The Contribution of Effortful Control to Reading Growth in Early Childhood

by

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ABSTRACT

This longitudinal study examined the relations between self-regulation and reading achievement from kindergarten through second grade. In addition to the broader concept of effortful control, this study looked at various sub-components, including attention focusing and inhibitory control. A series of unconditional latent growth curve models were estimated to assess the initial level and growth of children's parent- and teacher-reported effortful control and reading skills. In addition, parallel-process latent-growth curve models were estimated to examine the relations between the growth parameters (e.g., how the initial level and growth in self-regulation relates to the initial level and growth in reading). Parent-reported inhibitory control and effortful control displayed linear growth over this time period. Teacher-reported self-regulation did not change significantly. Reading achievement increased across all three time points, but the rate of growth was steeper from kindergarten through first grade than from first to second grade. Results from the parallel-process models showed that the kindergarten scores for parent-reported attention focusing and inhibitory control were negatively related to growth in Letter Word abilities from first through second grade, whereas initial teacher-reported attention focusing, inhibitory control, and effortful control were negatively related to growth in Passage Comprehension abilities from first to second grade. This study illustrates important relations between self-regulation and reading abilities throughout the first few years of elementary school.

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Mastery of reading involves a complex set of abilities and is important for children's academic success and future (Smith, Borkowski, & Whitman, 2008). Due to the importance of reading, scholars have devoted considerable resources toward understanding the factors and processes involved in its development. Increasingly, scientists are considering the role of socio-emotional factors for the development of reading. There is mounting evidence that self-regulation, and effortful control in particular, is of importance to emerging literacy (Blair & Razza, 2007; Deater-Deckard, Mullineaux, Petrill, & Thompson, 2009; Liew, McTigue, Barrois, & Hughes, 2008; Valiente, Swanson, & Eisenberg, 2012). The goal of this study is to explore if effortful control and two of its components, namely attention focusing and inhibitory control, relate to growth in reading from kindergarten through second grade.

In our modern world, learning to read is crucial to success. By second grade, children should be able to read a variety of words in fiction and nonfiction and begin to deploy appropriate strategies to improve comprehension (Griffin, Burns, & Snow, 1998). Nevertheless, many children experience reading difficulties and disabilities, and these deficits have profound implications for later life. The National Assessment of Adult Literacy found that 14% of adults in the U.S. have below basic literacy skills, and minority groups are overrepresented in this population (NAAL; Institute of Education Sciences, 2003). A prospective study found that children with reading disorders at 12 and 19 years of age had a higher risk of poor outcomes as young adults. These included lower SES, lower IQ, and lower educational and occupational achievement (Beitchman et al.,

2001). In adulthood, literacy is an important predictor of health status, as well as health-related knowledge and behaviors (Sentell & Halpin, 2006).

Five basic skills have been outlined as essential to reading development: the alphabetic principle, phonemic awareness, oral reading fluency, vocabulary, and comprehension (Griffin et al., 1998). The alphabetic principle and phonemic awareness involve the understanding that letters are symbols and that small combinations of letters can represent linguistic sounds (National Reading Panel, 2000). Vocabulary is the accumulation of word knowledge, and oral reading fluency is the ability to read text quickly, accurately, and with the proper expression. Comprehension, or the ability to understand what is read, is at the heart of reading and instruction. Educational goals for children include the ability to read texts independently, even when they are difficult or not intrinsically motivating (Griffin et al., 1998; National Reading Panel, 2000). Prior to children's development into fluent readers and writers, certain antecedent skills are necessary; these are termed emergent literacy skills and include oral language skills, such as the early expression and comprehension of syntax and vocabulary and code-related skills, or early understanding of print, the alphabet, early writing skills, and phonemic awareness (Cabell, Justice, Konold, & McGinty, 2011).

There is evidence that children acquire these various reading and pre-reading abilities at different rates, and these differences may be due to a variety of factors. For example, family SES and home environment are related to reading ability (Molfese, Modglin, & Molfese, 2003). In addition to environmental factors that influence reading skills, Molfese and colleagues highlight that individual characteristics of the child may play important roles; intelligence is one example. Another important child characteristic

that has come under consideration is self-regulation, or more specifically, effortful control.

Self-Regulation

Self-regulation is an important skill that develops throughout infancy and early childhood, and broadly refers to the ability to regulate one's own attention, emotions, and behaviors (Cartwright, 2012). Many of these self-regulatory mechanisms are considered a core aspect of temperament (Kochanska, Murray, & Harlan, 2000; Rothbart & Bates, 2006). Rothbart and Bates (2006), for example, define temperament as a set of "constitutionally based differences in reactivity and regulation;" reactivity concerns physiological responses and general dispositions, whereas regulation refers to the processes by which one moderates this reactivity, often via effortful control (EC; p. 100) and related processes.

According to Putnam and Rothbart (2006), EC is characterized by behaviors such as the ability to shift and focus attention, inhibitory control, low intensity pleasure, and perceptual sensitivity. Kochanska and colleagues (2000) also maintain that EC comprises functions such as delaying, slowing down motor activity, suppressing or initiating activity to signal, effortful attention, and lowering one's voice. Because they are two of the central domains comprised by EC, and are the two most commonly used indices of EC, the present study will focus on attention focusing and inhibitory control.

Unlike many other temperamental characteristics that are present in infancy (e.g., activity level or soothability), EC typically emerges later in development, during the second or third year of life; nevertheless, it is considered an innate, temperamental characteristic (Kochanska et al., 2000; Rothbart, Sheese, & Posner, 2007). Kochanska

and colleagues (2000) also found that certain antecedents of EC are present early in life, including infants' ability to focus attention. Kochanska et al. (2000) found that EC improved significantly from 22 months to 33 months, and there was significant continuity in EC in individual children over that time period.

