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Multi-Method Assessment of ADHD Characteristics in Preschool Children: Relations between Measures

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Abstract

Several forms of assessment tools, including behavioral rating scales and objective tests such as the Continuous Performance Test (CPT), can be used to measure inattentive and hyperactive/impulsive behaviors associated with Attention-Deficit/Hyperactivity Disorder (ADHD). However, research with school-age children has shown that the correlations between parent ratings, teacher ratings, and scores on objective measures of ADHD-characteristic behaviors are modest at best. In this study, we examined the relations between parent and teacher ratings of ADHD and CPT scores in a sample of 65 preschoolers ranging from 50 to 72 months of age. No significant associations between teacher and parent ratings of ADHD were found. Parent-ratings of both inattention and hyperactivity/impulsivity accounted for variance in CPT omission errors but not CPT commission errors. Teacher ratings showed evidence of convergent and discriminant validity when entered simultaneously in a hierarchical regression. These tools may be measuring different aspects of inattention and hyperactivity/impulsivity.

Keywords

Preschool; Inattention; Hyperactivity/Impulsivity; Continuous Performance Test; Behavioral Rating Scales

Despite substantial research on the neurological, genetic, and environmental causes of Attention Deficit/Hyperactivity Disorder (ADHD), no one factor has been identified as the primary cause of the disorder. Furthermore, researchers have posited theories of multiple pathways to ADHD, which may preclude the discovery of a single definitive test for identifying ADHD. As such, it is likely that high-quality ADHD diagnostic procedures will always benefit from a combination of informant ratings, background information (e.g., school records), and neuropsychological tests.

ADHD is characterized by three distinct forms of problem behaviors: inattention, hyperactivity, and impulsivity (American Psychological Association, 2000). Inattention refers to difficulties focusing and ignoring distractions. Hyperactivity is represented by difficulties with behaviors such as remaining still and engaging in a single activity for

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extended periods of time. Impulsivity is characterized by behaviors such as often interrupting and intruding during social interactions and academic situations. To warrant a diagnosis of ADHD, these symptoms must be causing the child impairment in two or more settings, which may include school or preschool. However, research has shown that behaviors associated with ADHD relate to the development of academic skills (Lonigan et al., 1999) and social development (Rydell, Diamantopoulou, Thorell, & Bohlin, 2009) even in samples that include children without clinically elevated levels of these behaviors.

Some common tools that have been used in practice and research to measure inattentive and hyperactive/impulsive behaviors include behavioral rating scales that are completed by individuals who interact often with the child and objective tasks such as the Continuous Performance Test (CPT). However, each assessment tool has limitations and drawbacks; no single tool has been identified as a “gold standard” for determining the presence of ADHD-characteristic behaviors. Although informant rating scales and objective tests both have been used to measure ADHD-characteristic behaviors, research has demonstrated generally low to moderate correlations between scores on each of these measures in school-age children (e.g., Achenbach, McConaughy, & Howell, 1987). Even less is known regarding the relations between these measures in preschool children. Given the recognized link between behavior problems in preschool and later elementary school (e.g., Willcutt & Pennington, 2000), efforts to measure effectively ADHD-characteristic behaviors in preschool and use these measures to predict the course of symptomatology have recently increased (Lahey, Pelham, Loney, Lee, & Willcutt, 2005; Re & Cornoldi, 2009). A greater understanding of the tools used to assess ADHD in school-age children is needed for preschool populations. The purpose of this study was to examine the overlap between parent-ratings of ADHD, teacher-ratings of ADHD, and CPT scores in a preschool sample and determine the convergent and discriminant validity across these measures.

Behavioral Ratings

Parent-ratings—Parents often have the most contact with clinicians and, thus, serve as a valuable resource for providing information. However, several characteristics of parent-ratings raise concerns regarding possible biases. Given the heritability of ADHD (e.g., Epstein et al., 2000), many parents of children with the disorder may also be afflicted. Parental symptomatology may impact ratings, which could compromise the validity of parent-ratings (Sayal & Taylor, 2005). Compared to other informants, parents also tend to report more symptomatology in children (Re & Cornoldi, 2009). This raises concerns of potential over-reporting of symptoms by parents.

Given the need to verify the presence of symptoms in multiple settings to diagnosis ADHD, parents may be asked to report on their child's school behavior if contacting the teacher is inconvenient. However, Sayal and Taylor (2005) found that when comparing parent-ratings of school and home behavior and teacher-ratings of school behavior, parent-ratings of school behavior correlated more strongly with parent-ratings of home behavior than with teacher-ratings of school behavior. This suggests that parents do not accurately infer how a child behaves in school and most likely base their ratings on the child's behavior at home. Parent reports of school behavior also would be secondhand through information gained from teachers and, therefore, may vary in part as a function of the degree and quality of contact between parent and teacher. These factors may become problematic when attempting to assess the pervasiveness of a disorder using only parent report. This suggests that an understanding of children's manifestation of the ADHD characteristics across domains requires additional informants.

Teacher-ratings—Problems in school are often the primary reason behind referrals for ADHD treatment (Loe & Feldman, 2007), making teachers important informants of children's behavior. Teachers are sometimes considered ideal informants for behavioral reports because they interact with children over long periods of time in a wide range of settings that vary in structure (e.g., Evans, Allen, Moore, & Strauss, 2005). Furthermore, teachers interact with many children of the same age, giving them a better reference point for making decisions regarding what behaviors should be deemed atypical. Correlations between teacher-ratings at different times and concurrent agreement between individuals with teacher roles (e.g., teachers and teacher's assistants) have been shown to be high (Loughran, 2003).

