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Learning-related skills and academic achievement in academically at-risk first graders

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Abstract

Using an academically at-risk, ethnically diverse sample of 744 first-grade children, this study tested a multi-method (i.e., child performance measures, teacher ratings, and peer ratings) measurement model of learning-related skills (i.e., effortful control [EC], behavioral self-regulation [BSR], and social competence [SC]), and their shared and unique contributions to children's reading and math achievement, above the effect of demographic variables. The hypothesized correlated factor measurement model demonstrated relatively good fit, with BSR and SC correlated highly with one another and moderately with EC. When entered in separate regression equations, EC and BSR each predicted children's reading and math achievement; SC only predicted reading achievement. When considered simultaneously, neither EC, BSR, nor SC contributed independently to reading achievement; however, EC had a direct effect on math achievement and an indirect effect on reading achievement via both BSR and SC. Implications for research and early intervention efforts are discussed.

Keywords

Learning-related skills; Measurement model; Reading; Math; Elementary students

Children who start school with poor literacy skills are at increased risk of low academic performance throughout their school careers (Alexander, Entwisle, & Horsey, 1997; Sonnenschein, Stapleton, & Benson, 2010). Poor learning-related skills (LRS) such as behavioral self-regulation, prosocial skills, and the ability to maintain and focus attention, are implicated in low academic readiness (Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003; Matthews, Kizzie, Rowley, & Cortina, 2010). Furthermore, minority and children from low income families are over-represented among children with low academic readiness skills and poor LRS (KewalRamani, Gilbertson, Fox, & Provasnik, 2007; Matthews et al., 2010). Given these facts, it is important to provide effective early interventions for children most at-risk for school failure. Selecting children for early intervention programs and assessing the success of these programs requires reliable and valid measures of LRS. The purpose of the current study is to test a multi-dimensional,

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multi-informant measurement model of LRS appropriate for use with first grade students with low academic readiness skills, and to determine the association between distinct dimensions of LRS and reading and math achievement.

Learning-related skills

An expanding body of research has demonstrated that children's LRS, which are also referred to as approaches to learning or learning-related behaviors, play an essential role in children's successful transition to school, and in children's academic achievement during the elementary school grades. Specifically, extant research shows that aspects of children's LRS are correlated with children's academic achievement in kindergarten and other elementary school grades (e.g., Howse et al., 2003; Malecki & Elliott, 2002; Ready, LoGerfo, Burkam, & Lee, 2005). Furthermore, aspects of children's LRS, measured in kindergarten, predict growth in children's academic achievement across the elementary school grades (e.g., Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010; Matthews et al., 2010) above and beyond the contribution of potential confounding variables (e.g., child age, IQ, economic adversity status, maternal education level, and prior academic achievement).

A longitudinal study by McClelland, Acock, and Morrison (2006) is illustrative of studies finding links between LRS and achievement. Specifically, teachers' ratings of 538 children's LRS (i.e., responsibility, independence, cooperation, and self-regulation) at kindergarten significantly predicted original levels (i.e., intercept) of math and reading, as well as growth (i.e., slope) in math and reading, between kindergarten and second grade, above children's IQ, ethnicity, age, and maternal education. Additionally, Matthews et al. (2010) demonstrated the important role that LRS play in racial and gender differences in achievement. Using teacher reports of children's LRS (i.e., task persistence, attentiveness, learning independence, eagerness to learn, and organization) and a large nationally representative sample, Matthews et al. first confirmed prior reports of the academic underperformance of African American boys compared to their female and Caucasian peers. Furthermore, in assessing the extent to which these gender and race effects were affected by measured behavior/social factors (i.e., socioeconomic status, interpersonal skills, externalizing problem behaviors, home literacy environment, and LRS), Matthews et al. found that LRS explained the most variance between gender and race literacy gaps. Additionally, LRS had the strongest effect on literacy achievement in kindergarten, and only LRS were significantly related to literacy growth through the fifth grade for all racial/ethnic and gender groups (i.e., African American and non-Hispanic White children).

It is clear that LRS are important child academic assets. However, the variety of measures grouped under the construct of LRS creates difficulty in comparing and integrating results of different studies. Although authors acknowledge the multi-dimensional nature of LRS, few studies have tested the shared and independent contributions of distinct dimensions of LRS to academic achievement. Given the breadth of child behaviors included under the broad construct of LRS, it is important to understand the relation among various measures and the shared and independent contribution of different dimensions of LRS to children's academic achievement. Next, various conceptualities of, and measurement approaches to, LRS are reviewed.

Defining and conceptualizing LRS

Scholars generally agree that LRS are recognizable behavioral patterns and characteristics that are exhibited by children as they partake in learning tasks and classroom interactions (Fantuzzo et al., 2007; McWayne, Fantuzzo, & McDermott, 2004). Throughout the psychological literature, LRS are viewed as emanating from executive functioning skills and reflecting the social and behavioral expression of such skills (Matthews et al., 2010; McClelland et al., 2006). Although scholars have yet to produce an agreed-upon list of LRS, LRS are often cited as involving the following skills: task persistence, following directions, receptiveness to challenges, organization, cooperation, prosocial behaviors, responsibility, learning/working independence, directed attention, flexibility, and ability to plan and problem-solve (Fantuzzo, Bulotsky-Shearer, Fusco, & McWayne, 2005; Malecki & Elliott, 2002; Matthews et al., 2010; McClelland et al., 2006; McWayne et al., 2004; Stipek, Newton, & Chudgar, 2010).

Consistent with the view that LRS represent a multi-dimensional construct, researchers have posited three distinct, yet interrelated dimensions: 1) effortful control; 2) behavioral self-regulation; and 3) social competence (Berhenke, Miller, Brown, Seifer, & Dickstein, 2011; Li-Grining et al., 2010; McClelland, Cameron, Wanless, & Murray, 2007). Each of these areas is briefly discussed below.

Effortful control (EC) is an important, temperamentally based predisposition that is essential to inhibitory control, a component of executive function. Generally, EC has been conceptualized as involving the abilities to enjoy activities of minimal intensity, to shift and focus attention in a deliberate manner, and to inhibit or initiate a response as required by particular circumstances (Gartstein, Putnam, & Rothbart, 2012; Putnam, Gartstein, & Rothbart, 2006). As in this study, some authors define EC in a more specific manner, specifying EC as “a temperamentally based ability to inhibit a dominant response and activate a subdominant response” (Murray & Kochanska, 2002, p. 503). Because EC permits individuals to voluntarily modulate their state of arousal and impulsive tendencies, behavioral rating scales of EC likely assess impulsivity and emotionality as well (Eisenberg, Smith, Sadovsky, & Spinrad, 2004). For these reasons, researchers recommend that child performance measures be used to assess EC (Diamond & Taylor, 1996; Eisenberg et al., 2004; Murray & Kochanska, 2002).

Some studies have demonstrated that children's EC has direct effects on their academic achievement in general (e.g., Blair & Razza, 2007; Liew, Barrois, McTigue, & Hughes, 2008; Obradović, 2010), whereas other studies (e.g., Lan, Legare, Ponitz, & Morrison, 2011) report that inhibition (to which EC plays an essential role) serves as a unique predictor of children's math skills, but not children's reading skills. A stronger connection between EC and math has been explained in terms of the fact that performing math calculations and problems is associated with activation of the prefrontal context, where EC is neurologically housed (Blair, Knipe, & Gamson, 2008).

Researchers have hypothesized that the ability to voluntarily inhibit a predominant response may be related to academic achievement via its effects on children's behavioral and emotional regulation (Eisenberg, Sadovsky, & Spinrad, 2005). Classrooms place significant demands on young children's self-regulatory abilities, as they must wait their turn, share with others, stay in their seat, monitor the accuracy of their work, manage emotions when provoked by peers, etc. Children who succeed in meeting these demands are better liked and achieve more. Consistent with this reasoning, EC has been described as “situated at the intersection of the temperament and behavioral regulation literatures” (Rothbart, Ellis, & Posner, 2004, p. 362) and as “underlying behavioral self-regulation” (Li-Grining et al., 2010, p. 1062). A number of studies have demonstrated that children's EC has indirect effects on their academic achievement through aspects of behavioral self-regulation and social competence (e.g., Neuenschwander, Röthlisberger, Cimeli, & Roebers, 2012; Valiente et al., 2011). For example, in a sample of 264 7- to 12-year-old children, Valiente, Lemery-Chalfant, Swanson, and Reiser (2008) found that social competence and aspects of behavioral self-regulation (i.e., classroom participation) partially mediated the effects of EC on change in achievement across one school year.

Behavioral self-regulation (BSR) entails the ability to apply executive function to behavioral doings (e.g., a child's ability to complete tasks, plan forthcoming tasks, and clean up after him or herself; Jahromi, Bryce, & Swanson, 2013; McClelland et al., 2007; Morrison, Ponitz, & McClelland, 2010). BSR is typically measured via behavioral ratings from parents (e.g., Jahromi et al., 2013) and teachers (e.g., Matthews et al., 2010; McClelland et al., 2006); although, peer sociometric measures (e.g., Wu, West, & Hughes, 2008), and direct observational measures (e.g., Greenwood, 1991) are also used. BSR has been shown to predict children's academic achievement above relevant covariates (e.g., DiPerna, Lei, & Reid, 2007; Howse et al., 2003).

