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Sustained Attention at Age 5 Predicts Attention-Related Problems at Age 9

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Abstract

This study tested whether two aspects of sustained attention (focused attention and lack of impulsivity) measured at child age 5 predicted attention problems reported by mothers and teachers at age 9. Because lack of impulsivity reflects the executive control network, and ADHD is commonly characterized as a deficit in executive function, it was expected to have more predictive power than focused attention. Data were drawn from the Fragile Families and Child Wellbeing Study. Focused attention and lack of impulsivity, measured in a laboratory task at age 5, were equally predictive of attention problems at age 9, including the mother's report of whether the child had been diagnosed with ADHD. However, age 9 teacher-reported hyperactivity was not predicted by focused attention, and only marginally predicted by lack of impulsivity. Results complement an earlier study showing that both focused attention and lack of impulsivity at age 5 predicted children's approaches to learning at age 9 (Razza, Martin, & Brooks-Gunn, 2011).

Keywords

sustained attention; attention deficit; impulsive behavior; ADHD

Attention-related skills are increasingly viewed as an essential ingredient for school success (McClelland, Acock, & Morrison, 2006; McDermott, Leigh, & Perry, 2002). For example, a meta-analysis of multiple national data sets found that children's attention skills at school entry predicted later achievement far better than behavior problems did (Duncan et al., 2007). In particular, sustained attention – the ability to direct cognitive resources to a stimulus or target in the environment and to process information related to it (Eisenberg et al., 2004; Ruff, 1986) – has been identified as a correlate and predictor of both academic achievement (Choudhury & Gorman, 2000; Rhoades, Warren, Domitrovich, & Greenberg, 2011) and social competence (Andrade, Brodeur, Waschbusch, Stewart, & McGee, 2009; Davies, Woitach, Winter, & Cummings, 2008). In a school setting, children's ability to sustain attention allows them to process the material presented, store information, and solve problems (Ruff & Rothbart, 1996). Sustained attention also allows children to encode information relating to social cues, which facilitates competent interactions with peers (Andrade et al., 2009; Davies et al., 2008).

Although the contribution of sustained attention to school readiness is increasingly recognized, there is still uncertainty surrounding the component(s) of sustained attention driving this association. Two commonly measured facets of sustained attention are the ability to concentrate on an often boring or repetitive task (often known as focused attention), and the resistance to the urge to perform an impulsive act (often referred to as lack of impulsivity). For example, the NICHD Study of Early Child Care and Youth

Development measured children's sustained attention at 54 months of age using a continuous performance task (CPT) that presented images on a computer screen; children were asked to press a button as fast as possible when a target stimulus (e.g., a butterfly) appeared while avoiding distractors. The number of correct hits measured focused attention, while the number of hits for incorrect targets measured impulsive errors. Both types of scores were associated with children's achievement and behavior (NICHD Early Child Care Research Network, 2003). However, those data were cross-sectional. More recent research using longitudinal data suggests that the two measures of sustained attention may have unique associations with indicators of child wellbeing. The Fragile Families and Child Wellbeing Study (FFCWS) measured sustained attention using the Leiter-R Attention Sustained task (Roid & Miller, 1997), a pencil and paper task that provides the child with a picture (e.g., a flower) at the top of a page containing multiple images and asks him/her to cross out as many images matching the target as s/he can in a limited amount of time. Razza, Martin, and Brooks-Gunn (2011) found that children's focused attention scores (the number of correct cross-outs) at age 5 predicted higher achievement scores at age 9, while their lack of impulsivity scores (the number of incorrect cross-outs, reflected) at age 5 predicted fewer internalizing problems at age 9. Notably, focused attention and lack of impulsivity both predicted better approaches to learning at age 9, which measured classroom behaviors such as following rules, paying attention, and completing tasks.

The present study extends this research by asking whether these same measures of focused attention and lack of impulsivity at age 5 in the FFCWS predict children's attention-related problems at age 9. The FFCWS is a multi-site birth cohort of predominantly low-income children in the U.S. It has the advantage of a rather lengthy window of observation (four years) between the measurement of sustained attention and later attention-related problems. A second advantage is the use of multiple reporters on children's attention problems at age 9. We examine teachers' reports of ADHD-related problems and hyperactivity problems, mothers' reports of attention problems, and, last, whether the mother had been told by a health professional that her child has ADHD.

