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Inattention, Hyperactivity, and Emergent Literacy: Different Facets of Inattention Relate Uniquely to Preschoolers' Reading-Related Skills

Darcey M. Sims and
Department of Psychology, Florida State University

Christopher J. Lonigan
Department of Psychology and the Florida Center for Reading Research, Florida State University

Abstract

Objective—Although extant studies indicate that there is a strong association between Attention Deficit/Hyperactivity Disorder (ADHD) and reading ability in elementary school children, knowledge regarding the relation between inattentive and hyperactive/impulsive behaviors and emergent literacy in preschool children is less established. This study examined the unique and overlapping relations between measures that assess inattention and hyperactivity/impulsivity and emergent literacy skills in preschool children.

Method—Participants included 204 preschool children (Mean age = 56 months; 50.9% female; 79.8% European American). Behavioral rating scales were completed by teachers and the Continuous Performance Test (CPT) and the Test of Preschool Early Literacy were completed by the preschoolers.

Results—Across measures, inattention was a unique correlate of emergent literacy skills whereas hyperactivity/impulsivity was not. Both rating scales and the CPT indices of inattention were uniquely associated with emergent literacy skills.

Conclusions—These results suggest that these measures are assessing different manifestations of inattention that are both unique correlates of early reading skills.

Keywords

Inattention; Emergent Literacy; Continuous Performance Test; Teacher Ratings; Preschool

Research provides strong evidence for an overlap between Attention-Deficit/Hyperactivity Disorder (ADHD) and reading ability (McClelland, Acock, & Morrison, 2006; Willcutt & Pennington, 2000); however, the large majority of work, to date, has focused on school-age and adolescent children with clinically diagnosed difficulties in these areas. Fewer studies have addressed the early developmental link between inattentive and hyperactive/impulsive behaviors and reading in the preschool years. Moreover, inattention (IA) and hyperactivity/impulsivity (H/I) are multi-faceted constructs that can be assessed using a variety of measures such as behavior-rating forms completed by informants (e.g., teachers, parents) or direct measures (e.g., neuropsychological tasks) completed by the child. Research has shown that both behavior-ratings and direct measures of IA and H/I have associations with reading skills (e.g., Harmon-Jones, Barratt, & Wigg, 1997); however, to date, no study has examined

Inquiries concerning this work can be sent to either Darcey Sims (sims@psy.fsu.edu) or Christopher J. Lonigan (lonigan@psy.fsu.edu), Department of Psychology, Florida State University, 1107 W. Call Street, Tallahassee FL 32306-4301.

directly whether these measures are unique or overlapping correlates of reading-related skills in young children. The purpose of this study was to examine how inattentive and hyperactive/impulsive behaviors, measured with different methods, relate to early reading-related skills in a preschool sample.

Clinically elevated levels of IA and H/I are associated with various difficulties in the academic arena, including school achievement (Johnson, McGue, & Iacono, 2005), reading ability (McClelland et al., 2006), and reading disability (RD; Dykman & Ackerman, 1991). The link between ADHD and reading has been reported both in studies of school-age children (e.g., Willcutt & Pennington, 2000) and in studies of adults (e.g., Samuelsson, Lundberg, & Herkner, 2004) as well as in numerous genetic studies (e.g., Couto, 2009; Loo et al., 2004; Martin, Levy, Pieka, & Hay, 2006; Willcutt, Pennington, & Defries, 2000). Although some authors have proposed a reciprocal causal relation between behavior problems and reading (i.e., difficulties in one domain exacerbate problems in the other; see Spira & Fischel, 2005 for review), recent genetic research has pointed to possible underlying mechanisms that simultaneously influence both domains (Cornish, Savage, Hocking, & Hollis, 2011; Hart, et al., 2010). Research with older children has shown that it is most likely the inattention, rather than the hyperactivity, component that accounts for the relation between ADHD and reading (e.g., Zumberge, Baker, & Manis, 2007). Whereas the link between inattention and reading is well documented in older children, less is known about the relations between inattentive and hyperactive/impulsive behaviors and reading-related skills when they first emerge in the preschool years.

Although identifying the presence or absence of IA and H/I as categorical outcomes [0]is useful for diagnostic purposes, these behaviors are generally accepted as continuous constructs (Levy, Hay, McStephen, Wood, & Waldman, 1997). Characterizing these behaviors dimensionally may be particularly useful in research with preschoolers because it is difficult to differentiate symptoms of IA and H/I that are atypical and excessive from occurrences of these behaviors that represent typical development in young children (Spira & Fischell, 2005). Furthermore, IA and H/I have been shown to relate to several areas of daily functioning (e.g., academic and social skills; Lonigan et al., 1999; Rydell, Diamantopoulou, Thorell, & Bohlin, 2009) when examined dimensionally in samples of children without clinically elevated behavior problems. Consequently, we examined IA and H/I in this study using a dimensional approach.

