THE CONTRIBUTION OF CHILD ATTRIBUTES

AND CLASSROOM ENVIRONMENTS

TO BEHAVIOR AND ACHIEVEMENT IN ELEMENTARY SCHOOL:

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APPROVAL OF THE DISSERTATION

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ABSTRACT

A compilation of three studies analyze the combined contribution of individual attributes and elementary classroom environments to children's behavior and achievement. The first study examines the contribution of a set of teacher practices *(RC)* to children's perceptions, behavior, and achievement. Three questions emerge: (a) What is the concurrent and cumulative relation between children's perceptions, behavior, and achievement? (b) What is the contribution of teacher's use of *RC* practices to children's perceptions, behavior, and achievement? (c) Do children's perceptions of the classroom mediate the relation between *RC* teacher practices and child outcomes? For a sample of 520 children in grades 3-5, results indicate a positive relation between *RC* teacher practices and child perceptions and outcomes over time. Further, children's perceptions partially mediated the relation between *RC* teacher practices and social competence.

The second study examines the relation between 'hot' and 'cool' executive function (EF) to children's achievement and behavior in kindergarten. This study asks: (a) what are the relative contributions of 'hot' and 'cool' EF to children's academic achievement? (b) What are the relative contributions of 'hot' and 'cool' EF to children's display of adaptive classroom behaviors? (c) Do adaptive classroom behaviors mediate the relation between EF and achievement? For a sample of 174 kindergarteners, cool EF predicted both achievement and adaptive classroom behavior. Hot EF predicted adaptive classroom behavior but not achievement. Adaptive classroom behavior mediated the relation between cool EF and achievement, yet cool EF contributed unique variance to gains in math.

The third study asks: a) Do hot and cool EF relate to achievement and behavior outcomes in first grade? b) Do classroom quality and activity setting contribute to gains in hot and cool EF in first grade? c) Do classroom quality and activity setting moderate the contributions of hot and cool EF to first grader's achievement and behavior outcomes? For a sample of 176 first graders, cool EF predicted achievement and behavior outcomes. Classroom processes contributed to gains in both hot and cool EF. A pattern of interactions indicate both hot and cool EF play a role in children's behavior and achievement dependent upon activity setting.

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Children's Perceptions of the Classroom Environment and Social and Academic Performance: A Longitudinal Analysis of the Contribution of the *Responsive Classroom* Approach

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Abstract

This study examines the contribution of *Responsive Classroom (RC)* Approach, a set of teaching practices that integrate social and academic learning, to children's perceptions of their classroom, and children's academic and social performance over time. Three questions emerge: (a) What is the concurrent and cumulative relation between children's perceptions of the classroom and social and academic outcomes over time? (b) What is the contribution of teacher's use of *RC* practices to children's perceptions and social and academic outcomes? (c) Do children's perceptions of the classroom mediate the relation between *RC* teacher practices and child outcomes? Cross-lagged autoregressive structural equation models were used to analyze teacher and child-report questionnaire data, along with standardized test scores collected over 3 years from a sample of 520 children in grades 3-5. Results indicate a significant positive relation between *RC* teacher practices and child perceptions and outcomes over time. Further, children's perceptions partially mediated the relation between *RC* teacher practices and social competence. However, the models did not demonstrate that child perceptions mediated the relation between *RC* practices and achievement outcomes. Results are explained in terms of the contribution of teacher practices to children's perceptions and student performance.

Keywords: academic achievement, social skill development, children's perceptions, teacher practices

Children's Perceptions of the Classroom Environment and Social and Academic Performance: A Longitudinal Analysis of the Contribution of the *Responsive Classroom* Approach

Educators are faced with the dual roles of optimizing student academic achievement and nurturing children's social development. These two goals of providing both academic and social support for children can be complementary in nature. A growing literature points to the importance of positive classroom social processes—children's positive interactions with teachers and peers—for improving children's social and academic performance (Baker, Bridger, Terry, & Winsor, 1997; Flook, Repetti, & Ullman, 2005; Hamre & Pianta, 2005).

Teachers play a pivotal role in creating opportunities for social-emotional and academic learning (Hawkins, Doueck, & Lishner, 1988; Solomon, Battistich, Kim, & Watson, 1997). Teachers create external environments to facilitate children's learning. However, teachers' efforts are only part of the equation. Learning is a process that occurs inside the child. Children need to be receptive, feel motivated, and connected in order for a well-facilitated classroom environment to contribute to their learning. Children's bonding to school is one way to assess children's engagement in the learning process. The purpose of this study is to examine children's perceptions of their classroom environment because it offers a unique lens from which to view the association between classroom processes and learning outcomes.

This study examines the contribution of the *Responsive Classroom® (RC)* Approach, a set of teaching principles and practices designed to integrate social and academic learning. The focus of the present study was to analyze the relation between teacher practices, children's perceptions of their classroom environment, and social and academic performance over 3 years. A second goal was to analyze the role of children's perception of the classroom as a potential mediator between *RC* teacher practices and child outcomes. We hypothesized the *RC* Approach would improve children's social and academic performance, that the contribution of *RC* would be cumulative over time, and that changes in children's perceptions would be associated with changes in social and academic performance.

Theoretical Perspective

The premise of this study derives from a motivational theory of self-system processes developed by Connell and Wellborn (1991). According to this theory, children have three basic psychological needs (competence, autonomy, and relatedness) all of which can be met in a classroom through children's interactions with teachers and the learning environment.

Competence. Competence is defined by Connell and Wellborn (1991, p.51) as "the need to experience oneself as capable of desired outcomes". Teachers can promote children's feelings of competence through constructive feedback that values the learning process (e.g. "I noticed that you put a lot of effort into working as a team"), rather than using generic praise or focusing on the product (e.g. "good job").

Autonomy. Autonomy describes "the experience of choice in the initiation, maintenance, and regulation of activity and the experience of connectedness between one's actions and personal goals and values" (Connell & Wellborn, 1991, p.51). Teachers can facilitate an autonomous learning environment where children to can choose, initiate, and direct their own activities. In so doing, children can select which mode of learning will best suit their interests and hold their attention.

Relatedness. For Connell and Wellborn (1991), relatedness "encompasses the need to feel securely connected to the social surround and the need to experience oneself as worthy and capable of love and respect" (p.52). Teachers who make an effort to learn about their students (e.g. family dynamics, cultural differences) can encourage school bonding. Teachers can promote relatedness by modeling prosocial interactions during organized group activities.

The motivational theory of self-system processes suggests fulfillment of these three key psychological needs motivates children's engagement, and engagement mediates the relation between children's perceptions and classroom performance. Specific teacher practices are associated with children's sense of competence (Eccles Parsons, Kaczala, & Mecce, 1982; Pintrich & Blumenfeld, 1985), autonomy (Reeve & Jang, 2006), relatedness (Solomon et al., 1997), and engagement (Kruif, McWilliam, Ridley & Wakely, 2000), all thought by Connell and Wellborn (1991) to be key ingredients in fostering children's social and academic outcomes.

Research suggests fulfillment of children's psychological needs contributes to positive social and academic outcomes. Children's perceptions of competence were associated with academic achievement (Kurdek & Sinclair, 2000). Teacher practices that supported autonomy improved childrens' motivation and perceptions of academic competence (Ryan & Grolnick, 1986). Kindergartener's feelings of relatedness to teachers, operationalized by teachers' ratings of dependence and conflict with the child, were related to social and academic outcomes through eighth grade (Hamre & Pianta, 2001). Taken together, these findings suggest that children's feelings of competence, autonomy, and relatedness are associated with social and academic outcomes.

The self-determination theory (Ryan & Deci, 2000) further suggests that experiencing competence, autonomy, and relatedness facilitate healthful socialization by nurturing children's development of self-regulation (e.g. the ability to persist at difficult tasks or wait for one's turn). Theoretically, children who have these three psychological needs met in the classroom become more internally regulated and thus exhibit more social competence. Emerging empirical evidence supports this assumption; for example, children's ability to self-regulate predicts teacher and parent report of children's social competence (Spinrad et al., 2006).

Teachers, through their quality of interactions with children and their choice of classroom practices, have the potential to create an environment that meets (or stifles) children's psychological needs, which may be reflected in children's social and academic outcomes. The *RC* Approach and other social and emotional learning interventions that are explicitly designed to address children's psychological needs can create an environment that fosters children's bonding to school and bolsters academic achievement.

Social and Emotional Learning Interventions

School-wide social and emotional learning interventions that alter teacher practices have been implemented to better address children's emotional and instructional needs. The Child Development Project was an elementary school-wide social development intervention that improved children's social skills and performance on problem solving and cognitive tasks (Battistich, Solomon, Watson, & Schaps, 1997). The

Seattle Social Development Project trained teachers in classroom management; children were exposed to the intervention from first through sixth grade. Findings at the end of sixth grade indicate children experienced increased bonding to school, improved achievement test scores, and exhibited more social skills, as compared to a control group (Abbott, et al., 1998; Hawkins et al, 1992; O'Donnell, Hawkins & Abbott, 1995). Further, children who received the intervention during elementary school experienced positive perceptions about learning and long-term school bonding at age 18 (Hawkins, Guo, Hill, Battin-Pearson, & Abbott, 2001). The Promoting Alternative Thinking Strategies (PATHS) curriculum was designed to enhance elementary students' social competence (Greenberg & Kusche, 1998). Exposure to the PATHS curriculum fostered improved performance in specific academic tasks, including nonverbal reasoning and block design (Greenberg, Kusche, & Riggs, 2004). Two years after implementation, the PATHS curriculum slowed the rate of growth in teacher-report of children's internalizing and externalizing behaviors (Kam, Greenberg, & Kusche, 2004). Taken together, findings from studies of school-wide interventions designed to alter the social-emotional environment of the classroom, suggest that children improve socially and academically. Evidence of their contributions is concurrent and longitudinal. The present study will examine both the effects of exposure to *RC* teacher practices within one school year and over the course of three years, thus furthering our understanding of concurrent and long-lasting effects of school-wide implementation.

Results from previous studies highlight the importance of examining the effectiveness of the *RC* Approach, especially given that *RC* teacher practices are already widespread with 60,000 teachers implementing the *RC* Approach in their classrooms

(NEFC, 1997). The primary goal of the *RC* Approach is to create an emotional climate that supports learning through a set of *RC* principles and practices. *RC* principles include: (a) an equal emphasis on the social and academic curriculum; (b) a focus on *how* children learn as much as *what* they learn; (c) a view that social interaction facilitates cognitive growth; (d) an emphasis on teachers' knowledge of children's individual, cultural, and developmental characteristics; and (e) an emphasis on cooperation, assertion, responsibility, empathy, and self-control as critical social skills for children to learn.

RC principles give rise to specific practices including (a) a daily 'Morning Meeting' to provide children with opportunity to practice pro-social skills; (b) collaboration between teachers and children to develop positively worded 'Rules and Logical Consequences'; (c) classroom organization that fosters social interaction, independence, and maximization of learning; (d) guided discovery, a teaching format that encourages children to care for their learning environment; and (e) academic choice, a format of instruction that cultivates children's interests, thus fueling motivation and allowing for a sense of autonomy (NEFC, 1997; NEFC, 2003). *RC* principles and practices are designed to nurture children's feelings of competence, relatedness, and autonomy which Connell and Wellborn (1991) describe as the three basic psychological needs of children. The design of the *RC* Approach suggests educators can meet children's psychological needs in the classroom by adopting *RC* teacher practices.

RC principles and practices are designed to create a classroom that provides both emotional and instructional support which is different from a typical classroom setting. The *RC* Approach alters daily routines, structure, climate, and organization of the classroom in a way that both increases teachers' self-efficacy, and children's pro-social behavior (Rimm-Kaufman & Sawyer, 2004; Rimm-Kaufman & Chiu, in press). Based on the nature of *RC* principles and practices and what is known about similar social and emotional learning interventions, we expect *RC* teacher practices will relate to children's perception of the classroom as well as enhance social and academic performance. If this is the case, the role of children's perceptions as a mediator between *RC* teacher practices and child outcomes may help explain how classroom processes affect performance.

Children's Perceptions

The degree to which children's psychological needs are met in the classroom can be viewed in terms of the perceptions children have about their school experience. Teachers create a learning environment that either promotes or constrains competence, autonomy, and relatedness in each child. Children's perceptions of these experiences may be good indicators of the success with which teachers meet the needs of children.

Children's perceptions of their classrooms rely on positive teacher-student relationships. Children who perceive social support from teachers display an increase in motivation toward academic and pro-social goals; this increase in motivation is related to academic achievement (Wentzel, 1998; Wentzel & Wigfield, 1998). Teachers can improve children's perceptions by engaging students and promoting positive feelings about learning. This positive emotional climate contributes to students' motivation to learn (Stipek, Salmon, Givvin, Kazemi, Saxe, & MacGyvers, 1998). Classroom interventions that address children's emotional needs can influence children's perceptions of their environment. Children's improved perceptions of their classroom have been shown to improve social and academic outcomes (Battistich, Schaps, & Wilson, 2004; Blankmeyer, Flannery, & Vazsonyi, 2002; Murray & Greenberg, 2000).

Personal attributes, including gender and sociodemographic risk factors influence children's perceptions of the classroom. Girls generally perceive more closeness and less conflict with teachers in elementary school (Salmon, 1999). Where as children identified as at-risk for school failure tend to spend less time on task, perceive themselves more negatively, and perceive their teachers more negatively (Montague & Rinaldi, 2001). Given these findings, the present study will account for contributions of both gender and sociodemographic risk factors (operationalized as low family income, low maternal education, limited English proficiency, or single parent status) in the analyses.

The Present Study

The present study derives from a quasi-experimental three-year longitudinal project, the *Social and Academic Learning Study (SALS)* addressing the efficacy of the *Responsive Classroom* Approach. This paper extends that research by analyzing the relation between *RC* teacher practices, children's perceptions of the learning environment, and children's social and academic gains. This study bridges what is known about children's perceptions of school during middle childhood and the literature examining socioemotional interventions in the classroom. The ultimate goal is to understand how *RC* teacher practices improve children's outcomes.

The *RC* Approach, like all other classroom interventions, can be expected to have an effect only if it is employed with integrity (Greenberg et al., 2003). Our aim is to investigate the association between teacher's use of *RC* practices and child outcomes. Thus, we measured teacher's use of *RC* practices as a continuous variable, allowing us to capture a range of treatment fidelity amongst teachers and to examine children's outcomes in the context of the integrity of *RC* teacher practices to which students were exposed over three years.

Three questions are examined. First, what is the relation between children's perceptions of the classroom and social and academic outcomes over a three year period? We hypothesize that children who positively perceive their environment will achieve greater gains in measures of social and academic performance and that these gains will become increasingly strong over time. Second, what is the contribution of the *RC* Approach to children's perceptions and social and academic outcomes? We hypothesize that children exposed to *RC* teacher practices will perceive their classroom environment more positively and that these associations will be most pronounced within a single year. Third, do children's perceptions of the classroom mediate the relation between *RC* teacher practices and child outcomes? We expect children exposed to *RC* teacher practices should have better social and academic outcomes, and that analyses will point to children's perceptions of their classroom environment as a mediator.

Method

Participants

Participants were 520 children attending one of six schools in a district in the northeast: 241 girls (46%), 270 boys (52%), 9 unknown (2%). Of those, 213 (41%) were identified as having one or more risk factors (low family income, single parent status, low maternal education, limited English proficiency). In terms of ethnicity, there were 349 (68.2%) Caucasian Americans, 68 (13.3%) Hispanic Americans, 52 (10.2%) African Americans, and 43 (8.4%) Asian Americans. Ethnicity data were not available for 8 (.02%) students. Data were collected on three cohorts of third-grade children over a 3 year period, thus the data set contains both longitudinal and cross-sectional information. For year one of the study, students attended third grade (N=125), for year two, students attended third grade (N=99) and fourth grade (N=117), for year three, students attended third grade (N=86), fourth grade (N=95) and fifth grade (N=114). In order to make comparisons between children over time, the data set was coded by grade level (3^{rd} grade: N=310 [48.7%], 4^{th} grade: N=212 [33.3%], 5^{th} grade: N=114 [18%]) to correspond with three observations, one for each grade level.

Participants included 51 teachers (*RC*: 27, comparison: 24). Years of teaching experience ranged from 1-34 years (mean=11.0). Teachers of 3^{rd}-5th grade during the 3 years of data collection were included in the study (year 1= 3^{rd} grade, year 2=3^{rd}-4^{th} grade, year 3=3^{rd}-5^{th} grade).

Design and Procedure

Teachers were invited by mail and in person to participate and received a stipend for their participation; 69% of teachers consented. Parents of children whose teachers were enrolled in the study received a letter by mail from the school district and the research team. Five hundred twenty parents consented for their children to participate and completed a demographic questionnaire.

Teachers reported on their use of *RC* practices (in the fall of each year), on participating students' social competence using the *Social Skills Rating Scale* and academic achievement using the *Mock Report Card* (in the spring of each year). Children's perceptions of the classroom were measured through the child-report *School-Related Attitudes* questionnaire, administered in the spring of each school year. Standardized test score data was collected in the spring of each year.

Measures

The *Child Demographic Questionnaire* was an 11 item questionnaire describing the demographic characteristics of families that parents completed upon study enrollment. Four sociodemographic risk factors were identified and dichotomous variables were created with 1 indicating the presence of a risk factor and 0 indicating the absence of a risk factor: a) a family income at or below $49,000[1] b) home language other than English, c) mothers' educational attainment equivalent to high school or less, and d) single parent status. The four variables were combined to create a composite indicator of sociodemographic risk.

The *Classroom Practices Measure* was custom-designed for this study and included 41 items to assess teachers' implementation of the *RC* approach. Teachers were asked to rate 34 items on a 1 to 5 scale, representing the degree to which the description matched their teaching style. Each of these items provided teachers with two statements describing a classroom practice, one of which was not at all characteristic of *RC* practices, and one of which was very characteristics of *RC* practices. In order to avoid biasing teachers' responses, classroom practices were not described using *RC* terminology. The items asked teachers about their use of: (a) hand signals, (b) classroom opening exercises, (c) classroom rules and consequences, (d) classroom organization, (e) introduction of materials, (f) student choice, (g) student reflection, (h) assessment and parent communication, (i) time-out, and (j) problem-solving class meetings. Teachers also responded to seven open-ended items about their classroom management and discipline strategies. These items were coded on a five-point scale, where zero equaled

[1] A cutoff point of $49,000 reflects the high cost of living in this region. An annual salary of $49,000 for a family of four approaches the cut off for free and reduced lunch eligibility.

inconsistency, three equaled partial consistency, and five equaled consistency with *RC* practices. Two raters agreed at a level of 85% or above for the total of these items. Reliability was computed for the 41 classroom practices items, resulting in a Cronbach's alpha of .94. Continuous scores were computed as an indicator of reported use of *RC* teacher practices.

Classroom observations were conducted to provide convergent validity for the *Classroom Practices Measure.* Questionnaire responses were compared with observed use of *RC* teacher practices in a validity study of 68 teachers. An observer blind to the conditions of the study conducted two hour observations, and reported on evidence of 16 different *RC* practices (e.g., does the teacher post rules in the classroom? Does the teacher allow time for a few students to share something personal?) Reponses ranged from 0=none, 1=some evidence of the practice, to 2=practice clearly in place. The scores of these observations were averaged and correlated with questionnaire assessments. Results showed a high correlation (r=.70, $p < .001$) (Rimm-Kaufman, Skibbe, Decker, Pianta & LaParo, under review).

