Early Childhood Research Quarterly 25 (2010) 51–64

Contents lists available at ScienceDirect

Early Childhood Research Quarterly

Child effortful control, teacher–student relationships, and achievement in academically at-risk children: Additive and interactive effects

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ARTICLE INFO

Article history:
Received 3 April 2008
Received in revised form 14 July 2009
Accepted 17 July 2009

Keywords:
Self-regulation
Effortful control
Temperament
Teacher characteristics
Teacher–student relationships
Academic achievement
Achievement gap

ABSTRACT

The joint contributions of child effortful control (using inhibitory control and task accuracy as behavioral indices) and positive teacher–student relationships at first grade on reading and mathematics achievement at second grade were examined in 761 children who were predominantly from low-income and ethnic minority backgrounds and assessed to be academically at-risk at entry to first grade. Analyses accounted for clustering effects, covariates, baselines of effortful control measures, and prior levels of achievement. Even with such conservative statistical controls, interactive effects were found for task accuracy and positive teacher–student relationships on future achievement. Results suggest that task accuracy served as a protective factor so that children with high task accuracy performed well academically despite not having positive teacher–student relationships. Further, positive teacher–student relationships served as a compensatory factor so that children with low task accuracy performed just as well as those with high task accuracy if they were paired with a positive and supportive teacher. Importantly, results indicate that the influence of positive teacher–student relationships on future achievement was most pronounced for students with low effortful control on tasks that require fine motor skills, accuracy, and attention-related skills. Study results have implications for narrowing achievement disparities for academically at-risk children.

A growing body of research documents the importance of self-regulatory capacities in children's academic competence (e.g., Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003; Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008). In particular, effortful control, defined as the ability to voluntarily inhibit a dominant response to activate a subdominant one, is an aspect of temperamental self-regulation that has shown promise in childhood research (Murray & Kochanska, 2002; Rothbart & Bates, 1998). Evidence indicates a linkage between effortful control and academic achievement in young school-aged children, including those from low-income and ethnic minority backgrounds (e.g., Blair & Razza, 2007; Li-Grining, 2007; Liew, McTigue, Barrois, & Hughes, 2008; McClelland et al., 2007). Because relatively few studies have examined how child and teacher characteristics simultaneously influence achievement outcomes (Hamre & Pianta, 2005; Rothbart & Jones, 1998; Wentzel, 2002), the present study examines the combination of children's effortful control and positive teacher–student relationships as predictors of academic achievement in students who were predominantly from low-income and ethnic minority families and assessed by their school district as entering first grade with below-average literacy skills.

Although the characteristics that students bring into the classroom may influence their learning, characteristics of the learning environment may also directly or indirectly influence students' achievement. An aspect of the learning environment that has received considerable attention is the quality of teacher–student relationships. In particular, positive

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doi:10.1016/j.ecresq.2009.07.005

teacher–student relationships consisting of a high level of warmth and low level of conflict has been associated with students' positive academic beliefs, motivation, and performance (Goodenow, 1993; Hamre & Pianta, 2005; Ladd, Birch, & Buhs, 1999; Palermo, Hanish, Martin, Fabes, & Reiser, 2007; Reddy, Rhodes, & Mulhall, 2003). In addition, preliminary evidence suggests that the link between positive teacher–student relationships and academic outcomes may especially be pronounced for students with behavioral or conduct problems (Hughes, Cavell, & Jackson, 1999; Pianta, Nimetz, & Bennett, 1997; Pianta & Walsh, 1996). Thus, the influence of positive teacher–student relationships on achievement may depend on child characteristics that pertain to behavioral regulation (Pianta et al.; Rudasill & Rimm-Kaufman, 2009). Effortful control is a child characteristic that has been linked to socially appropriate behavior and achievement (e.g., Blair & Razza, 2007; Eisenberg et al., 2005; Liew, Eisenberg, & Reiser, 2004; Liew et al., 2008; Valiente, Lemery-Chalfant, & Castro, 2007), but few empirical studies have examined how children's effortful control and positive teacher–student relationships operate simultaneously on children's achievement outcomes (Graziano, Reavis, Keane, & Calkins, 2007; Wentzel, 2002). Furthermore, early grade school successes or difficulties are strongly associated with future academic outcomes (Griffin, 2004; Juel, 1998; Stanovich, 1986), and may be exacerbated by disparities in students' socioeconomic resources (Duncan & Magnuson, 2005; Evans & Rosenbaum, 2008). Thus, the present study focuses on a sample of academically at-risk and predominantly low-income and ethnic minority children. Specifically, we examine whether positive teacher–student relationships would moderate the relation between effortful control and achievement so that children with low levels of effortful control at first grade would perform better academically when paired with a highly supportive teacher than similar children paired with a less supportive teacher. We also hypothesize that effortful control may serve as a protective factor for achievement in learning environments where students may be receiving or requiring little support from the teacher. Thus, we expect children with high levels of effortful control to perform relatively well in spite of not being afforded with highly positive teacher–student relationships.

1. Effortful control and academic achievement

Effortful control includes capacities for inhibitory control (e.g., deliberately slowing or stopping of motor activity) and attentional control (e.g., shifting or focusing attention) (Kochanska, Murray, & Harlan, 2000; Murray & Kochanska, 2002). A variety of procedures have been designed to assess effortful control, including tasks from a behavioral battery developed by Kochanska et al. (e.g., Kochanska, Murray, & Coy, 1997; Kochanska et al., 2000; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). In the present study, we use the ability to slow motor behavior and to complete fine motor tasks accurately as two different behavioral indices or proxy measures of effortful control. Such a conceptualization is consistent with Rothbart and Bates (2006) who include inhibitory control, attentional control, and abilities to follow instructions or correct errors as being part of effortful control. Particularly for fine motor tasks, a person needs to exhibit not only inhibitory control but also eye-hand coordination, working memory (e.g., remembering task instructions), and executive attention (e.g., paying attention to achieve a goal) in order to complete tasks accurately.

The emerging pattern of research findings on effortful control shows that inhibitory control skills contribute to concurrent and future academic achievement. In a study of low-income preschoolers enrolled in Head Start programs, Blair and Razza (2007) found that parent- and teacher-reported effortful control contributed to early mathematics and literacy skills. In another study on preschoolers, McClelland et al. (2007) found that observed effortful control (consisting of inhibitory control, attention, and working memory skills) was significantly associated with early literacy and mathematics skills. Furthermore, gains in observed effortful control predicted gains in emergent literacy, vocabulary, and mathematics skills. In a longitudinal study of first through third graders (consisting of children from the present study), effortful control predicted literacy achievement 2 years later (Liew et al., 2008). In middle childhood, Valiente et al. (2008) found that parent- and child-reported effortful control predicted grade point averages in a sample of 7 to 12-year-olds, above the effects of grade point averages from the previous semester and teacher–student relationship quality.

2. Teacher–student relationships and academic achievement

Although self-regulatory capacities such as effortful control may be important for children's academic achievement, a supportive teacher may play a compensatory role for children with self-regulatory difficulties by providing them an external source of regulation. As soon as children enter formal schooling, teachers become important agents of socialization and sources of support outside of the home environment for children. Thus, researchers have increasingly examined the role of positive teacher–student relationships on children's school functioning (Birch & Ladd, 1997; Wentzel, 2002). *Positive teacher–student relationships* could be characterized as teacher–student relationships that are supportive, warm, and low in conflict (e.g., Pianta et al., 1997), and are indexed in the present study by teachers' reports.

Researchers have found that positive teacher–student relationships are consistently linked with increased academic motivation and achievement as well as positive self-concept (Birch & Ladd, 1997; Howes, 2000; Hughes, Gleason, & Zhang, 2005; Hughes & Kwok, 2006; Palermo et al., 2007; Pianta, Steinberg, & Rollins, 1995; Ryan, Stiller, & Lynch, 1994). For example, kindergarteners with supportive teachers performed better than those with less supportive teachers on standardized measures of reading and mathematics skills (Graziano et al., 2007). Preliminary evidence also suggests that positive teacher–student relationships may protect children from suboptimal home environments including negative parent–child relationships (O'Connor & McCartney, 2007). In addition, Rimm-Kaufman et al. (2002) found that children who were classified as socially bold as 15-month-olds were more academically engaged as kindergarteners when paired with sensitive

teachers than similar children with less sensitive teachers. Consistent with the view that teacher characteristics could modify the strength or direction of the relation between child temperament and achievement outcomes, the present study examines whether positive teacher–student relationships would moderate the relation between effortful control and future achievement so that children with low levels of effortful control would perform better in reading or mathematics when paired with a highly positive and supportive teacher than similar children paired with a less positive and less supportive teacher. Furthermore, we hypothesize that effortful control may protect against under-achievement for students with less positive teacher–student relationships.