Although teacher-ratings are widely used in the assessment of ADHD-characteristic behaviors, this method of evaluation is not without criticism. Compared to assessments conducted by examiners from outside of the classroom, assessments of educational outcomes conducted by teachers contain a large proportion of assessor-level variance, raising concerns that teacher-level factors influence assessment scores (Waterman, McDermott, Fantuzzo, & Gadsden, in press). Concerns related to extraneous factors that may impact teacher assessments are magnified when considering behavioral problems, for which there is no “gold standard” for determining accuracy. Several potential biases have been noted in the literature. Just as parents tend to report higher levels of behavior problems than do teachers, teachers have been shown to report higher levels of behavior problems than do trained observers (Phillips & Lonigan, 2010), suggesting that teachers also may engage in over-reporting. There is evidence that teachers may be more likely to identify minority students, compared to non-minority students, as exhibiting hyperactive/inattentive behavior (Nolan, Gadow, & Sprafkin, 2001). These findings indicate that factors other than observed child behavior may affect teachers' ratings. Furthermore, the stability of cross-grade teacher-ratings of clinically significant inattentive behaviors has also been shown to be low (Rabiner et al., 2010), making the utility of teacher-ratings for predicting future behavior questionable.

Teachers' abilities to differentiate ADHD behaviors from symptoms of other disorders also have been challenged. Findings in several studies (e.g., Abikoff, Courtney, Pelham, & Koplewicz, 1993) have demonstrated that teachers often rate children with Oppositional Defiant Disorder (ODD) as having elevated levels of inattention and hyperactivity even when no behaviors directly indicative of these symptoms have been displayed. This bias, referred to as the *halo effect*, appears to be bi-directional such that teachers also rate children with ADHD characteristics with elevated oppositional scores (Hartung et al., 2010). These findings suggest a bias that may inflate teacher-ratings of ADHD in children with other comorbid behavior problems.

Discrepancies between informants—Although multiple informants are used often for diagnostic purposes, there is a growing body of literature suggesting only modest associations between parent and teacher ratings of ADHD (Collett, Ohan, & Myers, 2003). Low inter-rater agreement is found not only for clinical elevations of ADHD-characteristic behaviors, but also for parent and teacher ratings of more general behavior problems and social skills (Winsler & Wallace, 2002). Observed statistical relations may vary somewhat depending on the unit and method of analysis. For example, analysis of data conducted dimensionally, rather than categorically, produces results with higher estimates of parent-teacher agreement (Mitsis, McKay, Schulz, Newcorn, & Halperin, 2000). Furthermore, parent- and teacher ratings of ADHD-characteristic behaviors are similar in that both typically rate boys as exhibiting more problematic behaviors than girls (Newcorn et al., 2001). Still, correlations between raters are generally low in school-age samples. Research with preschoolers has also shown low correlations between teacher and parent ratings of

each symptom domain (Murray et al., 2007). Taken together, these findings suggest that there are inconsistencies across informants.

Discrepancies between informant ratings have created controversy regarding which informant is better at predicting diagnosis. In a study by Power et al. (1998), teacher-ratings of inattention and hyperactivity demonstrated better predictive validity than parent ratings for determining the presence or absence of an ADHD diagnosis as determined by a multi-method assessment battery including a diagnostic interview. However, the associations for both parent and teacher ratings ranged from only low to moderate. This study also found that teacher ratings were generally more useful than parent ratings for distinguishing between subtypes (e.g., primarily inattentive, primarily hyperactive/impulsive, combined inattentive and hyperactive) of children with ADHD. Other studies have found similar results (e.g., Owens & Hoza, 2003), although at least one study has found conflicting results showing that parent-ratings yielded more powerful subtype differentiation (DuPaul et al., 1998). The high sensitivity of parent-ratings supports their use as screening measures. However, the low specificity suggests that further inquiry is needed to minimize false positives (Tripp, Schaughency, & Clarke, 2006).

Although teacher ratings are often seen as a valid source of information for determining the presence of ADHD-characteristic behaviors because of teachers' extensive experiences with children, some evidence has suggested that combining ratings from both teachers and parents is optimal for predicting diagnosis compared to relying on either rater alone (Power et al., 1998). This indicates that each informant may provide useful, but distinct, information regarding symptomatology. However, the discrepancies between raters brings to light the question of how each of these informant ratings relates to objective measures that are presumed to measure inattentive and hyperactive/impulsive behaviors without the problem of subjective bias.

Continuous Performance Tests

Given concerns regarding bias and the common inter-rater disagreement found between informant ratings, measures that objectively assess behaviors associated with ADHD are of interest to circumvent subjective bias. Objective measures provide an opportunity to support or disconfirm the subjective ratings made by informants. The CPT is a computer-administered tool that has been reported to assess inattentive and hyperactive/impulsive behaviors. Originally developed to test for severe brain damage (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956), the CPT requires individuals to view a stimulus sequence on a screen while responding to target stimuli and withholding responses to non-target stimuli.