Finally, a child's *social competence* (SC) may be broadly defined as the ability to incorporate cognition, behavior, and affect to attain constructive developmental outcomes and to successfully engage in particular social tasks (Conduct Problems Prevention Research Group, 1999; Weissberg & Greenberg, 1998). In addition, SC represents “the outward manifestation of both executive function and behavioral self-regulation, with a particular focus on social interactions” (McClelland et al., 2007, p. 91). McClelland et al. (2007) specify that SC is comprised of several components, including cooperation (i.e., prosocial behavior). Specifically, cooperation entails a child's ability to share, work, and play well with peers. Compared to EC and BSR, SC exists at the most contextualized level (i.e., the level that is the most responsive to aspects of the environment) of these three areas of focus in the study of LRS. Thus, like BSR, SC is often measured with parent (e.g., Valiente et al., 2008), teacher (e.g., Ponitz, McClelland, Matthews, & Morrison, 2009), and peer ratings (e.g., Zeller, Vannatta, Schafer, & Noll, 2003). Studies have also demonstrated the importance of SC to children's academic performance and transition to school (e.g., Malecki & Elliott, 2002; Welsh, Parke, Widaman, & O'Neil, 2001).

Scholars have also investigated the joint effects of BSR and SC components on children's academic success. For example, in a three-year longitudinal study of 671 elementary school children, Hughes, Luo, Kwok, and Loyd (2008) found that teachers' ratings of BSR (i.e., behavioral engagement in learning) predicted their academic achievement above the effects of previous levels of academic achievement and teacher-rated social competence (example items include “gets along well with other children,” “tries to take advantage of others” (reverse scored), and “considerate and thoughtful”). However, children's SC failed to predict their academic achievement once previous levels of academic achievement and BSR were taken into account. These authors suggested that BSR and SC have their origins in temperament-based self-regulatory competence; however, “the aspects of self-regulatory competence that affect achievement are only those aspects that interfere with children's ability to attend to instruction and to persevere in academic tasks” (p. 11).

Based on the reasoning that EC underlies both BSR and SC, Valiente et al. (2008) assessed the independent contribution of BSR and SC, above EC, in predicting academic achievement (i.e., composite GPA for language and math) in a sample of children ages 7 to 11. In separate analyses for BSR and SC, they found that BSR and SC contributed to changes in academic achievement, above the effects of EC. Furthermore BSR and SC each mediated the effect of EC on achievement. Notably, BSR accounted for nearly twice the variance in achievement explained by EC than did SC.

Overall, the extant literature demonstrates that various aspects of LRS are important to children's academic achievement. However, to the best of the authors' knowledge, no study has assessed measures of multiple dimensions of LRS (i.e., EC, BSR, and SC) with multiple measurement sources. The lack of multi-source measures of distinct dimensions of LRS impedes the complete understanding of the individual and joint effects of LRS on children's academic functioning. Additionally, although studies such as those conducted by Matthews et al. (2010) and McClelland et al. (2006) have increased our understanding of the role of LRS in academic achievement, they have relied exclusively on teacher report of LRS. Whereas teachers are accurate reporters of children's behavior, their ratings may be influenced by their expectations of children's academic abilities, based on factors such as socioeconomic status or race (Downey & Pribesh, 2004). Because these factors may also be uniquely predictive of academic achievement, it is important to employ assessments of LRS obtained via multiple sources. Moreover, the use of multiple sources is important to separate trait and source effects of measures of LRS. Essentially, what is needed is a multi-source measurement model that identifies theoretically distinct LRS constructs and their relations to academic achievement. In addition, because previous research has demonstrated differential relations between aspects of LRS and reading or math achievement (e.g., Blair & Razza, 2007; Liew, Chen, & Hughes, 2010; Li-Grining et al., 2010; Ponitz et al., 2009), it is also important to investigate the unique and shared contributions of children's LRS to their reading and math achievement separately.

Purpose of this study

The first purpose of this study was to test a multi-method (i.e., child performance measures and peer and teacher ratings) measurement model of LRS that posits three correlated dimensions (i.e., EC, BSR, and SC). A finding of three distinct yet correlated dimensions of LRS assessed with teacher and peer ratings of BSR and SC and performance measures of EC would build on prior research identifying similar dimensions that used only behavioral ratings.

The second purpose of this study was to test the individual and joint contributions of the three LRS constructs (i.e., EC, BSR, and SC) to children's reading and math achievement. Specifically, we first examined the *separate*, or individual, effect of each LRS construct on reading and math achievement, above the covariates. Consistent with previous research (Swanson, Valiente, Lemery-Chalfant, Bradley, & Eggum-Wilkens, 2014; Valiente et al., 2008), we expected that, when considered separately, each LRS construct would predict reading and math achievement, above relevant demographic covariates (i.e., gender, IQ, and economic adversity). Next, we examined the joint contributions of the LRS constructs to children's reading and math achievement when considered *simultaneously*. Based on previous studies (Swanson et al., 2014; Valiente et al., 2008; Zhou, Main, & Wang, 2010), we expected that EC would emerge as a stronger predictor of math versus reading. Furthermore, based on the moderate to strong association between measures of BSR and SC, and the finding that only BSR has an independent effect on achievement (Hughes et al., 2008), we expected that only EC and BSR would make independent contributions to reading and math achievement.

The third purpose of this study was to test the hypothesis that EC has an indirect effect on reading and math achievement via BSR and SC, as found by Valiente et al. (2008), using parent ratings of EC rather than a performance measure, as in the current study. Ultimately, testing a multi-method, multi-dimensional measurement model of LRS permits clarification in understanding how the various dimensions of LRS are related to one another and how these dimensions act independently and in concert to contribute to children's academic achievement. Such a model would inform relevant intervention efforts (e.g., to target all or only particular domains of LRS).

Method

Participants

Participants included in the current study were drawn from a larger (N = 784) longitudinal study investigating the impact of grade retention on academic achievement. During their first-grade school years, participants for the longitudinal study were recruited across two chronological cohorts in the fall of 2001 and 2002. At that point in time, the participants were enrolled in one of three school districts located in Southeast Texas (two small cities and one urban city). The ethnic composition of first grade classrooms in these three school districts was 42% Caucasian, 25% African American, 27% Hispanic, and 5% Other; 53% were male and 44% qualified for free or reduced lunch. Children were eligible to participate in the larger longitudinal study if they spoke either English or Spanish, were not receiving special education services other than speech and language, had not been previously retained in first grade, and scored below the median score for their school district on a state approved, district-administered measure of literacy. Based on this latter criterion, the sample is considered to be academically at-risk. Relative to age, gender, ethnic status, family language, language status (i.e., limited English proficiency), and literacy test scores, no evidence of selective consent for participation in the longitudinal study was found. However, children with parental consent to participate in the longitudinal study were more likely to receive free or reduced lunch (62%) compared to children without parental consent for participation (38%).

Of the 784 participants in the overall longitudinal study, 744 (52.2% males and 47.8% females; 35.2% Caucasian, 22.4% African American, 37.1% Hispanic, and 5.2% Other) first-grade children were included in the current study based on the inclusion criterion that they have complete data for at least one indicator comprising each of the three LRS factors (i.e., EC, BSR, and SC). Analyses on a wide range of demographic variables, academic achievement, and study variables, found no systematic differences between the 744 students who met the inclusion criteria for the current study and the 40 students who did not. At the start of their first grade school year, participants in the current study had a mean age of 6.57 (*SD* = 0.39) years and a mean score of 93.24 (*SD* = 14.54) on the abbreviated Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998). As measured during their first grade school year, participants' age-standard scores on the Woodcock–Johnson III Tests of Achievement (WJ-III ACH) Broad Reading and Broad Mathematics tests (Woodcock, McGrew, & Mather, 2001) were 96.63 (*SD* = 18.11) and 100.96 (*SD* = 14.35), respectively. Furthermore, 58.9% of the participants in the current study were eligible for free or reduced lunch and 13.7% were enrolled in bilingual classrooms.

Assessment overview

Demographic information (i.e., child age, race/ethnicity, and familial economic adversity) was obtained from school district records. Children's EC was measured with two child performance tasks and children's BSR and SC were each measured with ratings from two sources (i.e., teacher and peers). From October through March of participants' first-grade school year, trained research staff visited schools and conducted two individual assessment sessions with student participants. During the first individual assessment session, tests of intelligence and academic achievement were administered to student participants, and during the second individual assessment session, tests of EC were administered. A few student participants were tested after March due to absences and moves. Importantly, children identified by the schools as LEP or speaking some Spanish were administered the Woodcock–Muñoz Language Survey (WMLS; Woodcock & Muñoz-Sandoval, 1993) to determine if they were more proficient in Spanish than English. Children more proficient in Spanish were administered all tests in Spanish.

During the spring semester of participants' first grade school year (i.e., April and May), trained research staff conducted individual socio-metric interviews that entailed asking children to nominate classmates who best fit several behavioral descriptors (e.g., behavioral control and prosocial behaviors) and to name classmates whom they preferred the most. Written parental consent was obtained for each child who participated in the sociometric interviews; yet, all children in a classroom were eligible to be rated or nominated. Furthermore, psychometrically sound sociometric data for behavioral characteristics can be gathered via the unlimited nomination method when a minimum of 40% of children in a classroom participate (Marks, Babcock, Cillessen, & Crick, 2012). Therefore, peer nomination scores were calculated only for student participants placed in classrooms where greater than 40% of their classmates participated in the sociometric interviews. The mean rate of classmate participation in the sociometric interviews was .65 (range from .40 to .95) and the median number of children in a classroom supplying nominations was 12.

The research staff members, who visited schools to conduct the aforementioned tasks with the student participants, received training in how to administer the measures of IQ, academic achievement, EC, and the sociometric interviews. Prior to conducting such tasks with actual study participants, the research assistants were required to demonstrate proficiency in administration procedures.

Finally, during the spring semester of participants' first grade school year, teachers were mailed a questionnaire for each student participant in their classroom. The teacher questionnaires tapped into several domains (e.g., students' classroom engagement and prosocial behaviors). Teachers were compensated for completing the questionnaires.