3. Study purpose

Building on previous research that found linkages between aspects of effortful control and emergent reading or mathematics skills (Blair & Razza, 2007; Liew et al., 2008; McClelland et al., 2007), the present study examines (above IQ, economic disadvantage, and previous academic achievement) the joint contribution of two aspects of children's effortful control (i.e., inhibitory control and task accuracy) and teachers' support on children's achievement. Based on previous research indicating differential associations between inhibitory control and reading or mathematics in children from low-income families (Blair & Razza), we examine potential additive or interactive contributions of two aspects of effortful control and positive teacher–student relationships on achievement separately for reading and for mathematics. We pursue these research questions with a sample of academically at-risk first-grade, predominantly low-income and ethnic minority, children who were selected for the larger study on the basis of scoring below their school district median on a measure of literacy given at the beginning of first grade. Burgeoning research shows that academically at-risk youth tend to have relatively poor self-regulatory skills (Blair, 2002; Ladd et al., 1999; Pianta et al., 1997) and tend to experience student–teacher conflicts (Birch & Ladd, 1997; Mantzicopoulos & Neuharth-Pritchett, 2003). Thus, understanding how child and teacher characteristics work jointly to contribute to future achievement may inform policies and practices to help narrow the achievement gap for academically at risk as well as low-income and ethnic minority children. Previous studies with this same longitudinal sample have documented main effects of both effortful control (Liew et al., 2008) and teacher support (Hughes & Kwok, 2006) on achievement. The present study extends past findings by investigating the additive and interactive effects of effortful control and positive teacher–student relationships on achievement.

4. Method

4.1. Participants

Participants were drawn from a sample of 784 first-grade children who participated in a longitudinal, prospective study examining the impact of grade retention on academic achievement in academically at-risk children. In fall of 2001 (cohort 1) and 2002 (cohort 2), participants were recruited from one of three school districts (one urban, two small cities) in Central and Southeast Texas. To be eligible to participate in the larger study, children had to score below the median score on a state-approved measure of literacy administered by the district in either May of kindergarten or September of first grade. Since 1996, the Texas Education Commissioner has been required to approve a list of assessment instruments for diagnosing reading skills and comprehension development in grades K-2. Local education agencies may choose a test from this list of research-based instruments or develop their own test that meets stated criteria. From the list of approved tests, each of the three school districts participating in the present study selected a different literacy test. However, a content analysis of the three tests revealed significant overlap in the literacy skills assessed (i.e., letter-sound linking, rhyming and blending skills, letter-naming, word reading, listening comprehension, text reading accuracy and comprehension). A total score was computed as the mean standardized score on each subtest, excluding subtests that correlated less than .20 with the total score. Because each district used a different test and the tests had not been equated, total scores were standardized within each district. Thus, participants were those who scored below the median on literacy relative to other students in their district. In addition, participants had to speak either English or Spanish, not be served by special education, and not previously retained in first grade. School records identified 1374 children as eligible to participate, and teachers were asked to distribute consent forms to parents using weekly folders that children brought home. However, the exact number of parents who received the consent forms cannot be determined. Incentives in the form of small gifts to children and the opportunity to win a larger prize in a lottery were instrumental in obtaining 1200 returned consent forms, of which 784 parents (65%) provided consent and 416 declined.

Analyses on a broad array of archival variables including performance on the district-administered test of literacy (standardized within district, due to differences in test used), sex, age, eligibility for free or reduced-price lunch, ethnicity, bilingual class placement, cohort, and school context variables (i.e., % ethnic/racial minority; % economically disadvantaged) did not indicate any differences between children with and without consent. The resulting sample of 784 participants (52.6% male) closely resembled the population from which they were drawn on demographic and literacy variables relevant to students' educational performance.

Participants in the present study were 761 children (52% male) who met the following criteria for participation in the current study: (a) had data for major predictors (i.e., inhibitory control at Year 1, task accuracy at Year 1, and Positive teacher–student relationships at Year 1) and (b) were still active in the study at Year 2. The racial/ethnic composition of the sample was 37% White Hispanic, 34% White non-Hispanic, 23% African American, 4% Asian or Pacific Islander, and 2% Other.

At entrance to first grade, children's mean age was 6.57 (SD = .39) years. Mean level of children's intelligence as measured with the Universal Nonverbal Intelligence Test (Bracken & McCallum, 1998) was 92.92 (SD = 14.62). Based on family income, 61.3% of participants were eligible for free or reduced lunch, based on school records when children were in first grade.

4.2. Procedures and measures

During November through March of the start of the present study (Wave 1) when child participants were in first grade, research staff individually administered tests of effortful control, general cognitive ability, and reading and mathematics achievement. One year later (Wave 2) when child participants were in second grade unless they were retained, the achievement tests were re-administered. In addition to data from child participants, teachers were mailed a questionnaire packet for each study participant in March of Wave 1. This packet included a measure of the teacher's perception of the support that she or he provided to a specific student to assess teacher–student relationships. Teachers were compensated monetarily after completing and returning the questionnaires.

4.3. Effortful control

Effortful control was assessed using behavioral indices that were collected by trained research assistants who individually administered four tasks from a behavioral battery designed to assess effortful control (Kochanska et al., 1997; Murray & Kochanska, 2002). For each task, children participated in three trials. In Trial 1, children's baseline responses were observed without any instructions to slow or inhibit their behaviors. In Trials 2 and 3, children were asked to voluntarily slow or inhibit their behaviors. To ensure that children understood task instructions, Trial 2 was considered a practice and only scores from Trial 3 were used to index effortful control. The selected tasks have been demonstrated to be reliable and valid measures of effortful control for toddlers through early grade school children (Murray & Kochanska) and have also been used by a number of researchers examining effortful control and social behaviors (Dennis & Brotman, 2003; Kieras, Tobin, Graziano, & Rothbart, 2005; Kochanska & Knaack, 2003). The four tasks were Walk-a-Line, Star, Telephone Poles, and Circle. In Walk-a-Line, children were asked to walk along a (12 ft long by 2.5 in wide) ribbon that was taped onto the floor. In Star, Circle, and Telephone Poles which were fine motor tasks, children were asked to trace geometric figures using a pencil without going outside the lines of the figures (i.e., Star and Circle) or to draw a line connecting two dots (i.e., Telephone Poles). In these selected tasks, children had to (a) slow or inhibit their motor activity (i.e., inhibitory control) and (b) attend to and follow instructions by completing fine motor tasks accurately (i.e., task accuracy). Thus, behavioral indices of effortful control tapped the ability to slow motor behavior and to complete fine motor tasks accurately as two different behavioral indices of effortful control.

4.3.1. Inhibitory control

Scores for (gross and fine motor) inhibitory control were represented by the duration (in seconds) that it took children to complete the tasks when they were told to do them as slowly as possible after children completed a practice trial. Prior to these trials, baseline measures were assessed by asking children to complete tasks without instructions to slow or inhibit their (gross and fine) motor behavior. Research assistants individually timed children's behavior using stopwatches as children completed the tasks (i.e., in real time). Because a single research assistant administered tasks for each child at the school and assessments were not video-recorded, calculations of reliability for timings used for measures of inhibitory control are not available.

4.3.2. Task accuracy

Scores for (fine motor) task accuracy were represented by the reversed score of the number of times children traced outside the lines on Star and/or Circle (i.e., reversed score of errors committed on tasks). Each instance in which the child traced from inside the circle or star to outside the circle or star, an error was counted. The length of time outside the circle or star was not factored into the score. Baseline measures were first assessed when children were asked to trace geometric figures without any instructions to slow or inhibit their behavior. Next, children completed two trials (the former being a practice) where they were asked to trace geometric figures as slowly as possible without tracing outside the lines of the figures. Whereas measures of (gross and fine) inhibitory control were timed by research assistants during the assessments, (fine motor) task accuracy was coded after the assessments by two trained research assistants. The main coder rated all, whereas the reliability coder rated 40 randomly selected participants' performance [inter-rater reliability (Pearson r) = .95].