The *Social Skills Rating Scale* (SSRS; Gresham & Elliott, 1990) was a 35-item questionnaire used to measure teachers' ratings on students' social skills. Three components were assessed: (a) cooperation (10 items; alpha = .92; e.g., "Puts work materials or school property away."); (b) assertion (10 items; alpha = .86; e.g., "Introduces him/herself to new people without being told."); and (c) self-control (10 items; alpha = .90; e.g., "Control temper in conflict situations with adults.").

The *School-Related Attitudes* questionnaire (Battistich et al., 2004) measured children's perceptions of their learning environment using a 5-point Likert scale along the following dimensions: (a) liking for school (four items, alpha = .73; e.g. "I am glad to get back to school after summer vacation"); (b) feelings about learning (four items, alpha = .71; e.g. "The times I feel best are when something I learn makes me want to find out more"); (c)feelings about teachers (four items, alpha = .69; e.g. "Teachers here really care about me"); (d) feelings about my classroom (three items, alpha = .75; e.g. "Students in my class help each other learn").

The *Mock Report Card* (Pierce, Hamm, & Vandell, 1999) was used to garner teachers' evaluations of students' academic grades. Four items measured teachers' ratings of students' school performance in the areas of reading, oral language, written language, and math. The academic grade measure uses a numeric scale resembling a standard A to F grading scale. Teachers rated their students' performance on a scale of 1 to 5 (where 1 indicated below grade level and 5 indicated beyond grade level).

Achievement Tests. All students enrolled in grades three through five, except those students with extreme mental disabilities (e.g. severe autism, Down's Syndrome), took standardized assessment tests in the spring of each school year. These tests were administered to the whole class in the children's home classrooms and yielded math and reading scores for each child.

The *Degrees of Reading Power* test is a nationally-normed, criterion-referenced, un-timed test of reading comprehension (Touchstone Applied Science Associates, 2002). This assessment is comprised of test paragraphs ranging from two to three sentences at third grade, to test passages comprised of eight to ten sentences at fifth grade. Specific words are missing from the text and students are expected to select the correct word from four or five possible options to place in each sentence. Thus, the activity requires decoding as well as comprehension across several sequential sentences. Books are scaled by age and possible scores range from 15 to 99 indicating the highest level of text students are able to read and understand.

The *Connecticut Mastery Test: Math Section* (CMT) is a standardized assessment used across the state to assess children's math abilities. Children took the CMT assessment each spring in third through fifth grade. The test held different point values corresponding to each grade. In third grade, a total of 83 points could be earned, in fourth grade 94 points, and in fifth grade 105 points. The assessment included a mix of multiple choice and open-ended questions. Each multiple choice question was worth one point whereas the open-ended questions ranged in value from one to three points. Questions were explicitly mapped to objectives, thus reflecting grade-specific curricula. Between two and four items tested each objective.

Means, standard deviations, and correlations for all variables included in the models are reported in Table 1.

Analytic Approach

To investigate the relation between *RC* teacher practices, children's perceptions, and their academic and social competence, a series of auto-regressive cross-lagged models in a structural equation modeling framework were fit to the data. This statistical technique was employed because it enabled us to examine interrelations between and within variables across time using all of our data. All analyses were computed using maximum likelihood estimation: missing data were not imputed, and did not come from *RC* or comparison schools differentially. While children were nested in classrooms at one time point, they did not remain in these same classrooms across grade levels, so

Hierarchical Linear Modeling would not be an appropriate analytic strategy for detecting change in child outcomes as related to teacher practices over time.

In the first set of analyses, an autoregressive model with cross-lag regressive parameters was estimated to investigate the possibility of a dynamic relation between children's perceptions and their academic/social competencies. Specifically, the first set of models assessed (a) the relation between child perceptions at one grade level (G1) and the next grade level (G2), (b) the relation between child outcomes (either teacher ratings of social skills, standardized math scores, standardized reading scores, or teacher ratings of academic skills) at G1 and G2, (c) the relation between child perceptions at G1 and child outcomes at G2, and (d) the relation between child outcomes at G1 and perceptions at G2. These models allow us to investigate the contribution of child perceptions and outcomes on each other over time, after taking into account the influence of the previous year's perceptions/outcomes[2]. Separate models were run for (a) social skills, (b) academic performance, (c) standardized reading scores, and (d) standardized math scores.

Next, as Figures 1-4 illustrate, gender and sociodemographic risk were added to the model as covariates, and the effects of *RC* practices on both perceptions and outcomes were evaluated. Gender and risk were used to predict children's perceptions of school, and academic and social competence at Grade 3. Teacher's reported use of *RC* practices was used to predict their students' perceptions and outcomes at each grade level. The predictors were allowed to correlate, as depicted by the two-headed arrow. The second

[2] There are several significant pairwise correlations in Table 1 that suggest cumulative associations over time between children's perceptions and various outcome variables. However, our conclusion that children's perceptions are only concurrently related to academic outcomes is derived from the results and parameter estimates from autoregressive cross-lagged structural equation models which take into account other variables.

set of analyses assessed the impact of *RC* practices on children's perceptions and outcomes while accounting for effects of gender and risk.

Finally, we ran a set of models to assess whether students' perceptions mediated the relation between *RC* practices and student outcomes at each grade. Additional autoregressive cross-lag models were fit with children's perceptions concurrently predicting children's outcomes. We then examined whether there were changes in the strength of the association between *RC* practices and children's outcomes in comparison to the previous models.

Results

Overall, we found that *RC* teacher practices were correlated with positive outcomes for students. Specifically, teachers who used more *RC* practices had children with better academic and social behavior, and more favorable perceptions of school. Contrary to our hypotheses, children's perceptions of the school environment were generally not correlated with academic or social outcomes over time. This finding points to concurrent, but not cumulative effects of child perceptions on school outcomes. We also found that children's perceptions concurrently mediated the relation between *RC* practices and teacher-rated social skills, but did not contribute to academic outcomes. Thus, teachers' use of *RC* practices influenced children's perceptions which, in turn, were associated with better social outcomes. Taken together, we can conclude that *RC* practices are associated with both better child perceptions and child outcomes, and that children's perceptions mediate the correlation between *RC* practices and teacher-rated social skills. Yet, the magnitude of these associations is small.

The first set of analyses consisting of autoregressive cross-lag models were an adequate fit to the data based on the RMSEA (Steiger & Lind, 1980; Browne & Cudeck, 1993). The results provide strong evidence for an autoregressive model: children's perceptions and academic/social abilities are significantly associated with their previous perceptions and abilities. All child outcomes had significant positive autoregressive parameters, meaning that achievement stability is high from year to year: children who scored high on an outcome at Time 1 were likely to score high on that outcome at Time 2. For the social skills model (model fit: $\chi^2(11)=52$, RMSEA = .09) the effect of teacher-rated social skills at the previous grade level on teacher-rated social skills at the current grade level was .40 ($t = 7.7$, $p < .01$). The effect of previous standardized math scores (model fit: $\chi^2(11)=62$, RMSEA = .10) on current scores was .71 ($t = 20.3$, $p < .01$), the standardized reading comprehension autoregressive parameter estimate was .53 ($t = 16.5$, $p < .01$, model fit: $\chi^2(11)=111$, RMSEA = .13), and the teacher-rated academic score estimate was .58 ($t = 13.3$, $p < .01$; model fit: $\chi^2(11)=67$, RMSEA = .10). Children's perceptions were also stable across time. All four models also had a strong relation between child's perceptions at one grade level, and their perceptions at the subsequent level. These parameter estimates were all positive and ranged from .28 to .33.

Contrary to our expectations regarding cross-lag effects between prior child perceptions and current outcomes, the only significant cross-lag effect was between prior child perceptions and current social skills ratings by teachers. The effect of previous child perceptions on current math scores, reading comprehension scores and teacher ratings of academic competence was non-significant. In contrast, the effect of children's prior perceptions on current teacher-rated social skills was significant and negative (-.02, t = -

3.3, $p<.01$). Therefore, controlling for teacher ratings of social skills at the prior grade, children with better perceptions of school at the prior grade had lower social skills as rated by teachers at the current grade level, a counterintuitive result.

There was also no relation between previous levels of competence and current children's perceptions. Being a competent student at one grade level was not associated with positive perceptions of school at the next grade level. The parameter estimates for this cross-lag were all nonsignificant. However, there were several significant correlations between children's academic/social outcomes and perceptions within grade levels. Fourth graders who had good perceptions of their teachers and school were also likely to have high scores on standardized math tests ($r = .22$, $p<.05$), and 5th and 6th graders with better perceptions had higher ratings by their teachers on academic skills ($r = .21, .22$, $p<.05$) and social skills ($r = .35, .35$, $p<.05$). Thus, it seems possible that children's perceptions are only related to changes in social and academic skills within a specific school year, and not over time.

The results of the first set of analyses indicate that (a) children's perceptions of school and academic/social outcomes at one grade level are associated with their perceptions and outcomes at the subsequent grade level and (b) overall children's perceptions of school are not correlated with their academic and social skills at the next grade, and (c) their academic and social competencies are not correlated with their perceptions at the next grade.

The results of the second set of analyses, with covariates (risk and gender) and *RC* practices added in the models are presented in Figures 1-4 and Table 2. The autoregressive and cross-lag components are nearly identical in strength and magnitude to the previous models and gender, risk, and *RC* teacher practices were correlated with several outcomes. *RC* teacher practices were positively associated with both children's perceptions and social and academic competence. Teachers who used more *RC* practices were more likely to have children that scored higher on standardized reading scores, and teacher ratings of social skills and academic competence, even after adjusting for the previous year's scores and accounting for the effects of gender and risk. The parameter estimates were .003 for *RC* practices on teacher-rated social skills ($t = 6.5$, $p < .01$), .05 for standardized reading scores, ($t = 3.3$, $p < .01$) and .04 for teacher-rated academic scores ($t = 2.2$, $p < .05$). There was no relation for standardized math scores.

RC practices also influenced children's perceptions of their class, school and teacher. This parameter estimate was significant for all four models: .03 for teacher-rated social skills ($t = 7.1$, $p < .01$), .02 for standardized math scores ($t = 4.8$, $p < .01$), .03 for standardized reading scores ($t = 6.7$, $p < .01$), and .03 for teacher-rated academic skills ($t = 6.7$, $p < .01$). There were also several significant effects of gender and risk which can be found in Figures 1-4. Males were more likely to be rated by teachers as demonstrating fewer social skills than females. Teachers also gave boys lower ratings of academic performance than girls, although there were no gender differences in children's perceptions or standardized tests scores. Students at risk performed more poorly on both reading and math standardized test scores, and also received low ratings of academic performance from teachers. Risk was not related to differences in social skill ratings by teachers or children's perceptions of school.

The results from the mediation models suggest that children's perceptions were a partial mediator of the relation between *RC* practices and teacher-rated social skills (Z =

4.8, $p < .001$, Sobel test of mediation), but not for teacher-rated academics and standardized scores on reading and mathematics tests. The regression parameter from *RC* practices to social skills remained significant, but changed from .003 (standardized estimate = .21) to .002 (standardized estimate = .13). In this model, the effect of children's perceptions on social skills was .05 (standardized estimated = .32).

For teacher-rated academics, the regression parameter from *RC* practices to teacher-rated academics changed from .04 (standardized estimate = .07) to .01 (standardized estimate = .02), a significant difference ($Z = 3.9$, $p <.001$). However, the effect from child perceptions to teacher-rated academics was non-significant, thus child perceptions was not a mediating variable.

Children's perceptions also did not mediate the relation between RC practices and standardized reading and mathematics. The effect of RC practices on these measures of achievement did not vary when children's perceptions was added as a predictor (Reading: $Z = 1.9$, p = NS, Math: $Z = 0.9$, p = NS).

There were significant autoregressive effects of children's perceptions and competence across grade level. After taking into account previous perceptions and abilities, the *RC* Approach still appears to be associated with the way children view their teacher, classroom, and school, as well as their performance in a variety of areas. Thus it appears that *RC* practices influence children's outcomes, in part, through changing children's perceptions.

Discussion

Three notable findings emerge. First, *RC* teacher practices contributed to children's social and academic competence. Teachers who implemented more *RC* practices had children in their classrooms who scored higher on ratings of social skills, academic competence, and standardized reading tests, even after controlling for gender, risk, and previous scores. Second, *RC* teacher practices contributed to children's positive perceptions of their classroom environment, after accounting for both previous perceptions and performance. Third, children's perceptions mediated the concurrent relation between *RC* practices and teachers' ratings of children's social skills, but not achievement outcomes.

Despite a pattern of positive associations between *RC* practices and children's perceptions and social and academic outcomes, the magnitude of these associations is small. Nonetheless, small changes in children's social and academic functioning are consistent with the magnitude of change in syntheses of research on social and emotional learning interventions (Borman et al., 2003; Weissberg, 2005).

Responsive Classroom and Social and Academic Performance

This study provides early evidence for the efficacy of socioemotional interventions, such as the *RC* Approach, in improving social and academic performance. A review of the figures reveals the estimated coefficients were significant (arrows stemming from *RC* practices to child outcomes for each grade level in Figures 1-4) in all models, with the exception of standardized math scores. These overall results are consistent with findings from other interventions (e.g., Battistich et al., 2004; Hawkins, et al, 2001). The *RC* Approach and similar interventions are likely to increase social and academic performance through teacher practices that promote proactive behavior management strategies, explicit social skill training, and improved delivery of instruction.

A major tenet of the *RC* Approach is proactive behavior management. For elementary school children in urban school districts, similar to the district in this study, off-task and disruptive student behavior comprised 15% to 25% of instructional class time, while the rates of student compliance to teacher requests were generally below 40% (Greenwood, 1991, as cited in Matheson & Shriver, 2005). A proactive behavior management strategy may set up classroom expectations and allow students to anticipate consequences for transgressions, freeing the teacher from constantly redirecting misbehavior or negotiating punishment throughout the school year.

Results of this study suggest that explicit social skill instruction is an effective way to improve children's social skills. Social competence may well be the mechanism whereby the *RC* Approach is associated with growth in academic performance. This hypothesis can be empirically tested in future studies of classroom processes.

RC teacher practices may also directly impact student achievement. An *RC* classroom is structured differently from a conventional classroom in several ways. *RC* practices provide teachers with alternative methods for delivery of instruction. These varied learning formats may serve to increase student engagement and motivation, thereby improving academic productivity and learner investment (NEFC, 2003). The *RC* Approach may bolster teacher practices that, in turn, are associated with improved child outcomes (Rimm-Kaufman, et al. under review). When exposed to high levels of emotional and instructional support in the classroom, even children at risk for school failure can make gains in academic achievement on par with low-risk peers (Hamre & Pianta, 2005).

Results of this study suggest *RC* teacher practices are also associated with children's positive perceptions of the classroom.

Responsive Classroom and Children's Perceptions

RC teacher practices contributed positively to children's perceptions of the classroom, as evidenced by significant estimated coefficients in all four models (arrows stemming from *RC* practices to child perceptions for each grade level in Figures 1-4). Children's perceptions of the classroom appear to change as a function of exposure to varying teacher practices. Other classroom interventions that instituted teacher practices comparable to the *RC* Approach reported children's improved perceptions of the classroom environment. The Seattle Social Development Project introduced a set of teaching practices that facilitated proactive behavior management, an interactive instructional format, and cooperative learning strategies; students exposed to this intervention reported more favorable attitudes toward academic content and more bonding to school (Hawkins et al, 1988). Similarly, the Child Development Project introduced collaborative learning and classroom management strategies that emphasized personal responsibility; children reported improved perceptions of their learning environment and increased bonding toward school (Battistich et al, 2004). Thus, teachers who meet children's diverse needs are more likely to have children in their classroom who perceive school favorably.

The present study is consistent with existing evidence that teacher practices focusing on academic, social, and emotional learning can improve children's perceptions of the classroom, which has been shown in other studies to promote long-term bonding to school. Healthful school adjustment (a liking for school) can serve as a protective factor and promote resiliency in children at risk for school failure (Durlak & Weissberg, 2005).

Children's Perceptions and Social and Academic Competence

An examination of the models shows a pattern of positive associations between children's perceptions and child outcomes within a given year (represented by the vertical arrows in Figures 1-4). This indicates that children who perceived school more favorably also made contemporaneous gains in social and academic performance. Yet, results of this study did not reveal a pattern of significant relations between children's perceptions and academic performance across grade levels (represented by the cross-lagged arrows in Figures 1-4). This suggests children who previously had positive perceptions of their classrooms did not necessarily continue to show growth in social and academic performance in subsequent years.

Because *RC* teacher practices were significantly related to children's positive perceptions of the classroom, it stands to reason that exposure to teaching practices in the current year are more influential to children's perceptions than exposure to teaching practices from the previous year. So, although one set of teaching practices may have lasting effects on a child's perception of school, these may be overshadowed by the current effects of a new set of teaching practices to which a child is exposed. Research indicates that the teacher quality a child encounters in one year has little relation with teacher quality the following year, even within the same school (NICHD-ECCRN, 2005; Pianta, Belsky, Houts, Morrison & NICHD-ECCRN, submitted). If the quality of teacher practices varies from year to year and influences children's perceptions for that year, then children's previous perceptions will not be a good indicator of future academic outcomes.

The mediation model revealed children's perceptions were a partial mediator of the concurrent relation between *RC* practices and social skills. This result suggests that children's increased bonding to school partially explains the mechanism that underlies the relation between teacher practices and children's social competence within a single year.

Contrary to our hypothesis, children's perceptions did not mediate the relation between *RC* teacher practices and academic performance. However, *RC* teacher practices related directly to both children's perceptions of the classroom and social and academic competence. *RC* teacher practices may exert more influence over children's academic performance and account for enough variance to the extent that it renders the contribution of children's perceptions undetectable.

The lack of association between child perceptions and academic performance across grade levels may lie in the normative fluctuations of school bonding trajectories in elementary school interventions. Hawkins et al (2001) found that children exposed to the Seattle Social Development Intervention, along with a control group, experienced a decrease in school bonding until age 16. Yet, by age 18, only the intervention group experienced significant bonding to school, increased academic achievement and pro-social behavior along with reduced susceptibility to crime, substance abuse, teen pregnancy, and school dropout or expulsion. These findings suggest that children exposed to socio-emotional interventions during elementary school may reap long-term benefits through late adolescence and into adulthood, but that these benefits may not be captured at the time of intervention. Perhaps certain teacher practices instill protective factors in children that remain latent during the tumultuous transition through early adolescence and only become evident once the child matures and is increasingly called upon to make major life decisions (Hawkins et al, 2001). Because the present study examines children's perceptions exclusively during elementary school, long-term effects can not be detected. Our findings suggest that perceptions of the classroom are not strongly related to children's future outcomes. Yet, it is still worthwhile to understand the nature of children's perceptions of school as well as the teacher practices that contribute to their change because of the likelihood of sleeper effects, where the full potential of such elementary school interventions can not be realized until later in children's development.

Limitations

This study had two limitations requiring mention. As noted above, the longitudinal nature of the study was modest. This study was conducted over a 3 year period; yet other research suggests that children exposed to interventions in earlier grades and for longer periods of time will make even greater gains socially and academically (Hawkins et al, 2001). Further investigation into the cumulative benefits of exposure to *RC* practices will help practitioners maximize the potential of the intervention.

Second, findings from this study do not allow for causal assertions about the effects of *RC* implementation due to the quasi-experimental nature of the design. Nonetheless, taken together, findings reveal an encouraging pattern of positive associations that merit further exploration.