Measures

Demographic variables—As mentioned previously, information regarding student participants' age, gender, race/ethnicity, and familial economic adversity was obtained from school district records. Eligibility for free or reduced lunch during their first grade school year was used as an indicator of student participants' economic adversity status.

Academic achievement—The Woodcock–Johnson Tests of Achievement, Third Edition (WJ-III ACH; Woodcock et al., 2001) is an assessment instrument that includes an assemblage of individually administered and norm-referenced tests that measure academic achievement for individuals ages 2 to adulthood. For the purposes of the current study, student participants' WJ-III ACH Broad Reading age standard scores and their WJ-III ACH Broad Math age standard scores were used. The WJ-III ACH Broad Reading score is based on the Letter–Word Identification, Reading Fluency, and Passage Comprehension subtests, and the WJ-III ACH Broad Math score is based on the Calculations, Math Fluency, and Applied Problems subtests. Extensive research documents both the reliability and construct validity of the WJ-III ACH (Woodcock et al., 2001). Student participants who were determined to be more proficient in Spanish than English per the WMLS (Woodcock & Muñoz-Sandoval, 1993) were administered the comparable Spanish tests from the Batería Woodcock-Muñoz Pruebas de aprovechamiento - Revisada (Batería-R APROV; Woodcock & Muñoz-Sandoval, 1996), which yield age standard scores for Broad Reading and Broad Math that are comparable to those of the Woodcock-Johnson Test of Achievement – Revised (WJ-R ACH; Woodcock & Mather, 1989, 1990), the precursor to the WJ-III ACH.

Cognitive ability (IQ)—The Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998) is a nationally standardized nonverbal measurement of the general intelligence and cognitive abilities of children and adolescents ages 5 years through 17 years. The UNIT assesses general intelligence by measuring memory and reasoning abilities via the use of culturally and linguistically common body and hand gestures. Student participants were administered the Abbreviated Battery of the UNIT, which is comprised of the Symbolic Memory and Cube Design subtests. The Abbreviated Battery of the UNIT yields a full scale IQ that is highly correlated with scores obtained with the full battery (r = .

91) and has demonstrated good test–retest and internal consistency reliabilities as well as construct validity (Bracken & McCallum, 1998; Hooper, 2003).

Effortful control (EC)—Trained research staff administered four child performance tasks designed to assess EC (Kochanska, Murray, & Coy, 1997; Murray & Kochanska, 2002). The four tasks were: Walk-a-Line, Star, Telephone Poles, and Circle. These four tasks serve as reliable and valid measures of effortful control for children who range in age from toddler through early elementary school (Dennis & Brotman, 2003; Kieras, Tobin, Graziano, & Rothbart, 2005; Kochanska & Knaack, 2003; Murray & Kochanska, 2002). Performance on these tasks has demonstrated considerable consistency across tasks (Kochanska, Murray, & Harlan, 2000), indicating that the tasks measure a common underlying ability.

The Walk-a-Line task assesses gross motor skills by requiring children to walk along a (12 ft long by 2.5 in wide) ribbon taped onto the floor. The Star and Circle tasks assess fine motor skills by requiring children to trace such geometric figures with a pencil while refraining from drawing outside the lines of the geometric figures. The Telephone Poles task also assesses fine motor skills by asking children to draw a line that connects two dots. Each of the four tasks entailed three trials. In the first trial, children responded to the research assistant's instructions for completion of the task without being instructed to quicken or to slow or inhibit their response behaviors. Therefore, in the first trial for each task, children completed the task at their own pace, which served as a baseline measure of the time it took each child to complete each task. In the second trial, children were asked to accelerate their behaviors (for Telephone Poles and Star) or to slow or inhibit their behaviors (for Walk-a-Line and Circle). In the third trial, children were consistently asked to slow or inhibit their behaviors across all four tasks. Trials 1 and 2 were considered practice trials, to ensure that children understood task instructions. Only scores from the third trial of each task were used to index EC.

Previous research (Liew et al., 2010) has established that the Walk-a-Line, Star, Telephone Poles, and Circle tasks measure two distinct behavioral indices of EC: 1) inhibitory control (IC); and 2) task accuracy (TA). Namely, in all four of the EC tasks, children had to slow or inhibit their motor activity (i.e., IC) during the third trial, and for two of the EC tasks (i.e., Star and Circle) children also had to attend to and follow instructions in order to accurately complete a fine motor task across all three trials (i.e., TA). IC and TA are correlated with each other as well as with positive teacher–student relationships and academic achievement (Liew et al., 2010).

Inhibitory control (IC): Following Liew et al. (2010) a composite score for IC was derived from averaging the number of seconds that children took to complete each of the four tasks task during the third trial (i.e., when they were instructed to complete the tasks as slowly as possible). For the current study, we controlled for the influence of the baseline measure (i.e., the mean seconds to complete the task in the first trial) on the composite score for IC. Research assistants used stopwatches to time each child's behavior as they partook in each task. Assessments were not video-recorded and each child was observed by one research assistant at his or her school; therefore, calculations of reliability for timings used for measures of IC are not available for the current study.

Task accuracy (TA): For all three trials of the Star and Circle tasks, an error was counted each time that a child traced from inside the circle or star to outside the circle or star. Baseline measures of TA were assessed for the Star and Circle tasks during the first trial when children were asked to trace these geometric figures without any instructions to slow or inhibit their fine motor behavior. Ultimately, the baseline measure is the reversed score of the average number of errors a child made during the first trial of the Star and Circle tasks (Liew et al., 2010). A composite score for (fine motor) TA was derived from the reversed score of the average number of times children traced outside the lines during the third trial of the Star and Circle tasks (i.e., reversed score of errors made on tasks). Fine motor TA was coded after the assessments by two trained research assistants; therefore inter-rater reliability was computed. The main coder rated all participants' performance; however, the reliability coder rated 40 randomly selected participants' performance (inter-rater reliability [Pearson *r*] = .95).

Behavioral self-regulation (BSR): Behavioral self-regulation was assessed from teacher ratings of classroom engagement and attention control and behavioral control, and from peer nominations regarding behavioral control and behavioral compliance.

Teacher-rated classroom engagement: Teachers completed a 10-item scale assessing students' task persistence, planning and organization, concentration, and task completion, using a 5-point Likert Scale (with anchors Almost Never to Almost Always or Strongly Disagree to Strongly Agree). Example items include: “Makes plans and follows through with them;” “Able to effectively set goals and work toward them;” and “Is easily distracted” (reverse scored). Across the 10 items, an average composite score was created to index student participants' classroom engagement from teachers' perspectives. Scores on this measure predict changes in children's academic outcomes, above relevant covariates (Chen, Hughes, Liew, & Kwok, 2010; Hughes et al., 2008; Wu, Hughes, & Kwok, 2010). The internal consistency of the 10 items for the sample used in the current study was .95.

Teacher-rated attention control and behavioral control: Teachers completed the Strength and Difficulties Questionnaire (SDQ; Goodman, 1997), which is a 25-item screening measure for psychopathology that yields five scales (i.e., Conduct Problems, Hyperactivity, Emotional Symptoms, Peer Problems, and Prosocial). Each of these five scales is comprised of five items rated on a scale of zero to two, on which teachers indicated whether each item was *not true, somewhat true*, or *certainly true* for each rated child. The results of a confirmatory factor analysis (CFA) support the five-factor structure of the SDQ (Hill & Hughes, 2007). Teacher-rated attention control and behavioral control are represented by a standardized average composite score created from the five-item Hyperactivity Scale for the teacher version of the SDQ. Basically, teacher-rated attention control and behavioral control was measured via a deficit in BSR; therefore, items were reverse scored as needed so that a higher composite score indicates a higher level of attention control and behavioral control. Examples include: “Restless, overactive, cannot stay still for long” (reverse scored); “Sees tasks through to the end, good attention span;” and “Thinks things out before acting.” The internal consistency of these five items for the sample used in the current study was .87.

Peer-nominated behavioral control and behavioral compliance: An adapted version of the Class Play (Masten, Morrison, & Pellegrini, 1985) was employed for the peer nominations segment of the sociometric interviews. Peer nominations were obtained for several behavioral descriptors. Two of these behavioral descriptors (i.e., “Some kids do strange things and make a lot of noise; they bother people who are trying to work,” and “Some kids get into trouble a lot”) were used to measure peer-nominated behavioral control and peer-nominated behavioral compliance, respectively, from a deficit standpoint. Thus, nomination scores obtained for each of these two behavioral descriptors were multiplied by – 1 so that a higher score indicates a higher level of behavioral control and behavioral compliance. Peer nomination scores for each item (i.e., behavioral control and behavioral compliance) were obtained by totaling all nominations each student participant received and then standardizing the nomination score within classrooms.

Social competence (SC): Social competence was assessed from teacher ratings of peer likability and prosocial behaviors; from peer-rated likability; and from peer nominations regarding prosocial behaviors.

Teacher-rated peer likability: Teacher-rated peer likability is represented by a standardized average composite score created from the five-item Peer Problems Scale included in the abovementioned teacher version of the SDQ (Goodman, 1997). Items were reverse scored as needed so that a higher composite score indicates a higher level of peer likability. Examples include: “Has at least one good friend;” “Generally liked by other children;” and “Picked on or bullied by other children” (reverse scored). The internal consistency of these five items for the sample used in the current study was .65.

Teacher-rated prosocial behaviors: For teacher-rated prosocial behaviors, a standardized average composite score was derived from the five-item Prosocial Scale for the teacher version of the SDQ (Goodman, 1997). Examples include: “Often volunteers to help others;” “Shares readily with other children;” and “Considerate of other people's feelings.” The internal consistency of these five items for the sample used in the current study was .86.