4.3.3. Data reduction of effortful control measures

Consistent with the conceptualization that effortful control includes (but not limited to) abilities to slow or inhibit behavior and to pay attention and follow instructions or correct errors (see Rothbart & Bates, 2006), we expected the latency and error scores from the four tasks to be differentiated and load on two factors: (a) inhibitory control and (b) task accuracy. To reduce the number of measures, a principal components factor analysis with a promax rotation was conducted with the six scores on the effortful control measures when children were asked to complete tasks as slowly as possible. The factor analysis yielded two factors. The first factor (i.e., inhibitory control) consisted of the duration to complete Walk-a-Line (λ = .80), Star (λ = .87), Telephone Poles (λ = .87), and Circle (λ = .85). The second factor (i.e., task accuracy) consisted of (reversed scoring of)

the number of errors committed for Star (λ = .84) and Circle (λ = .84). Similarly, a principal components factor analysis with a promax rotation was conducted with the six scores on these measures without instructions for children to modulate (e.g., slow or inhibit) their behaviors. This factor analysis also yielded two factors. The first factor (i.e., baseline inhibitory control) consisted of the duration to complete Walk-a-Line (λ = .59), Star (λ = .74), Telephone Poles (λ = .75), and Circle (λ = .76). The second factor (i.e., baseline task accuracy) consisted of (reversed scoring of) the number of errors committed for Star (λ = .84) and Circle (λ = .84). Furthermore, a confirmatory factor analysis was also conducted on the effortful control measures accounting for influences of baseline effortful control measures. The two-factor measurement model fit the data adequately well; all the model-estimated loadings for the latent factors of inhibitory control and task accuracy were significant and in the expected directions. Thus, based on findings from factor analyses, for the present study we computed composites for inhibitory control and task accuracy by averaging the standardized items that loaded on each factor. Composites for baseline inhibitory control and baseline task accuracy were also computed by averaging the standardized items that loaded on each baseline factor.

4.4. Positive teacher–student relationships

To assess positive teacher–student relationships, teachers rated 22 items (19 of which were used to index positive teacher–student relationships) on a 5-point scale from the Teacher Student Relationship Inventory (TSRI; Hughes, Cavell, & Willson, 2001). The items were derived from the Network of Relationships Inventory (Furman & Buhrmester, 1985), which is a child-report measure that was modified for use by teachers to self-report on their provision of six types of social support (i.e., affection, admiration, intimacy, satisfaction, nurturance, and reliable alliance) and conflict in their relationships with individual students. Exploratory factor analysis using principal axis factoring with promax rotation on 335 first grade participants from the second cohort of this longitudinal sample suggested three factors: Warmth (13 items), Intimacy (3 items), and Conflict (6 items). To test whether the three-factor structure from the second cohort is replicated in the first cohort, a confirmatory factor analysis was run. Results of confirmatory factor analysis on 449 first-grade participants from the first cohort found that the three factor model provided an adequate fit for the data (χ^2 = 697.803 (204), $p < .001$; CFI = .92; RMSEA = .074). Furthermore, the null hypothesis of factor invariance across cohorts and times could be retained at the .01 level. For the present study, items from the intimacy scale were not included because the focus was on teacher provision of emotional support and positive (or low conflict) teacher–student interactions. Thus, items from the Warmth (13 items) and Conflict (6 items) scales were included. Sample items on the Warmth scale were "I enjoy being with this child" (affection), "This child gives me many opportunities to praise him or her" (admiration), "I find I am able to nurture this child" (nurturance), and "It is easy to mend relationships with this child after a disagreement or conflict" (reliable alliance). Sample items on the Conflict scale were "This child and I often get upset with each other," "This child often opposes my authority or resists my control," and "This child requires much discipline for disobeying me." Items of the Conflict scale were reverse scored to reflect low conflict. Positive teacher–student relationships was computed by averaging across the 19 items from the Warmth and reversed conflict subscales (Cronbach's α = .95). Positive teacher–student relationships scale and peer assessments of teacher–student support have been positively correlated in the range of .29–.53 (Hughes & Kwok, 2007). Further, scale scores from TSRI that indicate positive teacher–student relationships have been positively associated with positive student outcomes such as peer acceptance, cooperative engagement, low aggression (Hughes & Kwok, 2006; Meehan, Hughes, & Cavell, 2003).

4.5. Academic achievement

Assessments of children's academic achievement at Waves 1 and 2 were based on children's performance on the Broad Reading and Broad Math portions of the WJ-III Achievement Battery (Woodcock, McGrew, & Mather, 2001). The test for Broad Reading consisted of three subtests that assessed children's letter-word identification, reading fluency, and passage comprehension. Similarly, the test for Broad Math consisted of three subtests to assess children's calculations, mathematics fluency, and mathematics calculation skills. For the 73 children whose dominant language was Spanish based on their performance on the Woodcock–Muñoz Language Proficiency Test (Woodcock & Muñoz-Sandoval, 1993), a Spanish version of the reading and mathematics achievement tests (the *Batería Woodcock-Muñoz: Pruebas de aprovechamiento–Revisada*; Woodcock & Muñoz-Sandoval, 1996) was administered. W scores (an interval-scaled, Rasch-type measure of ability) from the WJ III or the Spanish version (Batería-R) were used in all analyses. W scores are a measure of actual change or growth in mathematics and reading ability. W scores from the *Batería*-R are equated to W scores from the WJ-R, the predecessor of the WJ-III (Woodcock & Muñoz-Sandoval, 1996).

4.6. Child and family influences related to achievement

Child and familial variables such as sex, age, IQ, economic adversity, and ethnicity have been shown to be associated with children's achievement (Asbury, 1974; Stanovich, Cunningham, & Feeman, 1984). Because the present study focuses on examination of the unique and interactive contributions from behavioral indices of effortful control and from positive teacher–student relationships on academic achievement, we accounted for potential influences of age, sex, IQ, race, and economic adversity when conducting our primary (regression) analyses.

4.6.1. Cognitive ability (IQ)

Children's IQ was individually assessed in school at first grade with the Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998). The UNIT is a nationally standardized non-verbal measurement of the general intelligence and cognitive abilities of children and adolescents. The UNIT assesses general intelligence by measuring complex memory and reasoning abilities using culturally and linguistically universal hand and body gestures rather than receptive or expressive language. We used the abbreviated version of the UNIT that yields a full scale IQ that is highly correlated with scores obtained with the full battery ($r = .91$) and that has been demonstrated to have good test-retest and internal consistency reliabilities as well as construct validity (Bracken & McCallum; Hooper, 2003). In the standardization sample, the internal consistency reliability coefficients of the UNIT Abbreviated Battery FSIQ were .88 for 6-year-old and .84 for 7-year-old children (Bracken & McCallum). The corrected test-retest stability coefficient of the Abbreviated Battery at approximately 3 weeks ($M = 20.3$ days, ranging from 3 to 42 days) was .83 for children 5–7 years old ($n = 46$). When administered to 104 first to 10th graders, the correlation coefficients between the UNIT memory or reasoning IQ scores and the Woodcock–Johnson-Revised (WJ-R) broad cognitive ability score were .52 and .63, respectively (Reed & McCallum, 1995).

4.6.2. Economic adversity

Children's familial economic adversity was indexed by children's eligibility for free or reduced lunch at first grade, based on school records (coded as a dichotomous variable; 0 = not eligible and 1 = eligible). Eligibility for free or reduced lunch was based on children's family income as reported by school district records.

4.6.3. Ethnicity

Information regarding children's ethnicity was obtained from school district records. Analyses from earlier studies with this longitudinal sample (Hughes et al., 2005; Hughes & Kwok, 2007) indicated that teachers reported less supportive and more conflicted relationships with African American students relative to both Hispanic White and non-Hispanic White students (who did not differ from each other). In addition, MANOVA analysis indicated that the African American students had lower reading and mathematics achievement at Year 2 compared to other ethnic groups (i.e., Caucasian, Hispanic, Asian, and other). Thus, ethnicity was coded as African American (coded 1) or non-African American (coded 0).

5. Results

5.1. Plan of analyses

Descriptive and preliminary analyses were first conducted, and differences in children's sex, age, IQ, economic adversity, and ethnicity (i.e., coded as African American and non-African American) on the major variables of this study were examined to determine if these variables needed to be included in analyses as covariates. Correlational analyses were also conducted to examine within- and across-time relations among the major variables. Regression analyses were then conducted to test whether there were additive or multiplicative contributions from effortful control (i.e., inhibitory control and task accuracy) and positive teacher–student relationships at Wave 1 to academic outcomes at Wave 2.