Common assessments of EC include parent- and teacher-report measures (Rothbart, Ahadi, Hershey, & Fisher, 2001), as well as observational tasks. These may include a range of conflict tasks, such as a Stroop test, or tests that assess low-level attentional processes, like the Attention Network Task (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Petersen & Posner, 2012). These tasks require participants to inhibit their dominant response when presented with conflicting stimuli (e.g., when presented with a color word printed in a different color ink, children must say the color of the printed text when reading the word). In addition, Kochanska and colleagues have developed a battery of tests that are designed to measure EC in infants and toddlers (Kochanska, Murray, & Coy, 1997; Kochanska et al., 2000). These include delaying of snack or a gift, walking slowly in a line, and turn-taking. For kindergarteners, more sophisticated measures, such as the peg-tapping task or Continuous Performance Task (CPT), are used to simultaneously measure selective attention and impulsivity (Diamond & Taylor, 1996; Enger, Mirsky, Sarason, Bransome Jr., & Beck, 1956).

Self-Regulation and Reading

The literature is somewhat inconsistent in how it refers to the measures that are commonly used to assess self-regulation. At times, attention focusing and inhibitory control are measured together as part of EC (e.g., Blair & Razza, 2007), and in certain cases they are considered separately as self-regulatory functions (Carlson & Moses, 2001;

Welsh, Nix, Blair, Bierman, & Nelson, 2010). For consistency, the term self-regulation here is used to refer to EC and its components.

Self-regulation is important to children's success, particularly in school where it relates to students' maladjustment, social skills, relationships with teachers and peers, school engagement, and academic performance (Allan & Lonigan, 2011; Eisenberg, Valiente, & Eggum, 2010). Specifically, numerous studies have demonstrated the myriad ways that high levels of EC relate to children's reading development. For example, Deater-Deckard et al. (2009) found that school-aged children with higher EC had better reading skills compared to their peers. Teacher-reported and observed EC were found to be significantly related to letter knowledge in kindergarten (Ponitz, McClelland, Matthews, & Morrison, 2009). In addition, teacher-reported EC in preschool was found to significantly predict letter knowledge in kindergarten.

High levels of self-regulation have important implications for the social aspects of early education as well as cognitive benefits. Silva and colleagues (2011) found that EC in low-income 3-5 year olds was positively related to school attitudes through teacher-child relationship quality. EC has been shown to relate to factors like students' relationships with teachers and peers and school liking in children, in turn relating to the development of reading skills and general academic competence (Eisenberg et al., 2010; Valiente, Lemery-Chalfant, & Castro, 2007).

In addition to considering the broader construct of EC, it is of interest to consider how attention focusing and inhibitory control individually relate to the development of early literacy skills (Zhou, Chen, & Main, 2012). It is possible that these components of EC relate to reading abilities in different ways during early elementary school. It is

important in the context of previous work to examine the relation between EC as a whole and reading over time. The present study further extends this line of research by examining how reading growth simultaneously relates to individual components of EC.

Attention Focusing

Attentional control is a fundamental aspect of self-regulation (Petersen & Posner, 2012; Posner & Rothbart, 2007). Attention is understood as the ability to concentrate on information or tasks without distraction or fatigue (Cartwright, 2012). The attention system is one of many cognitive processing systems and is composed of three networks that are interconnected but discrete: alerting, orienting, and executive control (Petersen & Posner, 2012). The executive control network, which monitors and resolves conflict between other brain networks, is considered most relevant to discussions of self-regulation, particularly EC (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Rothbart et al., 2007). This network comprises the anterior cingulate cortex, medial frontal cortex, and lateral prefrontal areas of the brain (Petersen & Posner, 2012). These brain regions have also been implicated in monitoring and resolving conflict and systems of top-down cognitive control.

The regulation of attention plays an important role in early vocabulary development even before higher-level EC functions typically emerge. One of the mechanisms for this relation may be joint attention, or the ability to coordinate social attention toward a partner and an object (Bakeman & Adamson, 1984). Joint attention is a complex skill that requires "triadic" focusing of attention between the individual, another person, and a third object (Vaughan Van Hecke et al., 2007). Joint attention and other components of the parent-child dyad have been implicated in individual differences in EC

(Zhou et al., 2007). Furthermore, fMRI studies have associated the ventromedial frontal cortex, the left superior frontal gyrus, and the cingulate cortex with joint attention episodes (Williams, Waiter, Perra, Perrett, & Whiten, 2005); these same areas are part of the general attention network cited previously.

Joint attention is considered a prerequisite for vocabulary development (Mundy & Newell, 2007). Longitudinal studies have demonstrated that joint attention and vocabulary acquisition are significantly associated at 6-, 8-, 10-, 12-, and 18-months of age (Morales et al., 2000). Furthermore, responding to bids for joint attention significantly predicted language development at 30 months over and above parent-report of language abilities at 24-months. According to Mundy et al. (2007), joint attention development also reflects the emergence of social-cognitive processes, which might further provide a foundation for subsequent language development and social competence.

As children develop, attention focusing continues to play an important role in their academic experiences. Connor and colleagues' (2010) theoretical model postulates that students with higher levels of attention are better able to successfully focus their cognitive resources on specific learning tasks, more likely to perform well when self-direction is required, and less likely to become distracted. The cognitive advantages associated with high attention may lead to a more efficient use of learning time, and thus more efficient learning of important reading concepts.