Peer-rated likability: During the sociometric interviews, children were also asked to specify their liking for each child in the classroom on a 5-point scale. Specifically, the interviewer named each child in the classroom and asked the child being interviewed to point to one of five faces ranging from sad (1 = *don't like at all*) to happy (5 = *like very much*) for each named child. A child's mean liking score was the average rating received by classmates. Per Coie, Dodge, and Coppotelli (1982), peer-rated likability scores were calculated by subtracting each child's standardized “liked least” nomination score from his or her standardized “liked most” score. To avoid asking children to nominate children “liked least,” a rating of “1” was considered equivalent to a “liked least” nomination score (Asher & Dodge, 1986). All sociometric scores were standardized within classrooms.

Peer-nominated prosocial behavior: As previously explained, during the sociometric interviews, peer nominations were obtained for several behavioral descriptors. One of these behavioral descriptors (i.e., “Some kids help others, play fair, and share”) was used to measure peer-nominated prosocial behaviors. Peer nomination scores for this single item were obtained by totaling all nominations each student participant received and then standardizing the nomination score within classrooms.

Overview of analyses

Analyses were conducted in three phases using M*plus* (version 7.0, Muthén & Muthén, 1998–2012). The first phase of analyses used CFA to test the measurement model (see Fig. 1), which hypothesizes three distinct but correlated factors of EC, BSR, and SC. The second phase of analyses used hierarchical multiple regression analysis to examine the separate and joint contributions of the LRS constructs (i.e., EC, BSR, and SC) to children's reading and math achievement with the child's gender, economic adversity status, and IQ included as covariates. These covariates were employed based on their association with LRS (Matthews et al., 2010; Neuenschwander et al., 2012) and academic achievement (Kwok, Hughes, & Luo, 2007; Liew et al., 2010). In the third phase of analyses, using the MODEL INDIRECT routine in M*plus* (version 7.0, Muthén & Muthén, 1998–2012), we tested the indirect effects of EC via BSR and EC via SC on reading and math achievement. All analyses used full information maximum likelihood (FIML), which supplies appropriate adjustment for data that are missing at random (Enders, 2010) using M*plus* (version 7.0, Muthén & Muthén, 1998–2012). Based on Hu and Bentler (1999), the following cutoff criteria were used to determine whether a relatively good fit existed between the hypothesized measurement model and the observed data: a) larger than .95 for CFI; b) less than .08 for SRMR; and c) less than .06 for RMSEA. To account for the dependence among the observations nested within clusters (i.e., the student participants nested within classrooms), analyses were conducted using the TYPE=COMPLEX routine in M*plus* (version 7.0, Muthén & Muthén, 1998–2012). This accounts for the nested structure of the data by adjusting the standard errors of the estimated coefficients.

Results

Descriptive statistics

Descriptive statistics were conducted and the means, standard deviations, and percentage of missing data for all analysis variables included in all hypothesized models are presented in Table 1. The variables were screened for normality and outliers. All variables were within the normal range according to the cutoff values of two for skewness and seven for kurtosis (West, Finch, & Curran, 1995).

As depicted in Table 1, gender did not correlate significantly with student participants' first grade math achievement; however, girls had higher first grade reading achievement. Girls also performed better on all indicators of BSR and on some indicators of SC (i.e., teacher-rated prosocial behaviors and peer nominated prosocial behaviors). Economic adversity status was negatively associated with reading and math achievement as well as peer-rated likability and IQ. Students' IQ levels, IQ was positively associated with reading and math achievement, IC, and all indicators of BSR and SC. Based on these relation, children's IQ, economic adversity status, and gender were included as covariates in the regression analyses.

Reading achievement was positively associated with all indicators of BSR and SC. Math achievement was positively associated with all indicators of EC and BSR as well as teacher-rated peer likability and teacher-rated prosocial behaviors.

Measurement model

Using CFA, we first tested a correlated factor measurement model with three latent factors (i.e., EC with two indicators; BSR with four indicators; and SC with four indicators) to determine whether the hypothesized factor indicators would load on the hypothesized latent factors. Fig. 1 presents this correlated factor measurement model. For EC, we expected the child performance measures of inhibitory control (EC_IC) and task accuracy (EC_TA) to load on the latent factor of EC. Relative to BSR, we expected the teacher ratings of classroom engagement (BSR_CENG_T) and attention control and behavioral control (BSR_ACBC_T), as well as the peer nominations of behavioral control (BSR_BCON_P) and behavioral compliance (BSR_BCOM_P), to load on the latent factor of BSR. Finally, for SC, we expected the teacher ratings of peer likability (SC_PEERLIK_T) and prosocial behaviors (SC_PROSOC_T), as well as the peer ratings of likability (SC_LIKE_P) and peer nominations of prosocial behaviors (SC_PROSOC_P), to load on the latent factor of SC. The zero-order correlation coefficients between the specified factor indicators (presented in Table 1) were consistent with our expectations for the model. For ease of interpretation, the score for each factor indicator was re-coded as needed so that a high score on a factor indicator implies higher levels of the factor indicator's respective underlying latent factor.

In addition to the expectations detailed above, we also accounted for the possibility of source effects in the correlated factor measurement model. Namely, as demonstrated in Fig. 1, we correlated the residual variances of factor indicators deriving from the same source (i.e., teacher-ratings and peer-nominations or ratings) within and between the latent factors of BSR and SC.

The correlated factor measurement model demonstrated relatively good fit (Hu & Bentler, 1999), $\chi^2(20) = 63.955$, $p < .001$; CFI = .98; RMSEA = .05; SRMR = .02. The standardized factor loadings (β) are presented in Fig. 1. All standardized factor loadings were adequate (Comrey & Lee, 1992; Crocker & Algina, 1986) and significant at $p < .05$ in a positive direction. Specifically, for EC, $\beta_{EC\_IC} = .36$ and $\beta_{EC\_TA} = .40$. For BSR, for the teacher rated indicators, $\beta_{BSR\_CENG\_T} = .86$ and $\beta_{BSR\_ACBC\_T} = .92$, and for the peer rated indicators, $\beta_{BSR\_BCON\_P} = .54$ and $\beta_{BSR\_BCOM\_P} = .56$. For SC, for the teacher rated indicators, $\beta_{SC\_PEERLIK\_T} = .62$ and $\beta_{SC\_PROSOC\_T} = .73$ and for the peer rated indicators, $\beta_{SC\_LIKE\_P} = .45$, and $\beta_{SC\_PROSOC\_P} = .50$.

The latent factors of BSR and SC were highly correlated ($r = .97$) with one another and only moderately correlated with the latent factor of EC ($r = .30$ and $r = .34$, respectively). This correlated factor measurement model was considered appropriate for investigation of the unique and shared contribution of the three dimensions of LRS to children's academic performance.

Hierarchical multiple regression analyses

In the first set of regression analyses, we investigated the separate, or individual, effect of each LRS factor (i.e., EC, BSR, and SC) on participants' first grade reading and math achievement. We expected each LRS dimension would predict reading and math achievement above relevant covariates. Students' IQ, economic adversity status, and gender were entered in the first step of each regression model. EC, BSR, and SC were entered in the second step of each regression. The standardized parameter estimates (β) indicate the contribution of each LRS construct above the covariates.

When the three LRS constructs were considered separately (i.e., not in the context of the other LRS constructs), EC (β = .11, *SE* = .03, *p* = .002) and BSR (β = .10, *SE* = .05, p = .032) had a significant effect on math. Additionally, all three LRS constructs had a significant effect on reading; for EC β = .07, *SE* = .04, *p* = .049, for BSR β = .17, *SE* = .04, *p* < .001, and for SC β = .15, *SE* = .05, *p* < .001.

Second, we analyzed the *joint* contributions of EC, BSR, and SC on reading and math achievement (see Table 2). To determine the additional variance explained by the three LRS constructs, above the covariates, we compared the variance explained derived from two models: 1) a model in which the effect of each LRS was constrained to be zero; and 2) a model in which the effect of each LRS construct was free to vary. As shown in Table 2, when the three LRS constructs were considered together, LRS variables explained an additional 3% of the variance (i.e., adjusted R^2 change) in reading after controlling for students' IQ, economic adversity status, and gender. However, neither, EC, BSR, or SC was uniquely predictive of students' first grade reading achievement, in the context of the other two dimensions and the covariates. For math, the addition of the LRS variables also made a significant contribution (adjusted R^2 change=.02). Only EC made an independent contribution to students' first grade math achievement (β = .11, *SE* = .04, *p* = .003), in the context of the other two dimensions and the covariates.

Third, we tested the hypothesis that BSR and SC mediated the effect of EC on reading and math achievement. The results demonstrated that EC had a significant, indirect effect on reading via BSR (β = .02, *SE*= .01, *p* =.021). Likewise, EC had a significant, indirect effect on reading via SC (β = .02, *SE* = .01, *p* = .035).

Discussion

This study tested a multi-method measurement model of three LRS constructs (i.e., EC, BSR, and SC). Using CFA, we found that the hypothesized correlated factor measurement model of LRS provides a relatively good fit to the data. These findings extend the extant literature by providing clarification regarding dimensions of LRS and enhance our understanding of the associations among EC, BSR, and SC.

Furthermore, when considered separately EC and BSR had a significant effect on math and reading, above the covariates, whereas SC had a significant effect only on reading, above the covariates. When the three dimensions of LRS were considered together, EC uniquely predicted math; however, no dimension uniquely predicted reading achievement.