5.2. Preliminary analyses

Descriptive statistics were conducted, and the means and standard deviations for the major variables were presented in Table 1. According to the cutoff values of two for skewness and seven for kurtosis (West, Finch, & Curran, 1995), only scores for task accuracy and the corresponding baseline at Wave 1 were skewed. After identifying potential outliers and examining the frequencies and distribution of the skewed variable (Barnett & Lewis, 1994), all potential outliers' responses on task accuracy were found to be within reasonable ranges and were kept in analyses.

Table 1
Means and standard deviations of major composites.

Variable	*M*	SD
Inhibitory Control W1	28.14	16.82
Task Accuracy W1	−1.06	1.64
Teacher Support W1	3.75	.77
Reading W1	96.44	18.06
Reading W2	96.96	16.93
Mathematics W1	100.71	14.34
Mathematics W2	100.48	12.65

Note: $N = 761$. W1: first assessment (first grade); W2: second assessment (1 year after W1). Inhibitory Control was measured as total number seconds to complete tasks. Task Accuracy was measured as reversed score of errors committed on tasks. Teacher support was measured on a 5-point scale.

Table 2
Zero-order correlations among major composites and zero-order correlations between demographic variables and major composites.

Measure	Wave 1 (first grade)					Wave 2 (second grade unless retained)	
	1	2	3	4	5	6	7
1. Inhibitory Control W1	–						
2. Task Accuracy W1	.29**	–					
3. Teacher Support W1	.05	.08*	–				
4. Reading W1	.06	.08*	.17**	–			
5. Mathematics W1	.11**	.05	.09*	.53**	–		
6. Reading W2	.14**	.11**	.19**	.78**	.44**	–	
7. Mathematics W2	.21**	.07+	.10*	.49**	.76**	.54**	–
Economic Adversity	−.05	−.07	−.05	−.11**	−.35**	−.14**	−.35**
Age	.06	.04	.01	−.44**	−.41**	−.38**	−.39**
IQ	.05	.09*	.12**	.24**	.41**	.26**	.37**
Sex	.02	−.09*	−.21**	−.12**	.01	−.12**	.03
Ethnicity	−.03	−.12**	−.19**	−.24**	−.27**	−.31**	−.24**

Note: $N = 761$. W1: first assessment (first grade); W2: second assessment (1 year after W1). Sex: 0 = female, 1 = male; ethnicity: 0 = non-African American, 1 = African American.

+ $p < .10$.
* $p < .05$.
** $p < .01$.

Children's sex, age, IQ, economic adversity, and ethnicity were examined in relation to the major variables in this study, and the zero-order correlations were reported in Table 2. Overall, the pattern of correlations shows that child socio-demographic variables of high IQ, being a girl, high economic status, and non-African American status were positively associated with either reading or mathematics academic achievement. The negative correlation between age and reading and mathematics W scores meant that children who were older for grade tended to perform lower relative to their same age peers, but not necessarily relative to their same-grade peers. This finding may reflect a tendency for children whose academic readiness skills are low for their age to delay school entry. Consistent with prior research on socio-demographic factors and achievement (Duncan & Magnuson, 2005; Stevenson & Newman, 1986), children's age, sex, IQ, economic adversity, and ethnicity were included as covariates in subsequent regression analyses that were conducted to test the hypotheses.

5.3. Correlational analyses

Within- and across-time relations among the major variables were examined with zero-order correlations (Table 2). Recall the predictors (i.e., effortful control and positive teacher–student relationships measures) were from Wave 1, whereas academic outcomes were from Waves 1 and 2.

5.3.1. Relations among predictors and between predictors and outcomes

Within Wave 1, the two behavioral indices of effortful control (inhibitory control and task accuracy) were positively correlated with one another, but only task accuracy was correlated with positive teacher–student relationships. On the one hand, inhibitory control, but not task accuracy, was positively correlated with Wave 1 mathematics. On the other hand, task accuracy, but not inhibitory control, was positively correlated with Wave 1 reading. Positive teacher–student relationships were positively correlated with Wave 1 reading and mathematics achievement.

Cross-wave correlations indicated that all three Wave 1 predictors (i.e., inhibitory control, task accuracy, and positive teacher–student relationships) were at least marginally positively correlated with Wave 2 reading and mathematics achievement.

5.3.2. Relations among outcomes

Reading and mathematics were moderately correlated at Waves 1 and 2, but we kept reading and mathematics achievement separately for regression analyses because previous research found differential associations between inhibitory control and reading or mathematics in children from low-income families (Blair & Razza, 2007). Cross-wave correlations indicated that there was differential continuity (i.e., rank-order consistency) in reading and in mathematics achievement over 1 year.

5.4. Regression analyses

Multiple regression analyses were conducted using Mplus (v.5.2, Muthén & Muthén, 1998–2007) to test the hypothesized unique and interactive effects of two behavioral indices of effortful control (i.e., inhibitory control or task accuracy) and positive teacher–student relationships at first grade on academic achievement 1 year later. Recall that the task accuracy scores and the corresponding baseline at Wave 1 were skewed. Importantly, maximum likelihood estimation with robust standard errors (MLR) was used as the estimator in analyses, because it is robust to non-normality and non-independence of observations when used with the complex analysis feature of Mplus (Muthén & Muthén). Furthermore, non-normality

Table 3
Longitudinal effects of inhibitory control and teacher support on academic outcomes ($N = 761$).

Variable	Reading W2					Mathematics W2				
	B	*SE B*	β	R^2	ΔR^2	*B*	*SE B*	β	R^2	ΔR^2
Step 1										
Economic Adversity	−1.75	2.70	−.03			−5.08	2.57	−.07		
Age	.00	3.68	.00			−.08	3.34	.00		
IQ	.08	.08	.05			.17	.08	.10*		
Sex	−1.80	2.36	−.03			.57	2.27	.01		
Ethnicity	−3.57	2.86	−.04			1.09	2.76	.01		
Inhibitory Control W1 Baseline	.19	.22	.04	.046		.21	.22	.04*	.055	
Step 2										
Reading W1	.40	.08	.27*	.104	.058*					
Mathematics W1						.29	.08	.19*	.079	.024*
Step 3										
Inhibitory Control W1	.02	.08	.01	.104	.000	.02	.08	.01	.079	.000
Step 4										
Teacher Support W1	1.35	1.92	.03	.105	.001	.41	1.69	.01	.079	.000
Step 5										
Interaction	.13	.09	.05	.107	.002	.13	.08	.05	.081	.002

Note: W1: first assessment (first grade); W2: second assessment (1 year after W1). For simplicity, all regression coefficients (i.e., *B*, *SE* of *B*, and β) are from Step 5 analysis and based on the full information maximum likelihood (FIML) procedure using the maximum likelihood estimator. Sex: 0 = female, 1 = male; ethnicity: 0 = non-African American, 1 = African American.

* $p < .05$.

conditions has typically been found to have nearly no effect on the standard errors of parameter estimates especially with sample sizes larger than 100 (Lei & Lomax, 2005). Given that multiple regression analysis represents a special case of structural equation modeling (Bollen, 1989), the parameter estimates and test of significance should be relatively unaffected even with the skewed variables. According to attrition analyses, 4.7% of data on variables in the analysis were missing at random. Thus, the regression models were examined by using MLR and a mean-adjusted chi-square statistic test (v.5.2, Muthén & Muthén). To address missingness in data, the models were analyzed using the full information maximum likelihood (FIML) method under Mplus, which applies the expectation maximization algorithm described in Little and Rubin (2002).

Regression analyses also accounted for potential dependence among the observations (children) within clusters (classrooms). The 761 children were from 205 first-grade classrooms. The number of children nested in the classrooms ranged from 1 to 13, with the average number around 4 children per classroom. Among all the classrooms, 42% had four children or more. Having fewer people in each cluster does not mean that potential cluster effect should be ignored (Kenny, 2008). In addition, the intraclass correlation (ICC) values for reading and mathematics achievement were .30 and .20, respectively, which are considered relatively high (Raudenbush & Liu, 2000). According to Kenny, Kashy, and Bolger (1998), large ICC values result in too "liberal" test of statistical significance, namely, the null hypothesis is rejected too often. Therefore, we used the "type = complex" feature in Mplus (v.5.2, Muthén & Muthén, 1998–2007) to account for the dependence among the observations within clusters by adjusting the standard errors of the estimated coefficients.