Conclusion

As national attention turns to what works for whom and why, this study has important implications for public interest (U.S. Department of Education, 2003). Use of the *RC* Approach is widespread with over 60,000 teachers trained to implement *RC* practices. Yet, scant research exists that (a) addresses the effectiveness of *RC* teacher practices or (b) describes the mechanisms under which the *RC* Approach operates. The present study represents an early step in the development of a research base related to the *RC* Approach. A randomized-controlled trial is the logical next step to advance research on the effectiveness of the *RC* Approach and improve generalizability across contexts.

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Table 1. Means, Standard Deviations and Correlations

	1	2	3	4	5	6	7	8	9	10	11
Mean	0.89	0.53	119.83	127.92	125.74	1.48	1.53	1.53	47.14	47.82	49.55
Standard Deviation	1.20	0.50	31.71	24.88	26.47	0.43	0.40	0.42	12.96	11.98	12.08
1.Risk	1.00										
2. Male	.04	1.00									
3. *RC* Practices- G3	-.03	-.01	1.00								
4. *RC* Practices - G4	-.13*	-.06	.26*	1.00							
5. *RC* Practices - G5	-.05	-.20	.37*	.18*	1.00						
6. Social Skills- G3	-.07*	-.20*	.27*	.17*	.11	1.00					
7. Social Skills- G4	-.05	-.09	.12	.32*	-.11	.39*	1.00				
8. Social Skills- G5	-.09*	-.38*	.34	.35	.02	.43*	.65*	1.00			
9. Mock Report Card- G3	-.14*	-.16*	.21*	.08*	.03	.81*	.36*	.34*	1.00		
10. Mock Report Card- G4	-.08	-.05	.27*	.14	-.19	.46*	.77*	.58*	.55*	1.00	
11. Mock Report Card- G5	-.17*	-.11*	.33	.16	-.17	.52*	.66*	.77*	.53*	.81*	1.00
12. Standardized Reading- G3	-.18*	.00	.29*	.15*	-.06	.53*	.30*	.35*	.74*	.52*	..59*
13. Standardized Reading - G4	-.08	.01	.17	.14	-.33	.27*	.48*	.37*	.34*	.70*	.63*
14. Standardized Reading - G5	-.30*	-.02	.28	.23	-.18	.40	.45*	.42*	.59*	.60*	.69*
15. Standardized Math- G3	-.20*	.04	.36*	.07	.09	.54*	.34*	.42*	.66*	.57*	.71*
16. Standardized Math- G4	-.11	.06	.20	-.22*	-.10	.40*	.24*	.28	.57*	.64*	.54
17. Standardized Math- G5	-.23*	.08	.46	.15	-.02	.38*	.53*	.44*	.48*	.68*	.76*
18. Child Perceptions- G3	.00	-.07	.37*	-.06	.28	.19*	-.05*	-.01	.13*	.16	.22
19. Child Perceptions- G4	.07	-.05	.08	.21	-.11	.17	.36*	.23	.13	.25*	.20
20. Child Perceptions- G5	.22*	-.33*	.13	.04	.12	-.12	.19	.41*	-.26	.26	.24

Notes:

Full Information Maximum Likelihood estimates of the means, standard deviations, and correlations

'*' indicates a significant pairwise correlation at the 0.05 level (2-tailed)

12	13	14	15	16	17	18	19	20
54.55	62.34	68.25	1.58	1.56	1.65	0.16	-0.02	-0.17
14.34	12.49	13.11	0.69	0.59	0.67	2.57	2.53	3.65
1.00								
.54*	1.00							
.82*	.70*	1.00						
.70*	.41*	.64*	1.00					
.53*	.60*	.40	.69*	1.00				
.60*	.55*	.69*	.74*	.37	1.00			
.18*	.14	.17	.27*	.24*	.16	1.00		
.16*	.17*	.21	.03	.00	.12	.29*	1.00	
-.11	.16	-.02	.03	.08	.06	.41*	.30*	1.00

Notes:
Full Information Maximum Likelihood estimates of the means, standard deviations, and correlations
'*' indicates a significant pairwise correlation at the 0.05 level (2-tailed)

Table 2. Model Fit Statistics from Cross-Lag Autoregressive Models

	Model 1 Social Skills	Model 2 Standardized Math	Model 3 Standardized Reading	Model 4 Teacher ratings of academics
Chi-Square	111.71	171.90	176.73	129.98
df	35	35	35	35
RMSEA	.07	.09	.09	.07
RMSEA C.I.	.05-.08	.08-.1	.08-.10	.06-.09

Notes:

Chi-Square = Full Information Maximum Likelihood Chi-Square, df = degrees of freedom, RMSEA = Root Mean Square Error of Approximation (Steiger & Lind, 1980), RMSEA C.I. = RMSEA Confidence Interval

Figure 1. Path diagram of autoregressive cross-lagged model.

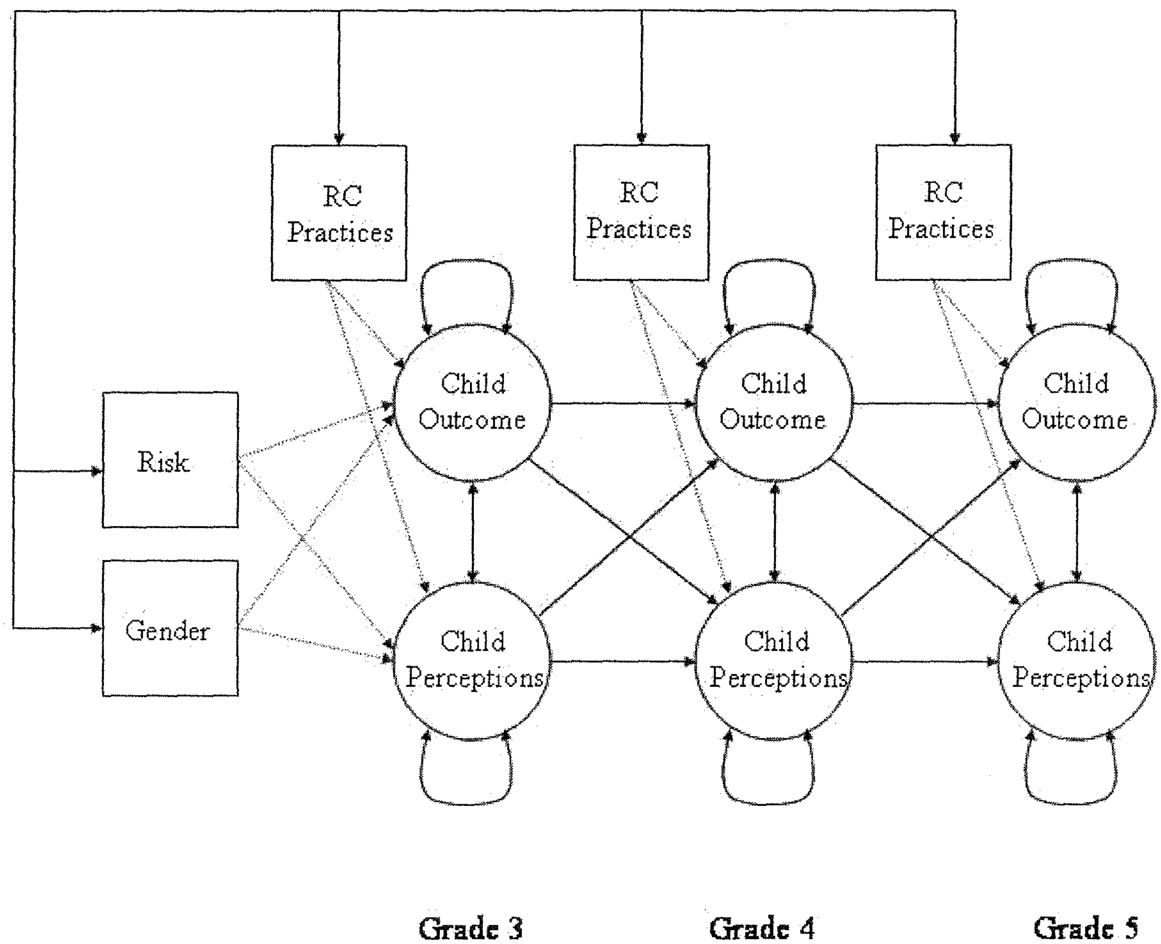


Figure 2. Results for model with teacher-rated social skills.

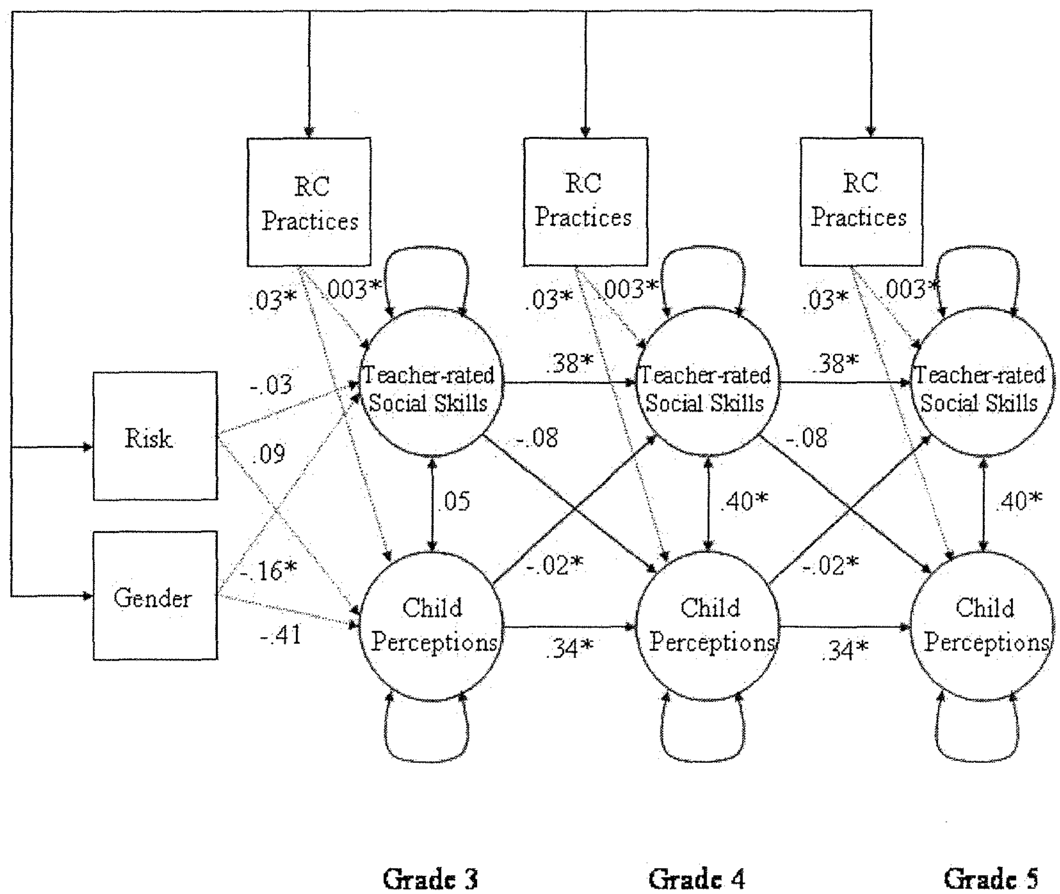


Figure 3. Results for model with teacher-rated academic skills.

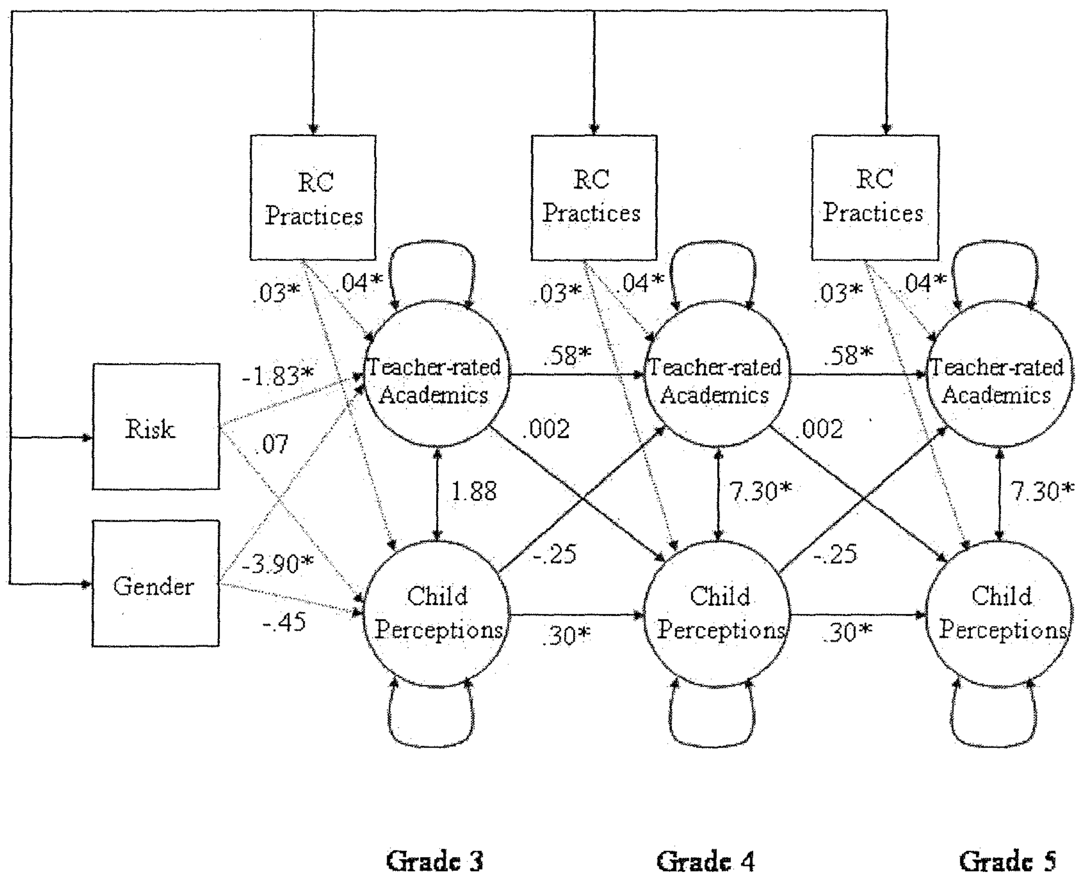


Figure 4. Results for model with standardized math scores.

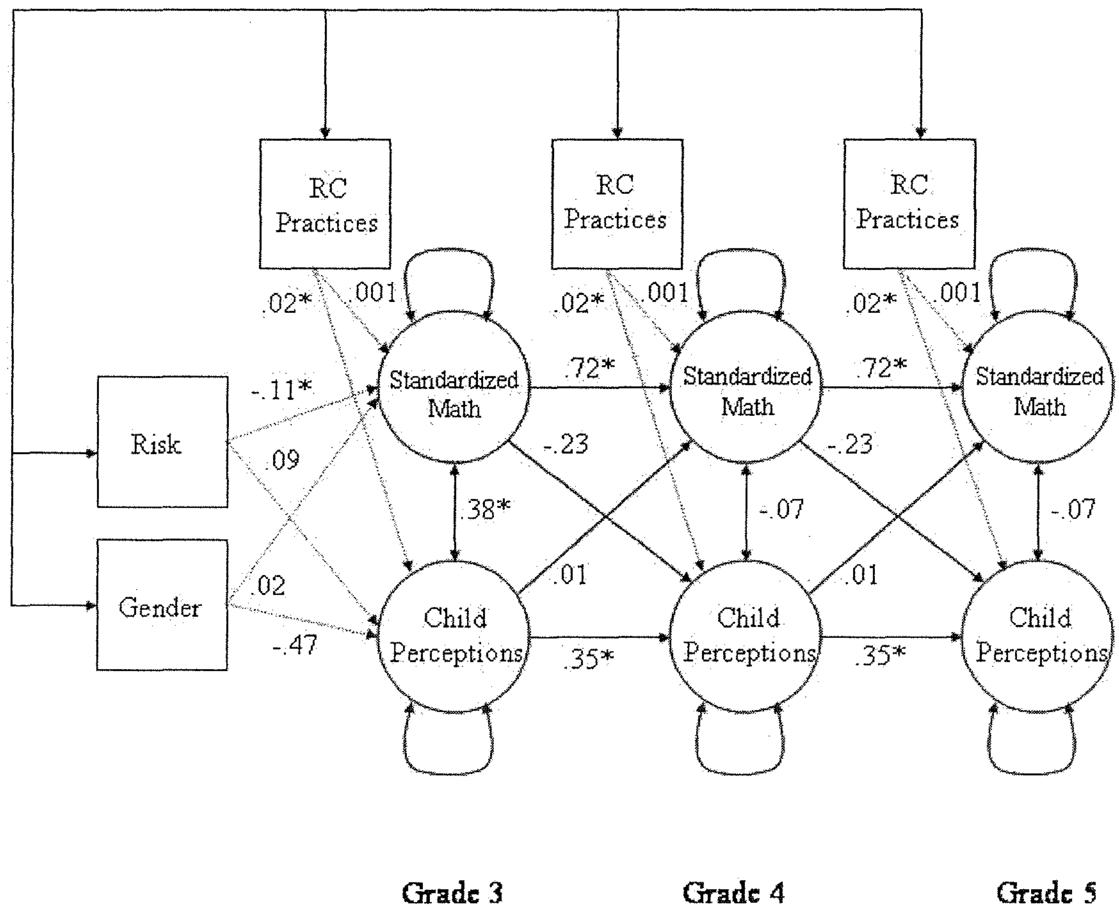
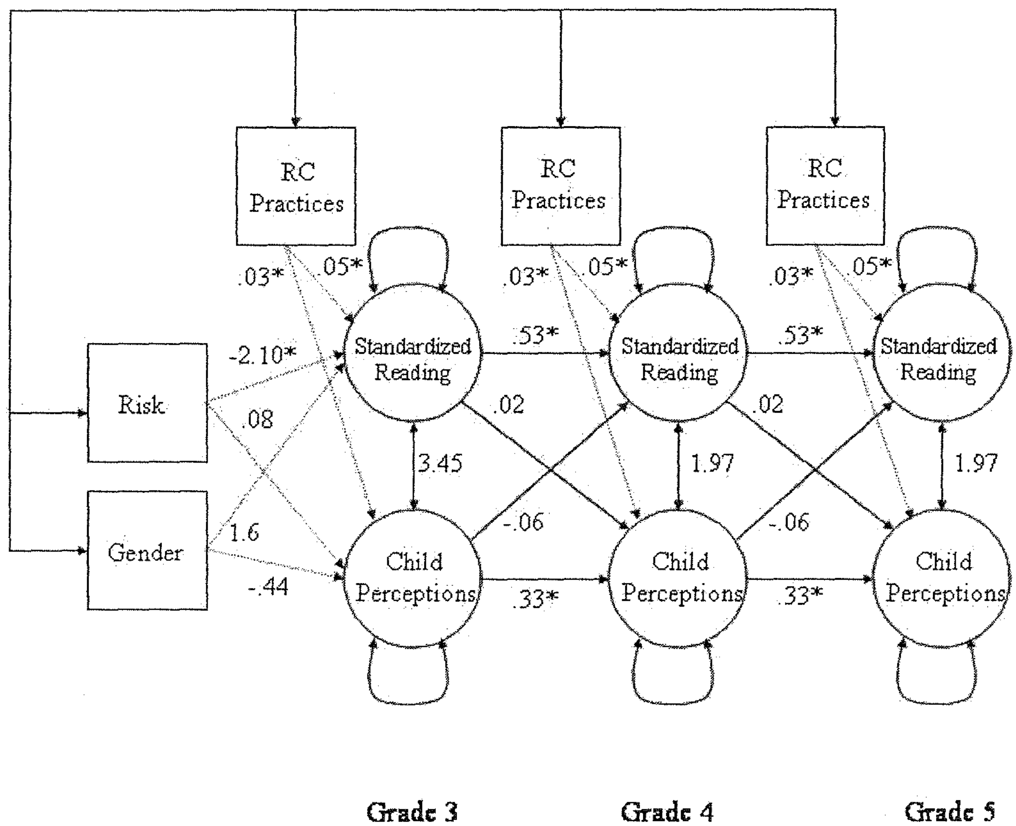


Figure 5. Results for model with standardized reading scores.