Empirical studies have also demonstrated the relation between attention focusing and reading development. Blair & Razza (2007) found that high levels of attention focusing in preschool and kindergarten were associated with higher levels of letter

knowledge and phonemic awareness in kindergarten. In addition, Welsh and colleagues (2010) found that attention focusing in preschool was related to print knowledge and phonemic awareness; furthermore, attention focusing predicted word and nonword reading and memory for stories at the end of the kindergarten year. Attention focusing in at-risk students was found to partially mediate the relation between reading readiness at 5 years and reading comprehension abilities at 14 years of age (Smith et al., 2008). The current study will explore this relation during the early elementary years by examining the extent to which attention focusing relates to growth in reading abilities from kindergarten through second grade. Most work examining this relation in early childhood is limited to one or two time points during the preschool to kindergarten transition; the present study will extend this work to first and second grade. In addition, it examines longitudinal relations between these constructs.

Inhibitory Control

Another important component of EC is inhibitory control, or the ability to plan actions and restrain responses appropriately. Inhibitory control is also a contributor to children's developing conscience and internalization (Kochanska et al., 1997; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). Researchers using fMRI technologies have implicated areas such as the dorsolateral prefrontal cortex, inferior frontal cortex, orbital frontal cortex, middle and inferior frontal gyri, frontal limbic area, anterior insula, and inferior parietal lobe in inhibitory control processes (Aron, Robbins, & Poldrack, 2004; Garavan, Ross, & Stein, 1999). The prefrontal cortex in particular is thought to be important for the executive control processes that are required for inhibitory control.

Numerous studies have indicated that inhibitory control plays an important role in children's early academic and social experiences. Theoretically, students who are better at inhibiting their responses to classroom distractions may create more opportunities for successful learning to take place (Connor et al., 2010). Blair and Razza, (2007) found that inhibitory control was a significant predictor of phonemic awareness and letter knowledge in kindergarteners. Further, Liew and colleagues (2008) found that inhibitory control in first grade significantly predicted reading performance in third grade.

Prior to kindergarten, children with higher levels of inhibitory control were found to achieve higher levels of emergent literacy and vocabulary than their more poorly regulated peers (McClelland et al., 2007). High levels of inhibitory control may help young students to follow teachers' instructions and enable them to focus on tasks without becoming distracted. Studies have also shown that students who struggle with reading comprehension have particular difficulties in tasks assessing inhibitory control (Cain, 2006; De Beni & Palladino, 2000).

Prior evidence suggests that EC, which is henceforth considered an average between attention focusing and inhibitory control, is an important contributor to early reading development. However, little is known about how these constructs contribute to reading growth in young children over time. The present study will explore the extent to which attention focusing, inhibitory control, and EC relate to reading growth from kindergarten to second grade. It is hypothesized that each measure of self-regulation will be positively related to children's observed reading skills in kindergarten and will predict growth in reading skills from kindergarten to second grade.

There is consistent evidence that girls have higher levels of EC than boys (Kochanska & Knaack, 2003; Kochanska et al., 2000; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005); however, studies have found very few gender differences in emerging literacy across this age group (Below, Skinner, Fearrington, & Sorrell, 2010). Although mean level differences in EC do not necessarily translate into differences in the growth of reading, given evidence that girls have slightly higher levels of EC, gender will be added as a covariate.

Methods

Participants

Data for this study were collected during a three-year longitudinal study of academic achievement that followed children from kindergarten through second grade (Valiente, Lemery-Chalfant, & Swanson, 2010). Participants included 291 children (46% girls) from regular education classrooms in public schools in the southwestern United States, as well as their teachers and parents. In the fall of their kindergarten year, the average age of children was 5.66 years (*SD* = .39 years). Parent-reported race and ethnicity indicated that 75% of participants were White, 14% were Latino, 8% were Asian, 3% were Black, and less than 1% were American Indian.

The majority of students were from two-parent homes (89%) and the primary caregiver was most often the child's mother (95%; 5% were fathers). The median reported family income was $70,000-$80,000 at kindergarten (Time 1) and ranged from $10,000 to greater than $100,000. The parent-reported education status of the primary caregivers included: less than 1% without a high school diploma; 4% with high school education; 5% with a 2-year college degree; 20% with some college education; 32% with

a 4-year college degree; and 23% who attended graduate school. Fifteen percent of parents did not report their education level.

Of the original participants, 9.3% (n = 27) dropped out of the study by Time 3. Those who did drop out by Time 3 were significantly different on parent reported relationship status than those who completed the study, $t(244) = -2.28$, $p < .05$. Parents of children who remained in the study were significantly more likely to be married, while those whose children dropped out were significantly more likely to be divorced or always single. No other significant differences between those who completed the study and those who dropped out were noted based on the child's age, parent-reported ethnicity, income, primary caregiver's level of education, number of parents in the household, effortful control scores in kindergarten, or reading scores in kindergarten.

Procedure

Parents of all incoming kindergarten students were given an introductory letter describing the study prior to the start of the academic year. Subsequently, research assistants gave a brief presentation to parents during school orientation and provided a time for parents to enroll in the study. Parents and students were invited to participate in kindergarten (Time 1), first (Time 2), and second grade (Time 3). Parents and teachers were compensated monetarily, and children received a small toy at each assessment.

In the fall of each academic year, parents and teachers were asked to complete questionnaires on children's attention focusing and inhibitory control. Research assistants administered tasks to students individually during school hours. In the late spring of each academic year (approximately March – early May), students were administered the

Passage Comprehension and Letter Word subscales from the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001).