In testing of the primary hypotheses, the predictors were centered, and the multiplicative (or interaction) terms were created by multiplying the centered scores of inhibitory control or task accuracy with centered scores on positive teacher–student relationships in order to reduce multicollinearity among predictors (Cohen, Cohen, West, & Aiken, 2003). Separate hierarchical regression analyses were conducted for each of the two aspects of effortful control (i.e., inhibitory control and task accuracy) on reading and mathematics achievement, resulting in four regression analyses (see Tables 3 and 4). Regression analyses included covariates (i.e., sex, age, IQ, economic adversity, and ethnicity) and baseline measures of inhibitory control or task accuracy to account for their potential influences on the Wave 2 achievement outcomes. In regard to baseline measures of inhibitory control or task accuracy, they were included so the unique contributions of inhibitory control or task accuracy on achievement above and beyond what children may naturally do when not provided with instructions to modulate or inhibit their behavior could be examined. To account for potential rank-order consistency effects on Wave 2 achievement outcomes, Wave 1 achievement outcomes (i.e., reading and mathematics achievement) were entered in the second step. Next, Wave 1 inhibitory control or task accuracy and positive teacher–student relationships, respectively, were entered in the third and forth steps. The corresponding multiplicative term was entered in the final step. R^2 and ΔR^2 for each block of predictors were reported in Tables 3 and 4 for the hierarchical regression analysis. Because the analyses were conducted in Mplus using maximum likelihood estimator, Chi-squared difference test for nested models was used to test whether the increment in R^2 was significant. When significant interactive effects were found, the relation between the effortful control and achievement variables was plotted at three levels (1 standard deviation above the mean/+1SD, the mean, and 1 standard deviation below the mean/−1SD) of positive teacher–student relationships (Aiken & West, 1991). When interactive effects were not found, we examined whether unique or additive effects were found for Wave 1 inhibitory

Table 4
Longitudinal effects of task accuracy and teacher support on academic outcomes ($N = 761$).

	Reading W2					Mathematics W2				
	B	*SE B*	β	R^2	ΔR^2	*B*	*SE B*	β	R^2	ΔR^2
Step 1										
Economic Adversity	−1.82	2.76	−.03			−5.10	2.63	−.07		
Age	−.19	3.73	.00			−.19	3.38	.00		
IQ	.08	.07	.05			.17	.08	.10*		
Sex	−1.48	2.36	−.02			.77	2.26	.01		
Ethnicity	−2.82	2.85	−.03			1.66	2.80	.02		
Task Accuracy W1 Baseline	−.23	.92	−.01	.043		−.20	.82	−.01	.051	
Step 2										
Reading W1	.40	.08	.27*	.103	.060*					
Mathematics W1						.30	.08	.19*	.077	.026*
Step 3										
Task Accuracy W1	1.11	.97	.05	.104	.001	.86	.90	.04	.078	.001
Step 4										
Teacher Support W1	1.37	1.90	.03	.105	.001	.48	1.68	.01	.078	.000
Step 5										
Interaction	−1.74	.66	−.06*	.108	.003*	−1.37	.65	−.05*	.080	.002*

Note: W1: first assessment (first grade); W2: second assessment (1 year after W1). For simplicity, all regression coefficients (i.e., *B*, *SE* of *B*, and β) are from Step 5 analysis and based on the full information maximum likelihood (FIML) procedure using the maximum likelihood estimator. Sex: 0 = female, 1 = male; ethnicity: 0 = non-African American, 1 = African American.

* $p < .05$.

control or task accuracy and positive teacher–student relationships on Wave 2 school adjustment. Because findings are reported in tables, we highlight the significant predictions of achievement from the regression analyses.

5.4.1. Longitudinal effects of inhibitory control and positive teacher–student relationships on academic outcomes

No interactive and no unique effects were found for inhibitory control and positive teacher–student relationships at first grade on reading or mathematics achievement 1 year later, above contributions from covariates and all other predictors in the model, including Wave 1 reading or mathematics score. Wave 1 reading and mathematics were entered into the models (in separate analyses) at Step 2, and the increment in R^2 was significant ($\Delta\chi^2(1) = 33.521$ and 16.589 for reading and mathematics respectively, $ps < .001$).

5.4.2. Longitudinal effects of task accuracy and positive teacher–student relationships on academic outcomes

Interactive effects were found between task accuracy and positive teacher–student relationships at first grade on academic outcomes 1 year later (Table 3). In the context of covariates and all other predictors in the model, including Wave 1 reading or mathematics score, the interaction terms in the equations for both reading ($\beta = -.06$, $p = .008$; Fig. 1) and mathematics ($\beta = -.05$, $p = .035$; the pattern is the same as in Fig. 1) were statistically significant. The increment in R^2 was significant at Step 2 when Year 1 reading or mathematics was added into the models ($\Delta\chi^2(1) = 28.940$ and 16.066 for reading and mathematics respectively, $ps < .001$). In addition, the increment in R^2 was significant at Step 5 when the interaction

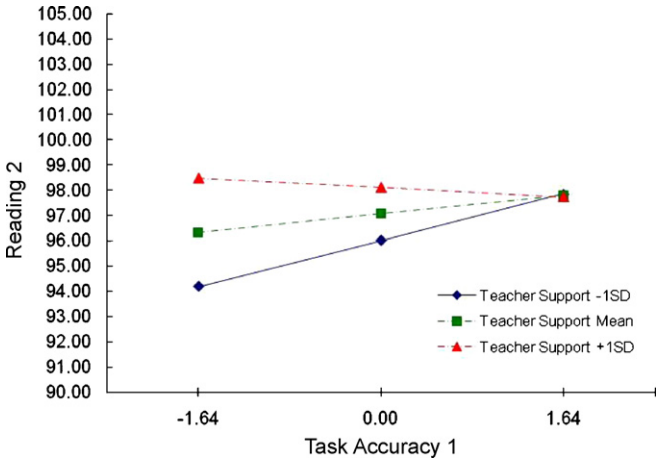

Fig. 1. Wave 1 teacher support as moderator of Wave 1 task accuracy and Wave 2 reading achievement. Dashed lines indicate non-significant slopes.

between positive teacher–student relationships and task accuracy was added ($\Delta\chi^2(1) = 7.599$ and 4.995, $ps = .006$ and .025 for reading and mathematics respectively).

To graphically depict the interactive effects, the relation between task accuracy and reading or mathematics was plotted at three levels (1 standard deviation above the mean/+1SD, the mean, and 1 standard deviation below the mean/−1SD) of positive teacher–student relationships (Aiken & West, 1991), with dashed lines indicating non-significant slopes. Tests of the three slopes indicated that the slopes at 1 standard deviation below the mean of positive teacher–student relationships was statistically different from zero ($\beta s = .12$ and .10, $ps = .03$ and .04 for reading and mathematics respectively). Results indicated that children with high task accuracy performed similarly well academically with or without being paired with a positive and supportive teacher. However, children with low task accuracy performed just as well academically as children with high task accuracy when paired with a positive and supportive teacher. Because the patterns of the interaction effect were similar between reading and mathematics, only the figure for reading is provided. The results were adjusted for covariates by using the means of covariates.

The influence of positive teacher–student relationships was also reflected by effect size of the academic achievement gap or difference between students with lower level of task accuracy and those with higher level of task accuracy. As shown in Fig. 1, at low levels of task accuracy (i.e., −1SD or −1.64), the effect size for the gap in reading achievement between children with high (+1SD) level of positive teacher–student relationships and children with low (−1SD) level of positive teacher–student relationships was .25. This was calculated using the following equation: $(\text{Read}_{+1\text{SD TS}} - \text{Read}_{-1\text{SD TS}})/\text{SD}_{\text{read}}$, where $\text{Read}_{+1\text{SD TS}}$ was the students' average reading score when receiving high level of positive teacher–student relationships, $\text{Read}_{-1\text{SD TS}}$ was the students' average reading score when receiving low level of positive teacher–student relationships, and SD_{read} was the standard deviation of the reading achievement at Year 2. In the same vein, the effect sizes of reading achievement gap/difference at low, medium and high levels of task accuracy were calculated as .25, .12, and −.01, respectively. For mathematics, the effect sizes of the achievement gap/difference at low, medium and high levels of task accuracy were calculated as .18, .10, and .01, respectively. The pattern of results show that the achievement gap increased as students' level of task accuracy became lower, with the moderational effect of positive teacher–student relationships with task accuracy on future achievement being most notable as the students' level of task accuracy became lower (i.e., when higher level positive teacher–student relationships became more important for future achievement).

In summary, results indicated that children with self-regulatory difficulties (particularly low task accuracy) performed just as well academically as children with high task accuracy when paired with a positive and supportive teacher. Effect sizes were .25 and .18 for improvement in reading and mathematics, respectively, which according to Cohen (1988) is a small to medium effect.