Emergent Literacy, IA, and H/I

Research has identified emergent literacy skills as strong predictors of later reading skills (Lonigan, Schatschneider, & Westberg, 2008). The three main components of emergent literacy, as identified by Whitehurst and Lonigan (1998), include oral language, phonological processing, and print knowledge. Oral language consists of definitional and expressive vocabulary as well as an understanding of syntactic structure and decontextualized language. Phonological processing requires awareness of the units of sound in spoken language and is the ability to discriminate, manipulate, and recall these units of sound. Print knowledge refers to the knowledge of the conventions of print, such as letter knowledge and understanding the difference between print and pictures (Clay, 1979). Print knowledge and phonological awareness are important for early decoding (Lonigan, Burgess, & Anthony, 2000; Tunmer, Herriman, & Nesdale, 1988) and oral language constructs become increasingly important for comprehension as children begin to read text for meaning (Storch & Whitehurst, 2002). The ability to assess emergent literacy skills and those inattentive and hyperactive/impulsive behaviors associated with problems in this area accurately facilitates early identification of children who are at-risk for experiencing later reading difficulties.

Several studies provide evidence that the link between inattentive and hyperactive/impulsive behaviors and reading-related skills emerges prior to the onset of conventional reading, although there are far fewer studies regarding the link during the preschool years than during the elementary-school years. As with older children, research with normative samples of preschool children has shown that it is most likely the IA, rather than the H/I, component that accounts for the relation between these constructs (Velting & Whitehurst, 1997; Willcutt et al., 2007). For example, Lonigan et al. (1999) found that IA in a preschool sample was negatively correlated with a number of emergent literacy skills, even when controlling for general cognitive ability. IA in preschool has also been shown to predict preliteracy skills in kindergarten longitudinally (Walcott, Scheemaker, & Bielski, 2010).

Measurement of IA and H/I

Examining the early link between inattentive and hyperactive/impulsive behaviors and emergent literacy skills is complicated by the variety of behavior assessment tools that can be completed by different individuals, each with a subset of questions, statements, or tasks that are presumed to represent IA and H/I. The most commonly utilized forms of assessment are rating scales that are completed by individuals, such as teachers, who are expected to be able to make judgments regarding a child's behavior. The efficiency of these tools contributes to their common use; however, concerns related to the subjective nature of these measures, (e.g., bias, inter-rater disagreement; Oord, Prins, Oosterlaan, & Emmelkamp, 2006) suggest the need for tests that objectively assess the child's inattentive and hyperactive/impulsive behaviors.

The Continuous Performance Test (CPT) is a computer-administered neuropsychological task that is used in research for differentiating between children with and without inattentive and hyperactive/impulsive behavior problems (Epstein et al., 2003; Youngwirth, Harvey, Gates, Hashim, & Friedman-Weieneth, 2006). The CPT requires individuals to view a stimulus sequence on a computer screen, respond to target stimuli and withhold responses to non-target stimuli. The original A-X task (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956) uses letters as stimuli and contains a working memory component that may exceed the cognitive abilities of preschoolers and confound results, given that cognitive factors such as working memory and visio-spatial storage are closely linked both to attention (Klingberg et al., 2005; Martinussen & Tannock, 2006) and to academic outcomes (Gathercole et al., 2004). Versions of the CPT designed to have minimal language and memory demands have been created for use with younger children. During these tasks, images of common objects are flashed on a computer screen and the child is required to press the space bar as soon as he or she sees the target object but not non-target objects. On trials in which the target is shown and the space bar is not pressed, an "omission error" is recorded, which is presumed to represent the construct of IA. On trials in which a non-target object is shown and the space bar is pressed, a "commission error" is recorded, which is presumed to represent H/I.

Although both teacher-ratings and neuropsychological tests such as the CPT are used to assess inattentive and hyperactive/impulsive behaviors, the correlations between these measures are generally low (e.g., Epstein et al., 2003; McGee et al., 2000), suggesting that they are actually measuring different constructs. Given differences in the natures of these assessment tools, they may measure different manifestations of IA and H/I. Whereas the CPT measures a child's ability to attend to stimuli during a cognitive task, teacher-ratings measure IA and H/I as they apply to observed behaviors in the classroom. Research on clinically diagnosed samples has shown that, of children with ADHD, those who demonstrate deficits on neuropsychological tests may be more likely to show deficits in reading and other academic skills (Biederman et al., 2004). Research on normative samples of school-age children (Lam, & Beale, 1991) also has revealed correlations between

performance on the CPT, behavioral ratings of IA, and reading-related skills. Research examining how these different methods of measuring IA and H/I are similarly and distinctly related to early reading skills in younger children is needed. Such research may facilitate an understanding of the underlying behavioral and cognitive deficits that are shared and unique to inattentive behaviors and reading.