Attention Problems and Executive Function

Although they are both considered indicators of sustained attention, focused attention and lack of impulsivity originate in different attentional networks that occupy distinct portions of the brain. The dominant model of attention distinguishes among three attentional networks, two of which have implications for sustained attention (Posner & Petersen, 1990). The first, the anterior attention system, is thought to be involved in the effortful control of behavior. It is called on to resolve conflict, handle novelty, and detect errors (Berger & Posner, 2000). Because it is susceptible to voluntary control, it is sometimes referred to as the executive control network (Berger & Posner, 2000). A test of impulsive errors on a sustained attention task should activate this attentional network because it requires response inhibition (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005).

The second attentional network, termed the vigilance or alerting system, is involved in maintaining a vigilant state. For example, it helps maintain alertness during tasks requiring prolonged attention to an infrequent target, specifically by allowing children to clear their mind in the service of staying ready to respond (Rothbart, Derryberry, & Posner, 1994). Thus, this attentional network would be activated by a test of focused attention (Willcutt et al., 2005). Last, the posterior attention system is involved in orienting to external stimuli. This system is not relevant to the current inquiry, as it does not facilitate sustained attention.

It has been proposed that ADHD consists primarily of a deficit in executive function (Barkley, 1997), and substantial research now supports this contention (see reviews by

Castellanos & Tannock, 2005; Nigg, 2001; Willcutt et al., 2005). Executive function is thought to include a suite of neuropsychological skills that are involved in planning, set shifting, interference control, and working memory (Pennington & Ozonoff, 1996). If children with ADHD or other attention problems are deficient in executive function, then their anterior attention network, or executive control system, should be the attentional network that is most compromised relative to typically developing children (Berger & Posner, 2000). Thus, we might expect that a lack of impulsivity during tests of sustained attention is more predictive than focused attention of subsequent attention problems.

On the other hand, the vigilance system has been found to be compromised in children with ADHD compared to controls (Hinshaw, 2002; Losier, McGrath, & Klein, 1996). Indeed, Huang-Pollock, Nigg, and Halperin (2006) found that children with both the inattentive and hyperactive subtypes of ADHD scored lower than controls on focused attention, suggesting that it may be one of the disorder's primary features. However, the research to date on focused attention, lack of impulsivity, and attention problems has focused almost exclusively on children with an ADHD diagnosis, although children with attention problems need not meet that standard in order to be at risk of compromised academic or social development. An exception is one recent study of children aged 9-14 that found that focused attention was correlated with parent-rated hyperactivity but not inattention, while lack of impulsivity was correlated with both teacher-reported inattention and hyperactivity; however, changes in focused attention and lack of impulsivity did not predict changes in inattention and hyperactivity scores over the course of one year (Vaughn et al., 2011). Thus, there is clearly a need for more research on focused attention and lack of impulsivity and their associations with continuous scales of inattentive and hyperactive behavior problems.

The advantage of such scales (e.g., counts of symptoms) is that they facilitate the conceptualization of attention deficits as lying on a continuum, on which greater deficits are more delimiting, even in the absence of a clinical diagnosis of ADHD. The ADHD diagnosis itself derives from such a scale. As Wilding (2005, p. 488) has noted, "Diagnosis depends in essence on the number of impaired behaviours noted from a checklist, not on the presence of a fixed set of necessary and sufficient symptoms. The criterion for the number of such behaviors that distinguish positive cases from non-cases is arbitrary, segmenting a continuous distribution, rather than separating two distinct categories." The use of a binary variable to indicate ADHD case status may lose valuable information by collapsing all non-cases, even those with high but sub-clinical symptoms, into a single category. There may be valuable insights to be gained by extending the research on attentional problems to non-clinical samples.