Several versions of CPTs exist that vary in stimulus presentation and complexity, making them more or less suitable for young children. Variations include the stimulus' time interval on the screen and the time interim between displayed stimuli, types of stimuli, and task complexity. Simpler CPT versions require a response if a certain stimulus is presented, whereas complex versions require a response to a target stimulus contingent on whether it follows another particular stimulus. These versions of the task, such as the original A-X task (Rosvold et al., 1956), contain a working memory component that may exceed the cognitive abilities of preschoolers. Generally, both preschoolers and school-age children commit more errors on complex tasks than on simple tasks (Oades, 2000). The original task also uses letters as stimuli, creating a concern that facility with letters may affect performance and confound results (McGee, Clark, & Symons, 2000). These concerns precipitated the creation of CPTs, such as the Test of Variables of Attention (T.O.V.A.; Greenberg, Kindschi, Dupuy, & Hughes, 1993), that are designed to have minimal language demands. Across different CPT versions, performance tends to vary as a function of age such that younger children generally produce more errors (Lin, Hsiao, & Chen, 1999). Gender differences have also

been found, but may vary as a function of the CPT versions. Boys make more errors than do girls on typical versions of the CPT (Greenberg & Waldmant, 1993), but girls make more errors than do boys when processing demands are added to the task (e.g., CPTs with visually degraded stimuli; Lin et al., 1999).

Utility of the CPT—A large body of research demonstrates the usefulness of the CPT for differentiating individuals with ADHD from controls in school-age samples (e.g., Oades, 2000). The CPT has also been found to have adequate test-retest reliability across a range of time spans (time elapsed = 4.8 months, *r*s = .65 to .74; time elapsed = one week, *r*s = .74 to .87; time elapsed = 90 minutes, *r*s = .70 to .87) and adequate split-half reliability (*r*s = .67 to .92) comparing performance on the 1st and 4th quarter blocks of the task to performance on the 2nd and 3rd blocks of the task (Halperin, Sharma, Greenblatt, & Schwartz, 1991; Leark, Wallace, & Fitzgerald, 2004). However, despite the adequate psychometric properties of the test and almost ubiquitous findings of abnormal performance by children with ADHD on CPTs, its utility as a primary diagnostic tool is weak (Nigg, Hinshaw, & Halperin, 1996) and its negative predictive power is low (Grodzinsky & Barkley, 1999). Although abnormal performance on the CPT indicates a high likelihood of an ADHD diagnosis, many children who are diagnosed with ADHD are able to obtain non-elevated scores on the test, making it insufficient for diagnosing ADHD.

Researchers' attempts to ascribe a particular performance characteristic to specific subtypes also are inconsistent and sometimes contradictory. An omission error, which occurs when the child fails to respond to a target stimulus, is presumed to indicate inattention. A commission error, which occurs when the child responds to a non-target stimulus, is presumed to measure hyperactivity/impulsivity. Many studies have assumed this view; however, many studies also report that that these error types are not related to symptom dimensions in hypothesized ways (Chhabildas, Pennington, & Willcutt, 2001) or relate indiscriminately to both types of symptomatology (Epstein et al., 2003).

Discrepancies between informant reports and CPTs—Research with older children often demonstrates inconsistent relations between the CPT and informant ratings of ADHD-characteristic behavior. Egeland, Johansen, and Ueland (2009) found that commission errors on the Conners' Continuous Performance Test (C-CPT; Conners, 2002) showed no significant relation to parent- or teacher-rated ADHD behaviors in a sample of school-age children. Omission scores were significantly correlated with both parent and teacher ratings of inattention and only with parent ratings of hyperactivity. A study by McGee et al. (2000) failed to demonstrate any significant relations between overall scores on the C-CPT and parent and teacher ratings of ADHD. Omission errors were modestly related to teacher-ratings of hyperactivity--a result inconsistent with the hypothesis that omission errors specifically relate to poor attention. Epstein et al. (2003) examined the relations with item-level data of parent ratings and found similar inconsistencies. Stronger relations between CPT parameters and informant ratings are found when parent and teacher ratings are combined as composite variables (Avila, Cuenca, Felix, Parcet, & Miranda, 2004). However, the use of a composite score precludes the ability to inspect the unique associations for each observer. Taken together, these results indicate that in school-age samples, relations between objective measures and informant ratings of ADHD-characteristic behaviors are weak and inconsistent.

In analyses that examine ADHD-characteristic behaviors, several factors also associated with these constructs warrant consideration. For example, cognitive ability has been shown to impact performance on CPT-type tasks (Weyandt, Mitzlaff, & Thomas, 2002). Younger children typically produce more errors on the CPT (Lin et al., 1999) and are generally rated as having higher levels of inattentive and hyperactive/impulsive behaviors (Lahey et al.,

2005) compared to older children, making age a relevant factor. Studies examining gender differences often find boys to be rated as exhibiting higher levels of ADHD-characteristic behaviors (e.g., Gershon & Gershon, 2002). Finally, socio-economic status (SES) may also influence the associations between measures of inattentive and hyperactive/impulsive behavior given that ADHD has been shown to relate to SES (Offord et al., 1987). Consequently, these potentially confounding factors should be controlled for when analyzing the relations between measures of ADHD-characteristic behaviors.

Summary and Purpose

Several forms of assessment are used to assess ADHD-characteristic behaviors, each with its own strengths and weakness. Although these assessment tools all are presumed to measure inattentive and hyperactive/impulsive behaviors, research has demonstrated low correlations between these measures. Few studies examine all three of these tools within the same sample, making it possible to examine convergent and discriminant validity across the measures, and none have done so in preschoolers, a population increasingly targeted for ADHD assessment and intervention. The purpose of this study was to examine the convergence and divergence between teacher ratings of ADHD, parent ratings of ADHD, and CPT performance in preschool children. Although evidence regarding the convergent and discriminant validity of each of these measures is mixed, we based our hypotheses on the conceptualizations of each measure as presented in the literature. It was expected that teacher-ratings and parent-ratings of inattention would be associated significantly with each other and with omission errors on the CPT. Teacher ratings of hyperactivity/impulsivity and parent-ratings of hyperactivity/impulsivity were expected to be associated with each other and with commission errors on the CPT.