Summary and Perspective

Although there is a well-established connection between behavior problems and reading skills in older children, less work exists on the overlap of these constructs with preschool children. The CPT and teacher-ratings are both used to assess IA and H/I; however, the correlations between these measures are generally weak (e.g., Epstein et al., 2003; McGee et al., 2000). Research is needed examining the unique and overlapping correlates of these measures to better understand the similarities and differences regarding the behavioral constructs that these measures reflect. The primary aim of this study was to examine how different manifestations of inattentive and hyperactive/impulsive behaviors, as measured by different methods of assessment, relate to emergent literacy while controlling for several important factors such as age (Lahey, Pelham, Loney, Lee, & Willcutt, 2005; Lin, Hsiao, & Chen, 1999), gender (Christian, Morrison, & Bryant, 1998; Gershon & Gershon, 2002), SES (Arnold & Doctoroff, 2003; Offord et al., 1987) and general cognitive ability (Weyandt, Mitzlaff, & Thomas, 2002) that have been shown to be associated with IA and H/I and with early reading abilities. It was hypothesized that, as with older children, measures of IA, but not H/I, would be uniquely related to measures of emergent literacy. Although no study has examined directly the unique and overlapping relations between emergent literacy skills and different measures of IA and H/I, the magnitudes of correlations between CPT performance and reading-related skills in the literature are typically smaller than the magnitude of correlations between teacher ratings of IA and reading-related skills (e.g., Hooper, et al., 2011; Lonigan et al., 1999; Valiente, Lemery-Chalfant, & Swanson, 2010). Therefore, it was hypothesized that IA as measured by teacher rating scales, but not IA as measured by the CPT, would be uniquely related to measures of emergent literacy skills.

Method

Participants

Participants included 204 children who were recruited from 16 private and public preschools in northeast Florida. Of the 198 children for whom ethnicity was reported, 79.8% were identified as white; 10.6% were identified as African American; and 9.6% were identified as other. The sample included 104 girls (50.9%). Participants ranged in age from 36 to 70 months (M = 56.37 months, SD = 6.98). Based on parents' reports, family annual income ranged from $5,000 to more than $175,000, with a median income range of $41–50,000. Income information was only available for 75.9% (n = 155) of the sample because 49 parents either did not return the parent survey or did not answer the question regarding income. Because income was intended to be used as a measure of SES, missing values were replaced with the median income of the child's respective preschool. As such, income was an approximate measure across the sample.

Measures

Conners' Teacher-ratings Scale Restandardized (CTRS-R)—The Conners' rating scales have been widely used for several decades to assess the presence of problem behaviors in children (Conners, 1990). The CTRS-R has been found to have good internal consistency (alphas ranging from .73 to .95) across subscales (Conners, Sitarenios, Parker, & Epstein, 1998). This measure also has good sensitivity (78%) and specificity (91%) for

distinguishing children with ADHD from those without the disorder. This scale contains items assessing both IA and H/I. One advantage of this measure for the purpose of this study is that it was normed on a large representative sample that includes children as young as 3-years-old. The factor structure outlined by Gerhardstein, Lonigan, Cukrowicz, and McGuffey (2003), based on a factor analysis of the items using a sample of preschoolers, was utilized for this study and contains 11 items that pertain to IA and 19 items that pertain to H/I. Both the IA (α α = .96) and H/I (α = .90) subscales had high internal consistency for this sample.

The Strengths and Weaknesses of ADHD-Symptoms and Normal-Behaviors Rating Scale (SWAN)—The SWAN (Swanson et al., 2001) includes 18 items that correspond to the diagnostic criteria for ADHD as described in the Diagnostic Statistical Manual Text Revision 4th Edition (American Psychiatric Association, 2001). Teachers rate children based on comparisons to same-age peers, and scores range from −27 to 27 for each subscale. The SWAN has been shown to have strong internal consistency (αs ≥ .95) and test-retest reliability (*r*s between .71 and .76) for each subscale (Lakes, Swanson, & Riggs, 2012). Although the SWAN is a relatively new measure and as such has limited information regarding clinical utility, researchers using different methods of determining cutoff scores with this measure (e.g., 95th percentile, below average ratings on five or more items for a given symptom) produce rates of ADHD and ADHD subtype classification similar to those found in other studies (Smalley, 2007; Young, Levy, Martin, Hays, 2009). Both the IA (α = .93) and H/I (α = .94) subscales had high internal consistency for this sample.

Continuous Performance Test (CPT)—The CPT (Rosvold et al., 1956) is a computer-based task in which pictures of objects are flashed 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. This task includes 220 trials (176 require non-response; 44 require response). Omission errors and commission errors were recorded. The CPT has been shown to have adequate test-retest reliability (*r*s = .65 to .74; Halperin, Sharma, Greenblatt, & Schwartz, 1991). In this study, the split-half reliabilities (i.e., *r*s of omission errors and commission errors from the first and last quarter blocks of performance to the middle two quarter blocks of performance on the task) were moderate (*r*s > .80).

Test of Preschool Early Literacy (TOPEL)—The TOPEL (Lonigan, Wagner, Torgesen, & Rashotte, 2007) is a nationally normed and standardized measure of preschool children’s emergent literacy skills. The measure includes 98 items across three subtests: Print Knowledge, Definitional Vocabulary, and Phonological Awareness. The measure is administered individually to children and takes approximately 25 to 30 minutes. According to the test manual, the TOPEL has high internal consistency reliability (α = .96). The test has good test-retest reliability (.91) and inter-scorer agreement (.98). Each subtest also has good criterion predictive validity, with high correlations (*r*s ≥ .59) between the subtests and other measures of similar constructs.