The Present Study

The present study asks how children's scores on two facets of sustained attention – focused attention and lack of impulsivity – measured at age 5 during a laboratory task predict a mother-reported scale of attention problems, mother-reported receipt of an ADHD diagnosis, and teacher-reported scales of attention and hyperactivity problems at age 9. The sample used for this analysis, the FFCWS, is particularly relevant to the study of attention-related problems, given that sustained attention is now commonly viewed as a sign of school readiness (Blair, 2002). Children from low-income families score lower than other children at the time of school entry on tests of language and math skills (e.g., Denton & West, 2002). It appears that they also exhibit poorer attention skills (Mezzacappa, 2004; Razza, Martin, & Brooks-Gunn, 2010; Stevens, Lauinger, & Neville, 2009). Thus, targeting low-income children's attention skills may be one strategy for closing the income gap in school readiness.

Children's poverty status may also be important if it moderates associations between early sustained attention and later attention problems. A previous study with this sample found that cross-sectional associations between sustained attention and achievement and behavior at age 5 turned on children's poverty status (Razza et al., 2010). Specifically, lack of impulsivity was associated with lower receptive vocabulary and higher externalizing behaviors for poor but not near-poor children. The present study tests whether the greater vulnerability of poor children to low impulse control extended to attention problems at age 9.

Methods

Participants

The FFCWS is a predominantly low-income, minority sample of nearly 4,900 children born between 1998 and 2000 in 20 U.S. cities. By design, children born to unmarried parents were oversampled ($n = 3,712$ vs. $n = 1,186$ children born to married parents), and cities were selected to be representative of all U.S. cities with populations of 200,000 or more (for additional information on sample selection, see Reichman, Teitler, Garfinkle, & McLanahan, 2001). Mothers were interviewed in the hospital within 48 hours of the child's birth and fathers were interviewed soon after. The core study consisted of mother and father phone interviews when the child was 1, 3, 5, and 9 years of age.

The present study draws on data from a substudy called the In-Home Longitudinal Study of Preschool Aged Children, which mothers were invited to join at the time of the age 5 core phone interview. Specifically, 2,863 families across 18 cities were eligible for inclusion in our analytic sample because they participated in this substudy at age 5, when sustained attention was assessed. For inclusion in our analytic sample, we required that cases have valid data on one of four outcomes measured at age 9, resulting in the exclusion of 346 cases. Compared to excluded cases, included cases ($n = 2,517$) were less likely to be in poverty at child age 5. Included mothers were also more likely to be married and white. However, included mothers scored higher on depression at child age 5 than excluded mothers, and included children scored higher than excluded children on age 5 externalizing behaviors. There were no differences between included and excluded cases on child sex or whether the mother reported that the child had received a diagnosis of ADHD by age 5.

Procedures

Families were visited in their homes at child ages 5 and 9 by trained data collectors. At both visits, children were directly assessed, and mothers (or primary caregivers) were interviewed about their family structure, household routines, and child's health and behavior. Also at age 9, mothers and children provided consent to contact the child's teacher. The teacher was then sent a questionnaire that assessed the child's behavior, social skills, and approaches to learning. Teachers were sent \$25 as a token of appreciation for their participation.

Measures

Sustained attention—Children's sustained attention at age 5 was assessed using the Attention Sustained task from the Leiter International Performance Scale-Revised (Roid & Miller, 1997). Children were shown a page with pictures of a variety of objects scattered throughout and a target object at the top. They were asked to cross out as many of the objects matching the target as possible without accidentally crossing out any other objects. Children were given a limited amount of time to perform four trials (30 seconds for the first three trials and 60 seconds for the fourth) but were not scored on speed. Their performance across trials was averaged to yield two attention scores. The number of cross-outs of objects matching the target reflected the child's *focused attention*, while the number of cross-outs of

objects not matching the target was reversed to represent the child's *lack of impulsivity*. Scores were standardized against a national norming sample ($M = 10$, $SD = 3$). The task has high internal reliability ($\alpha = .83$) for children ages 4 to 5 years and good test-retest reliability ($r = .85$; Roid & Miller, 1997).

Mother-reported medical diagnosis of ADHD—At the age 9 home visit, mothers were asked if they had ever been told by a doctor or health professional that their child had a diagnosis of attention deficit disorder (ADD) or attention deficit hyperactivity disorder (ADHD). Although the study did not verify this diagnosis, a lack of precision on this measure is acceptable for the purpose of the present study, which is concerned with the continuum of attention-related problems rather than a clinical diagnosis of ADHD.