Method

Participants

Participants included 65 preschoolers from a larger study designed to identify characteristics of children who do and do not go on to develop serious problems in learning to read. Children were recruited from 10 preschools in Northeast Florida. Informed consent was obtained by parents prior to their children's participation in the project. Participants included the children from this larger study who completed the CPT, whose teachers completed the Conners' Teacher Rating Scale (CTRS-44), and whose parents either completed a paper version of the CTRS-44 or were reached by phone to complete a 15-item version of the scale. Of the 65 children, 83.08% were identified as European American, 6.15% African American, and 4.62% were of “other” ethnic backgrounds. Four parents (6.15%) did not provide this information. The sample was comprised of 56.7% females. Participants ranged in age from 50 to 72 months of age (M = 57.72, SD = 6.98). Based on parents' reports, yearly family income ranged from $5,000 to greater than $125,000 with a median income range of $41-50,000. Income information was only available for 83.1% (n = 54) of the sample because 11 parents either did not return the parent survey or did not answer the question regarding income. Because income was used as a measure of SES, missing values were replaced with the median income of each child's respective preschool.

Measures

Conners' Teacher Rating Scale 15-Item (CTRS-15)—The CTRS-15 (Purpura & Lonigan, 2009) is a revised version of the CTRS-R (Conners, 1997) that includes five items corresponding to inattention (e.g., “short attention span”) and five items corresponding to hyperactivity/impulsivity (e.g.,“ restless, always on the go”). The Conners' rating scales have been widely used for several decades to assess the presence of problem behaviors in children and have been shown to have good sensitivity (78%) and specificity (91%) for

distinguishing children with ADHD from those without the disorder (Conners, 1997). The CTRS-15 was designed using item-response theory (IRT) to include the items of the CTRS-R that were appropriate for preschool children and most indicative of overall levels of inattention and hyperactivity/impulsivity in a preschool sample. Purpura and Lonigan showed that the CTRS-15, although brief, was psychometrically similar to the Conners' Teacher Rating Scale: Revised Short Form (Conners, 1997) and the CTRS hybrid version (i.e., the CTRS-44; see Gerhardstein, Lonigan, Cukrowicz, & McGuffey, 2003). They also found that this scale demonstrated criterion validity in that it significantly correlated with other informant-report measures of ADHD.

Continuous Performance Test (CPT; Rosvold et al., 1956)—This task has been utilized in research as an objective measure of children's inattentive and impulsive behaviors that are characteristic of ADHD. It is a computer-based task in which pictures of objects are displayed on a screen and the child is asked to press a button “as fast as you can” when the target image (a fish) appears on the screen. Responses are recorded in terms of reaction time, omission errors, and commission errors. This test has been shown to have adequate split-half reliability (*r*s = .67 to .92) and test-retest reliability (average time elapsed = 4.8 months; *r*s = .65 to .74) in terms of measuring sustained attention and impulsivity (Halperin et al., 1991). Split-half reliability for the current sample, comparing the 1st and 4th blocks of performance to the 2nd and 3rd blocks of performance, was good for omission errors (*r* = .84) and just below adequate for commission errors (*r* = .67).

Stanford-Binet Intelligence Scale Fourth Edition (Thorndike, Hagen, & Sattler, 1986)—The Copying subtest of the Stanford-Binet IV was used as a proxy for non-verbal cognitive ability. This test is comprised of 28 items. The first 12 items require the child to duplicate the examiner's design made from blocks. The final 16 items require the child to copy designs from drawings in the administration book. Overall, non-verbal subtests of the Stanford Binet have been shown to have high reliability (αs > .90) and adequate validity for children ages 2-5 years of age.

Procedure

The 44-item Conners' Teacher Rating Scale was completed by each participant's preschool teacher. The 44-item CTRS was also sent home to the parents of each participant. However, 27% of the sample's parents did not return the questionnaire and were contacted by phone. These parents were administered the CTRS-15, which was read to the parent as a part of a larger parent survey. The research assistants were trained to read the questionnaire word for word and to not rephrase the item even if the parent asked for clarification. The CPT and Copying subtest were completed by each child under the supervision of a research assistant who was trained to administer the tasks in a standardized fashion.

Results

Hyperactivity/Impulsivity and Inattention subscale scores were created based on the IRT analysis reported by Purpura and Lonigan (2009). Descriptive statistics for raw scores are presented in Table 1. Given that age is related to CPT performance and overall levels of ADHD-characteristic behavior, age-standardized scores for each subscale were computed by regressing raw scores on age. Outliers were identified as those values outside two inter-quartile ranges from the median. Outliers were corrected by changing their values to the respective limit, two interquartile ranges either above or below the median. Generally, the correction of outliers resulted in more conservative estimates of beta weights. To reduce the influence of outliers on significance levels, all analyses reported refer to data examined with corrected outliers. Following age-standardization and the correction of outliers, all measures

continued to evidence significant positive skew. Logarithmic transformations were utilized to correct for the non-normality in the data. Parent-ratings of inattention (α = .78) and hyperactivity/impulsivity (α = .79) demonstrated adequate reliability. Teacher-ratings of inattention (α = .87) and hyperactivity (α = .90) demonstrated good reliability. CTRS scores did not differ between children whose parents completed the pencil-paper versus phone versions (*p*s > .16).