Nonverbal cognitive ability—The Copying subtest of the Stanford-Binet Intelligence Scale 4th Edition (Thorndike, Hagen, & Sattler, 1986) was used as a control measure of nonverbal cognitive ability. This test is comprised of 28 items that require the child to duplicate designs made from blocks and drawings. The Copying subtest has adequate internal consistency (coefficients ≥ .81) and test-retest reliability (*r* = .71) for preschool-age children.

Parent Survey—A short survey, completed by children's parents, included eight items related to family background information and eight items related to family reading habits. The primary purpose of this survey was to obtain a measure of income as an index of SES.

Procedure

Consent forms containing a description of the project were sent home to the parents of all 3-to-5-year-olds in the participating preschools as an invitation to participate in the study. The normal distribution of scores on the SWAN and TOPEL (see Table 1) indicates that the sampling procedure resulted in a generally average sample. All testers were research assistants who had either completed a bachelor's degree in the social sciences or were working toward the completion of a degree. Testers were trained to administer the tasks in a standardized fashion. Testing took place over two or three testing sessions lasting 15 to 45 minutes each. Assessments were completed at varying times during the school year. All measures for each child were collected within a three week period. Throughout testing on the TOPEL and Copying test, children were given breaks if they appeared restless. Because the CPT is designed to place demands on children's attentional capacities, research assistants were instructed not to end testing on the CPT based solely on the appearance that the child was restless. For each participant, one preschool teacher completed the CTRS and SWAN.

Results

Descriptive statistics for raw scores are presented in Table 1. Standard scores were used for each of the TOPEL subtests and the Copying subtest of the Stanford-Binet-IV. There were no missing values on the TOPEL or the Copying subtest, and both measures had normal distributions following the correction of outliers[1]. Twenty-three children were missing data for one or two items on the CTRS or the SWAN (a total of < .05% of teacher-rating data). These values were replaced using expected maximization for the purpose of creating subscale scores. Because like subscales across teacher-rating scales were substantially correlated (i.e., $r = -.48$ and $r = -.61$ for IA and H/I, respectively) and analyses conducted with the SWAN and CTRS separately and combined yielded similar results, composite teacher-rating scores were created by averaging *z*-scores for each of the subscales (i.e., IA and H/I). The SWAN was reversed scored prior to creating the composite score so that higher ratings on both scales represented higher levels of behavior problems. Following the correction of outliers, CPT scores evidenced significant positive skew. Square-root transformations were used to correct for the non-normality in the data. This technique brought the skew of CPT omission errors to a level of non-significance. Although the magnitude of the skew for CPT commission errors was reduced, it was still significant ($p < .01$).

Partial correlations, controlling for age, income, Copying subtest scores, and child sex, between the different measures of IA and H/I and emergent literacy skills are shown in Table 2. There was significant overlap between teacher-rated IA and H/I ($r = .68$, $p < .001$) but not between different types of errors on the CPT ($r = .05$, $p = .41$). Correlations were small, but significant, between most CPT parameters and teacher-ratings of IA and H/I. Teacher ratings of IA and H/I correlated with scores on the Print Knowledge and Phonological Awareness subtests but not with scores on the Definitional Vocabulary subtest.

[1]Outliers were identified as those values outside two inter-quartile ranges from the mean. Outliers were corrected by changing their values to the respective limit, either two interquartile ranges above or below the mean. Generally, the correction of outliers resulted in a more conservative estimates. To reduce the influence of outliers on significance levels, all analyses reported refer to data examined with corrected outliers.

In contrast, CPT omission errors were significantly correlated with all three emergent literacy skills.

Unique Predictive Relations with Early Literacy Outcomes

Measures of inattention versus measures of hyperactivity/impulsivity—Given the significant correlations between emergent literacy skills and many indices of IA and H/I, two sets of simultaneous multiple regression were conducted to determine the extent to which these relations were unique or overlapping. The first set of regressions tested the hypothesis that inattentive behaviors, but not hyperactive/impulsive behaviors, would uniquely relate to each emergent literacy skill. Separate analyses addressed this question for each method of measurement (i.e., regressions were conducted for teacher ratings and CPT scores separately; see Table 3). Of the control variables in the models (i.e., age, sex, SES, nonverbal cognitive ability, month of testing), sex, nonverbal cognitive ability, income and month of testing were all significant unique correlates of phonological awareness, age and nonverbal cognitive ability were unique correlates of print knowledge, and nonverbal cognitive ability was a unique correlate of definitional vocabulary. Overall, for both teacher ratings and the CPT, the subscale/index associated with IA was uniquely associated with all three emergent literacy scores when controlling for H/I and other variables associated with early reading skills.