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MANUSCRIPT TWO

The Contributions of 'Hot' and 'Cool' Executive Function to Children's Academic Achievement and Adaptive Classroom Behavior in Kindergarten

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Abstract

Executive Functioning (EF) refers to higher-order cognitive processes considered foundational for problem solving. EF has both ‘cool’ cognitive and ‘hot’ emotional components. This study asks: (a) what are the relative contributions of ‘hot’ and ‘cool’ EF to children’s academic achievement? (b) What are the relative contributions of ‘hot’ and ‘cool’ EF to children’s display of adaptive classroom behaviors? (c) Do adaptive classroom behaviors mediate the relation between EF and achievement? For a sample of 174 kindergarteners, cool EF predicted both achievement and adaptive classroom behavior. Hot EF predicted adaptive classroom behavior but not achievement. Adaptive classroom behavior mediated the relation between cool EF and achievement, yet cool EF still contributed unique variance to gains in math.

The Contributions of 'Hot' and 'Cool' Executive Function to Children's Academic Achievement and Adaptive Classroom Behavior in Kindergarten

Contemporary conversations about school readiness present contradicting views. On one hand, a body of literature points to children's emotional and behavioral regulation as primary mechanisms driving school readiness (Blair, 2002; Raver, Garner, & Smith-Donald, 2007). Children who are emotionally prepared to comply with the demands of the classroom exhibit adaptive classroom behaviors that facilitate learning. For example, children who are able to share or take turns will be better equipped to engage with peers and learning materials, resulting in more opportunity for learning. In practice, most kindergarten teachers regard children's behavioral regulation as more important than children's academic knowledge in predicting their adjustment to kindergarten (Lin, Lawrence, & Gorell, 2003; Rimm-Kaufman, Pianta, & Cox, 2000), corroborating the view that children's socioemotional development drives school readiness.

On the other hand, policy increasingly emphasizes children's pre-academic skills as criteria for school readiness (The School Readiness Act of 2005). Empirical evidence supports this trend. A meta-analysis of six longitudinal studies consistently pointed not to children's socio-emotional functioning, but rather pre-academic skills and learning-related abilities, notably attention, as the important predictors in children's later achievement (Duncan et al., 2007). This recent finding raises a question: What ingredients, or combination of ingredients, do children need to succeed in the early years of school? The extent to which children's executive functioning (EF) contributes to early school success becomes an important topic to be addressed.

EF refers generally to the coordination of higher-order cognitive processes (including inhibitory control, working memory, and attention) considered foundational to problem-solving (Zelazo, Mueller, Frye, & Markovitch, 2003). As such, EF can be implicated in any novel situation that requires active control over one's thoughts and actions, making EF cumbersome to parse. One suggestion is to conceptualize an emotional component of EF (one that facilitates emotion regulation) and a cognitive component of EF (one that facilitates cognitive regulation) as two interrelated but distinct constructs (Blair et al., 2007, Metcalfe & Mischel, 1999). Zelazo and Muller (2002) applied the terms *hot EF* to describe the ability to problem-solve in an emotionally-laden context, and *cool EF* to describe the ability to problem-solve in an emotionally neutral context.

Applied to classrooms, children encounter abstract concepts and symbols (e.g., numbers and letters) and the extent to which they successfully engage with these materials is dictated, in part, by their attention, memory for instructions, and inhibitory control. Children also encounter problems that have an emotional valence, including tempting distractions and unpredictable consequences. They must wait for a turn, inhibit impulses to play with peers or toys, and comply with the demands of the classroom.

Recent laboratory research suggesting EF performance can be improved through intervention (Dowsett & Livesey, 2000; Klingberg et al., 2005; Oleson, Westerberg, & Klingberg, 2005; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). Because EF is amenable to change in highly controlled laboratory settings, children's EF performance may be a suitable target for classroom interventions (Diamond, Barnett, Thomas, & Munro, 2007). This study addresses a need to bridge basic and applied research by examining how performance on EF tasks relates to children's authentic classroom experiences. Findings from this study may uncover aspects of EF that are most predictive of children's successful transition to kindergarten.

Hot and Cool EF

The distinction between hot and cool EF has both a biological basis and behavioral corollaries (as measured by EF task performance). Neuroimaging evidence reveals two discrete brain regions are invoked for problem-solving: one that coordinates emotional processing and one that coordinates cognitive processing (Bechara, Damasio, Damasio & Anderson, 1994; Bush, Luu, & Posner, 2000). These two regions are functionally related to hot and cool EF. Adults with brain damage to the region responsible for cool EF lose the ability to learn novel material, or problem-solve new solutions, while brain damage to the region associated with hot EF results in impulsivity, an inability to engage in perspective-taking, and inappropriate behavior (see Ward, 2006).

Several tasks have been validated that tap primarily into either hot or cool EF. Cool EF tasks are devoid of tangible punishment, reward, or uncertainty. Examples include (a) the Stroop test (1935): children presented with color names written with a non-matching ink must say the color of the ink and inhibit reading the name; (b) the pencil tap (Smith-MacDonald et al., 2006): children tap a pencil once if the researcher taps twice or twice if the researcher taps once; (c) Bear & Dragon (Kochanska, Murray, & Harlan, 2000): children follow directions given by bear, but not dragon.

Hot EF tasks have an emotional component that children must negotiate in order to successfully problem-solve. Examples include (a) snack delay: children presented with a treat have the option to receive a small portion immediately or wait a period of time for a larger portion (Mischel, Shoda, & Rodriguez, 1989); (b) the gift wrap task: children must not peek while a researcher noisily wraps a gift (Kochanska et al., 2000); (c) whisper: children must whisper the names of favorite cartoon characters; in so doing they demonstrate and ability to down-regulate responses to excitatory stimuli (Kochanska et al., 2000).

Although hot and cool task performance is correlated, the unique aspects differentially predict emotional, behavioral, and temperamental characteristics in children (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). This suggests a hot and cool EF distinction is useful.

EF and Children's Outcomes

The classroom environment offers a wealth of opportunities for children to demonstrate cognitive and emotional problem-solving. As such, hot and cool EF may be critical competencies for children's learning and behavior in the classroom.

Academic Achievement

In the classroom, children's achievement relies on the ability to remember instructions and represent the goal of the lesson (working memory), to attend to the important features of the lesson (executive attention), and to stay on task (inhibitory control). Most instructional content in classrooms is delivered in an emotionally neutral context (e.g., worksheets), suggesting cool EF will play an important role in achievement. However, the classroom environment is replete with emotional stimuli. Thus, the extent to which children engage with academic content may depend in large part upon hot EF abilities.

Cool EF. Empirical evidence suggests a link between cool EF and academic achievement with notable contributions to gains in math. A meta-analysis of large-scale data sets found that cool EF abilities were an important indicator of school readiness (Duncan et al., 2007). Studies conducted with preschoolers (McClelland et al., 2007), and kindergarteners (Blair & Razza, 2007) implicate cool EF task performance with growth in reading, writing, and math. In middle childhood, cool EF was related to achievement in language arts, math, and science (St. Clair-Thompson & Gathercole, 2006). Longitudinally, cool EF abilities at school entry predict academic outcomes in second grade after controlling for prior achievement and sociodemographic risk (McClelland, Morrison, & Holmes, 2000). Preschoolers' cool EF task performance predicted verbal comprehension, understanding directions, and math at first grade, but uniquely predicted math when cognitive ability was held constant (Clark & Woodward, 2007).

Cool EF may be important for achievement on standardized tests (McClelland et al., 2007), and appears play a greater role in achievement outcomes for children with lower scores on cognitive ability tests (Mahone et al., 2006). Cool EF may also be more important for children with sociodemographic risk factors. In a sample of children from low-income families, cool EF accounted for up to 40% of the variance in standardized test scores (Waber et al., 2006), suggesting that EF plays an important role in achievement for children at risk for school failure.

Hot EF. Research also shows a pattern of associations between children's hot EF and academic outcomes. Hot EF appears to play a role in adolescent achievement, but findings are scant in early childhood.

Few published studies exist linking hot EF task performance with achievement in early childhood. Teacher and parent ratings of emotion regulation may shed more light on the link between hot EF and children's learning. A meta-analysis of indicators of school readiness suggests that children's display of emotion regulation does not significantly add to achievement outcomes in elementary school (Duncan et al., 2007). Two studies contradict this finding. Preschool (Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003) and kindergarten (Trentacosta & Izard, 2007) teacher ratings of emotion regulation were related to achievement outcomes the following year. Research conducted with adolescents suggests hot EF plays a greater role in later achievement. One study found that preschoolers' hot EF task performance predicted SAT scores ten years later (Mischel, Shoda, & Rodriguez, 1989). In eighth grade, hot EF abilities accounted for more variance in GPA than IQ (Duckworth & Seligman, 2005). Thus, evidence suggests both hot and cool EF are important predictors of long-term achievement. Hot EF seems particularly critical for tasks requiring children to adapt their behavior to put in sustained effort for delayed rewards, such as earned school grades. In this study, we explicitly examine links between EF tasks classified as hot versus cool and aspects of children's school performance, including achievement and adaptive classroom behavior.

Adaptive Classroom Behavior

Children's behavior in the classroom relies on mental representation of rules and routines (working memory), the ability to comply with teacher demands without distraction (executive attention), and the ability to control impulses in favor of doing what is required by the teacher (inhibitory control).

Cool EF. Of interest to prevention science, children appear to manifest cool EF deficits before problem behaviors, suggesting poor cool EF task performance may serve as an early marker of future problem behaviors (Riggs et al., 2003). In a study of preschoolers, children's cool EF task performance was related to behavioral regulation in the classroom (Cole, Usher, & Cargo, 1993). In another sample, poor cool EF task performance was predictive of problem behavior at age three, after controlling for social disadvantage and verbal ability (Hughes & Ensor, 2007). Longitudinally, cool EF deficits predicted steep problem behavior trajectories (Eisenberg et al., 2000; Zhou et al., 2007). Cool EF deficits in kindergarten were more predictive of high school dropout than observed aggression or opposition (Vitaro, Brendgen, Larose, & Tremblay, 2005). In adolescence, cool EF deficits were associated with poor behavior and peer rejection (Clark, Prior, & Kinsella, 2002).

Hot EF. Hot EF skills may be an important contributor both to children's behavior and relationships formed in the classroom. Hot EF skills influence children's adaptive classroom behavior (Mischel et al., 1988), as well as positive relationships with teachers and peers (Blair, Denham, Kochanoff, & Whipple, 2004; Raver, Blackburn, Bancroft, & Torp, 1999; Spinrad et al., 2006). Perhaps the extent to which children bond to school and the quality of teacher and peer relationships are partially determined by hot EF. In support of this hypothesis one study found school liking mediated the relation between EF and academic competence (Valiente, Lemery-Chalfant, & Castro, 2007). Gender may moderate the link between hot EF and problem behaviors. In one study, poor hot EF task performance was more indicative of problem behavior for girls (Hill, Degnan, Calkins, & Keane, 2006).

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Method

Participants

Participants attended one of 36 kindergarten classrooms at seven elementary schools located in four rural school districts in the southeast. Participants were 174 children, 91 (52%) male, 83 (48%) female. Parents reported children's ethnicity as follows: 126 (72.5%) Caucasian American, 29 (17%) African American, 6 (3%) other, 13 (7.5%) unreported. Participants also included 36 kindergarten teachers (1 male, 35 female). Teaching experience ranged from 1-37 years (mean=18 years).

Procedure

Parents of incoming kindergarten students were invited in person to participate during kindergarten registration and open house night. Parents completed a *Family Demographic Questionnaire* as they gave consent for their child to participate in the study. Parents of 333 kindergarteners signed consents. To obtain a final sample of 174 child participants, between four to six children were randomly selected from the consented students in each classroom. Chi-squared tests indicate the children selected in the final sample were not significantly different from the children whose parents consented to participate but were not selected. Teachers and principals were invited in person to participate in the study and received a stipend for their time.

In the fall and spring of kindergarten, research assistants administered EF and achievement tasks; children were also given a cognitive abilities test during a different sessions. These tasks were given to each child individually in a quiet location at school in the morning Each study child was observed approximately five times throughout the school year for a period of 15 minutes. Research assistants blind to the aims of the study observed in the classroom then rated *Children's Observed Engagement in Learning* (*Name omitted for blind review*, 2005).

In the spring teachers completed questionnaires regarding children's classroom behavior and achievement.

Measures

Independent Variables

The *Family Demographic Questionnaire* is a 10-item questionnaire describing the demographic characteristics of families. Parents reported their family income, maternal education, and marital status. The presence of each risk factor (i.e., family income less than $30,000, mothers' education high school or less, or single parent status) was coded as 1 and summed to create a composite indicator of family risk. Of the 174 families, 126 or 72% were identified as having one or more risk factors (low family income, single parent status, low maternal education). Parents were also asked whether the child had preschool or daycare experience.

The *Woodcock-Johnson III Test of Cognitive Abilities-Brief Intellectual Assessment (BIA)* is a widely recognized test of children's cognitive ability (Woodcock, McGrew & Mather, 2001). The BIA is comprised of three subtests: verbal comprehension, concept formation, and visual matching. Children's raw scores were converted into standardized W-scores taking into account age and school experience.

Hot and Cool EF. A live-coding battery, adapted from the Preschool Self-Regulation Assessment-PSRA (Cameron & Morrison, 2007: PSRA, Smith-MacDonald et al., 2006), was comprised of four tasks designed to tap different dimensions of executive function. Modifications during a piloting phase confirmed variability in a sample of kindergarten students. Raters administered the tasks during a piloting phase of the battery and dual coded to collect reliability data. An intraclass correlation coefficient between the two raters (two-way random model) across nine children equaled .99.

Cool EF was measured using the *Balance Beam* task and the *Pencil Tap* Task. In the *Balance Beam* task, children were asked to walk along a six-foot long piece of tape on the floor for three timed trials. The first trial, they were simply instructed to pretend the tape was a balance beam to habituate to the task. The second trial, children were asked to walk along the line as slowly as possible and research assistants verified children understood the directions. Research assistants repeated the instructions and timed the third trial. Children's rating on this task was determined by the time in seconds on the third trial. In the *Pencil Tap* task, children were asked to tap a pencil once when the examiner tapped the pencil twice and to tap twice when the examiner tapped once. Research assistants verified children's understanding of the task during a warm-up phase consisting of three trials. After children demonstrated an understanding of the task, they were given 16 scored trials. The incorrect number of taps (including errors and omissions) were tallied. These tasks have been validated and widely used in other research (see Blair & Razza, 2007; Diamond & Taylor, 1996; Kochanska, Murray, & Harlan, 2000).

Hot EF was measured through a *Toy Sort* task and two components of the *Gift Wrap* task. The *Toy Sort* task required children to sort a variety of attractive toys (e.g. toy cell phones) into bins without playing with them. A research assistant instructed, "These are a few of my favorite toys, but we don't have time to play with them today. Please don't play with these toys." Children were shown where each toy goes in the bin when the research assistant placed one of each of the toys correctly in the bins and were rated on whether they played with the toys at any time during the task. For children who did play with the toys, the elapsed time until they first played with the toys was recorded in seconds. During the *Gift Wrap* task, a research assistant explained to the child she brought a surprise, but forgot to wrap it. Children were situated with their backs to the table and instructed not to 'look' while the researcher noisily wrapped the gift for one minute. Children were rated on whether they looked (i.e., turned around) while the gift was being wrapped. The time at which they first looked was recorded in seconds. After the minute passed, children were reoriented toward the table and the gift was placed 6 inches away. Children were asked to wait an additional minute before opening the gift. Children were then rated on whether or not they touched the gift. The time at which they first touched the gift was recorded in seconds. These tasks have been validated and widely used in other research (see Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Kochanska at al, 2000; Li-Grining, 2007).

Dependent Variables

The *Woodcock-Johnson III Tests of Achievement* letter-word identification and applied problems subtests (Woodcock, McGrew, & Mather, 2001) are commonly used measures of children's early literacy and math skills. Children's raw scores were converted into standardized W-scores for both fall and spring measures.

The *Mock Report Card* (Pierce, Hamm, & Vandell, 1999) measured teachers' evaluation of children's work habits (six items, alpha=.95, e.g., "works well independently"). Teachers rated children's work habits on a scale of 1 to 5 (where 1 indicated very poor and 5 indicated very good). Teachers also rated children's academic performance (four items, alpha=.94, reading, oral language, written language, math) on a scale of 1 to 5 (where 1 indicated below grade level and 5 indicated excellent).

Adaptive classroom behaviors. Children's display of adaptive classroom behaviors is comprised of several related constructs and include teacher report of children's work-habits, self-control, self-directed behavior, hyperactive-distractibility, and direct observation of children's engagement in learning.

Two constructs were obtained from the *Social Competence and Adjustment Scale* (Ladd, Profilet, & Muth, 1996): (a) self-directed learning style (5 items, alpha=.85, e.g., "this child keeps working on tasks when he/she encounters difficulty) and (b) hyperactive-distractibility (5 items, alpha=.87, e.g., "This child has poor concentration or short attention span"). Teachers rated children on a scale of 1 to 3 (where 1 indicated "does not apply" and 3 indicated "definitely applies").

The *Teacher's Self-Control Rating Scale* (Humphrey, 1982) was a 15 item questionnaire using a 5-point frequency scale, alpha=.92, e.g., "this student makes careless errors because he/she rushes through work", "this student has to have things right away".

The *Observed Engagement in Learning Scale* (Name omitted for blind review, 2005) was an observational tool adapted from the NICHD Study of Early Child Care (NICHD-ECCRN, 2005). A research assistant observed a study child during 15 minutes of academic classroom time then rated five classroom behaviors on a scale from 1 to 7 (7 indicating high evidence or frequency of behavior): a) self-reliance, b) attention, c) disruptive behavior (reverse coded), d) compliance, and e) engagement. The five dimensions were summed to form a composite measure of engagement in learning (alpha=.88). The intraclass correlation was .89 across 20 dual-rated cases.

Results

The default approach is to examine EF under a one-factor model comprised of all EF variables (i.e., balance beam, pencil tap, gift wrap, and toy sort). Theoretically, hot and cool EF suggests a two-factor model may be a better a better fit. To test this alternative approach, the fit of a one factor model was compared to the fit of a two factor model in M-Plus.

To appropriately model the variables, the number of incorrect pencil tap trials and the time measurements for the toy sort and gift wrap were treated as censored variables (Jöreskog, 2002). Censored variables account for a large proportion of cases at the minimum or maximum, in this case, the uneven distribution of children who tended not to peek at the gift or touch the toys. The two-factor model fit slightly better than the one factor model ($X^2\Delta$=25.9, $df\Delta$=1, p<.05). Factor score estimates from the two factor model were used as predictors in subsequent regressions analyzing academic achievement and adaptive classroom behaviors in the kindergarten year.