Zero-order correlations between variables are shown in Table 1. Examination of the correlations between indices of inattention and hyperactivity/impulsivity across each method of assessment revealed no significant correlations between teacher and parent ratings of either inattention or hyperactivity/impulsivity. Although indices from the CPT were related significantly to the parent-ratings, these relations were not specific to the hypothesized indices/subscales. That is, omission errors were related to parent-ratings of both inattention and hyperactivity/impulsivity. Teacher-ratings of hyperactivity/impulsivity were not correlated with CPT errors. The correlation between teacher ratings of inattention and hyperactivity/impulsivity was statistically significant. The correlation between parent-ratings of inattention and hyperactivity/impulsivity also was statistically significant. However, the correlation between CPT omission errors and CPT commission errors was not significant.

Given the significant overlap of scores within rater, a series of hierarchical multiple regressions was conducted to examine the unique relations between variables across score type (i.e., teacher, parent, CPT). A summary of these analyses is shown in Table 2. All models included income, sex, and non-verbal cognitive abilities in step 1 as control variables; however, their inclusion did not change the relations between other variables in the models. The models examined the unique relations of teacher- or parent-ratings of inattention, hyperactivity, or both with the control variables in the models. The models with each subscale entered alone as a predictor in step 2 (see rows 2a, 2b, 3a, and 3b in Table 2) allowed us to examine the relations between each variable when accounting only for the control variables. The models with both subscales for each informant entered simultaneously (see rows 2c and 3c in Table 2) allowed us to determine the unique contribution of ratings of inattention and hyperactivity/impulsivity while accounting for the high within-informant overlap between the two subscales.

Teacher-ratings of ADHD

Results for teacher-rated inattention are shown in the first column in Table 2. Control variables accounted for 14% of the variance, $F(3, 64) = 3.28$, $p < .03$. Teacher-rated hyperactivity/impulsivity entered alone in step 2 (row 2b) produced a significant change in the amount of variance accounted for in teacher-rated inattention, $\Delta R^2 = .33$, $\Delta F = 36.57$, $p < .001$, $F(4, 64) = 13.04$, $p < .001$. Neither parent-rated inattention nor parent-rated hyperactivity/impulsivity accounted for significant additional variance in teacher-rated inattention when entered separately (rows 3a and 3b in Table 2, respectively) or when entered simultaneously (row 3c in Table 2).

Results for teacher-rated hyperactivity/impulsivity are shown in the second column of Table 2. Control variables accounted for 3% of the variance, $F(3, 64) = 0.72$, $p = .54$. Teacher-rated inattention, entered alone in step 2, produced a significant change in the amount of variance accounted for in teacher-ratings of hyperactivity/impulsivity, $\Delta R^2 = .37$, $\Delta F = 36.57$, $p < .001$, $F(4, 64) = 10.00$, $p < .001$. Parent-rated inattention, parent-rated hyperactivity/impulsivity, and both variables entered simultaneously did not account for significant additional variance in teacher-rated hyperactivity/impulsivity.

Parent-ratings of ADHD

Results for parent-rated inattention are shown in the third column of Table 2. Control variables accounted for 10% of the variance, $F(3, 64) = 2.31$, $p = .08$. Parent-rated hyperactivity/impulsivity, entered alone in step 2, produced a significant change in the amount of variance accounted for in parent-rated inattention, $\Delta R^2 = .17$, $\Delta F = 13.95$, $p < .001$, $F(4, 64) = 5.90$, $p < .01$. Teacher-rated inattention, teacher-rated hyperactivity/impulsivity, and both variables entered simultaneously did not account for significant additional variance in parent-rated inattention.

Results for parent-rated hyperactivity/impulsivity are shown in the fourth column of Table 2. Control variables accounted for 7% of the variance, $F(3, 64) = 1.54$, $p = .21$. Parent-rated inattention, entered alone in step 2, produced a significant increase in the amount of variance accounted for in parent-rated hyperactivity/impulsivity, $\Delta R^2 = .18$, $\Delta F = 13.94$, $p < .001$, $F(4, 64) = 4.88$, $p < .01$. Teacher-rated inattention, teacher-rated hyperactivity/impulsivity, and both variables entered simultaneously, did not account for significant additional variance in parent-rated hyperactivity/impulsivity.

CPT outcomes

Results for omission errors on the CPT are shown in the fifth column of Table 2. Control variables accounted for 2% of the variance, $F(3, 64) = 0.46$, $p = .71$. Neither teacher-rated inattention nor teacher-rated hyperactivity/impulsivity accounted for significant additional variance in CPT omission errors when entered alone in step 2. When entered simultaneously, however, teacher-rated inattention and hyperactivity/impulsivity produced a significant change in the amount of variance accounted for in CPT omission errors, $\Delta R^2 = .14$, $\Delta F = 5.14$, $p < .01$, $F(4, 64) = 2.37$, $p < .05$, and both variables were significant unique predictors. Both parent-rated inattention, $\Delta R^2 = .07$, $\Delta F = 4.47$, $p < .05$, $F(4, 64) = 1.48$, $p = .22$, and parent-rated hyperactivity/impulsivity, $\Delta R^2 = .07$, $\Delta F = 4.80$, $p < .05$, $F(4, 64) = 1.56$, $p = .20$, accounted for significant additional variance in CPT omission errors when entered separately in step 2. When both parent-rated inattention and parent-rated hyperactivity/impulsivity were entered simultaneously, they accounted for a significant amount of additional variance in CPT omission errors, $\Delta R^2 = .10$, $\Delta F = 3.27$, $p < .05$, $F(5, 64) = 1.60$, $p = .17$; however, neither were significant unique predictors when both were included in the model simultaneously. The overall models with parent-ratings as predictors and CPT omission errors as the predicted outcome were all non-significant.