Inattention measured by teachers' ratings versus CPT task—The second series of regressions was conducted to examine whether the relation between different methods of measuring inattentive and hyperactive/impulsive behaviors and emergent literacy skills were unique or overlapping. These analyses tested the hypothesis that teacher-ratings, but not CPT scores, would be uniquely related to emergent literacy skills and were conducted separately for IA and H/I (see Table 4). Of the control variables, sex, nonverbal cognitive ability, income, and month of testing were all significant unique correlates of phonological awareness, age and nonverbal cognitive ability were unique correlates of print knowledge, and nonverbal cognitive ability was a unique correlate of definitional vocabulary. Simultaneous multiple regressions examining the unique contribution of each method of assessing IA to variance in emergent literacy scores showed that both teacher-rated IA and CPT omission errors were significantly and uniquely associated with code-related emergent literacy skills (i.e., phonological awareness and print knowledge). Only CPT omission errors were uniquely related to definitional vocabulary. Simultaneous multiple regressions examining the unique contribution of each method of assessing H/I to variance in emergent literacy scores showed that no measure of H/I uniquely accounted for variance in definitional vocabulary. However, teacher-ratings of H/I accounted for unique variance in phonological awareness and print knowledge whereas CPT commission errors did not.

Prediction of Unique Variance in Outcome Measures

Although a large body of evidence has demonstrated that each of these three outcomes are separate constructs, the three early literacy outcomes have overlapping variance (see Table 2). To evaluate the specificity of the unique predictive relations of teacher ratings and the CPT task for the specific constructs measured by each of the three TOPEL subtests, analyses were conducted that controlled for the variance shared among the TOPEL subtests. For models in which the Print Knowledge or the Phonological Awareness subtest was the outcome, analyses were conducted first controlling for scores on the Definitional Vocabulary subtest and then controlling for scores on both the Definitional Vocabulary subtest and the other code-related subtest. For models in which the Definitional Vocabulary subtest was the outcome, analyses were conducted first controlling for scores on the Print Knowledge subtest and then controlling for scores on both the Print Knowledge and Phonological Awareness subtest.

Measures of inattention versus measures of hyperactivity/impulsivity—In general, for code-related emergent literacy skills, the pattern of results was retained when Definitional Vocabulary was included in the models. Both teacher ratings and CPT scores added significant unique variance to the model. Teacher-ratings of IA continued to be a significant unique predictor for Print Knowledge (β = −.27) but not for Phonological Awareness (β = −.12), whereas CPT omission errors was a significant unique predictor for both Print Knowledge (β = −.17) and Phonological Awareness (β = −.16). In contrast, when both Definitional Vocabulary and the other code-related subtest were included in the models, only the unique relation between the teacher-rated IA and Print Knowledge (β = −.24) continued to be significant. For Definitional Vocabulary, when the code-related skills were included in the model (either individually or together), neither teacher-rated IA nor CPT IA were significant unique predictors.

Inattention measured by teachers' ratings versus CPT task—In general, for code-related emergent literacy skills, the pattern of results was retained when Definitional Vocabulary was included in the models. Both teacher-rated IA (β = −.15) and CPT omissions (β = −.14) continued to be significant unique predictors of Phonological Awareness, and teacher-rated IA (β = −.24) was a significant unique predictor and CPT omissions (β = −.11) was a marginally significant unique predictor of Print Knowledge. Teacher-rated H/I continued to be a significant unique predictor of both Phonological Awareness and Print Knowledge (βs = −.14 for both). When both Definitional Vocabulary and the other code-related subtest were included in the models, only teacher-rated IA was a significant unique predictor of Print Knowledge (β = −.14), and teacher-rated H/I was a marginally significant unique predictor of both Phonological Awareness and Print Knowledge (βs = −.11 for both). In contrast, for Definitional Vocabulary, when the code-related skills were included in the model (either individually or together), the marginal unique relation between CPT omission errors and definitional vocabulary was no longer present.

Discussion

The primary goal of this study was to examine the relations between emergent literacy skills and inattentive and hyperactive/impulsive behaviors measured using two different methods of assessment. Results demonstrated that IA and H/I were linked to children's reading-related skills as early as preschool and that these relations were evident using multiple methods of assessing inattentive and hyperactive/impulsive behaviors. The results of this study provided evidence that, as with older children, it was primarily IA, rather than H/I, that was uniquely associated with literacy-related skills. The results of this study also revealed that teacher ratings of IA did not consistently demonstrate stronger relations with emergent literacy skills than did IA as measured by the CPT. In most cases, these two measures of IA--presumably representing the same construct--had unique associations with emergent literacy skills. These results have implications for the understanding and identification of distinct manifestations of inattention that may hinder or facilitate the development of early academic skills

Results indicated that the attention difficulties measured by the CPT and those measured by teacher ratings were only modestly correlated. This finding is consistent with prior research on older children that has reported generally weak and inconsistent relations between teacher-ratings of IA and H/I and CPT performance (e.g., Egeland, Johansen, & Ueland, 2009; McGee et al., 2000). Extant research suggests that specific errors on the CPT (i.e., omission errors and commission errors) do not consistently relate to informant ratings of the behaviors that these specific errors on the CPT are proposed to represent (i.e., IA and H/I, respectively; e.g., Epstein et al., 2003). In this study, both teacher-rated and CPT-measured

inattentive behaviors were uniquely associated with variance in overall emergent literacy skills. Taken together, these findings do not support the presumption that omission errors on the CPT and teacher-ratings of IA are measuring an identical construct. The pattern of results suggests that the low correlations between these measures is not evidence of high levels of measurement error but evidence that each measure is capturing distinct forms of behavior, both of which are associated with an important developmental skill.