Additionally, the three LRS dimensions altogether made a modest, but significant, contribution to the explained variance in children's reading and math achievement. Finally, EC had an indirect effect on reading, via BSR and SC; conversely, the direct effect of EC on math was not mediated by BSR or SC.

The failure of any single LRS dimension to predict reading achievement, above the effects of the other two dimensions of LRS as well as the covariates, is likely due to two considerations. First, BSR and SC are highly correlated with one another, leaving minimal unshared variance to uniquely predict reading achievement. Second, the results of the mediation analyses suggest that BSR and SC are important to reading in that they are the processes by which EC impacts reading. Essentially, these latter results provide a more complete portrayal of how the three LRS dimensions operate together to benefit children's reading achievement.

Considering math, the finding that EC had a direct effect on students' math achievement is consistent with the findings of other researchers in the field (e.g., Blair & Razza, 2007; Clark, Sheffield, Wiebe, & Espy, 2013; Espy et al., 2004). Specifically, researchers (e.g., Fuchs et al., 2008; Geary, 2007) have demonstrated that executive function skills, which include EC, influence children's ability to perform mathematical tasks. Results suggest that EC plays a critical role in children's ability to receive and retain instruction in mathematics. It is highly likely that children's ability to perform tasks slowly and accurately impacts the quality of their performance on math tasks. Consistent with this view, Bull and Lee (2014) assert that inhibition, which EC is essential to, may help children restrain from performing incorrect math strategies (e.g., using multiplication when division is needed); restrain from retrieving number bonds (e.g., retrieving “10” for 5 + 2 =); and refrain from employing irrelevant information that may be present in math word problems.

Furthermore, EC's significant, indirect effect on reading via BSR and SC may indicate that in order to develop reading skills, children not only require adequate EC skills, but they also need to be able to adequately transfer their EC skills to the regulation of their behaviors and social interactions in the classroom. For example, common reading activities require turn-taking and reading aloud with or to others (e.g., choral reading, partner reading, small reading groups, and Readers Theatre; Wendling & Mather, 2009; Young & Rasinski, 2009). Basically, being capable of regulating behaviors and social interactions (e.g., remaining engaged in the learning process without being distracted by others or causing distraction for others) likely helps children benefit from such common classroom reading activities.

Additionally, the finding that BSR and SC did not mediate the effect of EC on math is likely due to differences in the context of reading and math instruction in the early grades. Specifically, common, evidence-based instruction strategies for teaching and practicing math skills involve more independent learning (e.g., drill and practice techniques, including computer-assisted instruction, self-correcting materials, and the cover–copy–compare method; Fuchs et al., 2008). In contrast, common reading instructional practices, including those referenced above as well as in-class ability grouping (Chorzempa & Graham, 2006; McCoach, O'Connell, & Levitt, 2006), are characterized by a more social nature. Thus, reading instruction practices place a large demand on a child's social and behavioral regulatory skills.

Limitations and future directions

Although the current study uses a large, ethnically diverse sample and includes a multi-method, multi-informant measurement model, this study also possesses several limitations that must be considered when interpreting the study results. To begin with, the current study sample consists of academically at-risk students; thus, the study findings may not generalize to higher-achieving students. Additionally, this study utilized children's eligibility for free or reduced lunch as an indicator of familial economic adversity status; however, a more expanded measure of socioeconomic status would have been preferable. Moreover, although teachers and peers rated children's BSR and SC, the measure of children's BSR and SC may be advanced by including data gathered via direct classroom observations. Relative to the measure of EC, although observational data regarding children's EC was gathered, the measures of EC used in this study are not all-encompassing and represent only one aspect of executive function; future studies would benefit from utilizing a more thorough measure of executive function (i.e., attention control, activation control, planning, and inhibitory control, as illustrated in a study conducted by Raver et al. (2011). Finally, this study is observational in nature and not an experimental design; therefore, causal inferences regarding an effect of LRS on achievement are not warranted. Future, prospective studies that employ strong covariates, especially prior achievement, can reduce the possibility that the associations between LRS and achievement are due to the influence of unmeasured confounds.

Study implications

For researchers interested in studying children's LRS, the results of this study offer a more clear portrayal of EC, BSR, and SC as three dimensions of LRS. This study also provides a measurement model of LRS that permits researchers to test the combined and unique effects of EC, BSR, and SC, as three dimensions of LRS, on children's academic achievement. Thus, future research may seek to investigate whether BSR, as distinct from SC, predicts growth in children's academic achievement. Or, future research may compare BSR and SC to determine which (if either) predicts growth in academic achievement.

Study findings also support the practice of assessing children's LRS at young ages as a means of assessing school readiness and foretelling subpar academic achievement later in a single school year or in future grades. In turn, this would inform prevention and intervention efforts regarding which children should be targeted for such services. Relative to preventions and interventions, extant research shows some promising results for preventions and interventions aimed at improving aspects of children's LRS. For example, Riggs, Greenberg, Kusché, and Pentz (2006) found that the Promoting Alternative Thinking Strategies (PATHS) curriculum (i.e., a widely used prevention curriculum targeting decreases in aggression and behavior issues by fostering elementary school children's social-emotional competence) enhanced second and third grade children's verbal fluency and inhibitory control. Tools of the Mind, a program that trains teachers to execute exercises intended to foster children's BSR, attention, and memory, has demonstrated success with increasing preschooler's inhibitory control and attention to a significant degree (Diamond, Barnett, Thomas, & Munro, 2007).

Furthermore, LRS can be taught directly and explicitly on a daily basis within preschool and early elementary grade classrooms. Specifically, teachers may foster the development of children's LRS by using props (e.g., photos that remind children what to do). Also, children are more likely to become independent and responsible when their classroom possesses the following characteristics: materials are directly accessible to children, tasks are clearly explained, children are directly taught how to use materials and peers to complete tasks and to problem-solve, and teachers hold children responsible for their work by consistently reviewing work and by providing feedback and interactions to students (Stipek et al., 2010). Teachers can also strive to offer verbal feedback and emotional support when a student is struggling with employing components of LRS; teachers can create opportunities for students to partake in socio-dramatic play that necessitates the use of BSR; and teachers can work to develop positive teacher–student relationships with their students that feature responsiveness, warmth, and attachment (McClelland et al., 2007; Portilla, Ballard, Adler, Boyse, & Obradović, 2014).

Finally, teachers can involve children in games that incorporate aspects of EC, such as the numerous circle time games (e.g., Red Light, Purple Light and the Freeze Game) studied by Tominey and McClelland (2011). An early intervention program that included these elements improved Head Start children's EC, which predicted their achievement at school entrance (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008).

Ultimately, early prevention and intervention programs as well as daily classroom strategies, such as those discussed above, can enhance children's capability of learning and interacting effectively in classroom settings. With these various teaching strategies and programs in mind, fostering children's development of LRS within preschool and early elementary school classrooms essentially requires educators to work past straightforward child management strategies, toward comprehending that LRS play a key role in all classroom interactions (Matthews et al., 2010).

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References

Alexander KL, Entwisle DR, Horsey CS. From first grade forward: Early foundations of high school dropout. Sociology of Education. 1997; 70:87–107. http://dx.doi.org/10.2307/2673158.

Asher SR, Dodge KA. Identifying children who are rejected by their peers. Developmental Psychology. 1986; 22:444–449. http://dx.doi.org/10.1037/0012-1649.22.4.444.

Berhenke A, Miller AL, Brown E, Seifer R, Dickstein S. Observed emotional and behavioral indicators of motivation predict school readiness in Head Start graduates. Early Childhood Research Quarterly. 2011; 26:430–441. http://dx.doi.org/10.1016/j.ecresq.2011.04.001. [PubMed: 21949599]

Bierman KL, Nix RL, Greenberg MT, Blair C, Domitrovich CE. Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program.

Developmental and Psychopathology. 2008; 20:821–843. http://dx.doi.org/10.1017/S0954579408000394.

Blair C, Knipe H, Gamson D. Is there a role for executive functions in the development of mathematics ability? Mind, Brain, and Education. 2008; 2:80–89. http://dx.doi.org/10.1111/j.1751-228X.2008.00036.x.

Blair C, Razza RP. Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. Child Development. 2007; 78:647–663. http://dx.doi.org/10.1111/j.1467-8624.2007.01019.x. [PubMed: 17381795]

Bracken, BA.; McCallum, RS. Universal nonverbal intelligence. Itasca, IL: Riverside Publishing; 1998.

Bull R, Lee K. Executive functioning and mathematics achievement. Child Development Perspectives. 2014; 8:36–41. http://dx.doi.org/10.1111/cdep.12059.

Chen Q, Hughes JN, Liew J, Kwok O. Joint contributions of peer acceptance and peer academic reputation to achievement in academically at-risk children: Mediating processes. Journal of Applied Developmental Psychology. 2010; 31:448–459. http://dx.doi.org/10.1016/j.appdev.2010.09.001. [PubMed: 21113406]

Chorzempa BF, Graham S. Primary-grade teachers' use of within-class ability grouping in reading. Journal of Educational Psychology. 2006; 98:529–541. http://dx.doi.org/10.1037/0022-0663.98.3.529.

Clark CAC, Sheffield TD, Wiebe Sandra A, Espy KA. Longitudinal associations between executive control and developing mathematical competence in preschool boys and girls. Child Development. 2013; 84:662–677. http://dx.doi.org/10.1111/j.1467-8624.2012.01854.x. [PubMed: 23006040]

Coie JD, Dodge KA, Coppotelli H. Dimensions and types of social status: A cross-age perspective. Developmental Psychology. 1982; 18:557–570. http://dx.doi.org/10.1037/00121649.18.4.557.