Measures

Effortful control. Parents and teachers completed the Attention Focusing and Inhibitory Control subscales of the Child Behavior Questionnaire (CBQ; Rothbart et al., 2001) at each time point. Across assessments, the coefficient alphas as internal consistency estimates of reliability for parent ratings of attention focusing and inhibitory control were all above .80. For teacher ratings, alphas for both scales were above .90. Each subscale has a total of 13 items, and raters were required to mark each item on a 7-point Likert-scale, with responses ranging from "extremely untrue of this child" to "extremely true of this child." The Attention Focusing scale included items such as "This child, when picking up toys or other jobs, usually keeps at the task until it's done," whereas Inhibitory Control items included "This child can wait before entering into new activities if she or he is asked to." These two scales were chosen because they have shown to consistently load on an EC factor (Eisenberg et al., 2009; Morris et al., 2002). In order to evaluate different patterns between the components of EC and their relations to reading, attention focusing-related questions and inhibitory control questions were considered separately and in combination. Each mean score of these subscales served as an index of parent-reported and teacher-reported attention and inhibitory control. The average of these two subscales was used as an EC composite.

Reading abilities. In the spring of the academic year, students completed the Letter-Word and Passage Comprehension subtests from the WJ-III (Woodcock et al., 2001). This is a standardized test of reading and math abilities and can be administered to

respondents of ages 2 to 90 years. A respondent's score is compared against a normative score that represents the national average for that respondent's age. Participants' raw scores on the subtests were converted to scaled *W* scores to support longitudinal analyses via the WJ-III computer program (see Jaffe (2009) for a comprehensive explanation of *W* score calculation). Split-half reliability coefficients for all WJ-III subscales met recommended criteria of .80 or greater, and it has been evaluated by the developers for standards of content, concurrent, and construct validity (Woodcock, 1977).

Plan for Analysis

The goal of this study was to examine whether attention focusing, inhibitory control, and EC in kindergarten significantly predicted initial levels and growth in reading ability from kindergarten through second grade. Preliminary analyses included an examination of the means and standard deviations of all study variables. In addition, correlation analyses were conducted to assess the relation between the measures of self-regulation and reading abilities.

Parallel process latent growth curve analysis in Mplus version 7 statistical package was utilized to examine whether growth in EC is predictive of reading growth (Muthén & Muthén, 2010). Twelve tests were conducted to examine the contributions of 1) attention focusing, 2) inhibitory control, and 3) EC as rated by both parents and teachers to the initial kindergarten level (intercept) and growth (slope) of reading abilities. In order to account for missing data, Full Information Maximum Likelihood (FIML) estimation was used. The effect of gender was examined as a covariate, although no differences were expected between boys and girls.

Results

Descriptive Statistics

Means and standard deviations are shown in Table 1. Within reporter, correlations among measures of parent- and teacher-reported attention focusing, inhibitory control, and EC were all positive and statistically significant, as shown in Table 2. Parent- and teacher-reported attention focusing, inhibitory control, and EC were all fairly stable and highly correlated over time, as expected. In addition, each index of self-regulation was significantly related to the measures of reading (see Table 3).

Unconditional Latent Growth Curve Models

Unconditional linear latent growth curve models for EC, attention focusing, inhibitory control, and both reading measures were examined in Mplus (Muthén & Muthén, 2010). These models describe the rate of change in the focal variables over time. In each model, the intercept was set to represent the initial values from kindergarten. Because students were clustered within classroom, the "type=complex" command was used to account for potential dependency in the data associated with being in the same kindergarten class. As indicated by the fit statistics in Table 4, the models for EC, attention focusing, and inhibitory control all fit the data. The intercept values of all self-regulation and reading measures were significantly different from zero (Table 4). However, an examination of the slopes showed that only parent-reported inhibitory control and EC were statistically significant and increased slightly over this time period. The slopes for teacher-reported attention focusing, inhibitory control, and EC were all nonsignificant. In addition, all of the variances for the intercepts, but none of the variances for the slopes, were significant. This suggests that there was significant

variability in the initial level, but not slope, of attention focusing, inhibitory control, and EC according to parent- and teacher-report.

Linear latent growth curve models for both the Letter Word and Passage Comprehension assessments resulted in a non-positive definite residual covariance matrix for the Letter Word subtest and latent variable covariance matrix for the Passage Comprehension subtest. These errors, together with an examination of the means, variances, and plots of the measures, suggest that reading scores do not follow a pattern of linear growth across these time points. As a result, piecewise latent growth curve models for the two reading measures were examined. This approach allows for fitting of separate linear slopes for different time intervals, and can be useful when a linear model is not a good representation of the data (Chandrasekaran, Gopal, & Thomas, 2005). Estimation of the piecewise model was accomplished by setting the error variance of the reading measures at each time point to [(1-reliability)*variance] to approximate the trend in reading growth separately from Time 1 to Time 2 (i.e., from kindergarten to first grade, labeled as Slope 1 in Table 4) and subsequently for Time 2 to Time 3 (i.e., from first to second grade, labeled as Slope 2 in Table 4). Parameter estimates were obtained, but the resulting models were saturated and therefore goodness of fit could not be evaluated (see Table 4).

The intercepts and slopes for both Letter Word and Passage Comprehension were statistically significant (see Table 4). For both measures, the initial value of reading scores was negatively and significantly related to each slope, such that children with higher reading scores in kindergarten experienced less growth across this time period.

The results of the piecewise model indicate that reading performance as measured by both subtests increased across the three time points. However, the slope for the Letter Word subtest was steeper from kindergarten to first grade than from first to second grade (Table 4). A similar pattern was observed for the Passage Comprehension scores. These results suggest that growth in reading may be nonlinear; however, a quadratic model was unable to be fit because too few time points were collected to estimate the model.