Due to the nested nature of our data (children within classrooms) an intraclass correlation (ICC) was computed for each outcome variable to determine if there was any significant classroom level variance. All ICCs were nonsignificant with the exception of the classroom observations of engagement in learning (ICC=0.22, p<.01). Analyses were run using both Hierarchical Linear Modeling and hierarchical regression. Since findings were similar, and classroom level predictors were not of interest in the present study, regression results with standardized betas are presented here.

Descriptive statistics (means, standard deviations) and correlation coefficients were computed for predictor, control, and outcomes variables. Hierarchical regressions were conducted to examine the respective contribution of cool or hot EF skills upon school entry to children's academic performance and adaptive classroom behaviors (first modeled as a predictor, then as a mediator of school achievement) at the end of the school year. For all models, gender, family risk, and preschool experience were entered as a first step. Cognitive ability was entered second. For the standardized math and reading outcomes, fall scores were entered as a third step. Either cool or hot EF factor scores were entered at the last step. Finally, the significant achievement outcome variables were entered into a mediation model to test the extent to which adaptive classroom behaviors mediated the relation between EF and academic achievement (Baron & Kenny, 1986). Results are presented in Tables 2-6. The amount of variance explained at each step is indicated in the tables by the change in R^2. The standardized betas are reported at the final step with all variables added to the model.

Descriptive Statistics

Table 1 reports means, standard deviations, and Pearson correlation coefficients for all variables in the analyses. Overall, cool EF was more strongly and more frequently correlated to academic and behavioral outcomes than hot EF. Cool EF showed a stronger correlation to academic outcomes than behavioral outcomes. By contrast, hot EF showed a stronger correlation to behavioral outcomes than academic outcomes. Hot and cool EF were correlated, but only had 26% overlap in variance.

Control Variables

Gender did not predict differences in achievement. Boys were rated less favorably by teachers on work habits and self-control and by observers on engagement in learning. Family risk was nonsignificant for all outcomes. Preschool experience was nonsignificant in predicting achievement. Children who attended preschool were more likely to be rated by their teachers as possessing more self-control, better work-habits, and less hyperactive distractibility. Children who attended preschool were also rated by independent observers as exhibiting more engagement in learning. At step one, gender, family risk, and preschool experience accounted for up to15% of variance explained. At step two, cognitive ability accounted for 25%-27% of the variance explained for academic outcome analyses and 5%-12% of the variance explained for the adaptive classroom behavior analyses, after controlling for step one socio-demographic variables. Fall math and reading scores were entered at step three for corresponding spring standardized test score analyses and accounted for an additional 13%-15% of the variance, after controlling for socio-demographic variables and cognitive ability.

Academic Performance

Tables 2 and 3 depict regression analyses predicting children's achievement by hot and cool EF task performance. Table 2 shows cool EF task performance accounted for 2% of the variance for teacher report of academic performance, after controlling for covariates (i.e., gender, family risk, preschool experience, and cognitive ability upon entry to kindergarten). It is important to note the unique contribution of cool EF to children's academic performance, above and beyond cognitive ability. Table 2 indicates that cool EF task performance accounts for 3% of the variance for gains in standardized math scores, even after controlling for all covariates (i.e., gender, risk, preschool experience, cognitive ability, and math scores upon school entry). The model predicting gains in reading scores by cool EF task performance was nonsignificant (Table 2). As Table 3 indicates, children's hot EF task performance upon entry to kindergarten did not predict children's academic outcomes.

Adaptive Classroom Behaviors

Table 4 reveals that children who performed better on cool EF tasks upon entry to kindergarten were more likely to be rated by their teachers as possessing more adaptive classroom behaviors on all four teacher-rated dimensions. Cool EF task performance accounted for 4-6% of the variance in children's display of work habits, self-control, self-directed behavior, and hyperactive distractibility, after controlling for covariates. Further, multiple independent observations revealed that children's cool EF performance was predictive of children's engagement in learning, accounting for 2% of the variance after controlling for covariates. Because engagement in learning was measured at several time points throughout the school year by observers blind to the study, this finding is particularly useful for both corroborating the teacher report data and highlighting the role cool EF plays in children's daily functioning throughout the kindergarten year.

As table 5 indicates, hot EF predicted teacher ratings of children's adaptive classroom behavior, though less consistently across indicators. Children who performed better on hot EF tasks also exhibited better work habits, more self-control, and less hyperactive distractibility. Each of these factors accounted for 5% of the variance, even after controlling for gender, risk, preschool experience, and cognitive ability. Hot EF did not explain any variance in teacher's rating of self-directed behavior or observed engagement in learning.

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Classroom Behavior as a Mediator of the Relation between Cool EF and Achievement

To examine the potential mediating role of children's adaptive classroom behavior in the relation between cool EF and achievement, regression analyses were conducted for teacher rated academic performance and gains in standardized math scores. As Table 6 indicates, identical models for the statistically significant academic outcome variables were re-run with classroom behavior outcomes added as mediators.

The model for teacher rated academic performance revealed that cool EF, entered at the last step, became statistically nonsignificant after the variance explained by children's behavior was partialed out. The model for gains in standardized math scores revealed that cool EF still accounted for some of the variance in children's math scores. The initial regression equation predicting math scores by cool EF (Table 2) revealed an $\Delta R^2=.029$, $p<.01$, whereas, once classroom behaviors were added to the model, cool EF maintained an $\Delta R^2=.019$, $p<.05$ (Table 6). Thus, adaptive classroom behavior fully mediated the relation between cool EF and teacher report of academic performance. Adaptive classroom behavior partially mediated the relation between cool EF and children's standardized math scores, but cool EF still accounted for variance in math over and above the contribution of adaptive classroom behaviors.

Discussion

The present study offers insight into aspects of EF that contribute to success in kindergarten in both academic and social domains via direct observation, teacher report, and observation data. Three major findings emerge. First, children's display of cool EF predicted both academic performance and adaptive classroom behavior. This finding was evident even after controlling for many factors often linked to these outcomes, implicating the importance of cool EF for children's successful transition to school. Second, hot EF did not predict kindergarteners' academic achievement but was an important predictor of adaptive classroom behaviors. Third, adaptive classroom behaviors partially mediated the relation between cool EF and achievement, thus elucidating the underlying mechanisms that help explain the relation between cool EF and children's academic outcomes. Taken together, it is important to understand these findings in light of current discussions about what ingredients constitute school readiness.

Anomalously, family risk and preschool experience did not explain variance in the models analyzing academic achievement. These results may be due to the rural nature of the sample. Families with increased financial resources do not necessarily have more options for exposing children to enriching activities. Likewise, geographical restraints limit choices for preschool settings.

Cool EF

Cool EF predicted every child outcome, both academic and behavioral, with the exception of gains in standardized reading scores. The consistency with which cool EF predicted children's academic and behavioral outcomes is noteworthy in light of the fact that cognitive ability, test scores at school entry, and sociodemographic factors were all held constant.

As hypothesized, cool EF predicted teacher ratings of children's academic performance and standardized math scores. The skills required to perform well on cool EF tasks, including executive attention, inhibitory control, and working memory, are necessary precursors to learning. Other recent empirical investigations corroborate these findings. A meta-analysis of six large-scale longitudinal studies found that attentional indicators of cool EF were consistently predictive of children's academic outcomes, above and beyond cognitive ability and achievement levels at school entry (Duncan et al., 2007). In a sample of low-income children, inhibitory control (as measured by a peg-tap task similar to the pencil-tap administered in this study) prior to kindergarten entry predicted math and literacy achievement in kindergarten, above and beyond cognitive ability (Blair & Razza, 2007). Scores on working memory tasks have likewise shown strong associations with academic achievement (St.Clair-Thompson & Gathercole, 2006).

In this study cool EF did not predict gains in standardized reading scores during the kindergarten year. One reason for our lack of findings may be that the intense focus on reading achievement in kindergarten is such that most children show gains, regardless of EF skills. Studies of kindergarten classrooms indicate children spend a large proportion of time in teacher-directed literacy instruction (Pianta, La Paro, Payne, Cox, & Bradley, 2002). One study of rural kindergarten classrooms, comparable to classrooms in this study, found that children spent an average of 28% of the school day on language arts (also the largest amount of time spent on any subject), whereas only 6% of the school day was devoted to math (Hofer, Farran, Lipsey, Hurley, & Bilbrey, 2006). If kindergarten teachers exert most of their energy toward language arts, perhaps the majority of children receive sufficient quantity of reading instruction to make gains regardless of executive functioning at school entry. The fact that kindergarten children spend very little time in class developing math skills may also help explain our significant findings for math scores (Hofer et al., 2006). Children with stronger attention, memory, and inhibitory control upon entry to kindergarten may be more sensitive to small amounts of math instruction because of their ability to attend to and persist at a task.

Children who demonstrated strong cool EF skills were also more likely to be rated by their teachers as exhibiting better classroom behaviors. Independent observers also rated these same children as exhibiting more engagement in learning. Skills required for cool EF performance include paying attention, waiting for a turn, and staying on task. These are the same skills that are most often cited by teachers as being the critical ingredients for children's successful transition to kindergarten (Lin et al., 2003; Rimm-Kaufman et al., 2000). School readiness literature indicates that adaptive classroom behaviors are a necessary precursor to learning (Blair, 2002; Raver, 2002). Further, children who are engaged in learning and exhibit self-directed behavior are likely to make gains in achievement outcomes relative to those who are not engaged (Duckworth & Seligman, 2005).

Hot EF

Results of this study clearly point to a lack of association between hot EF and academic outcomes in kindergarten. This finding is consistent with other research on children's school readiness (see Duncan et al., 2007). One explanation may lie in the nature of kindergarten classrooms. Teachers anticipate many children will enter kindergarten lacking the capacity to regulate their emotional responses (Rimm-Kaufman et al., 2000). One potential explanation, which merits empirical inquiry, is that kindergarten teachers may structure the learning environment to support and compensate for students with few hot EF skills. Because of the structure of the kindergarten classroom (e.g., less choice, more teacher-directed activities) children with emergent hot EF skills may not spend less time engaged in learning (as evidenced by the nonsignificant relation between hot EF and observed engagement in learning). In classrooms where children's attention is teacher-managed, children may have the same opportunities for learning regardless of hot EF skills, and thus achieve at a similar pace. Beyond kindergarten, classroom contexts may not be as well aligned with children's developmental needs. Teachers may expect children to regulate their own emotions in order to attend to academic tasks, impacting achievement outcomes for children with poor hot EF skills.

Hot EF did show a pattern of associations with children's display of some, but not all, measured adaptive classroom behaviors. Results from this study suggest that children who perform better on hot EF tasks (via the ability to regulate an emotional response to stimuli) are also more adept at displaying adaptive classroom behaviors, specifically demonstrating better work habits, more self-control, and less distractibility.

Children's Behavior as a Mediator between EF and Academic Outcomes

Children's classroom behaviors fully mediated the relation between cool EF and teacher rated academic performance, but only partially mediated the relation between cool EF and math test scores. This discrepancy can be explained in terms of the different reporting sources for each outcome, and in terms of the unique contribution of EF on math ability.

Standardized test scores are an indicator of children's ability level, whereas teacher report of academic performance encompasses a global rating of children's daily efforts and accomplishments in academic activities. Children's classroom behavior may affect teachers' perceptions of academic performance. Teacher ratings of children's performance may also be more susceptible to subjective interpretation (Mashburn, Hamre, Downer, & Pianta, 2006). In a study analyzing a large representative sample of kindergarten children, teachers' ratings of children's behavior accounted for 13% of the variance in teacher-rated academic performance, but only 2% of the variance in test scores. By contrast, cognitive ability accounted for 3% of the variance in teacher rated academic performance and 15% of the variance on test scores (Schaefer & McDermott, 1999). This finding corroborates our results indicating children's behavior has a greater relative impact on teacher ratings of academic performance than on standardized measures of achievement.

Children's classroom behavior only partially mediated the relation between cool EF and math test scores, indicating that cool EF has an association with math ability that is distinct from prior math knowledge, cognitive ability, sociodemographic factors, and adaptive classroom behavior. These findings corroborate other studies drawing a link between cool EF and math ability (see Blair & Razza, 2007; Clark & Woodward, 2007; Espy et al., 2004). Research emanating from cognitive science suggests that EF and math ability might be connected at the neural level (Blair et al., 2007). Brain imaging studies reveal the regions responsible for children's conceptual math understanding (as opposed to learning rote math) share space with the regions associated with EF development (see Blair et al., 2007). Thus, children who perform well on cool EF tasks may have a unique advantage on tests of mathematical ability.

Practical significance

Results from this study have implications for research and practice. First, the finding that EF task performance upon school entry predicts kindergarten outcomes adds to a body of literature on school readiness. Measures that take into account cognitive and emotional problem-solving abilities can identify children who will need additional support during the transition to kindergarten. Traditional measures of school readiness that focus on academic skills may not provide a complete picture of children's preparedness to meet the demands of the classroom (Raver, 2002). Moreover, although measurement has impeded the utility of this construct in the past, significant recent advances mean that we are increasingly able to assess EF in meaningful and practical ways (Carlson, 2005). The EF tasks in this study were easy and quick to administer, inexpensive, and predicted children's achievement and behavior outcomes above and beyond sociodemographic factors, cognitive ability, and academic skills at school entry.

Second, this study provides early evidence for designing and implementing EF interventions that account for both hot and cool EF development in a classroom setting. Recent research indicates that early EF functioning is amenable to change with exposure to training and opportunity for practice. Aspects of cool EF, including inhibitory control (Dowsett & Livesey, 2000) executive attention (Rueda, et al., 2005) and working memory (Klingberg et al., 2005; Oleson et al., 2005) improved with regular exposure to activities that provided opportunity to hone those skills. Too, hot EF is amenable to change although considerably less is known in this area (Toner, Moore, & Emmons, 1980).

Findings from previous studies reveal that EF can be improved. This study draws a link between hot and cool EF and classroom performance. Taken together, these two lines of research suggest intervention efforts focused on hot and cool EF development might be an effective strategy for improving children's behavioral and academic competence. The next step is to explore optimal instructional practices for improving children's EF performance and to examine the contributions of hot and cool EF performance over time. This research can inform the development of an intervention to test whether laboratory findings of EF improvement withstand the complex nature of the classroom environment.

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Table 1

Means, Standard Deviations and Correlations of Predictor and Outcome Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Mean	.00	.00	—	1.29	.61	445.58	351.75	408.69	423.98	440.54	13.99	21.87	55.50	12.13	12.13	21.77
Standard Deviation	.72	.87	—	1.04	.49	14.34	23.78	23.94	18.69	14.80	3.98	6.35	12.15	2.39	2.39	3.38
1. Cool Executive Function	—															
2. Hot Executive Function	.51**	—														
3. Gender (male = 1)	-.12	-.06	—													
4. Demographic Risk	-.31**	-.16*	.00	—												
5. Preschool Experience (yes=1)	-.03	.05	.00	-.07	—											
6. Cognitive Ability	.42**	.17*	-.19*	-.21**	.07	—										
7. Fall Reading Scores	.37**	.11	-.14	-.27**	-.17*	.54**	—									
8. Spring Reading Scores	.38**	.16*	-.16*	-.25**	-.04	.56**	.64**	—								
9. Fall Math Scores	.46**	.18*	-.07	-.30**	-.03	.67**	.59**	.48**	—							
10. Spring Math Scores	.46**	.18*	-.11	-.23**	.10	.56**	.58**	.53**	.68**	—						
11. Academic Performance	.38**	.16*	-.13	-.14	-.08	.53**	.62**	.62**	.59**	.62**	—					
12. Work Habits	.38**	.36**	-.30**	-.13	.19*	.38**	.30**	.40**	.39**	.43**	.57**	—				
13. Self Control	.38**	.33**	-.24**	-.13	.22**	.37**	.23**	.28**	.27**	.30**	.39**	.82**	—			
14. Self-Directed Learner	.40**	.20*	-.19*	-.15	.11	.39**	.40**	.36**	.42**	.48**	.61**	.77**	.70**	—		
15. Hyperactive-Distractible	-.33**	-.33**	.18*	.05	-.26**	-.35**	-.21**	-.26**	-.25**	-.27**	-.37**	-.75**	-.85**	-.69**	—	
16. Behavioral Engagement	.31**	.13	-.31**	-.19*	-.15	.30**	.18*	.41**	.28**	.28**	.29**	.59**	.61**	.41**	-.52**	—

* $p < .05$ ** $p < .01$

Table 2

Regression Analyses Predicting Children's Academic Performance by Cool Executive Function

	Block			Step (at final)		
Dependent and Independent Variables	*F* change	Sig	R2 change	Beta	*t*	Sig.
Teacher-Report of Academic Performance						
Step 1	2.488	.063	.047			
Gender				-.036	-.533	.595
Demographic Risk				-.033	-.471	.638
Preschool Experience				-.116	-1.701	.091
Step 2	55.031	.000	.253			
Cognitive Ability				.453	6.061	.000
Step 3	5.097	.025	.023			
Cool Executive Function				.172	2.258	.025
Standardized Reading Scores						
Step 1	6.350	.000	.106			
Gender				-.053	-.909	.365
Demographic Risk				-.097	-1.592	.113
Preschool Experience				-.006	-.101	.920
Step 2	62.565	.000	.251			
Cognitive Ability				.266	3.739	.000
Step 3	40.468	.000	.130			
Fall Reading Scores				.438	6.146	.000
Step 4	1.606	.207	.005			
Cool Executive Function				.081	1.267	.207
Standardized Math Scores						
Step 1	4.036	.008	.070			
Gender				-.034	-.598	.550
Demographic Risk				-.005	-.087	.930
Preschool Experience				.081	1.442	.151
Step 2	65.131	.000	.269			
Cognitive Ability				.162	2.167	.032
Step 3	48.981	.000	.156			
Fall Math Scores				.485	6.391	.000
Step 4	9.692	.002	.029			
Cool Executive Function				.196	3.113	.002

Table 3

Regression Analyses Predicting Children's Academic Performance by Hot Executive Function

	Block			Step (at final)		
Dependent and Independent Variables	*F* change	Sig	R2 change	Beta	*t*	Sig.
Teacher-Report of Academic Performance						
Step 1	2.488	.063	.047			
Gender				-.042	-.615	.539
Demographic Risk				-.063	-.898	.371
Preschool Experience				-.134	-1.958	.052
Step 2	55.031	.000	.253			
Cognitive Ability				.507	7.150	.000
Step 3	.810	.370	.004			
Hot Executive Function				.063	.900	.370
Standardized Reading Scores						
Step 1	6.350	.000	.106			
Gender				-.056	-.961	.338
Demographic Risk				-.111	-1.851	.066
Preschool Experience				-.012	-.194	.846
Step 2	62.565	.000	.251			
Cognitive Ability				.286	4.107	.000
Step 3	40.468	.000	.130			
Fall Reading Scores				.448	6.305	.000
Step 4	.188	.665	.001			
Hot Executive Function				.025	.433	.665
Standardized Math Scores						
Step 1	4.036	.008	.070			
Gender				-.045	-.781	.436
Demographic Risk				-.038	-.636	.526
Preschool Experience				.065	1.134	.258
Step 2	65.131	.000	.269			
Cognitive Ability				.196	2.568	.011
Step 3	48.981	.000	.156			
Fall Math Scores				.528	6.909	.000
Step 4	.821	.366	.003			
Hot Executive Function				.053	.906	.366

Table 4

Regression Analyses Predicting Children's Classroom Behavior by Cool Executive Function