Mother-reported attention problems—At the age 9 home visit, mothers were given a self-administered questionnaire that included the Child Behavior Checklist (Achenbach & Rescorla, 2001). Only the Attention problems scale is considered here. This consists of 10 items describing behavioral manifestations of attention deficits (sample item: can't sit still, is restless, or hyperactive). Mothers indicated how true each item was of her child using a 3-point scale (0 = *not true*, 1 = *somewhat true*, 2 = *often true*). Items were summed ($\alpha = .85$).

Teacher-reported hyperactivity—Teachers reported on children's hyperactive behavior using the Conners Teacher Rating Scale – Revised Short Form (CTRS-RSF; Conners, 2001). The Hyperactivity subscale includes seven items tapping restlessness and low impulse control (sample item: Is always “on the go” or acts as if driven by a motor). Teachers reported how well each item described the child using a 4-point scale (0 = *not true*, 1 = *just a little true*, 2 = *pretty much true*, 3 = *very much true*). Items were summed ($\alpha = .92$).

Teacher-reported ADHD-related problems—Teachers completed the ADHD subscale of the CTRS-RSF (Conners, 2001). This scale includes 12 items tapping both inattentive and hyperactive behaviors (sample items: Cannot remain still, Short attention span). One item (excitable, impulsive) also appeared in the Hyperactivity subscale. The same 4-point response scale used for the Hyperactivity scale applied. Items were summed ($\alpha = .95$).

Controls—All multivariate models controlled for whether the mother reported at the age 5 home visit that the child had received a diagnosis of ADHD from a doctor or health professional. Additional characteristics of the child and family at child age 5 were included as controls. Indicator variables reflected the child's sex and mother's race/ethnicity (white, black, Hispanic, and other). Maternal age at the time of the child's birth was recorded at baseline. Maternal education was coded as less than high school, high school graduation or GED, or some college or more. Maternal marital status was coded as married, cohabiting, or single. A ratio of adults to children living in the household was calculated based on a household roster. The family's poverty status expressed the total household income as a proportion of that year's poverty threshold using the following categories: 1 = 0-49%, 2 = 50-99%, 3 = 100-199%, 4 = 200-299%, and 5 = 300%+.

The child's receptive vocabulary was assessed using the PPVT-III (Dunn & Dunn, 1997). Child externalizing problems were measured using the scale of that name from the Child Behavior Checklist/4-18 (Achenbach, 1991). This measure summed 35 items ($\alpha = .91$) describing externalizing behavior problems that mothers endorsed on a 3-point scale (0 = *not true* to 2 = *very true*). Maternal depression was a count of depressive symptoms (0-7) during the past year collected via the Composite International Diagnostic Interview – Short Form Section A (Kessler, Andrews, Mroczek, Ustun, & Wittchen, 1998). Maternal warmth and

provision of learning materials were measured using items from the HOME Inventory (Caldwell & Bradley, 1984). Maternal warmth was the average of eight dichotomous items ($\alpha = .80$) observed by the data collector that denoted the mother's responsiveness and affection towards the child during the home visit. Provision of learning materials was the average of 11 dichotomous items ($\alpha = .67$) indicating the availability of toys and other materials that promote learning and motor development. Difficult temperament in infancy was assessed at 1 year and represents the average of three items ($\alpha = .60$) drawn from the Emotionality scale of the Emotionality, Adaptability, Sociability Temperament Survey for Children (Buss & Plomin, 1984).

Missing data

Rates of missingness on most measures at age 5 fell below 5%; however, rates ranged from 20% to 29% on the variables that required face-to-face contact because some mothers (e.g., those who had left the region) completed the interview by phone. Multiple imputation was conducted on the assumption that data were missing at random; this condition posits that missingness can be modeled by observed variables (Allison, 2009) – a reasonable assumption given that our imputation models incorporated data from multiple waves and sources (and included numerous auxiliary variables that did not appear in our analytic models; Graham, 2009). Five imputed data sets were created (McCartney, Burchinal, & Bub, 2006). Age 9 outcomes were used to impute values of all other measures but only unimputed values were themselves analyzed in models, per von Hippel (2007). Thus the number of cases with valid values varies across outcomes and is noted in tables accordingly. The ICE command in Stata was used to generate the imputed data files, while the MI ESTIMATE and MIBETA commands were used to combine estimates across data files.

