makes careless mistakes)	0	1	2	3
2. Fidgets with hands or feet or squirms in seat (taps hands or feet)	0	1	2	3
3. Has difficulty sustaining attention in tasks or play activities	0	1	2	3
4. Leaves seat in classroom, during meals, or in other situations in which remaining seated is expected	0	1	2	3
5. Does not seem to listen when spoken to directly (tunes you out)	0	1	2	3
6. Runs about or climbs excessively in situations in which it is inappropriate	0	1	2	3
7. Does not follow through on instructions and fails to finish tasks (i.e. "go upstairs, get your shoes, and socks;" has difficulty with transitions)	0	1	2	3
8. Has difficulty playing quietly (alone or in groups)	0	1	2	3
9. Has difficulty organizing tasks and activities (i.e., choosing an activity, getting materials, doing steps, in order)	0	1	2	3
10. Is "on the go" or acts as if "driven by a motor"	0	1	2	3
11. Avoids tasks that require sustained mental effort (i.e., puzzles, learning ABC's, writing name)	0	1	2	3
12. Talks excessively	0	1	2	3
13. Loses things necessary for tasks or activities (mittens, shoes, backpack)	0	1	2	3
14. Blurts out answers before questions have been completed	0	1	2	3
15. Is easily distracted	0	1	2	3
16. Has difficulty awaiting turn	0	1	2	3
17. Is forgetful in daily activities(forgets papers, forgets directions)	0	1	2	3
18. Interrupts or intrudes on others	0	1	2	3

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