	Block			Step (at final)		
Dependent and Independent Variables	*F* change	Sig	R2 change	Beta	*t*	Sig.
Teacher Report of Work Habits						
Step 1	8.563	.000	.143			
Gender				-.222	-3.245	.001
Demographic Risk				-.031	-.436	.663
Preschool Experience				.176	2.574	.011
Step 2	25.385	.000	.122			
Cognitive Ability				.266	3.538	.001
Step 3	10.455	.002	.047			
Cool Executive Function				.248	3.233	.002
Teacher Report of Self-Control						
Step 1	6.656	.000	.116			
Gender				-.165	-2.342	.020
Demographic Risk				-.006	-.087	.931
Preschool Experience				.209	2.968	.003
Step 2	20.535	.000	.106			
Cognitive Ability				.231	2.983	.003
Step 3	12.075	.001	.058			
Cool Executive Function				.275	3.475	.001
Teacher Report of Self-Directed Behavior						
Step 1	3.725	.013	.067			
Gender				-.114	-1.590	.114
Demographic Risk				-.027	-.371	.711
Preschool Experience				.098	1.374	.172
Step 2	21.693	.000	.116			
Cognitive Ability				.245	3.108	.002
Step 3	12.010	.001	.060			
Cool Executive Function				.279	3.466	.001
Teacher Report of Hyperactive-Distractibility						
Step 1	5.790	.001	.101			
Gender				.103	1.439	.152
Demographic Risk				-.065	-.883	.379
Preschool Experience				-.260	-3.666	.000
Step 2	21.038	.000	.109			
Cognitive Ability				-.249	-3.180	.002
Step 3	8.992	.003	.044			
Cool Executive Function				-.239	-2.999	.003
Observed Engagement in Learning						
Step 1	9.454	.000	.147			
Gender				-.253	-3.579	.000
Demographic Risk				-.102	-1.409	.161
Preschool Experience				.131	1.878	.062
Step 2	10.869	.001	.053			
Cognitive Ability				.167	2.166	.032
Step 3	5.918	.016	.028			
Cool Executive Function				.191	2.433	.016

Table 5

Regression Analyses Predicting Children's Classroom Behavior by Hot Executive Function

Dependent and Independent Variables	Block			Step (at final)		
	F change	Sig	R2 change	Beta	*t*	Sig.
Teacher Report of Work Habits						
Step 1	8.563	.000	.143			
Gender				-.223	-3.255	.001
Demographic Risk				-.054	-.775	.439
Preschool Experience				.142	2.086	.039
Step 2	25.385	.000	.112			
Cognitive Ability				.320	4.556	.000
Step 3	10.614	.001	.048			
Hot Executive Function				.227	3.258	.001
Teacher Report of Self-Control						
Step 1	6.656	.000	.116			
Gender				-.166	-2.331	.021
Demographic Risk				-.038	-.532	.596
Preschool Experience				.186	2.381	.019
Step 2	20.535	.000	.106			
Cognitive Ability				.296	4.047	.000
Step 3	9.354	.003	.046			
Hot Executive Function				.222	3.058	.003
Teacher Report of Self-Directed Behavior						
Step 1	3.715	.013	.067			
Gender				-.124	-1.670	.097
Demographic Risk				-.076	-1.010	.314
Preschool Experience				.067	.917	.361
Step 2	21.693	.000	.116			
Cognitive Ability				.332	4.366	.000
Step 3	1.862	.174	.010			
Hot Executive Function				.103	1.364	.174
Teacher Report of Hyperactive-Distractibility						
Step 1	5.790	.001	.101			
Gender				.102	1.442	.151
Demographic Risk				-.045	-.620	.536
Preschool Experience				-.227	-3.222	.002
Step 2	21.038	.000	.109			
Cognitive Ability				-.299	-4.104	.000
Step 3	10.095	.002	.049			
Hot Executive Function				-.230	-3.177	.002
Observed Engagement in Learning						
Step 1	9.454	.000	.147			
Gender				-.257	-3.607	.000
Demographic Risk				-.140	-1.945	.054
Preschool Experience				-.112	-1.595	.113
Step 2	10.813	.001	.053			
Cognitive Ability				.237	3.184	.002
Step 3	.184	.668	.001			
Hot Executive Function				.047	.658	.668

Table 6

Mediation Model Predicting Children's Academic Performance via Adaptive Classroom Behaviors

	Block			Step (at final)		
Dependent and Independent Variables	*F* change	Sig	R2 change	Beta	*t*	Sig.
Teacher-Report of Academic Performance						
Step 1	2.337	.076	.044			
Gender				.057	.981	.328
Demographic Risk				.000	.005	.996
Preschool Experience				.153	2.608	.010
Step 2	54.187	.000	.254			
Cognitive Ability				.316	4.946	.000
Step 3	18.060	.000	.269			
Work Habits				.496	4.316	.000
Self-Control				-.364	-2.834	.005
Self-Directed Behavior				.381	4.091	.000
Hyperactive-Distractibility				.041	.373	.710
Engagement in Learning				.041	.577	.565
Step 4	.432	.512	.001			
Cool Executive Function				.043	.658	.512
Standardized Math Scores						
Step 1	3.320	.022	.063			
Gender				.002	.041	.967
Demographic Risk				.003	.053	.958
Preschool Experience				-.067	-1.109	.269
Step 2	59.775	.000	.271			
Cognitive Ability				.170	2.198	.030
Step 3	47.732	.000	.164			
Fall Math Scores				.410	4.997	.000
Step 4	3.146	.010	.050			
Work Habits				.087	.738	.462
Self-Control				-.132	-1.007	.316
Self-Directed Behavior				.265	2.772	.006
Hyperactive-Distractibility				.123	1.105	.271
Engagement in Learning				.057	.783	.435
Step 5	6.122	.015	.019			
Cool Executive Function				.166	2.474	.015

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MANUSCRIPT THREE

Individual Differences in Executive Function:

Implications for Behavior and Achievement in First Grade Classrooms

Laura L. Brock

Abstract

Executive function (EF) describes the coordination of higher-cognitive functions that are engaged during cognitive 'cool' and emotional 'hot' problem-solving. Emerging evidence suggests social processes facilitate EF development. This study examines the relation between classroom social processes, hot and cool EF, and behavior and achievement in a sample of 176 first graders. This study asks: a) Do hot and cool EF relate to academic achievement and behavior outcomes in first grade? b) Do classroom quality and activity setting contribute to gains in hot and cool EF in first grade? c) Do classroom quality and activity setting moderate the contributions of hot and cool EF to first grader's achievement and behavior outcomes? Cool EF predicted gains in a standardized math test, teacher-rated academic performance, and learning-related behaviors. High quality classrooms contributed to gains in both hot and cool EF. Time spent in orient-organize and non-instruction were both negatively associated with gains in hot EF. A pattern of interactions indicate both hot and cool EF play a role in children's behavior and achievement dependent upon activity setting. More time spent in non-instruction is especially detrimental for children with low hot EF ability. These findings are notable in light of previous studies that have had difficulty detecting a significant relation between hot EF and academic achievement in early childhood.

Individual Differences in Executive Function:

Implications for Behavior and Achievement in First Grade Classrooms

Recent research has established a link between executive function (EF) and children's learning (Blair & Razza, 2007; St. Clair-Thompson & Gathercole, 2006). EF describes the coordination of higher-cognitive functions (e.g., inhibitory control, working memory, and attention) invoked during problem-solving or novel learning (Zelazo, Mueller, Frye, & Markovitch, 2003). As such, EF is foundational to academic achievement (McClelland, Cameron, Connor, Farris, Jewkes, & Morrison, 2007; Waber, Gerber, Turcios, Wagner, & Forbes, 2006) and appears to be especially predictive of children's math achievement (Clark & Woodward, 2007; Espy et al., 2006). Indeed, EF is a predictor of achievement from preschool through high school (Mischel, Shoda, & Peake, 1988) and explains more variance in achievement than cognitive ability by adolescence (Duckworth & Seligman, 2005).

EF is also a determinant of children's ability to manage their behavior and demonstrate self-control, skills that are necessary in order for learning to take place (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2008). Further, EF is required for perspective-taking, a precursor to empathy (Carlson, Moses, & Breton, 2002; Hughes & Ensor, 2006). High EF performance is predictive of self-reliant, goal-directed behavior (Brock et al., 2007) and positive relationships with teachers and peers (Blair, Denham, Kochanoff, & Whipple, 2004). In sum, having solid EF skills bolsters other aspects of children's development.

Low EF is predictive of impulsivity, aggression, and problem behaviors—all of which impact children's achievement (Clark, Prior, & Kinsella, 2002; Cole, Usher, & Cargo, 1993). Beyond the classroom, EF deficits are associated with a range of externalizing behavior disorders, including Attention Deficit Hyperactivity Disorder, Oppositional Defiant Disorder, and Conduct Disorder (Fischer, Barkley, Smallish and Fletcher, 2005; Sonuga-Barke, Dalen, & Remington, 2003; Van der Meere, Marczocchi & De Meo, 2005). Low EF is associated with psychopathology from early childhood into adulthood and is predictive of future delinquency, antisocial behavior, and criminal activity (Speltz, DeKlyen, Calderon, Greenberg, & Fisher, 1999). EF skills are critical both in the classroom and in the larger society. It is therefore important to understand how EF development can be maximized.

Two limitations of the conventional conceptualization of EF are evident and are addressed in the present study. First, the predominant focus has been to study EF as a domain-general, unitary construct (e.g., Zelazo et al., 2003). In other words, EF has been conceptualized as a relatively stable attribute akin to temperament (Kagan, Kahn, Snidman, & Towsley, 2007) or cognitive ability (Bornstein et al., 2006), implying EF is fixed and may be difficult or impossible to improve. Yet, there is an increasing acknowledgement that EF ability is not a stable attribute but rather a manifestation of complex biological, environmental, and social interactions (Deater-Deckard, Petrill, Thompson, & DeThorne, 2006). Emerging empirical evidence suggests that EF is malleable (e.g., Dowsett & Livesey, 2000). Preliminary findings support the notion that classroom social processes may influence children's EF development (Diamond, Barnett, Thomas, & Munro, 2007; Lillard & Else-Quest, 2006; Ponitz & Morrison, 2008).

Second, EF has been used as an umbrella term to describe problem-solving of all types, including problem-solving in emotionally laden and emotionally neutral contexts. There is also an emerging recognition that EF is comprised of cognitive and emotional components (Carlson, 2005; Hongwanishkul, Happaney, Lee & Zelazo, 2005; Zelazo & Muller, 2002). In classrooms, children engage in problem-solving that is predominantly cognitive in nature (e.g., attending to a math worksheet) as well as problem-solving that requires emotion regulation (e.g., waiting for a turn). Both cognitive and emotional problem-solving are critical skills for school success.

The present study bridges research exploring social processes that facilitate EF development with research examining cognitive and emotional components of EF. One aim is to identify social processes occurring within classrooms that facilitate cognitive and emotional components of EF development. Another aim is to test whether cognitive and emotional components of EF differentially contribute to children's behavior and achievement. The ultimate goal of this study is to understand how children's EF interacts with classroom social processes to determine whether certain classroom environments are especially helpful or harmful to children's behavior and achievement gains depending upon children's initial EF ability.

Theoretical Framework

Bronfenbrenner and Morris's (2006) Bioecological Model provides a framework for studying how social processes influence children's development. Bronfenbrenner proposed that children's development (cognitive, emotional, and behavioral) relies on increasingly complex reciprocal interactions between people, objects, and symbols in the immediate environment. When these reciprocal interactions, termed *proximal* *processes*, occur on a regular basis over an extended period of time, they become the "primary engines of development" (p. 797, Bronfenbrenner & Morris, 2006). Classrooms are one such environment where proximal processes can have a profound effect on children's development. Within classrooms, children interact with teachers, peers, and instructional materials. The nature of these interactions, including the quantity and quality of both positive and negative interactions is highly variable across classrooms (Nye, Hedges, & Konstantopoulos, 2004; Pianta, Belsky, Houts, Morrison, & NICHD-ECCRN, 2007). Teachers, through their instructional practices, facilitate a range of contexts that constrain the nature of proximal processes children experience and thus create opportunities for children to exercise and ostensibly improve EF performance (Blair, 2002).

Bronfenbrenner and Morris (2006) propose the Person-Process-Context-Time (PPCT) Model to enable the empirical application of the theory presented in the Bioecological Model. Proximal *processes* describe increasingly complex interactions between the organism and environment. Teacher support of child behavior is one example of proximal processes that grows in complexity over the course of the school year. *Person* characteristics include disposition, resources (ability, past experience, EF skills), and demand traits of an individual that can invite, sustain, or discourage proximal processes. EF ability level may partially determine the range of proximal processes available to a child. For example, a child with poor hot EF may be called upon less often to speak in class, for fear he will not cooperate or control his emotions. *Context* refers both to the immediate environment as well as those that are more remote. This study will focus on the classroom as the primary context for development, while acknowledging the contribution of the home environment as another context for development. *Time* describes the frequency and duration of proximal processes. In order for proximal processes to exert influence, they must occur for a sustained period of time (e.g., an hour), with relative frequency (e.g., daily), over the course of a broad time interval (e.g., a school year). This study will examine the extent to which proximal processes in the classroom context contribute to children's EF, achievement gains, and positive behaviors in the classroom context over the course of first grade.

Hot and Cool EF

EF describes the coordination of higher-cognitive functions considered foundational to problem-solving (Zelazo et al., 2003). As such, EF can be implicated in any novel situation that requires active control over one's thoughts and actions. One way of compartmentalizing EF into more meaningful parts is to conceptualize an emotional component of EF (one that facilitates emotion regulation) and a cognitive component of EF (one that facilitates cognitive regulation) as two interrelated but distinct constructs (Blair et al., 2007; Metcalfe & Mischel, 1999). Zelazo and Muller (2002) applied the terms *hot EF* to describe the ability to control emotional responses to appetitive or aversive stimuli, and *cool EF* to describe the voluntary manipulation of cognitive functions in an emotionally neutral context. The distinction between hot and cool EF has both a biological basis (e.g., Bechara, Damasio, Damasio & Anderson, 1994) and behavioral corollaries (Carlson, 2005; Hongwanishkul et al., 2005).

Neuroimaging evidence reveals two discrete brain regions are invoked for problem-solving: one that coordinates emotional processing and one that coordinates cognitive processing (Bechara et al., 1994; Bush, Luu, & Posner, 2000). These two regions are functionally related to hot and cool EF. Adults with brain damage to the region responsible for cool EF lose the ability to learn novel material, or problem-solve new solutions; in contrast, brain damage to the region associated with hot EF results in impulsivity, an inability to engage in perspective-taking, and inappropriate behavior (see Ward, 2006).

Several tasks have been validated that tap primarily into either hot or cool EF. Cool EF tasks require children to employ inhibitory control, working memory, and attention but are devoid of tangible punishment, reward, or uncertainty (e.g., the Stroop Task, Stroop, 1935; the pencil tap, Smith-Donald, Raver, Hayes, & Richardson, 2007; self-ordered pointing (SOP) task, Archibald & Kerns, 1999). Hot EF tasks have an emotional component that children must negotiate in order to successfully problem-solve. For example, children must down regulate emotional responses in order to resist temptation (e.g., choice delay of gratification, Hongwanishkul et al., 2005; the gift wrap task, Kochanska, Murray, & Harlan, 2000; the gambling task; Bechara et al., 1994). In adults, hot or cool EF task performance results in activation of the regions of the brain associated with either hot or cool EF (Bechara et al., 1994). Data on brain imaging is difficult to obtain in children, but hot and cool EF task performance is differentially associated with cognitive, emotional, behavioral, and temperamental characteristics in children (Brock et al., 2008; Hongwanishkul, et al., 2005).

In terms of achievement, cool EF appears to be more strongly associated than hot EF in early childhood. Numerous studies indicate cool EF is related to academic achievement from preschool through second grade (Blair & Razza, 2007; McClelland et al., 2007; McClelland, Morrison, & Holmes, 2000; St. Clair-Thompson & Gathercole,

2006) In a study of kindergarteners that concurrently examined the differential contribution of hot and cool EF to achievement, findings indicated that cool, but not hot, EF contributed to children's academic outcomes (Brock et al., 2008). Studies examining the relation between hot EF-related skills and achievement begin to emerge in adolescence (Duckworth & Seligman, 2005; Mischel, et al., 1988), suggesting the link between hot EF and achievement may be more relevant in the later years of schooling, as children are increasingly expected to manage their own learning.

Hot and cool EF may be related to different types of behaviors considered important for school success. High cool EF appears to promote learning-related behaviors and self-regulation (Cole et al., 1993), whereas hot EF may be an important but indirect contributor to children's behavior via relationships formed with peers and teachers (Blair et al., 2004; Raver, Blackburn, Bancroft, & Torp, 1999; Spinrad et al., 2006).

Hot and cool EF deficits differentially predict externalizing behavior disorders, perhaps representing extreme behavioral manifestations of each EF component. Cool EF deficits are characterized by inattention, difficulty concentrating, and difficulty learning (Wu, Anderson, & Castiello, 2002). Hot EF deficits manifest as hyperactivity and risk-taking behavior that can lead to rule-violating behavior in extreme cases (e.g., Solanto et al., 2001). Cool EF deficits are associated with Attention Deficit Hyperactivity Disorder (e.g., Fuggetta, 2006; Shallice et al., 2002; Seidman et al, 2005). Children who perform poorly on hot EF tasks are at increased risk for developing Oppositional Defiance and Conduct Disorders (e.g., Solanto et al., 2001; Van der Meere, Marczocchi & De Meo, 2005). In sum, cool EF appears to be related to behaviors that directly impact academic performance (e.g., attention, persistence, concentration). Hot EF appears to be related to behaviors that indirectly impact academic performance (e.g., following rules, forming relationships).

EF and Classroom Social Processes

Emerging empirical evidence suggests that social processes contribute to EF development. Family social processes that are associated with improved EF trajectories can be characterized as either cognitively stimulating (Hughes & Ensor, 2005; Landry, Miller-Loncar, Smith, & Swank 2002; Noble, Norman, & Farah, 2005) or emotionally responsive (Carpendale et al., 2007; Hughes & Ensor, 2006; Landry et al., 2007). Opportunities for such social processes are also available in the classroom environment (Hamre & Pianta, 2007).

Laboratory experiments have also improved EF performance, providing more specific information about the nature of social processes that contribute to EF gains. For example, cool EF performance can be improved with explicit instruction and targeted feedback (Dowsett & Livesey, 2000; Klingberg et al., 2005; Rueda, Rothbart, McCandliss, Saccomanno & Posner, 2005). Lewis and Solis-Trapala (2007) found that children who received a task relevant comment (e.g., "your teacher tells me you can pay careful attention") outperformed children who received a task irrelevant comment (e.g., "your teacher tells me you can read chapter books") before engaging in a cool EF task. A task-relevant or orienting comment appears to alert children to the skills required for an upcoming activity. Masters and Santrock (1976) showed that task administrators could influence children's hot EF task performance by delivering instructions with an affectively positive, neutral, or negative tone. Toner, Moore, and Emmons (1980) found that children who were encouraged by a task administrator beforehand performed better on a hot EF task. The above studies all have in common social processes that likely occur in first grade classrooms: offering feedback, preparing children for upcoming tasks with orienting comments, and communicating in an affectively positive manner. Research linking social processes with EF performance sets the stage for understanding how EF can be promoted in the classroom. In this study classroom social processes, are measured via classroom quality and activity setting.