The small correlation between teacher-rated and CPT-measured IA is consistent with the assertion that attention required for young children to focus on stimuli during a time-limited neuropsychological task differs from that required to attend to tasks, responsibilities, and social interactions during routine classroom activities. Biederman et al. (2005) reported that among children with ADHD, those with deficits on neuropsychological tasks were at an increased risk for academic difficulties. Although our study was conducted on a sample of younger, typically developing children, our results are in line with these findings in that performance on the CPT was uniquely associated with emergent literacy skills even when behavioral ratings of IA were accounted for. That is, of children who presumably exhibited similar levels of attention to daily school-related behaviors, those with a better ability to perform well during a time-limited neuropsychological task were likely to have higher levels of emergent literacy skills. It was also true that teacher-ratings of IA were uniquely associated with emergent literacy skills even after accounting for performance on the CPT. That is, of children with the same capacity for focusing during the CPT, those rated as having a stronger ability to attend to school-related tasks were likely to perform better academically. The unique contribution of IA, as measured by each method, to variation in emergent literacy skills suggests that both “aspects” of attention play an important role in the development of early reading skills independent of each other.

The attentional difficulties measured by each of these methods may differ in their implications in clinical practice for both identification and intervention. The small correlation between these measures indicates that they are not interchangeable assessments of attention difficulties. However, the finding that both measures demonstrate a unique relation to an important developmental skill implies that both should be considered in the diagnostic process. Attention difficulties identified by either measure may suggest the need for different intervention strategies. Poor performance on the CPT may point to the need for training in attention focusing during specific tasks or training for improving executive processes (Bellgrove, Hawi, Kirley, Gill, & Robertson, 2005). Higher ratings of IA from teachers may indicate a need for skills training in classroom supportive behaviors. Although the causal relation between behavior problems and academic achievement has not been elucidated fully, the link between constructs suggests that treatment in either of these forms of attention may bolster early academic development.

Consistent with the hypotheses of this study and prior research (Lonigan et al., 1999; Velting & Whitehurst, 1997; Willcutt et al., 2007), IA, but not H/I, was a unique correlate of emergent literacy skills. It has been argued that the apparent higher comoridity of the inattentive subtype of ADHD with reading disability can be attributed to differences in presentation across subtypes. That is, children with predominantly inattentive ADHD may be less likely to present for assessment or treatment than their hyperactive peers unless they have co-occurring academic difficulties (Sawyer et al., 2004). However, the current study and others (e.g., Martin et al., 2006) on non-clinical populations of children suggest that rate of presentation differences across subtypes does not fully explain the differential relations of IA and H/I with academic difficulties. These differences may be better accounted for by each symptom’s potential to interfere with learning. Many inattentive behaviors imply that a particular child is not engaging in learning activities (e.g., “does not finish school work”). In contrast, many hyperactive/impulsive behaviors, although disruptive (e.g., “squirms in

seat"), do not necessarily preclude academic engagement. Thus, H/I may not negatively influence reading ability as extensively as IA.

Relations between IA and each Emergent Literacy Skill

Results of this study indicated that teacher ratings of IA were generally associated with code-related outcomes (i.e., phonological awareness and print knowledge) even when controlling for definitional vocabulary. These results did not hold when controlling for the overlapping variance between the two code-related outcomes, indicating that the unique relations between teacher-rated IA and emergent literacy skills were specific to code-related emergent literacy skills but were not specific to either phonological awareness or print knowledge. In contrast, teacher ratings of IA were generally not associated with definitional vocabulary. Overall, these findings are similar to results from studies of older children documenting the relation of IA to performance on code-related reading tasks, such as word decoding, more so than meaning-related reading tasks, such as reading comprehension (e.g., Arnold et al., 2005; Rabiner & Coie, 2000). Twin studies (e.g., Willcutt et al., 2007) have demonstrated a genetic link between IA and early reading difficulties and suggest that this genetic influence is stronger for phonological awareness than it is for print knowledge or vocabulary. Thus, the results of this study demonstrate that even prior to the onset of conventional reading, the relation between inattentive behaviors and skills that are the precursors to reading in preschoolers mirrors the relation that exists between inattentive behaviors and reading in older children.