Results for CPT commission errors are shown in the sixth column of Table 2. Control variables accounted for 6% of variance, $F(3, 64) = 1.25$, $p = .30$. Teacher-rated inattention, teacher-rated hyperactivity/impulsivity, and both entered simultaneously did not account for significant additional variance in CPT commission errors. Parent-rated inattention, parent-rated hyperactivity/impulsivity, and both entered simultaneously also did not account for a significant amount of additional variance in CPT commission errors.

Discussion

The purpose of this study was to examine how teacher ratings, parent ratings, and objective measures of inattentive and hyperactive/impulsive behaviors relate in a preschool sample, both accounting for and not accounting for the high within-informant overlap in ratings of each behavior. The results of this study highlight the inconsistencies between assessments used to measure inattentive and hyperactive/impulsive behaviors. Despite using the same items to identify children as exhibiting hyperactive/impulsive and inattentive behaviors, there were no significant relations between teacher ratings and parent ratings of either component of ADHD-characteristic behaviors, even when controlling for the high within-

informant correlations between subscales. This finding is consistent with past research findings of little or no correlation between teacher and parent ratings of ADHD-characteristic behaviors in preschool samples (Murray et al., 2007). Also, the indices of each component of ADHD did not demonstrate the expected pattern of convergent and discriminant relations across measures. That is, each index/subscale did not relate to the indices/subscales they should (e.g., parent-rated inattention should relate to teacher-rated inattention) and not relate to the indices/subscales they should not (e.g., parent-rated hyperactivity/impulsivity should not relate to CPT omission errors).

The high within-informant associations between ratings of each component observed in this study indicate that individuals who rate a child as exhibiting high levels of inattentive behavior also rate them as displaying high levels of hyperactivity/impulsivity. This finding demonstrates that teachers and parents are not rating each ADHD-characteristic behavior independently of the other. These results are consistent with other research (e.g., Power et al., 1998) that has demonstrated moderate to strong inter-factor correlations within informants and may also represent a halo effect similar to those detected in studies concerning ADHD and ODD (Abikoff et al., 1993). That is, the presence of one form of ADHD behavior could lead informants to rate erroneously the presence of the other form of ADHD behavior. This pattern exemplifies the influence that an observed behavior problem may have on a rater's perceived observation of another behavior problem and demonstrates one potential factor that contributes to low informant-agreement.

In this study, CPT commission and omission errors demonstrated several relations to informant ratings. However, consistent with other research (Egeland et al., 2009; Epstein et al., 2003; McGee et al., 2000), commission errors and omission errors did not distinctively relate to ratings of hyperactivity/impulsivity and inattention, respectively. Parent-rated inattention demonstrated convergent relations with omission errors in that it significantly accounted for variance in these scores; however, parent-rated hyperactivity/impulsivity also accounted for variance in omission errors and was not significantly associated with CPT commission errors. This pattern is the reverse of what would be expected if commission errors were an index of the same construct as parent-rated hyperactivity/impulsivity. Furthermore, when the high correlation between parent ratings of inattention and hyperactivity/impulsivity was taken into account in the analyses, neither of the subscales were unique predictors of CPT omission errors. This finding suggests that, overall, parent ratings capture a form of behavior that is associated with performance on a time-limited attention task but that these ratings do not measure two distinct forms of behavior. It also should be noted that the overall model for predicting CPT omission errors was not statistically significant, indicating that the variables in combination did not account for significant variance in CPT omission errors and possibly low power resulting from the small sample size in this study.

The results concerning the relation between teacher ratings and CPT omission errors showed some evidence of discriminant and convergent associations and highlighted the possible influence of the high within-informant overlap on results. When entered alone at step 2 in a regression predicting CPT omission errors, neither teacher-rated inattention nor hyperactivity/impulsivity accounted for significant variance. However, when entered together, thus controlling for the high overlap between inattention and hyperactivity/impulsivity ratings, both were significant unique predictors in opposite directions. This finding suggests that the high overlap across subscales between teacher ratings of different behaviors, possibly representative of a halo effect, makes it difficult to detect the unique associations between teacher ratings and the CPT that support convergent and discriminant relations between these measures. These findings could also be representative of statistical suppression that is characterized by both predictor variables being positively related to each

other but inversely related to the criterion variable. Due to this pattern, teacher-ratings of both inattention and hyperactivity/impulsivity were more informative predictors of omission errors when both were included in the model than when each was considered alone.

Although the results of this study demonstrate inconsistencies across measures of inattention and hyperactivity/impulsivity, they may not necessarily solely point to error in the measurement tools examined. The assessments examined in this study may complement each other in that they capture different manifestations of inattentive and hyperactive/impulsive behavior. The CPT may supplement behavioral ratings in ways that compensate for potential subjective bias. Conversely, informant ratings provide information about daily functioning that the time-limited task-specific CPT may not capture. Teachers and parents may provide varying information regarding daily functioning across domains that assists in determining the pervasiveness of behavior problems. In summary, these three forms of assessment may function in unison to provide a comprehensive conceptualization of a child's symptomatology. Still, the discrepancies between these measures highlight the field's underdeveloped understanding of, and ability to measure reliably, inattentive and hyperactive/impulsive behavior problems. Such findings call for a more solid understanding of the discrepancies between these different measures.