Parallel Process Latent Growth Curve Models

Twelve parallel process latent growth models (6 predictors X 2 outcomes) were estimated to assess the relation between each of the self-regulation measures and each of the reading measures from kindergarten through second grade. Again, the intercept was set to represent the initial values from kindergarten in each model, and piecewise models were estimated for the reading assessments. Gender was also included in each model as a covariate. Results from these analyses are presented in Tables 5, 6, and 7. Table 5 summarizes the standardized intercepts and slopes for all self-regulation and reading measures across all models. The values were slightly different from those in the unconditional models, due to the addition of variables in the parallel process models. The model measuring parent reported EC and the Letter Word subtest resulted in nonpositive definite latent variable covariance matrices, as did the models measuring parent reported inhibitory control with the Passage Comprehension subtest and parent reported EC with the Passage Comprehension subtest. Results from these analyses are not discussed further. The errors could be a result of very small residual variances in the slopes of inhibitory control and EC.

All parallel process models for the parent-report models had adequate to good fit. Gender was significantly related to the initial status of parent reported inhibitory control, such that girls were more likely to be rated higher on these measures ($p < .001$). In addition, there were some significant relations between the growth parameters. The initial level of parent-reported attention focusing and inhibitory control were positively related to the initial level of Letter Word scores; that is, children who were had high attention focusing in kindergarten also had higher reading scores in kindergarten. Furthermore, the initial level of parent-reported attention focusing and inhibitory control was negatively related to the slope of Letter Word scores from first to second grade (Table 6). Additionally, the initial level of parent-reported attention focusing was also positively related to the initial level of Passage Comprehension.

The parallel process models for the teacher-report models had adequate to good fit (Table 7). Fit was slightly poorer for the models including the Passage Comprehension subscales ($\chi^2 < .05$), but the CFI was above the recommended value and the lower bound for the 90% confidence interval for the RMSEA was below recommendations (Wu, West, & Taylor, 2009). Again, gender was significantly related to the initial status of teacher reported attention focusing, inhibitory control, and EC, such that girls were more likely to be rated higher on these measures ($p < .001$). The intercept for teacher-reported measures of attention focusing, inhibitory control, and EC were positively related to the initial levels of both Letter Word and Passage Comprehension in kindergarten (see Table 7). Teacher-reported attention focusing, inhibitory control, and EC in kindergarten were also all significantly negatively related to the slope for Passage Comprehension from first to second grade (Slope 2; Table 7).

Discussion

This study examined the relation between children's self-regulation, as indexed by parent- and teacher-rated attention focusing, inhibitory control, and EC, and their reading growth during the transition from kindergarten to second grade. Specifically, it sought to evaluate both the zero-order relations between self-regulation and reading abilities, as well as the relations between growth in self-regulation and reading abilities. Results illustrated that children's initial level of effortful control was generally related to their initial level of reading skills in kindergarten. There was some evidence to suggest that the initial levels for parent-reported attention focusing and inhibitory control were negatively related to growth in Letter Word abilities from first through second grade. The intercepts for all teacher-reported self-regulation measures were negatively related to growth in Passage Comprehension abilities from first to second grade.

Unconditional Latent Growth Curve Models

Growth in self-regulation differed based on the component of self-regulation and the rater. The unconditional latent growth models showed that parent-reported inhibitory control showed small, linear increases from kindergarten through second grade. Studies using neuropsychological measures note that inhibitory control increases through early childhood throughout adolescence, with important increases occurring from 3 to 7 years (Diamond & Taylor, 1996; Williams, Ponesse, Schachar, Logan, & Tannock, 1999). Parent-reported attention focusing, however, did not show increases over this time period. This finding is consistent with previous findings demonstrating that attention focusing as measured by the CBQ is becoming stable from 5 to 10 years (Zhou et al., 2007). Parent-

reported EC also showed small linear increases over time, albeit smaller than those observed for inhibitory control.

None of the teacher-reported measures of self-regulation increased linearly across this time period. The result for teacher-reported attention focusing is consistent with existing literature as well (Zhou et al., 2007). It is worth noting that this does not necessarily reflect a lack of growth in these abilities in early childhood because these measures were completed by different teachers at each time point. It is possible that teachers, who typically only see children for one academic year, based their ratings on an individual student's standing compared to his or her same age peers, whereas parents may make judgments that are informed by their child's behavior over time.

Reading abilities in this study increased from kindergarten through second grade. However, growth in neither Letter Word nor Passage Comprehension abilities followed a linear pattern over this time period. Instead, they had much steeper growth from kindergarten to first grade, followed by a period of less growth from first to second grade. The WJ-III is a psychometrically sound and widely used instrument for this age range, and it is possible that these skills emerge in different ways at different ages. In this case, Letter Word identification is described as the ability to detect and analyze the featural aspects of letters, recognize visual word forms, and access the pronunciations of visual word forms, whereas Passage Comprehension refers to the ability to construct representations of a passage from printed words and make inferences based on what has been read (Woodcock, et al., 2001). These results are consistent with prior work showing that, in general, reading skills do not progress linearly in the first few years of school (McCoach, O'Connell, Reis, & Levitt, 2006). Rather, growth in reading may be

accelerated or decelerated at different times depending on a child's place in their overall developmental trajectory. Furthermore, the variability in reading skills at each time point, as indexed by significant residual variances, is consistent with studies highlighting that individual variation is an important factor to consider in early reading instruction.