Results

Table 1 presents descriptive statistics for all study variables. It shows that the sample was generally low-income. For example, 21% of children came from families whose income represented less than 50% of the poverty threshold. Another 20% of the children had families whose income fell between 50 and 99% of the poverty threshold. While generally low-income, the sample represented considerable racial/ethnic diversity. Twenty-two percent of mothers were white, 52% were black, 22% were Hispanic, and 3% were another race/ethnicity. Mothers of 4% of children reported that their child had been diagnosed with ADHD by age 5, while 13% reported the receipt of this diagnosis by age 9. Nationally, 8% of mothers of children aged 5-11 report that their children have been diagnosed with ADHD (Bloom, Cohen, & Freeman, 2011); thus, the prevalence of ADHD in our sample was unusually high. However, this was expected because the prevalence of ADHD is higher among low-income children than other children (Bloom et al., 2011). Children in our sample scored higher than the national norming sample on focused attention ($M (SD) = 12.7 (3.3)$ versus $10.0 (3.0)$) but the same on lack of impulsivity ($10.1 (2.9)$ versus $10.0 (3.0)$).

Bivariately, both focused attention and lack of impulsivity at age 5 were negatively associated with all four age 9 outcomes (Table 2). Correlations between focused attention and the outcomes ($r_s = .13 - .19, p < .001$) and between lack of impulsivity and the outcomes ($r_s = .12 - .15, p < .001$) fell in a similar range, which should be considered small in size (Cohen, 1988). The correlation between focused attention and lack of impulsivity was $.15 (p < .001)$. Correlations among the age 9 outcomes were medium- to-large in size ($r_s = .32 - .89, p < .001$).

Regression results are presented in Table 3. Because focused attention and lack of impulsivity were included in a single model to predict age 9 outcomes, the coefficient for each component of sustained attention reflects its association with the outcome net of the

other component. Robust standard errors adjusted for families sampled from the same city. All controls listed above were included. Results showed that both focused attention and lack of impulsivity at age 5 significantly predicted lower odds of the mother reporting at age 9 that the child had been diagnosed with ADHD (OR = .93, $p < .01$ and OR = .91, $p < .05$, respectively). A post-estimation comparison of coefficients for focused attention and lack of impulsivity showed that they did not significantly differ from each other, $F(1, 10.5) = 0.10$, $p = .76$. That is, they were similarly predictive of the mother's report of an ADHD diagnosis by age 9.

Similarly, both focused attention ($B = -0.10$, $SE = 0.03$, $\beta = -0.09$, $p < .01$) and lack of impulsivity ($B = -0.08$, $SE = 0.04$, $\beta = -0.06$, $p < .05$) at age 5 predicted mother-reported attention problems at age 9. That is, children with higher scores on both components of sustained attention scored lower on mother-reported attention problems four years later. A post-estimation test revealed that the coefficients for focused attention and lack of impulsivity did not significantly differ from each other, $F(1, 10.4) = 0.18$, $p = .69$. Both focused attention and lack of impulsivity also predicted teacher-reported ADHD problems, though coefficients were small ($B = -0.18$, $SE = .08$, $\beta = -0.07$, $p < .05$ and $B = -0.23$, $SE = 0.10$, $\beta = -0.08$, $p < .05$, respectively). Again, a post-estimation test showed that the two coefficients did not significantly differ from each other, $F(1, 14.2) = 0.12$, $p = .73$). Thus, higher scores on both aspects of sustained attention predicted lower teacher-reported ADHD problems. Last, neither aspect of sustained attention was significantly associated at the $p < .05$ level with teacher-reported hyperactivity scores. However, lack of impulsivity was marginally associated with lower hyperactivity scores ($B = -0.12$, $SE = .05$, $\beta = -0.07$, $p = .05$).

Tests of moderation by children's poverty status were conducted by creating interactions between a binary measure of poverty (1 = below poverty threshold) and both focused attention and lack of impulsivity. These interaction terms were tested separately in models of all four outcomes. They were never statistically significant (results not shown). Therefore, associations between sustained attention at age 5 and all measures of attention problems at age 9 were the same for children below and above the poverty line.