Reasons for Discrepancies between Informants

Several explanations for the discrepancies between teacher and parent ratings of ADHD-characteristic behaviors have been proposed, including low within-measure reliability and differences in children's behavior in different environments. It has been suggested that informant reliability influences between-informant agreement. Parents have been shown to be less reliable than teachers when rating ADHD-characteristic behaviors (Owens & Hoza, 2003). Such problems with reliability inevitably compromise the construct validity of these tasks and affect the ability to obtain high inter-rater reliability. However, the adequate to good reliability of the rating scales in this study indicates that the psychometric qualities of these data allowed for significant relations to be observed. Therefore, this explanation is insufficient to explain the low correlations between teachers' and parents' ratings observed in this study.

Informant ratings may also be influenced by the time period during which the child is observed or other environmental factors. Loughran (2003) found that teacher ratings made at a single time-limited reunion party that occurred three years after the children had left their classrooms produced higher between-teacher agreement compared to ratings made when the children were students in the teachers' classroom. During the time-restricted follow-up period, both teachers observed the child during the same period of time, giving them fewer opportunities to observe different behaviors that would influence ratings. This study illustrates how disagreement between raters may be due to genuine differences in the behaviors that are observed. Environmental elements may also influence the agreement between parents and teachers. Phillips and Lonigan (2010) found that parent-teacher agreement on children's activity and impulsivity levels was significantly higher for students from middle-income preschools than students from low-income preschools. Taken together, these findings highlight how discrepancies between behaviors reported by raters may be due to differences in children's behavior across environments, differences in the salience of behavior problems across environments, or both. Therefore, even well-designed measurement tools may be limited in their relations to each other.

Reasons for Discrepancies between the CPT and Informants

Despite the objectivity of the CPT, concerns have been raised regarding the generally low-to-moderate ability to identify correctly children with and without ADHD using this

measure. The two primary reasons posited to explain this discrepancy are the artificial nature of the CPT and the impact of other psychological disorders that influence CPT performance. Studies have found agreement between the CPT and ADHD diagnosis to be as low as 22% (DuPaul, Anastopoulos, Shelton, Guevremont, & Metevia, 1992) and as high as 80% (Fischer, Newby, & Gordon, 1995). Some propose that the sterile environment of CPT administration does not mirror the distracting conditions under which many symptoms of hyperactivity and inattention manifest, thus causing false negatives and deviation from the ratings provided by individuals who see the child in typical daily settings (Adams, Finn, Moes, Flannery, & Rizzo, 2009). Virtual reality versions of the task that aim to provide greater ecological validity have been designed as an attempt to resolve this limitation. During these tasks, children use a headset to view a classroom-like environment in which the CPT is presented amongst ecologically valid visual and auditory distractions (e.g., cars driving by on an outside street). However, the support for the improved utility of virtual reality versions is weak (Adams et al., 2009; Pollak et al., 2009), suggesting that they do not sufficiently ameliorate the weaknesses of the original task.

A multitude of other psychological factors (e.g., Oppositional Defiant Disorder, cognitive ability) may also contribute to abnormal scores on the CPT. Fischer et al. (1995) examined the disagreement that occurs using the CPT to diagnose ADHD. They posited that the diagnosed children who are and are not identified as having ADHD using the CPT may differ qualitatively. They found that diagnosed children who were not identified as having ADHD (i.e., false negatives) were significantly less impaired than children who were correctly identified as having ADHD. Furthermore, in cases of disagreement, parent-rated psychosomatic symptoms and conduct problems were also elevated. These findings imply that the CPT demonstrates greater utility for detecting more severe and pure cases of ADHD.

Conclusions and Future Directions

This study is the first to examine the convergent and discriminant relations between parent ratings of ADHD, teacher-ratings of ADHD, and CPT performance in the same preschool sample. However, there are a few limitations. The split-half reliability for CPT commission errors (.67) was slightly below what is generally considered acceptable. This psychometric property implies the need for caution in interpreting results related to this variable. Although power was sufficient to detect a large correlation between measures (i.e., power > .78), it was not adequate to determine whether small-to-moderate correlations were significantly different from the absence of a correlation. Several of the non-significant correlations observed in this study may have reached significance given a larger sample size. Moreover, the use of an unselected sample may have reduced the number of cases with higher levels of symptoms, reducing variance on the measures, and limiting the size of correlations. Although the high correlation within scale seems to preclude this latter possibility, the interpretation of these results warrants caution.

Our small sample size precluded the ability to examine how the relations between measures differ for each gender. Given differences between boys and girls on measures of ADHD-characteristic behaviors (e.g., Greenberg & Waldmant, 1993; Lin et al., 1999; Newcorn et al., 2001) and findings that boys are more likely to exhibit ADHD-characteristic behaviors than girls (e.g., Gershon & Gershon, 2002), agreement between measures may have differed by gender. Despite these drawbacks, all of the correlations between presumed indices of the same ADHD component were small (Cohen, 1992) in size and are in line with the results of other studies (e.g., Collett et al., 2003; McGee et al., 2000). Regardless of significance levels, the sizes of these correlations are inconsistent with the assertion that these measures are assessing identical constructs.

The use of an unselected sample of preschool children in this study may have affected, and potentially limited, our results. Because we did not have information available regarding how many children were receiving clinical services at the time of our study, we were unable to determine whether behavioral or psycho-pharmaceutical treatments may have affected the assessments of some participants. Also, agreement between measures may differ in a sample containing more children with identified behavioral problems. As such, future research should examine how these measures relate in a clinical sample. Although our findings provide information about how different measures of inattention and hyperactivity/impulsivity relate in the general population, future research should also examine how well these three methods of measuring ADHD-characteristic behaviors function as predictors of diagnosis in preschool children. This is particularly important given that this is one of the primary uses of these tools. The low correlations between these measures imply that they are not measuring the same form or severity of behavior problems. Therefore, each may differ in its utility for distinguishing between children with and without ADHD.