Parallel Process Latent Growth Models

The results of the parallel process latent growth curve models indicate that, in general, self-regulation does relate to reading abilities in kindergarten. That is, for all parallel process models that converged, the initial level of self-regulation was related to the initial level of reading ability. These relations were found for both parent- and teacher-report self-regulation predictors. The literature has consistently shown that EC and associated self-regulatory skills are important predictors of emerging literacy skills, both concurrently and over time (Blair & Razza, 2007; Deater-Deckard et al., 2009; McClelland et al., 2007). The present study reinforces this pattern and expands upon this body of work by describing how self-regulation and reading relate to each other in the early school years.

An interesting finding concerns the relation between self-regulation and reading growth over this time period. For the Letter Word subtest, the intercepts for parent-reported attention focusing and inhibitory control were both negatively related to reading growth from first to second grade, but not from kindergarten to first grade. That is, the self-regulation in kindergarten was negatively related to the slope of reading skills between first and second grade, but not from kindergarten to first grade. The same pattern was true for teacher ratings of attention focusing, inhibitory control, and EC with the Passage Comprehension score. These results suggest that children with lower initial

levels of self-regulation, as well as lower initial reading scores, had steeper reading growth from first to second grade. These findings are consistent with some intervention work that suggests that reading interventions are often more effective for children who are initially further behind (O'Connor, 2000; Welsh et al., 2010). That is, children who are identified as poorer readers in kindergarten may benefit from more intense, targeted reading interventions in first grade that allow them to make more significant reading gains later on (O'Connor, 2000).

The present study also highlights the importance of using multiple raters when assessing a particular skill, as well as the complicated interpretations that may arise when doing so. Results show that teacher ratings are more predictive of Passage Comprehension skills, whereas parent ratings are more predictive of Letter Word skills. Teachers observe their students in a context that is often different from parents, as teachers typically have a larger pool of children from which to compare, and they have limited time interacting with a child on an individual basis. On the other hand, teachers may have much more access to a child's behavior in a structured, classroom setting, and they often directly influence a child's reading through instruction. Letter and word identification is an important ability that is relevant in myriad other contexts, whereas passage comprehension is a skill that is almost uniquely taught and assessed in a school setting. As a result, teachers may have a unique perspective on how a child's self-regulatory skills relate to his or her reading comprehension skills.

The pattern of relations between reading and attention focusing and inhibitory control over time were quite similar. It is worth noting that statistical problems (i.e., models would not converge) did eliminate three potential parent-reading models from

analyses, so questions about the relation between parent reported self-regulation and reading abilities could not be fully explored. Nevertheless, the results presented here indicate that attention focusing and inhibitory control both contribute to reading in similar ways. It is possible that success on the reading measures used here requires a broad range of regulatory skills, and both are important contributors to growth in these domains. Alternatively, it is possible that the measures used here are not specific enough to disentangle any different relations. Future work with a broader array of measures may clarify if and when the relation may differ.

In addition to furthering our knowledge of the development of these skills over time, this work informs future intervention efforts. This study suggests that a child's early self-regulatory abilities may have more distal effects on the growth of other academic skills, like reading. Previous work has explored the impact of intense reading intervention in these early years; however, limitations in resources can make delivering interventions difficult to deliver to those who need it most (O'Connor, 2000). As children progress through school, reading becomes an increasingly important means of acquiring information. It is possible that as children move through school, poorer readers are more easily identified in daily instruction and receive compensatory instruction as a result. By examining the trajectory of these skills over time and alongside the growth of other important self-regulatory abilities, future work can develop more efficient, targeted interventions that leverage children's own developmental susceptibilities.

The present study helps to clarify the relations between self-regulatory abilities and reading growth in early childhood, and there are many possible explanations for the existence of this link. One hypothesis is that attentional and inhibitory control have

behavioral correlates that promote early literacy, such as the sustained ability to sit still, follow classroom rules, and learn through listening and watching (Connor et al., 2010; McClelland et al., 2007). Particularly with regard to attention, the cognitive capacities involved in emerging reading skills may also be related to high levels of self-regulation. Future longitudinal work on other, more cognitive aspects of self-regulation, such as direct assessments of attentional control and working memory, may further explain the mechanisms behind the relations observed here. Joint attention is important contributor to vocabulary development, and may facilitate letter-word learning (Mundy & Newell, 2007). In addition, attention and working memory may contribute to word learning and reading comprehension skills by promoting the encoding and retrieval of information from long-term memory and the ability to form and manipulate mental representations (Davidson, Amso, Anderson, & Diamond, 2006).

Limitations

While these results are encouraging, it is important to note the limitations of this work. For instance, the measures of self-regulation were limited to parent- and teacher-report assessments of attention focusing and inhibitory control. Previous studies have found that neuropsychological tests of attention focusing and inhibitory control are weakly related to or uncorrelated with report-based assessments (Blair & Razza, 2007). Therefore, future work should also employ administered tests of these measures, such as peg tapping or Stroop tasks, in order to gain a better understand of how these self-regulatory abilities relate to reading development (Kochanska et al., 1997). Similarly, the teacher-reported assessments were completed by different individuals each year as the children progressed through school. Therefore, caution should be used when interpreting

these results, as they do not necessarily measure consistent growth in EC the same way as parent-reported or child measures assess growth. In addition, only the Attention Focusing and Inhibitory Control subscales of the CBQ were used to assess EC; however, other scales in this assessment can be used as indicators of EC, including Low-Intensity Pleasure and Perceptual Sensitivity (Rothbart et al., 2001). Continuing work can explore these questions using other indices of self-regulation and EC.