Classroom Quality

Classroom quality is a global indicator of the instructional, emotional and organizational climate of the classroom (Hamre & Pianta, 2007). Instructional support in the classroom is characterized by social interactions between teachers and children that facilitate exposure to high-level concept development, high quality feedback, and rich language modeling (Hamre & Pianta, 2007). Emotional support in the classroom encompasses the presence of positive affect, the absence of negative affect, teacher sensitivity, and regard for student perspectives (Hamre & Pianta, 2007). Classroom organization comprises behavior management, productivity, and instructional learning formats, or the variety of learning modalities and materials offered to children (Hamre & Pianta, 2007). All three domains of classroom quality are important contributors to children's academic and socio-emotional functioning (see Hamre & Pianta, *in press,* for a review). Preliminary evidence suggests classroom quality may also contribute to gains in EF.

In terms of instructional support, findings from an intervention study conducted in elementary school revealed that teachers who embedded concept development tools and high-quality feedback into their instructional practices had children in their classrooms that made greater gains in EF skills relative to a control group (Glaser & Brunstein, 2007). Exposure to a rich language environment has been associated with better EF performance (Landry et al., 2002). Language modeling is hypothesized to support EF development by articulating goal-directed behavior, verbally modeling problem-solving, and using mental state words (Hughes, Graham, & Grayson, 2004).

Socioemotional interventions that emphasize emotional support in the classroom have demonstrated improved EF-related competencies in children include the Child Development Project (Battistich, Solomon, Watson, & Schaps, 1997), Promoting Alternative Thinking Strategies (Greenberg, Kusche, & Riggs, 2004), and I Can Problem Solve (Kumpfer, Alvarado, Tait, & Turner, 2002). These interventions have in common the goal of teaching emotion understanding and social problem-solving skills. Increased verbal fluency about emotion states and awareness of the link between actions and consequences are thought to improve cognitive and emotional regulation (Greenberg et al., 2004).

Classroom organization was emphasized in the *Tools of the Mind* intervention explicitly designed to facilitate the development of EF (Bodrova & Leong, 2007). Classroom activities were organized to maximize productivity and student interest. As well, proactive behavior management strategies were embedded throughout the school day (Bodrova & Leong, 2007). Findings reveal *Tools of the Mind* improved both EF and academic performance in at-risk preschoolers (Diamond, et al, 2007).

Montessori classrooms offer another example of classrooms that adhere to an organizational schema not typically found in conventional classrooms. Montessori classrooms are organized to vary instruction and maximize productivity by offering children choice (see Lillard, 2005). To this end, Montessori teachers tend to endorse less frequent teacher-managed instruction in favor of child-managed instruction. At age five, children who attended a Montessori classroom showed greater EF ability than children who received a conventional education (Lillard & Else-Quest, 2006). In sum, instructional, emotional, and organizational supports in the classroom appear to be associated with gains in EF. This study may elucidate whether this pattern is similar for both hot and cool EF gains.

Classroom Activity Setting

Classroom activity setting refers to the teacher's facilitation of instruction and speaks to preparation and time management. For the purposes of this study, activity settings are operationalized as the amount of time teachers devote to child-managed instruction (e.g., seat work), teacher-managed instruction (e.g., whole group lessons), orienting and organizing (e.g., preparing children for instruction, as with explicitly modeling how to use materials), and time spent in non-instruction (e.g., waiting for the teacher, transitioning from one activity to another) (Cameron, Connor, & Morrison, 2005).

Teachers' choice of activity setting has implications for how children display behavioral manifestations of EF ability in the classroom. In a study of kindergarteners, children exhibited less off-task behavior during teacher-managed activities (Rimm-Kaufman, La Paro, Downer, & Pianta, 2005), most likely because teacher-managed activities place few demands on children to manage their own attention. Yet, child-managed activities may afford children more opportunity to exercise and improve EF skills by placing more demands on their ability to manage their own attention and persist at tasks (see Lillard, 2005). In preschool, teachers who spent more time organizing and orienting children to an upcoming activity had children in their classrooms who made greater gains on an EF task relative to children who experienced more non-instructional time (Ponitz & Morrison, 2008). In first grade, teachers who spent more time in orient-organize at the beginning of the school year also had children who made greater gains in reading relative to peers in other classrooms (Cameron, Connor, Morrison, & Jewkes, 2007). It is possible that the achievement gains related to orient-organize exposure could be explained by improved EF functioning, as is suggested by the Ponitz and Morrison (2008) study.

First grade teachers with students who made greater achievement gains efficiently managed transitions, interruptions, and student behaviors in order to maximize learning time; where as teachers with students who made relatively smaller achievement gains managed time poorly and took more time to begin instruction in the morning (Wharton-McDonald, Pressley, & Hampston, 1998).

In sum, teachers are constantly making choices about how to facilitate lessons and manage time. The impact of classroom social processes on children's EF development is a relatively understudied phenomenon. The relation between classroom social processes and children's achievement hints that EF gains may also be associated with variation in processes across classrooms. Children are exposed to a range of quality and activity settings across classrooms, some of which may be more or less beneficial to children with differing levels of hot or cool EF.

The Interaction of EF and Classroom Social Processes

Bronfenbrenner's Bioecological Model posits that proximal processes "vary systematically as a joint function of the characteristics of the developing person and the environment" (p. 798, Bronfenbrenner & Morris, 2006). Child attributes create a lens through which children view interactions, thus proximal processes are unique to each child, even in shared environments (e.g., Deater-Deckard et al., 2006). Children in a classroom may be exposed to the same social processes, but an individual child's resources (e.g., EF skills) will partially determine how the child interacts with and benefits from the classroom environment.

Sameroff and Mackenzie (2003) further argue for the application of transactional models of development where children's outcomes (e.g., behavior, achievement) are viewed as an interaction between the individual and the immediate environment. Children's outcomes are "neither a function of the individual alone nor a function of the experiential context alone" (p. 614, Sameroff & Mackenzie, 2003). Transactional models typically call for analyses examining moderation, thus the interaction between children's hot or cool EF and classroom quality and activity setting will be explicitly tested to determine how these predictors in combination contribute to children's achievement and behavior. Further, Baron and Kenny (1986) recommend employing a moderator analysis when a predictor has a weak or unexpectedly nonsignificant relation with an outcome. Hot EF is theorized to be an important contributor to children's school success, yet empirical studies linking hot EF-related abilities with early school outcomes has been disappointing to date (e.g., Brock et al., 2008; Duncan et al., 2007). Moderator analyses may provide a more nuanced approach for examining the role of hot EF in the classroom.

Other Factors in EF Development

EF development is undoubtedly a function of biological contributions (Deater-Deckard et al., 2006), including age-related changes (Klenberg, Korkman, & Lahti-Nuutila, 2001), and gender (Hill, Degnan, & Calkins, 2006). Emerging evidence suggests that EF development can also be explained by variation in early childhood environments (e.g., Li-Grining, 2007). For example, socioeconomic status is related to EF (Ardilla, Rosselli, Matute & Guajardo, 2005; Noble et al., 2005). For the purposes of this study, age, gender, and family income will be held constant in order to examine the impact of classroom social processes on EF gains.

Present Study

Three research questions are examined: (a) Do hot and cool EF relate to academic achievement and behavior outcomes in first grade? It is hypothesized that cool EF will contribute to gains in achievement, where as both hot and cool EF may contribute to behavioral competence in first grade. (b) Do classroom quality and time spent in activity setting contribute to gains in hot and cool EF in first grade? High quality classrooms are expected to improve both hot and cool EF. Time spent in specific activity settings, including orient-organize and child-managed instruction are expected to improve cool EF by promoting reasoning skills and affording children the opportunity to manage their own attention. Time spent in teacher-managed instruction and non-instructional time are not expected to facilitate gains in hot or cool EF. (c) Do classroom quality and time spent in activity setting moderate the contributions of hot and cool EF to first grader's achievement and behavior outcomes? Interactions between children's EF and classroom quality and activity setting are also anticipated. Children with low hot or cool EF in high quality classrooms may perform on par with high EF peers. Children with low cool EF may thrive in teacher-managed activity settings where the teacher supports children's attention. Whereas children with high cool EF may excel in child-managed activities when self-regulation is required. Time spent in orient-organize may facilitate gains in cool EF by explicitly modeling problem-solving strategies and multi-step activities. Children with low hot EF who spend more time in non-instruction may exhibit less advantageous classroom behaviors relative to higher EF peers as they may be less able to wait patiently in tempting situations.

Method

Participants

Three hundred thirty three families consented to participate in the study during kindergarten registration or an open house night, representing approximately 59% of families who were in attendance. Following, 187 consented children were selected randomly into the study. Prior to first grade data collection, families of four children relocated and seven children were retained in kindergarten resulting in a final sample of 176 first graders who attended one of seven schools, across four rural school districts in the southeast. The sample was comprised of 86 females (48%) and 92 males (52%). Parents reported children's ethnicity as follows: 131 Caucasian (74%), 34 African-American (19%), 8 other (4%), and 5 unreported (3%). In terms of family risk, parents of 57 (33%) children reported an annual income of less than $30,000; mothers of 50 (28%) children pursued education beyond a high school diploma; and families of 46 (16%) children reported a single parent status. Teacher participants were 36 teachers, with an average of 13.5 years teaching experience (SD=9.2). All teachers in the study held a Bachelor's degree and 15.4% further obtained a Master's degree.

Procedure

Parents completed a demographic questionnaire prior to kindergarten entry. Research assistants administered a battery of 45 minute tests, including standardized achievement tests and hot and cool EF tasks, to children in a quiet location at school upon entry to first grade (September-October). Throughout the school year (October-May) research assistants observed each classroom on three occasions (approximately 2.5 hours in the morning). Each child was observed for 50 minutes over the course of three visits; assistants collected data measuring time spent in activity settings with the First Grade Observation Measure (Rimm-Kaufman, 2005) and classroom quality with the CLASS observation tool (Pianta, La Paro, & Hamre, 2007). In the spring, teachers completed questionnaires about the behaviors and academic performance of each study child in their classroom. At the end of the school year (May-June), research assistants again administered EF tasks and achievement tests to children in a quiet location at school.

Measures

Child-Level Variables

Hot EF. Hot EF was assessed with a choice delay of gratification task adapted from Hongwanishkul and colleagues (2005). Children were faced with the decision to have an enticing object immediately or wait a period of time to have more of the objects later. After completing other assessments, children were instructed they were going to play a game. Research assistants informed children they brought some "fun things" with them and the children could "choose to have some now or wait until you get home after school". Research assistants then presented two demonstration trials. In the first instance, the research assistant presented a cup with one candy and another cup with two candies. The research assistant modeled that she could choose one candy now or two later and chose to save two candies for later. Next, she presented a cup with one (scratch and sniff) sticker now or six stickers later. The research assistant opted for one sticker immediately, smelled it and put it on her shirt. Six test trials were created by crossing two types of rewards (candies and stickers) with three amounts of reward (2, 4, or 6). If children chose to delay items, they were removed from the table to prevent distraction. Scores were the number of times children chose to delay summed across six trials. Raters administered the tasks during a piloting phase and dual coded to collect reliability data. Inter-rater reliability was perfect in both fall and spring.

Cool EF. Cool EF was assessed using a self-ordered pointing task from Archibald and Kerns (1999) and Hongwanishkul and colleagues (2005) adapted and piloted for this age group. Children were presented with a binder containing sets of pictures of common objects arranged in a grid on one page. Subsequent pages contained the same pictures arranged in a different order in the grids. To demonstrate the task, children were shown a page with four pictures and instructed "I want you to point to one picture and remember which one you pointed to." The research assistant turn to the following three pages and instructed "Now I want you to point to a picture you haven't pointed to yet." Different test administrations were given in fall and spring to account for growth and to avoid spring ceiling effects. In the fall, the test phase consisted of 16 objects in a grid presented across 16 pages arranged in different orders. In the spring children were presented with 24 rearranged across 24 pages. Children received one point each time they pointed to a novel object. The dependent measure was the number of points received out of a possible 16 in the fall, and 24 in the spring. Raters administered the tasks during a piloting phase and dual coded to collect reliability data. Inter-rater reliability was perfect in the fall and .93 in the spring.

Achievement. The *Woodcock-Johnson III Tests of Achievement* letter-word identification and applied problems subtests (Woodcock, McGrew, & Mather, 2001) assessed children's early literacy and math skills. Children's raw scores were converted into standardized W-scores for both fall and spring measures. For 6-year-olds, the internal consistency reliability coefficient is .98 for Letter-Word and .88 for Applied Problems.

Learning-Related Behaviors. The learning-related behaviors construct represents a summed composite of four highly correlated behavior constructs reported by teachers (r= .69-.85, p <.01). Two constructs were obtained from the *Social Competence and Adjustment Scale* (Ladd, Profilet, & Muth, 1996): (a) self-directed learning style (5 items, alpha=.85, e.g., "this child keeps working on tasks when he/she encounters difficulty) and (b) hyperactive-distractibility, reverse scored (5 items, alpha=.87, e.g., "This child has poor concentration or short attention span"). Teachers rated self-directing learning and hyperactive-distractibility on a scale of 1 to 3 (where 1 indicated "does not apply" and 3 indicated "definitely applies"). The third construct, work habits, was derived from the *Mock Report Card* (Pierce, Hamm, & Vandell, 1999) (six items, alpha=.95, e.g., "works well independently"). Teachers rated children's work habits on a scale of 1 to 5 (where 1 indicated very poor and 5 indicated very good). The fourth construct, self-control, was assessed using the *Teacher's Self-Control Rating Scale* (Humphrey, 1982) was a 15 item questionnaire using a 5-point frequency scale, alpha=.92, e.g., "this student makes careless errors because he/she rushes through work", "this student has to have things right away". An exploratory factor analysis revealed the four teacher-rated behavior constructs loaded onto one factor. The factor scores were compared with a summed composite of z-scores of the four constructs and results were identical in subsequent analyses; the summed composite was employed.

Observed Classroom Engagement. The Observed Classroom Enagement Scale (Rimm-Kaufman, 2005) is an observational tool adapted from the NICHD Study of Early Child Care (NICHD-ECCRN, 2005). A research assistant observed a study child during 15 minutes of academic classroom time then rated five classroom behaviors on a scale from 1 to 7 (7 indicating high evidence or frequency of behavior): a) self-reliance, b) attention, c) disruptive behavior (reverse coded), d) compliance, and e) engagement. The five dimensions were summed to form a composite measure of engagement in learning (alpha=.88). In terms of reliability, the intraclass correlation was .89 across 20 dual-rated cases.

Classroom Activity Setting. Classroom activity setting was categorized into four groups: (a) child-managed instruction: in this setting the child is managing his or her own attention, as with seat-work; (b) teacher-managed instruction: in this setting the teacher is managing the child's attention, as with circle time; (c) orient-organize: in this setting the teacher is preparing children for an activity by explaining the goal or steps needed to complete the task; (d) non-instructional time: refers to the amount of time children spend transitioning from one activity to another, standing in line, or waiting for the teacher. Classroom activity setting was assessed at the child-level using the *First Grade*

Observation Measure (Rimm-Kaufman, 2005), an observational tool that captures the duration of specific activity settings that occur in a first grade classroom. Classroom activity setting durations were live-coded at the child level and measured in seconds, over the course of ten minute cycles. Inter-rater reliability was .97 on 23 dual-coded video segments.

Demographic Variables. Covariates were collected via parent-report with the *Family Demographic Questionnaire*, a 10-item questionnaire describing the demographic characteristics of children and families, including age, gender, and family income. Annual family income is an ordinal variable measured as follows: (a) less than $15,000; (b) $15,00-$29,999; (c) $30,000-$44,999; (d) $45,000-59,999; (e) $60,000-$74,999; (f) $75,000-$89,999; (g) 90,000-99,999; (h) more than $100,000.

Classroom-Level Variables

Classroom Quality. The *Classroom Assessment Scoring System* © (*CLASS*; Pianta, La Paro, & Hamre, 2007) is an observation tool used to assess overall classroom quality. Classroom quality is a composite of ten dimensions likely to be related to children's school outcomes. The ten dimensions are scaled 1 (low evidence or frequency) through 7 (high evidence or frequency) and include: (a) positive climate reflects the emotional connection between the teacher and children as evidenced by matched affect, respect, and positive communication; (b) negative climate (reversed for analyses) describes expressed negativity in the classroom including sarcasm, punitive control, negative affect and bullying among peers; (c) teacher sensitivity measures the teachers awareness of and responsiveness to children's emotional and academic needs; (d) regard for student perspectives refers to the teacher's ability to incorporate children's ideas and perspectives into classroom activities. Examples include the teacher's support of autonomy, responsibility, and leadership; (e) behavior management measures the teacher's ability to provide clear behavioral expectations and to prevent or effectively redirect misbehavior; (f) productivity in a classroom is measured by the teacher's preparedness, ability to transition to different activities efficiently and to maximize learning time; (g) instructional learning formats describes the ways in which teachers organize lessons so that learning objectives are clear, students are engaged, and a variety of modalities and materials are presented effectively; (h) concept development measures the teacher's use of classroom activities to promote higher-order thinking skills including problem-solving, brainstorming and linking concepts; (i) quality of feedback measures the extent to which teacher's feedback increases children's understanding. Teachers who ask children to explain their responses, in lieu of "good job" statements would receive a high score on feedback; (j) language modeling describes the extent to which teachers use advanced language and promote student talk via open-ended questions and frequent conversation.

The ten dimensions of the CLASS theoretically form three domains: emotional support, instructional support, and classroom organization. The three domains of classroom quality were highly correlated in this sample, (r =.66-.76, p<.01). In order to avoid multicollinearity, all domains were summed to form a global quality indicator.

Research assistants attended a two day CLASS training workshop conducted by the creators of the instrument and were assessed for reliability upon training completion. Reliability is measured after watching and coding six 15-minute classroom video segments; responses must be within one scale point of the gold standard on 80% of the responses. Reliability assessments prepared by the instruments' authors were conducted on four occasions throughout the school year to test for drift. Research assistants exceeded 80% reliability on each testing occasion.

Results

The aims of the present study were to analyze the contribution of hot and cool EF to academic and behavior outcomes, the contribution of classroom processes to hot and cool EF, and the contribution of classroom processes to behavior and achievement for first graders with varying levels of hot or cool EF. A preliminary description of children and classrooms are presented below.

Characteristics of Children and Classrooms

Means, standard deviations, and correlations for all variables are reported in Table 1. Children, on average, exhibited the ability to delay on 50% of the hot EF trials and correctly responded to 75% of the cool EF trials. Fall and spring cool EF scores were weakly correlated, $r = .16, p < .05$; fall and spring hot EF scores were moderately correlated, $r = .39, p < .01$; hot and cool EF were uncorrelated at fall and spring. Class quality was uncorrelated with fall hot and cool EF scores, yet correlated with both spring hot EF, $r = .20, p < .01$, and spring cool EF, $r = .16, p < .05$.

Children in this sample were exposed to classrooms of average quality, M = 3.84, SD = .60, on a scale of 1 to 7. In an average 10 minute morning block, children spent an average of three minutes in teacher-managed instruction (range 0-7.7 minutes), three minutes in child-managed instruction (range 0-8 minutes), one minute in orient-organize (range 0-3 minutes), and three minutes in non-instructional time (0-6.6 minutes).

The Contribution of Hot and Cool EF to Children's Behavior and Achievement

As a first step, variability in children's behavior and achievement outcomes were modeled at the child level and classroom level. Five unconditional models were created and intraclass correlations (ICCs) computed using Hierarchical Linear Modeling (HLM 6.05) software. Classroom level variability was significant for three of five outcomes with ICC's ranging from .03 to .20[1]. ICC's above .10 typically warrant HLM analyses. In order to maintain consistency as well as appropriately account for the nested structure of the data by adjusting standard errors, subsequent analyses were conducted in HLM.