Comrey, AL.; Lee, HB. A first course in factor analysis. Hillsdale, NJ: Erlbaum; 1992.

Conduct Problems Prevention Research Group. Initial impact of the fast track prevention trial for conduct problems: II. Classroom effects. Journal of Consulting and Clinical Psychology. 1999; 67(5):648–657. [PubMed: 10535231]

Crocker, L.; Algina, J. Introduction to classical and modern test theory. Philadelphia, PA: Harcourt Brace Jovanovich College Publishers; 1986.

Dennis TA, Brotman LM. Effortful control, attention, and aggressive behavior in preschoolers at risk for conduct problems. Annals New York Academy of Sciences. 2003; 1008:252–255. http://dx.doi.org/10.1196/annals.1301.026.

Diamond A, Barnett WS, Thomas J, Munro S. Preschool program improves cognitive control. Science. 2007; 318:1387–1388. http://dx.doi.org/10.1126/science.1151148. [PubMed: 18048670]

Diamond A, Taylor C. Development of an aspect of executive control: Development of the abilities to remember what I said and to “do as I say, not as I do.”. Developmental Psychobiology. 1996; 29:315–334. http://dx.doi.org/10.1037/0012-1649.18.4.557. [PubMed: 8732806]

DiPerna JD, Lei P, Reid EE. Kindergarten predictors of mathematical growth in the primary grades: An investigation using the Early Childhood Longitudinal Study – Kindergarten cohort. Journal of Educational Psychology. 2007; 99:369–379. http://dx.doi.org/10.1037/0022-0663.99.2.369.

Downey DB, Pribesh S. When race matters: Teachers' evaluations of students' classroom behavior. Sociology of Education. 2004; 77:267–282. http://dx.doi.org/10.1177/003804070407700401.

Eisenberg N, Sadovsky A, Spinrad T. Associations of emotion-related regulation with language skills, emotion knowledge, and academic outcomes. New Directions for Child and Adolescent Development. 2005; 109:109–118. http://dx.doi.org/10.1002/cd.143. [PubMed: 16342899]

Eisenberg, N.; Smith, CL.; Sadovsky, A.; Spinrad, TL. Effortful control: Relations with emotion regulation, adjustment, and socialization in childhood. In: Baumeister, RF.; Vohs, KD., editors. Handbook of self-regulation: Research, theory, and applications. New York, NY: Guilford Press; 2004. p. 259-282.

Enders, CK. Applied missing data analysis. New York, NY: Guilford Press; 2010.

Espy KA, McDiarmid MM, Cwik MF, Stalets MM, Hamby A, Senn TE. The contributions of executive functions to emergent mathematical skills in preschool children. Developmental

Neuropsychology. 2004; 26:465–486. http://dx.doi.org/10.1207/s15326942dn2601_6. [PubMed: 15276905]

Fantuzzo JW, Bulotsky-Shearer R, Fusco RA, McWayne C. An investigation of preschool classroom behavioral adjustment problems and social-emotional school readiness competencies. Early Childhood Research Quarterly. 2005; 20:259–275. http://dx.doi.org/10.1016/j.ecresq.2005.07.001.

Fantuzzo JW, Bulotsky-Shearer R, McDermott PA, McWayne C, Frye D, Perlman S. Investigation of dimensions of social–emotional classroom behavior and school readiness for low-income urban preschool children. School Psychology Review. 2007; 36(1):44–62.

Fuchs LS, Fuchs D, Powell SR, Seethaler PM, Cirino PT, Fletcher JM. Intensive intervention for students with mathematics disabilities: Seven principles of effective practice. Learning Disability Quarterly. 2008; 31(2):79–92. [PubMed: 18815627]

Fuchs LS, Fuchs D, Stuebing K, Fletcher JM, Hamlett CL, Lambert W. Problem solving and computational skill: Are they shared or distinct aspects of mathematical cognition? Journal of Educational Psychology. 2008; 100:30–47. http://dx.doi.org/10.1037/0022-0663.100.1.30. [PubMed: 20057912]

Gartstein MA, Putnam SP, Rothbart MK. Etiology of preschool behavior problems: Contributions of temperament attributes in early childhood. Infant Mental Health Journal. 2012; 33:197–211. http://dx.doi.org/10.1002/imhj.21312.

Geary DC. An evolutionary perspective on learning disability in mathematics. Developmental Neuropsychology. 2007; 32:471–519. http://dx.doi.org/10.1080/87565640701360924. [PubMed: 17650991]

Goodman R. The Strengths and Difficulties Questionnaire: A research note. Journal of Child Psychology and Psychiatry. 1997; 38:581–586. http://dx.doi.org/10.1111/j.1469-7610.1997.tb01545.x. [PubMed: 9255702]

Greenwood CR. Longitudinal analysis of time, engagement, and achievement in at-risk versus non-risk students. Exceptional Children. 1991; 57(6):521–535. [PubMed: 2070811]

Hill CR, Hughes JN. An examination of the convergent and discriminant validity of the Strengths and Difficulties Questionnaire. School Psychology Quarterly. 2007; 22:380–406. http://dx.doi.org/10.1037/1045-3830.22.3.380. [PubMed: 18843384]

Hooper VS. 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. 2003; 63(12-A):4221.

Howse RB, Calkins SD, Anastopoulos AD, Keane SP, Shelton TL. Regulatory contributors to children's kindergarten achievement. Early Education and Development. 2003; 14:101–120. http://dx.doi.org/10.1207/s15566935eed1401_7.

Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling. 1999; 6:1–55. http://dx.doi.org/10.1080/10705519909540118.

Hughes JN, Luo W, Kwok O, Loyd LK. Teacher-student support, effortful engagement, and achievement: A 3-year longitudinal study. Journal of Educational Psychology. 2008; 100:1–14. http://dx.doi.org/10.1037/0022-0663.100.1.1. [PubMed: 19578558]

Jahromi LB, Bryce CI, Swanson J. The importance of self-regulation for the school and peer engagement of children with high-functioning autism. Research in Autism Spectrum Disorders. 2013; 7:235–246. http://dx.doi.org/10.1016/j.rasd.2012.08.012.

KewalRamani, A.; Gilbertson, L.; Fox, MA.; Provasnik, S. Status and trends in the education of racial and ethnic minorities (NCES 2007-039). National Center for Education Statistics. Washington, DC: U.S. Department of Education; 2007.

Kieras JE, Tobin RM, Graziano WG, Rothbart MK. You can't always get what you want: Effortful control and children's responses to undesirable gifts. Psychological Science. 2005; 16:391–396. http://dx.doi.org/10.1111/j.0956-7976.2005.01546.x. [PubMed: 15869699]

Kochanska G, Knaack A. Effortful control as a personality characteristic of young children: Antecedents, correlates, and consequences. Journal of Personality. 2003; 71:1087–1112. http://dx.doi.org/10.1111/1467-6494.7106008. [PubMed: 14633059]

Kochanska G, Murray K, Coy KC. Inhibitory control as a contributor to conscience in childhood: From toddler to early school age. Child Development. 1997; 68(2):263–277. [PubMed: 9180001]

Kochanska G, Murray KT, Harlan ET. Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. Developmental Psychology. 2000; 36:220–232. http://dx.doi.org/10.1037/0012-1649.36.2.220. [PubMed: 10749079]

Kwok O, Hughes JN, Luo W. Role of resilient personality on lower achieving first grade students' current and future achievement. Journal of School Psychology. 2007; 45:61–82. http://dx.doi.org/10.1016/j.jsp.2006.07.002. [PubMed: 18084626]

Lan X, Legare CH, Ponitz CC, Morrison FJ. Investigating the links between the subcomponents of executive function and academic achievement: A cross-cultural analysis of Chinese and American preschoolers. Journal of Experimental Child Psychology. 2011; 108:677–692. http://dx.doi.org/10.1016/j.jecp.2010.11.001. [PubMed: 21238977]

Liew J, Barrois L, McTigue E, Hughes J. Adaptive and effortful control and academic self-efficacy beliefs on achievement: A longitudinal study of 1st through 3rd graders. Early Childhood Research Quarterly. 2008; 23:515–526. http://dx.doi.org/10.1016/j.ecresq.2008.07.003. [PubMed: 19169387]

Liew J, Chen Q, Hughes JN. Child effortful control, teacher-student relationships, and achievement in academically at-risk children: Additive and interactive effects. Early Childhood Research Quarterly. 2010; 25:51–64. http://dx.doi.org/10.1016/j.ecresq.2009.07.005. [PubMed: 20161421]

Li-Grining C, Votruba-Drzal E, Maldonado-Carreño C, Haas K. Children's early approaches to learning and academic trajectories through fifth grade. Developmental Psychology. 2010; 46:1062–1077. http://dx.doi.org/10.1037/a0020066. [PubMed: 20822223]

Malecki CK, Elliott SN. Children's social behaviors as predictors of academic achievement: A longitudinal analysis. School Psychology Quarterly. 2002; 17(1):1–23.

Marks PEL, Babcock B, Cillessen AHN, Crick NR. The effects of participation rate on the internal reliability of peer nomination measures. Social Development. 2012 http://dx.doi.org/10.1111/j.1467-9507.2012.00661.x (Advance online publication).

Masten AS, Morrison P, Pellegrini DS. A revised class play method of peer assessment. Developmental Psychology. 1985; 21(3):523–533.

Matthews JS, Kizzie KT, Rowley SJ, Cortina K. African Americans and boys: Understanding the literacy gap, tracing academic trajectories, and evaluating the role of learning-related skills. Journal of Educational Psychology. 2010; 102:757–771. http://dx.doi.org/10.1037/a0019616.