6. Discussion

Our findings indicate that aspects of child effortful control (i.e., inhibitory control and task accuracy) and positive teacher–student relationships operate jointly to contribute to future child academic achievement. Importantly, results suggest that positive and supportive teachers play a compensatory role for students with self-regulatory difficulties via creating a positive (low conflict) learning environment that promotes future academic achievement, while specific aspects of children's self-regulatory skills may serve as protective factors for achievement in learning environments where students may be receiving or requiring little support from the teacher (Rudasill & Rimm-Kaufman, 2009; Winsler, 2003). For students with self-regulatory difficulties as indicated by low task accuracy, being paired with positive and supportive teachers was important for their future academic achievement.

6.1. Joint contributions of inhibitory control and positive teacher–student relationships to academic outcomes

We expected that inhibitory control and positive teacher–student relationships at first grade would have interactive or unique (additive) effects on academic achievement 1 year later, but neither was found. Importantly, note that inhibitory control and positive teacher–student relationships were positively associated with reading and mathematics achievement 1 year later in correlational analyses (see Table 2). Given that variables such as children's socio-demographic variables and prior levels of achievement were already associated with their future achievement, an additional contribution to achievement from either child inhibitory control or positive teacher–student relationship would be difficult to find considering that there was no significant change in the rank-ordering on reading and mathematics achievement over 1 year. In regards to inhibitory control, the measure in the present study consisted primarily of observed gross and fine motor inhibition. Because we focus primarily on gross and fine motor inhibitory skills in the present study, our study adds to the literature by highlighting that children's abilities to regulate behavior in the classroom may be critical for learning and achievement during entrance into formal schooling (e.g., McClelland et al., 2007), but other aspects of self-regulatory abilities such as executive attention may become particularly critical for and predictive of academic success in later grades. Previous studies found that attention-related skills such as task persistence at kindergarten predicted reading and mathematics achievement at third grade (Duncan et al., 2007). Yet, it is important to note that motor and attention-related problems are often linked (Piek et al., 2004) and may suggest a common underlying neurocognitive mechanism (Askan & Kochanska, 2004; Kochanska & Knaack, 2003; Rueda, Posner, & Rothbart, 2005). Thus, present study results highlight a need to differentiate the motor

and attentional aspects of effortful control and the use of various behavioral indices of effortful control when examining child functioning (also see Blair & Razza, 2007; Rothbart, 2004).

6.2. Joint contributions of task accuracy and positive teacher–student relationships to academic outcomes

For task accuracy and positive teacher–student relationships on reading and mathematics achievement 1 year later, interactive effects were found. Results indicate that children who exhibited low task accuracy may especially benefit academically from having a teacher who offers high levels of support, relative to moderate or low levels of support. Thus, there is tentative evidence supporting the view that supportive teachers play a compensatory role for academically at-risk children's future achievement (particularly those with difficulties on tasks that require fine motor skills, accuracy, and attention-related skills). We speculate that positive teacher–student relationships offer children with difficulties in completing fine motor tasks accurately an external source of motivation and regulation that facilitates student's learning and achievement. In contrast, children who are adept at fine motor tasks and could complete them accurately may be able to stay on-task and complete class or homework assignments with or without positive teacher–student relationships as an external source of motivation and regulation. Thus, abilities for high task accuracy may serve as a protective factor for children who may not be paired with a positive and supportive teacher.

Our findings of interactive contributions of the task accuracy and positive teacher–student relationships are consistent with mounting evidence showing a need to understand children's psychosocial and academic outcomes by examining the child within her or his environment (Eisenberg et al., 2007; Ladd, 2003; Ladd & Burgess, 2001; Martel & Nigg, 2006). These interactive effects are compatible with findings from Ladd and Burgess (2001) who found that certain child by environment processes on school adjustment are interactive (e.g., positive classroom relationships and child aggression on school adjustment). Further, present findings are consistent with previous research that show the link between positive teacher–student relationships and academic outcomes may especially be pronounced for at-risk students who exhibit self-regulatory difficulties (Hughes et al., 1999; Pianta et al., 1997; Pianta & Walsh, 1996). For children who have difficulties completing fine motor tasks that may require attention and effortful control to complete such tasks accurately, a supportive teacher could compensate for students' difficulties by motivating such students to persist in learning goals that then contributes to future achievement.

Previous research has documented negative associations between children's level of externalizing problems and positive teacher–student relationships (Baker, 2006; Birch & Ladd, 1997; Silver, Measelle, Armstrong, & Essex, 2005). Consistent with this view, child inhibitory control was not associated with positive teacher–student relationships in our sample during first grade (Table 2). Perhaps teachers recognize individual or developmental differences amongst first graders' abilities for motor control and may tolerate certain levels of behavioral problems associated with low inhibitory control (Kauffman & Wong, 1991; Poulou & Norwich, 2002). However, higher levels of positive teacher–student relationships were correlated with higher levels of child task accuracy (Table 2). Such an association is consistent with a study on teachers' classroom management and child temperament that found that teachers viewed children's task orientation (i.e., activity level, persistence, and distractibility) as particularly important information in making decisions about classroom management (Pullis & Cadwell, 1982).

6.3. Study limitations and future directions

Although the strength of the present study included a prospective longitudinal design with observational data on children's effortful control, study results need to be interpreted in the context of several study limitations. The present study focuses on academically at-risk students, and caution needs to be taken if applying findings to general or high-achieving students. Our measure of positive teacher–student relationships is based on teachers' self-reports, and inclusion of naturalistic observations in classrooms would allow for identification and specification of the teacher behaviors and teacher–student interactions that account for study findings. Perhaps students who experience positive teacher–student relationships, relative to those with less positive relationships, are more committed to complying with teachers' requests and more motivated and persistent at school work. Further, students with positive relationships with teachers may feel comfortable asking their teachers for help when they need it. Additionally, assessments of effortful control in the present study were conducted at children's schools by a single research assistant and were not filmed so reliabilities of inhibitory control could not be calculated. Importantly, it should be noted that research assistants demonstrated proficiency with the measurement of inhibitory control prior to assessing actual cases. Although not always feasible, future studies that are conducted in naturalistic settings such as classrooms could video-record participants during assessments to allow for fine-grained data coding and calculations of reliabilities on observed measures. Also, the length of errors committed on the Star and Circle tasks were not recorded for measures of task accuracy. Moreover, inclusion of ratings from teachers or parents about children' self-regulatory skills or abilities might provide indirect information about the validity of observed measures of effortful control. In the present study, inhibitory control was measured by tasks requiring gross and fine motor abilities whereas task accuracy was measured by tasks requiring primarily fine motor abilities. Thus, further research is needed to explore the relative contributions on achievement from effortful control abilities that primarily rely on attentional rather than motor skills, including greater differentiation between gross and fine motor skills. We also acknowledge that a number of our study results were significant but relatively small effects. Yet, it is equally important to acknowledge that early and small differences may result

in meaningful or large differences over time as illustrated by the Matthew and fan-spread effects where initial strengths or vulnerabilities not only continue but increase over time (Cook & Campbell, 1979). To better understand such processes, longitudinal studies that examine long-term achievement outcomes are needed.

6.4. Implications for policy and practice

Teachers' provision of social and emotional support for young children appears to be associated with concurrent and later academic achievement in academically at-risk students who were predominantly from low-income and ethnic minority backgrounds. However, the interactive effects of positive teacher–student relationships and child task accuracy on future achievement suggest that the provision of a positive teacher–student relationship would be particularly beneficial for children who exhibit difficulties on academic tasks that require fine motor skills, accuracy, and paying attention to details and instructions. Further, task accuracy served as a protective factor so that children with high task accuracy performed well academically with or without being paired with a positive and supportive teacher. Overall, results suggest that targeting joint-efforts at enhancing specific aspects of children's self-regulatory capacities and at teacher professional development that emphasize positive rapport and support with students offer complementary contributions to children's learning and achievement.