The differential link between code-related and meaning-related emergent literacy skills to IA may also be attributed to differences in how these skills are typically acquired. Children typically learn code-related skills during structured group and individual activities (Tunmer et al., 1998) that may place demands on their attentional capacities. Phonological awareness, despite being less well understood by teachers in terms of underlying constructs and importance to academic growth (McCutchen & Berninger, 1999), is becoming a more common element of preschool curricula. Although some instruction is devoted to vocabulary development in preschool classrooms (Brabham & Villaume, 2002), children primarily acquire language through implicit processes such as exposure and naturally occurring opportunities to practice skills during verbal interactions (Pinker, 1994). Children may be less impacted by their capacity to be restrained and attentive during these everyday activities. As such, attentional difficulties may not impact the development of language to the same extent that they affect the acquisition of code-related skills.

In contrast to teacher-ratings of IA, CPT omission errors had a marginally significant relation to performance on the Definitional Vocabulary subtest. This finding is similar to the results of a study in a small sample of slightly older children indicating that overall performance on vigilance tasks is associated with vocabulary skills (Finneran, Francis, & Leonard, 2009). This pattern may emerge as a result of other behavior problems, beyond IA and H/I, that impact scores on the CPT. Children who cease performing the CPT due to oppositional behavior may obtain high numbers of omission errors, which were identified in the current study as representing IA. Given that research has shown more general behavior problems (e.g., conduct problems and oppositional behavior) to be associated with meaning-related reading skills (Plomin, Price, Eley, Dale, & Stevenson, 2002), this unexpected finding may reflect the oppositional behaviors that are captured by omission scores. However, it should be noted that this was only a marginally significant finding and when code-related skills (i.e., print knowledge and/or phonological awareness) were controlled for in analyses, the unique relations between CPT indices and definitional vocabulary were no longer present. Therefore, the finding that CPT performance was uniquely associated with meaning-related emergent literacy skills should be interpreted with caution.

Conclusions and Future Direction

In contrast to the amount of research concerning the linkage between behavior and academic skills in older children, little is known regarding this link in preschool. Some argue that a relation between IA and emergent literacy skills in preschoolers may not exist because attention and restraint is not needed to engage in learning activities through which preschoolers acquire literacy skills (Spira & Fischell, 2005); however, this does not appear to be the case. Children in preschool programs are expected to gain basic skills that closely reflect behaviors required to succeed and benefit in formal education settings (Spira & Fischell). Children who fail to acquire these skills may not be as well prepared to learn in the context of structured learning activities. The results of this study demonstrate that a relation between IA and reading emerges prior to the onset of elementary school when most formalized instruction begins.

Although this study provides initial evidence of the utility of different methods for detecting distinct types of behavior problems that are associated with learning difficulties, there are a few notable limitations. One limitation is the concurrent nature of this study. Replication using data collection at multiple time-points would provide an opportunity to study how different methods of assessing IA in preschoolers predict growth in emergent literacy skills. Developmental research on behavior disorders has suggested that in preschool samples, factors such as frequency of behavior, intensity of behavior, and response to reprimands must be considered when differentiating problem behaviors that are atypical from those that occur as a part of normative development (Chacko, Wakschlag, Hill, Danis, & Epsy, 2009). Although the present study demonstrates the significance of inattentive behaviors to important developmental outcomes in preschool children, in future research, it may be useful to examine whether the strength of the association between teacher ratings of IA and emergent literacy skills is impacted by the consideration of these factors. It also may be useful to extend this research to a sample containing more children with elevated levels of behavior problems to examine whether these results hold in a more severe population.

The amount of variance accounted for in the models was relatively small (6% to 21%). This was somewhat expected given that these results are in line with the results of other studies using regression models to examine the link between IA and early reading skills (e.g., Lonigan et al., 1999). However, there are several other unmeasured variables that, if included, may have augmented the amount of variance accounted for. It would have been ideal to control for oppositional behavior, which has been shown to impact both CPT performance (Avila, Cuenca, Felix, Parcet, & Miranda, 2004) and teacher-ratings of IA (Stevens & Quittner, 1998). Cognitive factors such as working memory and processing speed are highly associated with academic development (Gathercole et al., 2004) and may have served as powerful predictors in the models. Other familial factors, such as parents' levels of education or involvement in children's education may have also been relevant additions to the models.

In summary, the results of this study demonstrated that IA in children as young as three years of age are associated with reading-related skills. The present study extends the current literature on this topic by showing that different assessment methods may offer insight into related, but distinct, manifestations of IA that are associated with the acquisition of emergent literacy. Research examining the correlates (e.g., motivation, oppositional behavior, executive function) of different methods of assessing IA is needed to gain a better understanding of the underlying constructs represented by these measures. This, in turn, will increase the field's understanding of behaviors that may help or hinder learning in early childhood, and offer guidance as to areas in which intervention may be most beneficial to specific children, depending on their profile of behavior.