Finally, one of the main limitations of this study is that too few data points were obtained to estimate quadratic or other polynomial growth trends. This proved problematic when estimating linear latent growth curves for the Letter Word and Passage Comprehension tests, which resulted in errors in estimation. Future work should continue to follow children longitudinally to assess change in reading over time and the contributors to change.

Conclusions

This study is the first to assess the simultaneous growth of indices of self-regulation, including attention focusing, inhibitory control, and EC, alongside growth of reading abilities for three years in early childhood. Results show that self-regulation does relate to reading abilities in the kindergarten year in addition to later school years, specifically from first to second grade. Negative relations were found between effortful control in kindergarten and reading growth from first to second grade, indicating that students with lower initial EC, who also had low initial reading levels were most poised to gain later on. This study reinforces prior work demonstrating the importance of self-regulation to early academic success, particularly in regard to reading. Further, the longitudinal nature of this study, as well as its use of multiple perspectives, offers

important contributions to this literature. Finally, these results present important avenues for future research into the relation between reading abilities and self-regulation throughout the first few years of school. For example, future studies could examine these relations in preschool, at the time when early self-regulatory functions are developing. Behavioral assessments of self-regulation could also be used to examine how these measures relate to reading growth over time.

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APPENDIX A

TABLES

Table 1

Means and Standard Deviations of Self-Regulation and Reading

		Mean	*SD*
Parent Report			
Time 1	Attention Focusing	4.80	0.83
	Inhibitory Control	5.03	0.82
	EC	4.91	0.74
Time 2	Attention Focusing	4.84	0.84
	Inhibitory Control	5.11	0.81
	EC	4.98	0.73
Time 3	Attention Focusing	4.84	0.79
	Inhibitory Control	5.25	0.82
	EC	5.05	0.71
Teacher Report			
Time 1	Attention Focusing	4.83	1.17
	Inhibitory Control	4.93	1.21
	EC	4.88	1.14
Time 2	Attention Focusing	4.75	1.22
	Inhibitory Control	4.98	1.17
	EC	4.87	1.15
Time 3	Attention Focusing	4.90	1.23
	Inhibitory Control	4.97	1.16
	EC	4.94	1.14
Reading			
Time 1	Letter Word	414.3	24.957
	Passage Comprehension	440.43	21.593
Time 2	Letter Word	457.45	25.294
	Passage Comprehension	476.9	15.583
Time 3	Letter Word	483.62	21.442
	Passage Comprehension	493.73	13.819

Table 2

Correlations between Parent- and Teacher-Reported Self-Regulation

	Time 1			Time 2			Time 3		
	AF	IC	EC	AF	IC	EC	AF	IC	EC
Time 1									
AF	-	.625**	.904**	.745**	.499**	.708**	.676**	.408**	.607**
IC	.847**	-	.899**	.476**	.760**	.699**	.547**	.736**	.725**
EC	.960**	.962**	-	.682**	.700**	.783**	.690**	.643**	.751**
Time 2									
AF	.558**	.595**	.600**	-	.551**	.885**	.734**	.368**	.614**
IC	.535**	.651**	.620**	.838**	-	.876**	.524**	.791**	.742**
EC	.570**	.649**	.636**	.961**	.957**	-	.722**	.663**	.778**
Time 3									
AF	.461**	.503**	.504**	.513**	.483**	.518**	-	.585**	.886**
IC	.486**	.586**	.558**	.529**	.566**	.570**	.830**	-	.894**
EC	.495**	.568**	.554**	.545**	.548**	.568**	.959**	.954**	-

Note. ** $p < 0.01$; Parent-report measures are presented above the diagonal and teacher-report are below the main diagonal. AF= Attention Focusing; IC= Inhibitory Control; EC= Effortful Control.

Table 3

Correlations between Reading and Self-Regulation

		Time 1		Time 2		Time 3	
Parent Report		Letter Word	Passage Comp	Letter Word	Passage Comp	Letter Word	Passage Comp
Time 1	AF	.274**	.195**	.241**	.264**	.205**	.216**
	IC	.184**	.182**	.204**	.228**	.164*	.208**
	EC	.255**	.210**	.247**	.273**	.205**	.235**
Time 2	AF	.341**	.282**	.306**	.341**	.253**	.331**
	IC	.173**	.183**	.217**	.280**	.175*	.261**
	EC	.294**	.265**	.299**	.354**	.244**	.337**
Time 3	AF	.257**	.252**	.338**	.300**	.319**	.399**
	IC	.154**	.246**	.208**	.185**	.202**	.306**
	EC	.230**	.279**	.305**	.271**	.292**	.395**
Teacher Report							
Time 1	AF	.273**	.303**	.273**	.335**	.257**	.282**
	IC	.197**	.248**	.179**	.240**	.166**	.176**
	EC	.242**	.285**	.235**	.298**	.220**	.237**
Time 2	AF	.320**	.296**	.358**	.410**	.323**	.261**
	IC	.176**	.203**	.234**	.318**	.222**	.170**
	EC	.257**	.259**	.308**	.378**	.281**	.221**
Time 3	AF	.330**	.343**	.357**	.385**	.317**	.378**
	IC	.198**	.228**	.224**	.293**	.210**	.284**
	EC	.278**	.300**	.305**	.355**	.277**	.347**

Note. ** $p < 0.01$. AF= Attention Focusing; IC= Inhibitory Control; EC= Effortful Control, Comp= Comprehension.