The present findings may have implications for efforts at narrowing or closing the achievement gap for at-risk students. Note that present results were found in a sample of students who began first grade with relatively low literacy skills, and were predominantly low-income (62%) and ethnic minority (60% African American or Hispanic). Evidence indicates that low-income and ethnic minority students tend to lag behind their non-minority and economically more affluent classmates at entrance to school on measures of academic achievement (Duncan & Magnuson, 2005; Shonkoff & Phillips, 2000) as well as on measures of self-regulation (Blair, 2002; Ladd et al., 1999; Pianta et al., 1997). They also tend to experience more conflict and less support in their relationships with teachers (Alexander & Entwistle, 1988; Hamre & Pianta, 2001; Hughes & Kwok, 2006; Meehan et al., 2003). In light of such risks for low-income and ethnic minority children, present findings suggest that, in the absence of a supportive teacher–student relationship, children with underdeveloped self-regulatory skills will continue to lag behind academically. Unfortunately, children who are at greatest risk for academic failure in the early grades, due to poor academic skills and family background, are the least likely to be enrolled in classrooms that provide a positive and responsive climate for learning (Stuhlman & Pianta, 2009). Thus, these findings suggest that efforts to provide low-income and ethnic minority students with positive and supportive teacher–student relationships need to be an integral component of policies, programs, and interventions designed to narrow achievement disparities between racial/ethnic and income groups.

In summary, our findings support the view that educational policies need to emphasize both social–emotional and instructional practices in early childhood education to maximize students' learning and achievement (Mashburn et al., 2008; McTigue, Washburn, & Liew, 2009), particularly for students who are academically at-risk or from low-income and ethnic minority background. Our findings highlight the interactive nature by which child and teacher characteristics contribute to future achievement, and support the view that children's school outcomes need to be understood using a child within environment perspective (Ladd, 2003). For economically disadvantaged, ethnic minority, or academically at-risk children, early investment in helping them develop self-regulatory and effortful control skills may pay dividends in their future achievement (Duncan et al., 2007; Evans & Rosenbaum, 2008; Liew et al., 2008). And for academically at-risk students who exhibit self-regulatory difficulties, interventions or training that provide in-service teachers with on-going, individualized feedback focused on improving teachers' social-emotional support for students (e.g., Mashburn et al.) may play a role in the prevention of academic under-achievement and help narrow achievement disparities.

References

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage.

Alexander, K. L., & Entwistle, D. R. (1988). Achievement in the first 2 years of school: Patterns and processes. *Monographs of the Society for Research in Child Development*, *53*(2, Serial No. 218).

Asbury, C. A. (1974). Selected factors influencing over- and under-achievement in young school-age children. *Review of Educational Research*, *44*, 409–428.

Askan, N., & Kochanska, G. (2004). Links between systems of inhibition from infancy to preschool years. *Child Development*, *75*, 1477–1490.

Baker, J. A. (2006). Contribution of teacher-child relationships to positive school adjustment during elementary school. *Journal of School Psychology*, *44*, 211–230.

Barnett, V., & Lewis, T. (1994). *Outliers in statistical data* (3rd ed.). New York: Wiley.

Birch, S. H., & Ladd, G. W. (1997). The teacher-child relationship and children's early school adjustment. *Journal of School Psychology*, *35*, 61–79.

Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist*, *57*, 111–127.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*, 647–663.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley.

Bracken, B. A., & McCallum, R. S. (1998). *Universal Nonverbal Intelligence Test examiner's manual*. Itsaka, IL: Riverside.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Erlbaum.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis for field settings*. Chicago: Rand McNally.

Dennis, T. A., & Brotman, L. M. (2003). Effortful control, attention, and aggressive behavior in preschoolers at risk for conduct problems. *Annals New York Academy of Sciences*, *1008*, 252–255.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental Psychology*, *43*, 1428–1446.
Duncan, G. J., & Magnuson, K. A. (2005). Can family socioeconomic resources account for racial and ethnic test score gaps? *Future of Children*, *15*, 35–53.
Eisenberg, N., Ma, Y., Chang, L., Zhou, Q., West, S. G., & Aiken, L. (2007). Relations of effortful control, reactive undercontrol, and anger to Chinese children's adjustment. *Development and Psychopathology*, *19*, 385–409.
Eisenberg, N., Zhou, Q., Spinrad, T. L., Valiente, C., Fabes, R. A., & Liew, J. (2005). Relations among positive parenting, children's effortful control, and externalizing problems: A three-wave longitudinal study. *Child Development*, *76*, 1055–1071.
Evans, G. W., & Rosenbaum, J. (2008). Self-regulation and the income-achievement gap. *Early Childhood Research Quarterly*, *23*, 504–514.
Furman, W., & Buhrmester, D. (1985). Children's perceptions of the personal relationships in their social networks. *Developmental Psychology*, *21*, 1016–1024.
Goodenow, C. (1993). Classroom belonging among early adolescent students: Relationships to motivation and achievement. *Journal of Early Adolescence*, *13*, 21–43.
Graziano, P. A., Reavis, R. D., Keane, S. P., & Calkins, S. D. (2007). The role of emotion regulation in children's early academic success. *Journal of School Psychology*, *45*, 3–19.
Griffin, S. (2004). Building number sense with number worlds: A mathematics program for young children. *Early Childhood Research Quarterly*, *19*, 173–180.
Hamre, B. K., & Pianta, R. C. (2001). Early teacher–child relationships and the trajectory of children's school outcomes through eighth grade. *Child Development*, *72*, 625–638.
Hamre, B. K., & Pianta, R. C. (2005). Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child Development*, *76*, 949–967.
Hooper, V. S. (2003). Concurrent and predictive validity of the Universal Nonverbal Intelligence Test and the Leiter International Performance Scale–revised. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *63*(12-A), 4221.
Howes, C. (2000). Social-emotional classroom climate in child care, child-teacher relationships and children's second grade peer relations. *Social Development*, *9*, 191–204.
Howse, R., Calkins, S., Anastopoulos, A., Keane, S., & Shelton, T. (2003). Regulatory contributors to children's kindergarten achievement. *Early Education and Development*, *14*, 101–119.
Hughes, J. N., Cavell, T. A., & Jackson, T. (1999). Influence of the teacher-student relationship in childhood conduct problems: A prospective study. *Journal of Clinical Child Psychology*, *28*, 173–184.
Hughes, J. N., Cavell, T. A., & Willson, V. (2001). Further support for the developmental significance of the quality of the teacher-student relationship. *Journal of School Psychology*, *39*, 289–301.
Hughes, J. N., Gleason, K., & Zhang, D. (2005). Relationships as predictors of teachers' perceptions of academic competence in academically at-risk minority and majority first-grade students. *Journal of School Psychology*, *43*, 303–320.
Hughes, J. N., & Kwok, O. (2006). Classroom engagement mediates the effect of teacher-student support on elementary students' peer acceptance: A prospective analysis. *Journal of School Psychology*, *43*, 465–480.
Hughes, J. N., & Kwok, O. (2007). The influence of student-teacher and parent-teacher relationships on lower achieving readers' engagement and achievement in the primary grades. *Journal of Educational Psychology*, *99*, 39–51.
Juel, C. (1998). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology*, *80*, 437–447.
Kauffman, J., & Wong, K. (1991). Effective teachers of students with behavioral disorders: Are generic teaching skills enough? *Behavioral Disorders*, *16*, 225–237.
Kenny, D.A. (2008, July 2). *Fixed and random effects communicating to each other: Examples from dyadic research*. Keynote speech presented at the 73rd annual meeting of the Psychometric Society (IMPS 2008), Durham, NH.
Kenny, D. A., Kashy, D. A., & Bolger, N. (1998). Data analysis in social psychology. In D. Gilbert, S. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (4th ed., Vol. 1, pp. 233–265). Boston: McGraw-Hill.
Kieras, J. E., Tobin, R. M., Graziano, W. G., & Rothbart, M. K. (2005). You can't always get what you want: Effortful control and children's responses to undesirable gifts. *Psychological Science*, *16*, 391–396.
Kochanska, G., & Knaack, A. (2003). Effortful control as a personality characteristic of young children: Antecedents, correlates, and consequences. *Journal of Personality*, *71*, 1087–1112.
Kochanska, G., Murray, K., & Coy, K. C. (1997). Inhibitory control as a contributor to conscience in childhood: From toddler to early school age. *Child Development*, *68*, 263–277.
Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology*, *36*, 220–232.
Kochanska, G., Murray, K., Jacques, T. Y., Koenig, A. L., & Vandegeest, K. (1996). Inhibitory control in young children and its role in emerging internalization. *Child Development*, *67*, 490–507.
Ladd, G. W. (2003). Probing the adaptive significance of children's behavior and relationships in the school context: A child by environment perspective. *Advances in Child Development and Behavior*, *31*, 43–104.
Ladd, G. W., Birch, S. H., & Buhs, E. S. (1999). Children's social and scholastic lives in kindergarten: Related spheres of influence? *Child Development*, *70*, 1373–1400.
Ladd, G. W., & Burgess, K. B. (2001). Do relational risks and protective factors moderate the linkages between childhood aggression and early psychological and school adjustment? *Child Development*, *72*, 1579–1601.
Lei, M., & Lomax, R. G. (2005). The effect of varying degrees of nonnormality in structural equation modeling. *Structural Equation Modeling: A Multidisciplinary Quarterly*, *12*, 1–27.
Li-Grining, C. P. (2007). Effortful control among low-income preschoolers in three cities: Stability, change, and individual differences. *Developmental Psychology*, *43*, 208–221.
Liew, J., Eisenberg, N., & Reiser, M. (2004). Preschoolers' effortful control and negative emotionality, immediate reactions to disappointment, and quality of social functioning. *Journal of Experimental Child Psychology*, *89*, 298–319.
Liew, J., McTigue, E., Barrois, L., & Hughes, J. N. (2008). Adaptive and effortful control and academic self-efficacy beliefs on literacy and math achievement: A longitudinal study on 1st through 3rd graders. *Early Childhood Research Quarterly*, *23*, 515–526.
Little, R. J., & Rubin, D. B. (2002). *Statistical analysis with missing data* (2nd ed.). New York: Wiley.
Mantzicopoulos, P., & Neuharth-Pritchett, S. (2003). Development and validation of a measure to assess head start children's appraisals of teacher support. *Journal of School Psychology*, *41*, 431–451.
Martel, M. M., & Nigg, J. T. (2006). Child ADHD and personality/temperament traits of reactive and effortful control, resiliency and emotionality. *Journal of Child Psychology and Psychiatry*, *47*, 1175–1183.
Mashburn, A. J., Pianta, R. C., Hamre, B. K., Downer, J. T., Barbarin, O. A., Bryant, D., et al. (2008). Measures of classroom quality in prekindergarten and children's development of academic, language, and social skills. *Child Development*, *79*, 732–749.
McClelland, M. M., Cameron, C. E., Connor, C. M., Farris, C. L., Jewkes, A. M., & Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology*, *43*, 947–959.
McTigue, E. M., Washburn, E. K., & Liew, J. (2009). Academic resilience and reading: Building successful readers. *The Reading Teacher*, *62*, 422–432.
Meehan, B. T., Hughes, J. N., & Cavell, T. A. (2003). Teacher-student relationships as compensatory resources for aggressive children. *Child Development*, *74*, 1145–1157.