Research is also needed to determine how these measures differentially relate to important areas of daily functioning (e.g., early academic skills and social relationships) and the severity of functional impairment. An atypical score on an informant-rated ADHD measure may point to different behavioral deficits than poor performance on the CPT. For example, poor parent ratings may indicate poor behavior management implementation in the home, which may suggest parent training as an effective treatment strategy, whereas atypical CPT scores may indicate attention focusing and shifting difficulties that point to the need for medication. In this way, understanding how assessment tools capture different types of functional impairment may help guide the focus of intervention.

The discrepancies observed in this study may result from true differences in children's behavior across settings. Clearly, many variables can precipitate behavior problems that mimic ADHD but remain isolated to specific situations. The different demands placed on children across settings may lead to different levels of behavior problems in each of these settings. Given that this study was conducted on a normative sample, the lack of consistency between assessment tools may reflect the tendency for typically developing preschoolers to exhibit some ADHD-characteristic behavior but not exhibit it consistently across domains. This pattern of limited functional impairment may be caused by factors such as normative boundary testing or cognitive deficits that elicit inattention only during certain learning activities or cognitive tasks (Mitsis et al., 2000). Discrepancies between different measures of ADHD-characteristic behaviors may help differentiate children with setting specific difficulties from those with pervasive symptomatology (Rapoport, Donnelly, Zametkin, & Carrougher, 1986) and the inconsistencies observed in this study may simply exist because these measures are operating as would be expected in a non-clinical sample. Still, these discrepancies underscore the need for a greater understanding of the construct of attention and the multiple means by which it is measured.

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Research Highlights

- Correlations between different ADHD assessment tools were small.
- Parent-ratings were uncorrelated with teacher-ratings of ADHD-related behaviors.
- Teacher-ratings of ADHD-related behaviors were uncorrelated with errors on the CPT.
- Parent-ratings of ADHD-related behaviors were correlated with CPT omission errors.

Table 1

Descriptive Statistics and Zero-Order Correlations for Demographic Variables and Teacher-ratings, Parents-ratings, and the Continuous Performance Test

	Measure								
Measure	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. Teacher-rated Inattention	---								
2. Teacher-rated H/I	.63**	---							
3. Parent-rated Inattention	.18	.01	---						
4. Parent-rated H/I	.01	-.09	.46**	---					
5. CPT Omission Errors	.18	-.17	.28*	.27*	---				
6. CPT Commission Errors	.01	.23	.14	-.04	-.04	---			
7. Age (Months)	.10	.07	-.02	.00	.10	.01	--		
8. Family Income (1,000s)	-.16	-.06	-.24	-.22	-.02	-.01	-.04	--	
9. S-B Copying Subtest	-.22	-.12	-.18	-.01	-.11	-.19	.01	-.21	--
Mean	2.49	2.49	2.72	4.26	10.77	10.14	57.72	41-50	5.05
SD	2.87	3.15	2.58	3.06	15.09	18.22	6.98	--	2.15
Range	0 - 15	0 - 12	0 - 11	0 - 14	0 - 40	0 - 84	50 - 72	5 - 125	2 - 13
Skew	1.94*	1.38*	1.11*	1.05*	1.69*	1.86*	0.72	-1.58*	1.58*

Note. $N = 65$. H/I = hyperactivity/impulsivity; CPT = Continuous Performance Test. Descriptive statistics are on measures uncorrected for outliers and skew. Correlation coefficients are on measures age-standardized and with outliers and skew corrected.

* $p < .05$.

** $p < .01$.

Table 2

Summary of Hierarchical Regression Analyses Predicting Parent-ratings, Teacher-ratings, and Errors on the CPT

Predictor Variables	Predicted Outcomes											
	Teacher Ratings				Parent Ratings				CPT Error Type			
	Inattention		H/I		Inattention		H/I		Omission		Commission	
	β	sr^2	β	sr^2	β	sr^2	β	sr^2	β	sr^2	β	sr^2
1. *Control Variables*[a]		.14*		.03		.10		.07		.02		.06
2. *Teacher Ratings*												
a. Inattention	---		.65**	.36	.12	.01	-.08	.00	.15	.02	.05	.00
b. Hyperactivity/Impulsivity	.58**	.32	---		-.03	.00	-.13	.02	-.19	.04	.20	.03
c. Inattention	---		---		.22	.03	.01	.00	.45**	.11	-.13	.01
Hyperactivity/Impulsivity	---		---		-.15	.01	-.13	.01	-.46**	.12	.27+	.04
3. *Parent Ratings*												
a. Inattention	.12	.01	-.03	.00	---		.44**	.18	.28*	.07	.16	.01
b. Hyperactivity/Impulsivity	-.07	.00	-.14	.02	.43**	.17	---		.28*	.07	-.06	.00
c. Inattention	-.18	.02	.04	.00	---		---		.19	.03	.22	.04
Hyperactivity/Impulsivity	-.15	.02	-.15	.02	---		---		.18	.03	-.15	.02

Note: $N = 65$. H/I = hyperactivity/impulsivity; CPT = Continuous Performance Test.

[a] Value is R^2 when only control variables are included in the model.

* $p < .05$.

** $p < .001$.