Discussion

The present study finds that two aspects of sustained attention – focused attention and lack of impulsivity – measured at the age of school entry predicted attention problems four years later according to multiple reporters. These attention problems included the mother's report of whether the child had been diagnosed with ADHD, her report of the child's attention behavior problems, and the teacher's report of ADHD-related behavior problems. The measure of teacher-reported hyperactivity problems was only marginally associated with lack of impulsivity. Thus, it appears that sustained attention may be a more powerful predictor of subsequent inattention than hyperactivity (although the measures of inattention also measured hyperactivity in part, as discussed in further detail below.)

It is widely believed that a deficit in executive function, and more particularly, response inhibition, is the primary hallmark of ADHD (e.g., Castellanos & Tannock, 2002; Willcutt et al., 2005). Although our sample was not limited to clinically diagnosed children, we expected that lack of impulsivity, which reflects the executive control attentional network, would have greater predictive value than focused attention, which reflects the vigilance attentional network, for subsequent attention problems. In point of fact, we found that they were equally predictive, not only of mother-reported ADHD diagnosis, but of mother- and teacher-reported attention problems. Pending replication, this finding suggests that

inattentive behavior at the age of school entry may well indicate a fundamental deficit with lasting implications for the child's development.

However, it should be noted that our measures of attention problems at age 9 combined symptoms of inattention with symptoms of impulsivity and hyperactivity. Specifically, the mother-reported attention problems scale included signs of both types of problem behaviors, as did the teacher-reported ADHD problems scale. In addition, the children reported to have been diagnosed with ADHD at age 9 may have exhibited, en masse, both inattention and hyperactivity symptoms. A shortcoming of our study is our reliance on mothers' report of an ADHD diagnosis instead of a clinical diagnosis, and our concomitant inability to distinguish children according to their ADHD subtype: predominantly inattentive, predominantly hyperactive-impulsive, and combined (Barkley, 1997). While focused attention and lack of impulsivity were equally strongly predictive of reported ADHD diagnosis, we were unable to test whether they were equally predictive of the same subtypes.

Another study with this sample found that focused attention at age 5 predicted achievement at age 9, while lack of impulsivity predicted internalizing behavior problems (Razza et al., 2011). However, approaches to learning – a composite of teacher-reported items tapping attention, persistence, and independence – was predicted by both focused attention and lack of impulsivity. The current study similarly finds that mother- and teacher-reported scales that combine cognitive and behavioral processes are predicted by both focused attention and lack of impulsivity.

Also consistent with Razza et al. (2011), associations between sustained attention at age 5 and our outcomes of interest did not vary by children's poverty status. Although an earlier study found that lack of impulsivity at age 5 was concurrently associated with achievement and behavior for children in poverty but not other low-income children (Razza et al., 2010), it appears that such differential associations have faded by age 9. Razza et al. (2010) hypothesized that children in poverty had fewer experiences at home, such as book-reading, that resembled paper and pencil activities at school, so that the transition to school was particularly demanding of their impulse control skills. By age 9, poor and non-poor children have both had ample exposure to school activities, and their impulse control skills may be equally predictive of positive adjustment.

Curiously, our sample scored nearly a full standard deviation higher than the Leiter-R norming sample on focused attention, although the proportion of children reported to have received an ADHD diagnosis was higher than average. National estimates show that the mothers of low-income children are generally more likely to report an ADHD diagnosis than the mothers of higher-income children (Akinbami, Liu, Pastor, & Reuben, 2011). The reason for the high focused attention score is harder to explain. The children in the norming sample performed the Attention Sustained task as part of the full 90-minute Leiter-R battery, whereas it was the only task from the Leiter-R administered to the children in our sample (although they completed other tests). The children in the norming sample may have scored lower due to fatigue or boredom. Alternatively, the norming sample data were collected in the mid-1990s. It is possible that the popularization of video games for younger children has produced an overall increase in focused attention scores because video games can improve eye-hand coordination (see Spence & Feng, 2010). It may be that new norming data for this task are in order.