Murray, K. T., & Kochanska, G. (2002). Effortful control: Factor structure and relation to externalizing and internalizing behaviors. *Journal of Abnormal Child Psychology*, *30*, 503–514.
Muthén, L. K., & Muthén, B. O. (1998–2007). *Mplus user's guide*. Los Angeles: Muthén & Muthén.
O'Connor, E., & McCartney, K. (2007). Examining teacher-child relationships and achievement as part of an ecological model of development. *American Educational Research Journal*, *44*, 340–369.
Palermo, F., Hanish, L. D., Martin, C. L., Fabes, R. A., & Reiser, M. (2007). Preschoolers' academic readiness: What role does the teacher-child relationship play? *Early Childhood Research Quarterly*, *22*, 407–422.
Pianta, R. C., Nimetz, S. L., & Bennett, E. (1997). Mother-child relationships, teacher-child relationships, and school outcomes in preschool and kindergarten. *Early Childhood Research Quarterly*, *12*, 263–280.
Pianta, R. C., Steinberg, M., & Rollins, K. B. (1995). The first two years of school: Teacher-child relationships and reflections in children's classroom adjustment. *Development and Psychopathology*, *7*, 295–312.
Pianta, R. C., & Walsh, D. (1996). *High-risk children in the schools: Creating sustaining relationships*. New York: Routledge.
Piek, J. P., Dyck, M. J., Nieman, A., Anderson, M., Hay, D., Smith, L. M., et al. (2004). The relationship between motor coordination, executive functioning and attention in school aged children. *Archives of Clinical Neuropsychology*, *19*, 1063–1076.
Poulou, M., & Norwich, B. (2002). Cognitive, emotional and behavioral responses to students with emotional and behavioural difficulties: A model of decision making. *British Educational Research Journal*, *28*, 111–138.
Pullis, M., & Cadwell, J. (1982). The influence of children's temperament characteristics on teachers' decision strategies. *American Educational Research Journal*, *19*, 165–181.
Raudenbush, S., & Liu, X. (2000). Statistical power and optimal design for multisite randomized trials. *Psychological Methods*, *5*, 199–213.
Reddy, R., Rhodes, J. E., & Mulhall, P. (2003). The influence of teacher support on student adjustment in the middle school years: A latent growth curve study. *Development and Psychopathology*, *15*, 119–138.
Reed, M. T., & McCallum, R. S. (1995). Construct validity of the Universal Nonverbal Intelligence Test (UNIT). *Psychology in the Schools*, *32*, 277–290.
Rimm-Kaufman, S. E., Early, D. M., Cox, M. J., Saluja, G., Pianta, R. C., Bradley, R. H., et al. (2002). Early behavioral attributes and teachers' sensitivity as predictors of competent behavior in the kindergarten classroom. *Applied Developmental Psychology*, *23*, 451–470.
Rothbart, M. K. (2004). Commentary: Differentiating measures of temperament and multiple pathways to childhood disorders. *Journal of Clinical Child and Adolescent Psychology*, *33*, 82–87.
Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (5th ed., pp. 105–176). New York: Wiley.
Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon & R. M. Lerner (Series Eds.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (6th ed., pp. 99–166). New York: Wiley.
Rothbart, M. K., & Jones, L. B. (1998). Temperament, self-regulation, and education. *School Psychology Review*, *27*, 479–491.
Rudasill, K. M., & Rimm-Kaufman, S. E. (2009). Teacher-child relationship quality: The roles of child temperament and teacher-child interactions. *Early Childhood Research Quarterly*, *24*, 107–120.
Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: Contributions to the emergence of self-regulation. *Developmental Neuropsychology*, *28*, 573–594.
Ryan, R. M., Stiller, J. D., & Lynch, J. H. (1994). Representations of relationships to teachers, parents, and friends as predictors of academic achievement and self-esteem. *Journal of Early Adolescence*, *14*, 226–240.
Shonkoff, J. P., & Phillips, D. (Eds.). (2000). *From neurons to neighborhoods: The science of early childhood development*. Washington, DC: National Academy Press.
Silver, R. B., Measelle, J. R., Armstrong, J. M., & Essex, M. J. (2005). Trajectories of classroom externalizing behavior: Contributions of child characteristics, family characteristics, and the teacher-child relationship during the school transition. *Journal of School Psychology*, *43*, 39–60.
Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, *21*, 360–406.
Stanovich, K. E., Cunningham, A. E., & Feeman, D. J. (1984). Intelligence, cognitive skills, and early reading progress. *Reading Research Quarterly*, *19*, 278–303.
Stevenson, H. W., & Newman, R. S. (1986). Long-term prediction of achievement and attitudes in mathematics and reading. *Child Development*, *57*, 646–659.
Stuhlman, M. W., & Pianta, R. C. (2009). Profiles of educational quality in first grade. *The Elementary School Journal*, *109*, 323–342.
Valiente, C., Lemery-Chalfant, K., & Castro, K. S. (2007). Children's effortful control and academic competence: Mediation through school liking. *Merrill-Palmer Quarterly*, *53*, 1–25.
Valiente, C., Lemery-Chalfant, K., Swanson, J., & Reiser, M. (2008). Prediction of children's academic competence from their effortful control, relationships, and classroom participation. *Journal of Educational Psychology*, *100*, 67–77.
Wentzel, K. R. (2002). Are effective teachers like good parents? Teaching styles and student adjustment in early adolescence. *Child Development*, *73*, 287–301.
West, S. G., Finch, J. F., & Curran, P. J. (1995). Structural equation models with nonnormal variables: Problems and remedies. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues and applications* (pp. 56–75). Thousand Oaks, CA: Sage.
Winsler, A. (2003). Vygotskian perspectives in early childhood education: Translating ideas into classroom practice. *Early Education and Development*, *14*, 253–269.
Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III tests of achievement*. Itasca, IL: Riverside.
Woodcock, R. W., & Muñoz-Sandoval, A. F. (1993). *Woodcock-Muñoz language survey*. Chicago: Riverside.
Woodcock, R. W., & Muñoz-Sandoval, A. F. (1996). *Bateria Woodcock-Muñoz: Pruebas de habilidad cognoscitiva-Revisada [The Bateria-R in neuropsychological assessment]*. Chicago: Riverside.