McClelland MM, Acock AC, Morrison FJ. The impact of kindergarten learning-related skills on academic trajectories at the end of elementary school. Early Childhood Research Quarterly. 2006; 21:471–490. http://dx.doi.org/10.1016/j.ecsq.2006.09.003.

McClelland, MM.; Cameron, CE.; Wanless, SB.; Murray, A. Executive function, behavioral self-regulation, and social–emotional competence: Links to school readiness. In: Saracho, ON.; Spodek, B., editors. Contemporary perspectives on research in social learning in early childhood education. Greenwich, CT: Information Age; 2007. p. 83-107.

McCoach DB, O'Connell AA, Levitt H. Ability grouping across kindergarten using an Early Childhood Longitudinal Study. Journal of Educational Research. 2006; 99:339–346. http://dx.doi.org/10.3200/JOER.99.6.339-346.

McWayne CM, Fantuzzo JW, McDermott PA. Preschool competency in context: An investigation of the unique contribution of child competencies to early academic success. Developmental Psychology. 2004; 40:633–645. http://dx.doi.org/10.1037/0012-1649.40.4.633. [PubMed: 15238049]

Morrison, FJ.; Ponitz, CC.; McClelland, MM. Self-regulation and academic achievement in the transition to school. In: Morrison, FJ.; Ponitz, CC.; McClelland, MM., editors. Child development at the intersection of emotion and cognition. Washington, DC: American Psychological Association; 2010. p. 203-224.

Murray KT, Kochanska G. Effortful control: Factor structure and relation to externalizing and internalizing behaviors. Journal of Abnormal Child Psychology. 2002; 30:503–514. http://dx.doi.org/10.1023/A:1019821031523. [PubMed: 12403153]

Muthén, LK.; Muthén, BO. Mplus user's guide (version 7). [Computer software]. Los Angeles, CA: Muthén & Muthén; 1998–2012.

Neuenschwander R, Röthlisberger M, Cimeli P, Roebers CM. How do different aspects of self-regulation predict successful adaption to school? Journal of Experimental Child Psychology. 2012; 113:353–371. http://dx.doi.org/10.1016/j.jecp.2012.07.004. [PubMed: 22920433]

Obradović J. Effortful control and adaptive functioning of homeless children: Variable-focused and person-focused analyses. Journal of Applied Developmental Psychology. 2010; 31:109–117. http://dx.doi.org/10.1016/j.appdev.2009.09.004. [PubMed: 20401161]

Ponitz CC, McClelland MM, Matthews JS, Morrison FJ. A structured observation of behavioral self-regulation and its contribution to kindergarten outcomes. Developmental Psychology. 2009; 45:605–619. http://dx.doi.org/10.1037/a0015365. [PubMed: 19413419]

Portilla XA, Ballard PJ, Adler NE, Boyse WT, Obradović J. An integrative view of school functioning: Transactions between self-regulation, school engagement, and teacher–child relationship quality. Child Development. 2014 http://dx.doi.org/10.1111/cdev.12259 (Advance online publication).

Putnam SP, Gartstein MA, Rothbart MK. Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. Infant Behavior and Development. 2006; 29:386–401. http://dx.doi.org/10.1016/j.infbeh.2006.01.004. [PubMed: 17138293]

Raver CC, Jones SM, Li-Grining C, Zhai F, Bub K, Pressler E. CSRP's impact on low-income preschooler's preacademic skills: Self-regulation as a mediating mechanism. Child Development. 2011; 82:362–378. http://dx.doi.org/10.1111/j.1467-8624.2010.01561.x. [PubMed: 21291447]

Ready D, LoGerfo L, Burkam D, Lee V. Explaining girls' advantage in kindergarten literacy learning: Do classroom behaviors make a difference? The Elementary School Journal. 2005; 106:21–38. http://dx.doi.org/10.1086/496905.

Riggs NR, Greenberg MT, Kusché CA, Pentz M. The meditational role of neurocognition in the behavioral outcomes of a social-emotional prevention program in elementary school students: Effects of the PATHS curriculum. Prevention Science. 2006; 7:91–102. http://dx.doi.org/10.1007/s11121-005-0022-1. [PubMed: 16572300]

Rothbart, MK.; Ellis, LK.; Posner, MI. Temperament and self-regulation. In: Baumeister, RF.; Vohs, KD., editors. Handbook of self-regulation: Research, theory, and applications. New York, NY: Guilford Press; 2004. p. 357-370.

Sonnenschein S, Stapleton LM, Benson A. The relation between the type and amount of instruction and growth in children's reading competencies. American Educational Research Journal. 2010; 47:358–389. http://dx.doi.org/10.3102/0002831209349215.

Stipek D, Newton S, Chudgar A. Learning-related behaviors and literacy achievement in elementary school-aged children. Early Childhood Research Quarterly. 2010; 25:385–395. http://dx.doi.org/10.1016/j.ecresq.2003.12.001.

Swanson J, Valiente C, Lemery-Chalfant K, Bradley RH, Eggum-Wilkens ND. Longitudinal relations among parents' reactions to children's negative emotions, effortful control, and math achievement in early elementary school. Child Development. 2014 http://dx.doi.org/10.1111/cdev.12260 (Advance online publication).

Tominey SL, McClelland MM. Red light, purple light: Findings from a randomized trial using circle time games to improve behavioral self-regulation in preschool. Early Education and Development. 2011; 22:489–519. http://dx.doi.org/10.1080/ 10409289.2011.574258.

Valiente C, Eisenberg N, Haugen R, Spinrad TL, Hofer C, Liew J, et al. Children's effortful control and academic achievement: Mediation through social functioning. Early Education and Development. 2011; 22:411–433. http://dx.doi.org/10.1080/10409289.2010.505259. [PubMed: 22573931]

Valiente C, Lemery-Chalfant K, Swanson J, Reiser M. Prediction of children's academic competence from their effortful control, relationships, and classroom participation. Journal of Educational Psychology. 2008; 100:67–77. http://dx.doi.org/10.1037/0022-0663.100.1.67. [PubMed: 21212831]

Weissberg, RP.; Greenberg, MT. School and community competence-enhancement and prevention programs. In: Siegel, I.; Renninger, A., editors. Handbook of child psychology Child psychology in practice. 5th ed.. Vol. 4. New York, NY: Wiley; 1998. p. 877-954.

Welsh M, Parke RD, Widaman K, O'Neil R. Linkages between children's social and academic competence: A longitudinal analysis. Journal of School Psychology. 2001; 39:463–481. http://dx.doi.org/10.1016/S0022-4405(01)00084-X.

Wendling, BJ.; Mather, N. Reading fluency. In: Kaufman, AS.; Kaufman, NL., editors. Essentials of evidence-based academic interventions. Hoboken, NJ: John Wiley & Sons; 2009. p. 52-76.

West, SG.; Finch, JF.; Curran, PJ. Structural equation models with nonnormal variables: Problems and remedies. In: Hoyle, RH., editor. Structural equation modeling: Concepts, issues and applications. Thousand Oaks, CA: Sage; 1995. p. 56-75.

Woodcock, RW.; Mather, N. WJ-R Tests of Achievement: Examiner's manual. In: Woodcock, RW.; Johnson, MB., editors. Woodcock–Johnson Psycho-educational Battery – Revised. Allen, TX: DLM Teaching Resources; 1989, 1990.

Woodcock, RW.; McGrew, KS.; Mather, N. Woodcock–Johnson III Tests of Achievement. Itasca, IL: Riverside Publishing; 2001.

Woodcock, RW.; Muñoz-Sandoval, AF. Woodcock–Muñoz Language Survey. Itasca, IL: Riverside Publishing; 1993.

Woodcock, RW.; Muñoz-Sandoval, AF. Woodcock–Muñoz Pruebas de aprovechamiento-Revisada. Itasca, IL: Riverside Publishing; 1996.

Wu J, Hughes JN, Kwok O. Teacher-student relationship quality type in elementary grades: Effects on trajectories for achievement and engagement. Journal of School Psychology. 2010; 48:357–387. http://dx.doi.org/10.1016/j.jsp.2010.06.004. [PubMed: 20728688]

Wu W, West SG, Hughes JN. Effect of retention in first grade on children's achievement trajectories over 4 years: A piecewise growth analysis using propensity score matching. Journal of Educational Psychology. 2008; 100:727–740. http://dx.doi.org/10.1037/a0013098. [PubMed: 19337582]

Young C, Rasinski T. Implementing readers theatre as an approach to classroom fluency instruction. The Reading Teacher. 2009; 63:4–13. http://dx.doi.org/10.1598/RT.63.1.1.

Zeller M, Vannatta K, Schafer J, Noll RB. Behavioral reputation: A cross-age perspective. Developmental Psychology. 2003; 39:129–139. http://dx.doi.org/10.1037/0012-1649.39.1.129. [PubMed: 12518814]

Zhou Q, Main A, Wang Y. The relations of temperamental effortful control and anger/frustration to Chinese children's academic achievement and social adjustment: A longitudinal study. Journal of Educational Psychology. 2010; 102:180–196. http://dx.doi.org/10.1037/a0015908.