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Table 1

Descriptive Statistics for the TOPEL, SB-IV Copying Subtest, and Measures of IA and H/I

Assessment tool	Mean	*SD*	Minimum	Maximum	Skew
TOPEL					
Print Knowledge	106.92	14.58	71	144	−0.30
Phonological Awareness	101.46	13.23	61	135	−0.34
Definitional Vocabulary	99.88	11.13	57	144	−0.15
SB-IV Copying subtest	41.38	4.68	29	58	0.49
CTRS					
Inattention	5.96	5.81	0	31	1.07*
Hyperactivity/Impulsivity	12.66	12.29	0	51	1.07*
SWAN					
Inattention	2.65	6.75	-15	19	0.20
Hyperactivity/Impulsivity	2.18	9.03	−20	30	0.27
CPT					
Omission errors	13.35	11.30	0	44	0.93*
Commission errors	15.84	20.18	0	139	2.44*

Note. $N = 204$; All values represent scores uncorrected for outliers and skew. IA = inattention; H/I = hyperactivity/impulsivity; TOPEL = Test of Preschool Early Literacy; CTRS = Conners' Teacher Rating Scale; SWAN = The Strengths and Weaknesses of ADHD-symptoms and Normal-behaviors Rating Scale; CPT = Continuous Performance Test; SB-IV = Stanford-Binet IV.

Skew values denoted with asterisks are significant.

Table 2

Partial Correlations between IA and H/I Measures and Emergent Literacy Skills Measures Controlling for Income, Age, Sex, and Stanford-Binet Copying Subtest Scores

Variable	1	2	3	4	5	6	7
1. Teacher-Rated Inattention	--						
2. Teacher-Rated H/I	.68***	--					
3. CPT Omission errors	.15*	.04	--				
4. CPT Commission errors	.16*	.16*	.05	--			
5. Print Knowledge	−.29***	−.16*	−.20**	−.07	--		
6. Phonological Awareness	−.21*	.15**	−.22**	−.05	.43***	--	
7. Definitional Vocabulary	−.07	−.03	−.12+	.02	.38***	.48***	--

Note. N = 204; IA = inattention; H/I = hyperactivity/impulsivity; CPT = Continuous Performance Test.

+ marginally significant.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Summary of Simultaneous Regression Analyses Testing the Unique Variance in Emergent Literacy Scores Accounted for by IA and H/I (within Measure) Controlling for Income, Age, Sex, Month of Testing, and Stanford-Binet Copying Subtest Scores

	TOPEL subtest											
	Phonological Awareness				Print Knowledge				Definitional Vocabulary			
Predictor variables	R^2	$sr^{2\wedge}$	β	sr^2	R^2	$sr^{2\wedge}$	β	sr^2	R^2	$sr^{2\wedge}$	β	sr^2
Overall Model	.16***				.20***				.07***			
Control Variables		.06				.08				.03		
Teacher-Rated Variables		.04				.07				.03		
Inattention			−.22*	.02			−.35***	.05			−.23*	.02
H/I			−.00	.00			−.07	.00			.16	.01
Overall Model	.17***				.16***				.08***			
Control Variables		.10				.15				.06		
CPT Variables		.04				.04				.02		
CPT Omission Scores			−.24**	.04			−.21**	.03			−.17*	.02
CPT Commission Scores			−.03	.00			−.07	.00			.06	.00

Note. N = 204. IA = inattention; H/I = hyperactivity/impulsivity; TOPEL = Test of Preschool Early Literacy; CPT = Continuous Performance Test; $sr^{2\wedge}$ = overall squared semi-partial correlation coefficient; sr^2 = squared semi-partial correlation coefficient.

* $p \leq .05$,

** $p \leq .01$,

*** $p \leq .001$.

Table 4

Summary of Simultaneous Regression Analyses Testing the Unique Variance in Emergent Literacy Scores Accounted for by Each Index of IA and H/I Across Measures Controlling for Income, Age, Sex, Month of Testing, and Stanford-Binet Copying Subtest Scores

	TOPEL subtest											
	Phonological Awareness				Print Knowledge				Definitional Vocabulary			
Predictor variables	R^2	$sr^{2\wedge}$	β	sr^2	R^2	$sr^{2\wedge}$	β	sr^2	R^2	$sr^{2\wedge}$	β	sr^2
	.19***				.21***				.08***			
Control Variables		.07				.12				.05		
Inattention variables		.07				.09				.03		
Teacher-ratings			−.18*	.03			−.26***	.06			−.09	.01
CPT Omission Scores			−.20**	.03			−.16*	.02			−.15+	.02
	.14***				.15***				.06***			
Control Variables		.08				.12				.05		
H/I variables		.02				.02				.00		
Teacher-ratings			.14*	.02			.15*	.02			.00	.00
CPT Commission Scores			−.01	.00			−.05	.00			.07	.00

Note. N = 204. IA = inattention; H/I = hyperactivity/impulsivity; TOPEL = Test of Preschool Early Literacy; CPT = Continuous Performance Test; $sr^{2\wedge}$ = overall squared semi-partial correlation coefficient; sr^2 = squared semi-partial correlation coefficient.

+ marginally significant,

* $p \leq .05$,

** $p \leq .01$,

*** $p \leq .001$.