Table 4

Parameter Estimates and Fit Statistics for Unconditional Latent Growth Curve Models

Model	Fit Statistics			Means		Variances	
	Chi Square	RMSEA (90% CI)	CFI	Intercept	Slope	Intercept	Slope
PR AF	.689(1)	0.0 (0.0-0.15)	1.0	4.80 (.05)**	.01 (.02)	.60 (.08)**	.05 (.03)
PR IC	.013(1)	0.0 (0.0-0.07)	1.0	5.02 (.05)**	.1 (.02)**	.51 (.07)**	.02 (.04)
PR EC	.182(1)	0.0 (0.0-0.18)	1.0	4.91 (.05)**	.06 (.02)**	.44 (.07)**	.006 (.03)
TR AF	2.00 1)	0.0 (0.0-0.18)	.99	4.81 (.08)**	.03 (.05)	.94 (.19)**	.13 (.07)
TR IC	2.31(1)	0.0 (0.0-0.12)	1.0	4.94 (.07)**	.02 (.04)	1.03 (.18)**	.02 (.07)
TR EC	2.48(1)	0.0 (0.0-0.12)	1.0	4.87 (.07)**	.03 (.04)	.96 (.17)**	.07 (.05)

				Means			Variances		
				Intercept	Slope 1	Slope 2	Intercept	Slope 1	Slope 2
LW	-	-	-	414.2 (2.3)**	43.5 (1.3)**	26.1 (.93)**	584.8 (79.1)**	252.9 (27.0)**	88.9 (16.8)**
PC	-	-	-	440.4 (2.3)**	36.7 (2.1)**	16.7 (.71)**	408.8 (39.2)**	218.8 (46.2)**	86.3 (17.9)**

Note. * = $p < .05$, ** = $p < .01$; PR= Parent report; TR= Teacher report; AF= Attention Focusing; IC= Inhibitory Control; EC= Effortful Control. Degrees of freedom for chi-square values are in parentheses; all other parentheses are standard errors. Dashes indicate uninterpretable values for fit statistics.

Table 5

Standardized Intercepts and Slopes for Reading and Self-Regulation in Parallel Process Latent Growth Curve Models

	Estimates			Residual Variances		
Variable	Intercept	Slope		Intercept	Slope	
PR AF	6.41 (.44)**	.10 (.16)		.99 (.01)**	.10 (.01)**	
PR IC	7.53 (.53)**	2.61 (19.88)		.91 (.05)**	.89 (1.7)	
PR EC	-	-		-	-	
TR AF	5.20 (.50)**	.29 (.19)		.95 (.02)**	.97 (.04)**	
TR IC	5.19 (.43)**	.27(.29)		.88 (.03)**	.98 (.05)**	
TR EC	5.18 (.08)**	.08 (.05)		.90 (.15)**	.08 (.05)	
	Intercept	Slope 1	Slope 2	Intercept	Slope 1	Slope 2
LW	17.16 (1.12)**	2.73 (.17)**	2.68 (.26)**	.99 (.003)**	1.00 (.001)**	.99 (.012)**
PC	21.86 (1.06)**	2.48 (.31)**	1.75 (.22)**	.994 (.01)**	1.00 (.001)**	1.00 (.007)**

Note. * $p < .05$; ** $p < .01$*;* PR= Parent report; TR= Teacher report. Values in parentheses are standard errors. Dashes are reported for models that would not converge.

Table 6

Fit Statistics and Standardized Inter-Measure Correlations for Parent Report Models

	Fit Statistics			Inter-Measure Correlations				
	Chi Square	RMSEA (90% CI)	CFI	SR I – R I	SR I - R S1	SR I – R S2	SR S - R S1	SR S - R S2
Letter Word								
Attention Focusing	6.53 (5)	0.03 (0.0-0.09)	.998	0.335**	-.391	-.206*	.189	-.003
Inhibitory Control	3.99 (5)	0.0 (0.0-0.07)	1.00	0.216**	.103	-.190*	-.090	.504
EC	-	-	-	-	-	-	-	-
Passage Comprehension								
Attention Focusing	6.07 (5)	0.03 (0.0-0.89)	.998	0.248**	-.022	-.112	-.042	.282
Inhibitory Control	-	-	-	-	-	-	-	-
EC	-	-	-	-	-	-	-	-

Note. * $p < .05$; ** $p < .01$; Degrees of freedom for chi-square values are in parentheses. SR refers to the self-regulation measure corresponding to each model; R refers to the reading measure for each model. I = Intercept; S = Slope. Dashes indicate uninterpretable results due to nonpositive definite matrices.

Table 7

Fit Statistics and Standardized Inter-Measure Correlations for Teacher Report Models

	Fit Statistics			Inter-Measure Correlations				
	Chi Square	RMSEA (90% CI)	CFI	SR I - R I	SR I - R S1	SR I - RS2	SR S - R S1	SR S - R S2
Letter Word								
Attention Focusing	7.556 (5)	0.042 (0.0-0.099)	.99	.347**	.015	-.171	.108	-.200
Inhibitory Control	4.683 (5)	0.0 (0.0-0.079)	1.0	.241**	.004	-.114	.245	-.105
EC	5.033 (5)	0.005 (0.0-0.082)	1.0	.297**	.008	-.141	.155	-.169
Passage Comprehension								
Attention Focusing	16.244 (5)**	.088 (.043-.137)	.973	.376**	-.081	-.218**	.002	.049
Inhibitory Control	11.663 (5)*	.068 (.014-.119)	.985	.298**	-.103	-.209**	.311	.121
EC	14.761 (5)*	.082 (.035-.132)	.979	.342**	-.097	-.210**	.206	0.066

Note. * $p < .05$; ** $p < .01$. Degrees of freedom for chi-square values are in parentheses; SR refers to the self-regulation measure corresponding to each model; R refers to the reading measure for each model; I = Intercept; S = Slope.