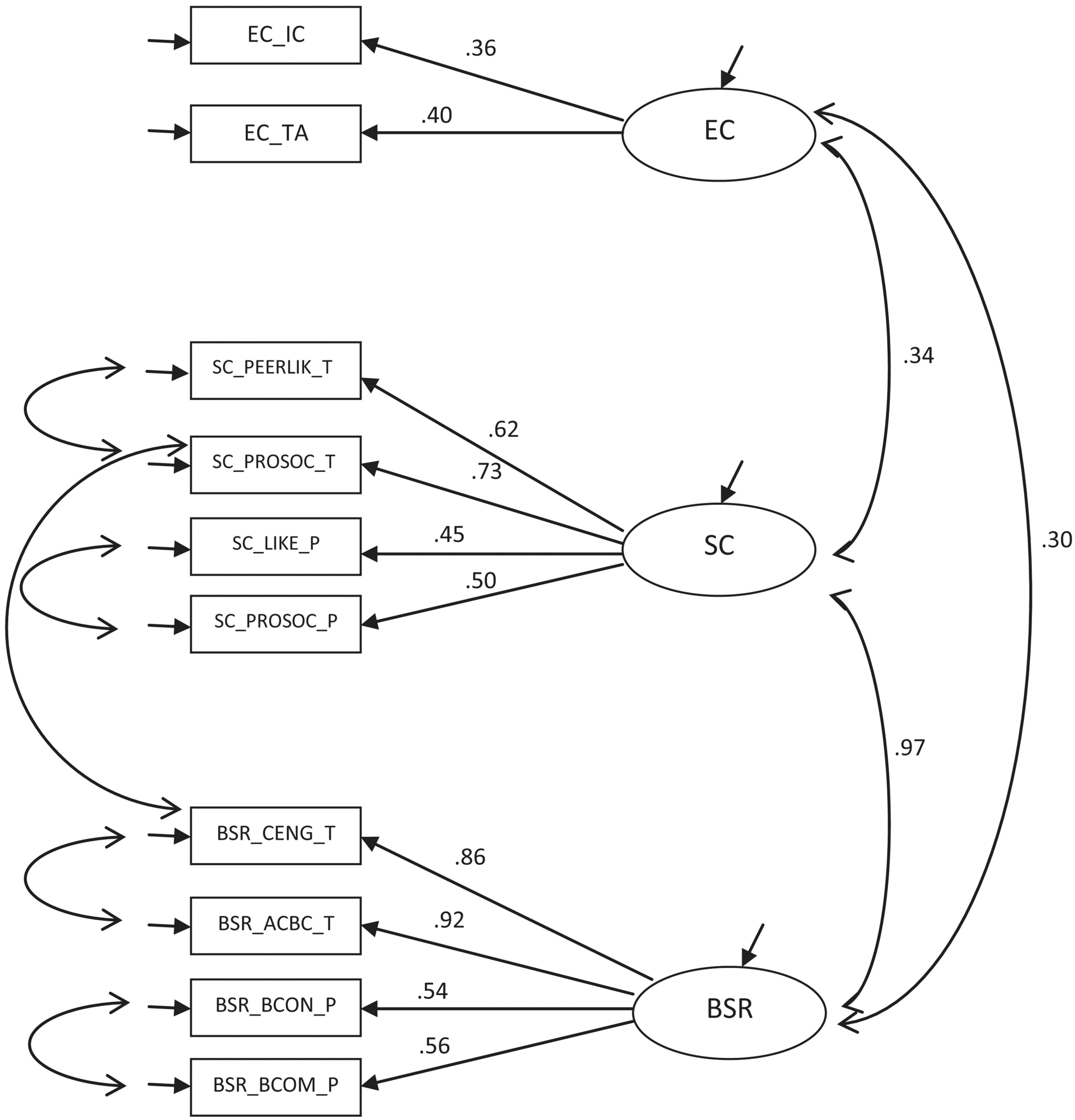

Fig. 1.

Hypothesized correlated factor measurement model with three latent factors; $\chi^2(20)$ = 63.955, $p < .001$; CFI = .98; RMSEA = .05; SRMR = .02. All coefficients are standardized estimates and significant at $p < .05$ (two-tailed). To reduce the complexity of the figure, most correlated residuals between SC and BSR for specifying the same source were omitted in the figure. Variable naming convention: Alphabet (_T and _P) at the end of variables indicates source of measured variables; _T = teacher-rated and _P = peer-rated. EC = effortful control; SC = social competence; BSR = behavioral self-regulation; EC_IC =

inhibitory control; EC_TA = task accuracy; SC_PEERLIK_T = teacher-rated peer-rated likability; SC_PROSOC_T = teacher-rated prosocial behavior; SC_LIKE_P = peer-rated likability; SC_PROSOC_P = peer-rated prosocial behavior; BSR_CENG_T = teacher-rated classroom engagement; BSR_ACBC_T = teacher-rated attention control & behavioral control; BSR_BCON_P = peer-rated behavioral control; BSR_BCOM_P = peer-rated behavioral compliance.

Table 1

Descriptive statistics and zero-order correlations of all analyses variables.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	GENDER	–																	
2	ECON STATUS	−.017	–																
3	IQ	.038	−.124**>	–															
4	READ	−.130**>	−.108**>	.236**>	–														
5	MATH	.008	−.352**>	.406**>	.533**>	–													
EC																			
6	IC	.066	−.059	.082*>	.069	.142**>	–												
7	TA	−.061	−.022	.054	.062	.091*>	.145**>	–											
BSR																			
8	CENG_T	−.235**>	−.031	.235**>	.324**>	.220**>	.099**>	.118**>	–										
9	ACBC_T	−.281**>	.004	.173**>	.201**>	.131**>	.082*>	.118**>	.782**>	–									
10	BCON_P	−.318**>	−.006	.129**>	.140**>	.111**>	.044	.107*>	.430**>	.518**>	–								
SC																			
11	BCOM_P	−.331**>	.028	.153**>	.105*>	.117**>	.060	.060	.439**>	.531**>	.772**>	–							
12	PEERLIK_T	−.011	−.004	.092*>	.135**>	.130**>	.101**>	.092*>	.440**>	.422**>	.263**>	.290**>	–						
13	PROSOC_T	−.179**>	−.036	.170**>	.167**>	.160**>	.098*>	.098*>	.534**>	.532**>	.396**>	.424**>	.516**>	–					
14	PROSOC_P	−.299**>	−.073	.147**>	.170**>	.057	.049	.031	.456**>	.436**>	.329**>	.405**>	.323**>	.336**>	–				
15	LIKE_P	−.013	−.121**>	.139**>	.121**>	.072	.080	.053	.396**>	.353**>	.357**>	.397**>	.388**>	.293**>	.501**>	–			
16	EC composite	−.003	−.050	.085*>	.088*>	.152**>	.756**>	.757**>	.147**>	.133**>	.097*>	.078	.130**>	.129**>	.050	.084*>	–		
17	BSR composite	−.348**>	.016	.229**>	.244**>	.172**>	.097*>	.118**>	.802**>	.856**>	.823**>	.830**>	.431**>	.574**>	.488**>	.450**>	.142**>	–	
18	SC composite	−.177**>	−.069	.186**>	.221**>	.143**>	.121**>	.080	.620**>	.602**>	.448**>	.504**>	.764**>	.736**>	.719**>	.732**>	.131**>	.657**>	–
Mean		0.52	0.61	93.24	96.63	100.96	0.00	1.00	0.00	0.00	−0.05	−0.06	0.00	0.00	−0.17	−0.10	0.50	−0.02	−0.06
SD		0.50	0.49	14.54	18.11	14.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.89	0.93	0.76	0.82	0.70
Missing (%)		0	4	2	2	3	4	7	5	5	20	20	5	6	20	21	7	25	25

Note. GENDER (1 = male; 0 = female). ECON STATUS = economic adversity status (1 = economically disadvantaged; 0 = not economically disadvantaged). IQ = Abbreviated Battery of the UNIT. READ = WJ-III ACH standardized age score for reading. MATH = WJ-III ACH standardized age score for math. EC = effortful control. IC = inhibitory control. TA = task accuracy. BSR = behavioral self-regulation. CENG_T = teacher-rated classroom engagement. ACBC_T = teacher-rated attention control & behavioral control. BCON_P = peer-rated behavioral control. BCOM_P = peer-rated behavioral compliance. SC = social competence. PEERLIK_T = teacher-rated peer likability. PROSOC_T = teacher-rated prosocial behavior. PROSOC_P = peer-rated prosocial behavior. LIKE_P = peer-rated likability.

* $p < .05$.

** $p < .01$.

Table 2

Joint contributions of EC, BSR, and SC to achievement (results of hierarchical multiple regression analyses).

	Reading		Math	
Variables	**First step** β[a] (*SE*)	**Second step** β[a] (*SE*)	**First step** β[a] (*SE*)	**Second step** β[a] (*SE*)
Demographic variables				
IQ	0.23** (0.04)	0.19** (0.05)	0.38** (0.03)	0.36** (0.04)
ECON STATUS	−0.09 (0.05)	−0.05 (0.05)	− 0.31** (0.04)	− 0.27** (0.04)
GENDER	− 0.13** (0.03)	−0.08 (0.04)	−0.01 (0.03)	0.04 (0.04)
LRS factors				
BSR		0.09 (0.06)		0.09 (0.07)
EC		0.04 (0.04)		0.11** (0.04)
SC		0.08 (0.06)		−0.02 (0.06)
Adjusted R^2	.08[b],**	.03[c],**	.26[b],**	.02[c],**

Note. ECON STATUS = economic adversity status (1 = economically disadvantaged; 0 = not economically disadvantaged); GENDER (1 = male; 0 = female); BSR = behavioral self-regulation; EC = effortful control; SC = social competence; Reading = WJ-III ACH standardized age score for reading; Math = WJ-III ACH standardized age score for math.

[a]Based on standardized parameter estimates.

[b]Total variance (adjusted R^2) of demographic variables (i.e., IQ, ECON STATUS, and GENDER).

[c]Joint contribution of the three LRS constructs of BSR, EC, and SC (i.e., adjusted R^2 change from a model in which the effect of each LRS was constrained to be zero to a model in which the effect of each LRS construct was free to vary).

** $p < .01$.