In sum, these results add to accumulating research showing that early attention skills have significant ramifications for development across multiple domains (Andrade et al., 2009; Duncan et al., 2007; Razza et al., 2011; Rhoades et al., 2011). Children who, at age 9, are described by their teacher as having a short attention span, lacking the ability to finish what

they start, and being unable to remain still are no doubt at a disadvantage, both scholastically and socially, compared to their peers. The seriousness of the implications of attention deficits for both academic and behavioral growth has spurred some to consider attention as a fruitful area for early intervention. Rueda, Rothbart, McCandliss, Saccomanno, and Posner (2005) improved attentional control in 4- and 6-year-old children using computerized training exercises in 2-3 weeks. More recently, Wass, Porayska-Pomsta, and Johnson (2011) succeeded in improving infants' sustained attention through lab activities over the course of 15 days. Research is now needed to determine the dosage of attention intervention that is necessary to produce cascading effects on young children's achievement and behavior.

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Table 1

Description of study measures

	%	M (SD)
Sustained attention at age 5		
Focused attention		12.7 (3.3)
Lack of impulsivity		10.1 (2.9)
Controls		
Child male	52%	
Mother's age at child birth		25.1 (6.0)
Poverty category		
0-49%	21%	
50-99%	20%	
100-199%	26%	
200-299%	14%	
300%+	19%	
Mother's race		
White	22%	
Black	52%	
Hispanic	22%	
Other	3%	
Mother's education		
< HS degree	30%	
HS degree	27%	
> HS degree	44%	
Mother's marital status		
Single	40%	
Married	34%	
Cohabiting	26%	
Household adults:children		1.0 (0.7)
Maternal depression		1.0 (2.1)
Child PPVT		94.0 (16.1)
Maternal warmth		0.8 (.3)
Learning materials at home		0.9 (.1)
Mother-reported medical diagnosis of ADHD	4%	
Child's externalizing problems		9.4 (6.4)
Outcomes at age 9		
Mother-reported medical diagnosis of ADHD	13%	
Mother-reported attention problems		3.7 (3.6)
Teacher-reported ADHD problems		9.3 (8.9)
Teacher-reported hyperactivity		3.7 (4.7)

Note. Calculations are based on five multiply imputed data sets. $N = 2,517$.

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Table 2
Correlations among measures of sustained attention and later attention problems

	1.	2.	3.	4.	5.	6.	7.
1. Focused attention	--						
2. Lack of impulsivity	.15	--					
3. Mother-reported medical diagnosis of ADHD	-.13	-.12	--				
4. Mother-reported attention problems	-.15	-.12	.44	--			
5. Teacher-reported ADHD problems	-.19	-.15	.34	.45	--		
6. Teacher-reported hyperactivity	-.13	-.13	.32	.38	.89	--	

Note. All correlations are significant at the $p < .001$ level.

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Table 3
Longitudinal associations between sustained attention at age 5 and attention problems at age 9

	Mother-reported medical diagnosis of ADHD			Mother-reported attention problems			Teacher-reported ADHD problems			Teacher-reported hyperactivity		
	OR	(SE)	B	(SE)	β	B	(SE)	β	B	(SE)	β	
Focused attention	0.93 ^{**}	(.02)	-0.10 ^{**}	(0.03)	-0.09	-0.18 [*]	(.08)	-0.07	-0.05	(.04)	-0.03	
Lack of impulsivity	0.92 [*]	(.03)	-0.08 [*]	(0.04)	-0.06	-0.23 [*]	(.10)	-0.08	-0.12 [†]	(.05)	-0.07	
N		2,503		2,372			1,626			1,624		
R ² or pseudo R ²		.20		.22			.19			.15		

Note. Table presents odds ratio (OR) from a logistic regression model for mother-reported diagnosis of ADHD, and B, (SE), β from regression models for other outcomes. Estimates are based on 5 multiply imputed data sets. All models include the following controls: child sex, maternal race/ethnicity, maternal marital status, maternal education, poverty status, household ratio of adults to children, child difficult temperament, child receptive vocabulary, maternal depression, maternal age, availability of learning materials, child externalizing problems, and mother-reported diagnosis of ADHD at age 5. Robust standard errors are used to adjust for clustering by city.

† $p < .10$,
* $p < .05$,
** $p < .01$,
*** $p < .001$.