Following, a final model was built by adding hot and cool EF as well as theoretically important control variables, all at the child level. The final model for children's behavior and achievement outcomes is represented by the equation below.

$Y_{ij} = \beta_{0j} + \beta_{1j}\,(\text{age}) + \beta_{2j}\,(\text{gender}) + \beta_{3j}\,(\text{family income}) + \beta_{4j}\,(\text{fall hot EF}) + \beta_{5j}\,(\text{fall cool EF}) + r_{ij}$

$$\beta_{0j} = \gamma_{00} + u_j$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

Y_{ij} or the model intercept is the average learning or behavior outcome score for child i in classroom j, accounting for the contributions of age, gender, family income, fall hot EF, fall cool EF, and error at the child level; the intercept is further defined as a function of the average of the classroom mean and error at the classroom level

[1] Applied Problems ICC = .20, *p* <000; Letter Word ID ICC = .13, *p* = .005; Academic Performance ICC = .03, *p* = .227; Learning-Related Behaviors ICC = .09, *p* = .028; Observed Self-Regulation ICC = .06, *p* .091.

(Raudenbush & Byrk, 2002). Effects for slopes $\beta_{1j} - \beta_{5j}$ were fixed. All variables were centered for ease of interpretation, with the exception of gender (female = 0; male = 1). Analyses conducted in linear regression produced similar findings.

HLM results predicting achievement outcomes by hot and cool EF in the fall are presented in Table 2. Cool EF significantly predicted gains in applied problems, $t = 2.94$, $p<.01$, $d = .13$, and teacher-rated academic performance, $t = 2.31$, $p <.05$, $d = .17$. Hot EF did not contribute to the prediction of any achievement outcomes. Fall applied problem scores, $t = 11.30$, $p <.001$, and fall letter word identification scores, $t = 23.71$, $p <.001$, significantly predicted spring scores. Older children, $t = 2.52$, $p <.05$, girls, $t = -3.78$, $p <.001$, children who came from wealthier households, $t = 4.51$, $p <.001$, were all rated by their teachers as displaying better academic performance. Effect sizes suggest small associations between cool EF and academic outcomes (.13 to .17), after controlling for previous achievement and child demographics.

HLM results predicting behavioral outcomes by hot and cool EF in the fall are presented in Table 3. Children with more cool EF, $t = 3.40$, $p <.001$, $d = .20$, older children, $t = 2.55$, $p <.05$, girls, $t = -3.68$, $p <.001$, and children who came from wealthier households, $t = 2.76$, $p <.01$, were all rated by their teachers as displaying more learning-related behaviors. Neither hot nor cool EF were predictive of observed classroom engagement. Girls were observed to display more classroom engagement, $t = -2.06$, $p <.05$. Effect sizes suggest small associations between cool EF and learning-related behaviors (.20) after controlling for child demographics.

The Contribution of Classroom Quality and Activity Setting to Gains in EF

As a first step, variability in hot and cool EF in the spring were modeled at the child level and classroom level. Two unconditional models were created and ICC's were computed for hot EF ICC <.00, p>.50, and cool EF ICC = .02, p>.50. These ICC's indicate very little of the variance hot and cool EF in the spring can be attributed to classrooms. Nonetheless, HLM is better equipped to estimate standard errors when variables at the child level share characteristics at the classroom level, as is the case for the classroom quality analyses. As such, a final model was constructed in HLM and is represented by the equation below.

$$Y_{ij} = \beta_{0j} + \beta_{1j}\,(\text{age}) + \beta_{2j}\,(\text{gender}) + \beta_{3j}\,(\text{family income}) + \beta_{4j}\,(\text{fall EF}) + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\,(\text{classroom quality}) + u_j$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

Results presented in Table 4 indicate that children exposed to higher quality classrooms, t = 2.89, p <.01, d = .17, made greater gains in hot EF over the course of first grade. Likewise, children exposed to higher quality classrooms, t = 2.94, p <.01, d = .18, made greater gains in cool EF. Children coming from wealthier households, t = 3.52, p <.001, and with higher initial hot EF scores, t = 6.90, p <.001, also made greater gains in hot EF. Effect sizes suggest small associations between classroom quality and EF outcomes (.17 to .18), after controlling for initial EF and child demographics.

Table 5 depicts the contribution of classroom activity settings to EF performance, all modeled at the child level. Children who spent less time in orient-organize, $t = -2.26, p < .05, d = .18$, and those who spent less time in non-instruction, $t = -2.01, p < .05, d = .18$, displayed better hot EF in the spring. Older children, $t = 2.52, p < .05$, children from wealthier households, $t = 4.08, p < .001$, and those with higher initial hot EF scores, $t = 6.37, p < .001$, likewise displayed better hot EF in the spring. Classroom activity settings did not contribute significantly to cool EF performance in the spring. Effect sizes suggest small associations between activity setting and EF outcomes (.18 and .18, respectively), after controlling for initial EF and child demographics.

The Interaction of Activity Setting and Hot and Cool EF

The interaction between activity settings and hot and cool EF were analyzed. An example of the final model testing the interaction between TMI and EF is presented below. $Y_{ij} = \beta_{0j} + \beta_{1j}\,(\text{age}) + \beta_{2j}\,(\text{gender}) + \beta_{3j}\,(\text{family income}) + \beta_{4j}\,(\text{hot EF}) + \beta_{5j}\,(\text{cool EF}) + \beta_{6j}\,(\text{TMI}) + + \beta_{7j}\,(\text{TMI*hot EF}) + \beta_{8j}\,(\text{TMI*cool EF})\ r_{ij}$

$$\beta_{0j} = \gamma_{00} + u_j$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

$$\beta_{6j} = \gamma_{60}$$

$$\beta_{7j} = \gamma_{70}$$

$$\beta_{8j} = \gamma_{80}$$

This model was employed for each of the four activity settings, examining the interaction between activity setting and EF for all five behavior and achievement outcomes. Of the twenty interactions tested, nine significant interactions were detected, depicted in Figures 1-9. As time spent in non-instruction increased, children with lower hot EF showed smaller gains in applied problems, $t = 2.28$, $p < .05$, $d = .10$, received lower ratings of teacher-rated academic performance, $t = 2.49$, $p < .01$, $d = .15$, received lower ratings of learning-related behaviors, $t = 2.81$, $p < .01$, $d = .20$, and displayed less classroom engagement, $t = 3.31$, $p < .01$, $d = .23$, relative to counterparts with more hot EF ability. As children with low cool EF spent more time in orient-organize, they made smaller gains in letter-word identification, $t = 2.15$, $p < .05$, $d = .07$, relative to counterparts with more cool EF ability. As children with low cool EF spent more time in teacher-managed instruction, they made smaller gains in applied problems, $t = -1.98$, $p < .05$, $d = .09$, relative to counterparts with more cool EF. As children with low hot EF spent more time in teacher-managed instruction, they received higher ratings of learning-related behaviors, $t = -2.14$, $p < .05$, $d = .15$, and displayed more classroom engagement, $t = -2.23$, $p < .05$, $d = .16$, relative to peers who spent less time in teacher-managed instruction. As children with low cool EF who spent more time in child-managed instruction, they received lower ratings of learning-related behaviors, $t = 2.14$, $p < .05$, $d = .14$, relative to counterparts with more cool EF ability. There were no interactions detected between classroom quality and EF. Effect sizes suggest small associations for the interactions between activity setting and EF (.07 to .23) in predicting academic and behavior outcomes, after controlling for child demographics, prior achievement, EF, and activity setting.

Discussion

The present study offers insight into aspects of EF that contribute to success in first grade in both academic and behavioral domains. Three major findings emerge. First, cool, but not hot, EF in the fall predicts gains in math, teacher-rated academic performance, and learning-related behaviors. Second, high quality classrooms contribute to gains in both hot and cool EF. Time spent in orient-organize and non-instruction were both associated negatively with gains in hot EF. Third, a pattern of interactions indicate that individual differences in both hot and cool EF play a role in children's behavior and achievement, dependent upon activity setting. Notably, children with low hot EF ability performed worse than peers with higher hot EF ability on four out of five outcomes as they were exposed to more time spent in non-instruction. Taken together, these findings suggest that hot and cool EF play distinct roles in children's achievement and behaviors that facilitate achievement.

The Role of Cool EF in Academic and Behavioral Outcomes

Results indicated that cool EF in the fall of first grade was directly associated with gains on a standardized math assessment, teacher report of academic performance, and learning-related behaviors. Hot EF was not directly associated with any child outcomes measured in this study. These results replicate findings from previous work indicating cool, but not hot, EF abilities at kindergarten entry played a significant role in determining academic and behavioral outcomes at the end of the kindergarten year (Brock, et al., 2008; Duncan et al., 2007). Thus, cool EF shows a stable pattern of significance across the early years of schooling.

In this study and in previous work (Brock et al., 2008; Clark & Woodward, 2007), cool EF was related to gains in math but not reading. Two plausible explanations exist. First, the skills that underlie math and reading development may account for differences in the contribution of cool EF. Inhibitory control, attention, and memory are foundational to rule switching and cognitive flexibility; necessary skills for children's conceptual math understanding and exemplified in the test of applied problems (see Blair et al., 2007). Whereas, basic reading skills assessed in the test of letter-word identification rely heavily on rote memorization of letters and sounds, and does not tax EF in the same way.

Alternatively, differences in literacy and math instruction may account for the unique contribution of cool EF to math. The amount of time spent in literacy instruction is more robust, with children spending an average of 21% of academic time on literacy instruction and 8% of academic time devoted to math instruction (Early et al., 2005). Many classrooms may offer a dose of literacy instruction sufficient to produce gains in most children regardless of EF ability. In addition, elementary teachers' training in math instruction, beliefs about the importance of math, and their affinity for math instruction tend to be more variable than is the case for literacy instruction and may contribute to the overall quality of math instruction (Ginsberg, Sun Lee, & Stevenson Boyd, 2008).

Cool, but not hot, EF was also related to teacher report of learning-related behaviors. Cool EF has been linked to learning-related behaviors in other studies (e.g., Cole et al., 1993). The relation between cool EF and academic performance was fully mediated by learning-related behaviors in previous work (Brock et al., 2008), suggesting that cool EF plays an important role in determining behaviors that are directly associated with learning. Hot EF may be associated with other aspects of classroom behavior that are beyond the scope of this study. For example, hot EF has been linked to teacher relationships and peer relationships in other studies (Blair, et al., 2004; Raver, et al., 1999; Spinrad et al., 2006). In addition, hot EF has been implicated in adolescents' learning-related behaviors and achievement (Duckworth & Seligman, 2005; Mischel, Shoda, & Peake, 1988). By high school, students are increasingly asked to manage their own time during study halls and after school; they are expected to delay gratification (e.g., watching television) in lieu of striving for long-term academic goals (e.g., studying for college entrance exams). Bembenutty and Karabenick (2004) suggest academic delay of gratification, which taxes hot EF, is necessary for later school success. In first grade, children are less often called upon to manage their own time and learning. In sum, cool EF is directly associated with positive behaviors in first grade classrooms. Hot EF may prove to be an important skill as children progress beyond elementary school and are expected to manage their own time—as is suggested in the pattern of interactions found between hot EF and time spent in non-instruction.

Neither hot, nor cool, EF significantly predicted observed classroom engagement. This discrepancy may lie in reporting methods. Teacher report data incorporates information gathered about students over the course of the year. Observer data provides a brief snapshot of student behavior as measured by an independent rater. In this study observer data is recorded after ten minutes of observation in the morning at three time points during the school year. It may be that morning routines in first grade classrooms are less likely to tax EF competencies. Teacher-rated behaviors may reflect a more diverse set of learning contexts and take into account children's behaviors throughout the school day.

The Contribution of Classroom Quality to Gains in Hot and Cool EF

Classroom quality is a significant predictor of gains in both hot and cool EF, suggesting that social interactions between teachers and children facilitates development in both cognitive and emotional EF domains. Yet very little to none of the variance in children's EF gains was attributable to the classroom (p = *n.s.*). One substantive interpretation of these findings lies in the possibility that children experience classroom quality differently because of some unmeasured child characteristic (e.g., temperament; Rimm-Kaufman et al., 2002). Alternatively, children within classrooms may be exposed to varying levels of quality based on individual teacher-child interactions. Classroom quality is a global indicator of the richness of instructional, emotional, and organizational supports offered by teachers and is a measure of the experience of the average child in the classroom. Some children may elicit more positive or negative teacher-child interactions, while others may receive very little teacher attention (Martin, Nagel, & Paget, 1983). Individual experiences are not captured in classroom quality measured at the classroom level.

Empirically, these hypotheses are not possible to test with the data. In the conventional sense, the unconditional model assessing classroom level variance, notably the hot EF model (ICC=.00) posed a nonconvergeable solution, perhaps representing a statistical artifact that is beyond the scope of available multi-level modeling software. Other studies that examined the contribution of classroom experiences to EF gains (Diamond et al., 2007; Lillard & Else-Quest, 2007) were unable to model nesting due to the structure of the data, thus little is known about the amount of variance in EF gains that can be attributed to the classroom. Future research examining the link between EF development and classroom processes may provide more definitive solutions.

The Contribution of Activity Setting to Gains in Hot and Cool EF

The contribution of activity setting to hot and cool EF gains was measured as the amount of time teachers devote to (a) child-managed instruction, for example seat work or centers, (b) teacher-managed instruction, or whole group lessons, (c) orienting and organizing, or preparing children for instruction, as with explicitly modeling how to use materials, and (d) time spent in non-instruction, including waiting for the teacher, transitioning from one activity to another (Cameron, et al., 2005). Time spent in activity setting was not related to gains in cool EF. Time spent in orient-organize and non instruction were negatively related to gains in hot EF.

Contrary to expectations, the amount of time spent in child-managed or teacher-managed instruction did not contribute to gains in hot nor cool EF. It was anticipated that child-managed instruction would afford children an opportunity to exercise EF skills. Although child versus teacher managed instructional settings differentially contribute to achievement gains (Perry, Donohue, & Weinstein, 2007; Stipek et al., 1998), there was not a similar pattern for EF gains. More time spent in non-instruction has adverse consequences for children's learning and behavior (Brown & Saks, 1986), and unsurprisingly also hindered hot EF development. Time spent in orient-organize was expected to positively contribute to gains in EF given that teachers' organizational practices have produced positive outcomes for children in previous studies (e.g.,Wharton-MacDonald et al, 1998). It may be that time spent in orient-organize represents a time when teachers regulate children's thoughts and actions—children are only required to sit and listen, and therefore do not experience social interactions that bolster hot EF skills. In order to boost hot EF skills, time may be better spent allowing children plenty of opportunity to do, rather than prepare.

The amount of time spent in orient-organize and non-instructional time did not directly contribute to gains in cool EF. These findings are consistent with previous work that found no direct association between activity setting and cool EF; yet significant setting by EF by gender interactions were detected, where boys with low cool EF spent more time-off task and boys with high cool EF spent more time in orient-organize (Ponitz & Morrison, 2008). In the present study two-way interactions between EF and activity settings were tested with significant findings.

The Contribution of Activity Setting for Children with Varying Levels of EF

A test of the combined contribution of classroom context and hot and cool EF to children's academic and behavioral outcomes reveal nine significant interactions. Notably, a pattern of four interactions emerged where children with low hot EF who spent more time in non-instruction tended to make smaller gains in math, received lower scores of teacher-rated academic performance, exhibited poorer learning-related behaviors and less observed classroom engagement. Effective time management serves to boost children's engagement and subsequent achievement trajectories (see Hamre & Pianta, 2007).Arlin (1979) found that teachers who poorly managed transitions, experienced more off-task and disruptive student behavior during non-instructional time, but more importantly disruptive and off-task behavior persisted into subsequent instructional time. A child with low hot EF, by definition, has difficulty waiting in lieu of other 'enticing' options (i.e., engaging in disruptive, off-task behavior). The wait-time imposed during non-instructional activity settings may cause children with low hot EF to succumb to off-task behaviors that persist, even after instruction recommences. This scenario would explain the pattern of poor behavior and achievement ratings for children with low hot EF who were exposed to increased non-instructional time. Off-task behavior may be especially deleterious to gains in math due to the small proportion of time spent in math instruction (Early et al., 2005).

A complimentary set of findings indicates children with low hot EF exhibited learning-related behaviors and classroom engagement comparable to peers with more hot EF ability when exposed to more teacher-managed instruction. Children with low hot EF had difficulty as they spent more time in non-instructional but behaved on par with peers of higher hot EF ability as they spent more time in teacher-managed activities. The demands placed on children to regulate their own behavior during teacher-managed instruction are minimal and thus less likely to engage hot EF skills. These results are consistent with previous findings that children in the early years of school exhibited more learning-related behaviors in classrooms that relied on teacher-managed instruction, rather than child-managed instruction (Stallings, 1975; Stipek, Feiler, Daniels, & Milburn, 1995).

Conversely, children with low cool EF exhibited poorer learning-related behaviors relative to high cool EF peers when exposed to more child-managed instruction. During child-managed activities, children are expected to manage their own attention. Results suggest children with low cool EF are less able to engage with the academic material and display self-directed behavior when teachers are not directing the lesson. Vile Junod, DuPaul, and Jitendra (2006) found that first graders with ADHD (marked by cool EF deficits) were more likely to display learning-related behaviors if they were engaged in an active (e.g., writing) versus passive (e.g., listening) activity. An examination of the combined contribution of time spent in activity setting and type of activity may provide a more nuanced understanding of how to promote learning-related behaviors in children with low cool EF.

Children with low cool EF made smaller gains in letter-word identification relative to high cool EF peers as they spent more time in orient-organize. Other work examining first grade activity settings found that time spent in orient-organize in the fall was beneficial to growth in letter-word identification whereas more time spent in orient-organize throughout the year resulted in less growth (Cameron, Connor, Morrison, & Jewkes, 2008). Findings from this study show that less total time spent in orient-organize was associated with more gains in letter-word identification for children with low cool EF. Although the present study did not account for change in the proportion of time spent in orient-organize throughout the school year—but rather summed observations throughout the school year, it can be assumed that in order to receive a high score in orient-organize, a teacher would presumably employ this activity setting throughout the school year. For children with low cool EF less time spent in orient-organize overall was related to gains in letter-word identification, perhaps because children with limited attention, persistence, and concentration were unable to stay on-task if they received too much explanation prior to learning.

Children with low cool EF also made smaller gains in applied problems relative to high cool EF peers as they spent more time in teacher-managed instruction. This finding represents that only interaction that ran counter to expectations. It was anticipated that children with low cool EF would benefit from teacher-managed instruction because the teacher would ostensibly manage the child's attention. In a study examining literacy outcomes, low-performing students benefited more from teacher-managed instruction, whereas high-performing students benefited more from child-managed instruction (Connor, Morrison, & Katch, 2004). Differences in the quality of teacher-managed literacy and math instruction may account for these anomalous findings. Ginsberg and colleagues' (2008) synthesis of early math education suggests math instruction is lackluster in the typical American classroom. For children with low cool EF (i.e., children with poor attention and persistence), exposure to teacher-directed math activities that are rote and poorly executed, may be less advantageous than other forms of instruction, for example group activities or work with manipulatives that promote self-discovery. In this sample, children with low cool EF actually outperformed high cool EF peers on a standardized math test, when exposed to less time spent in teacher-directed activities.

Taken together, these findings point to the important role of time spent in different classroom contexts when examining the contribution of hot and cool EF to behavior and achievement outcomes. The interactions between hot EF and activity setting are especially notable in light of previous studies that have had difficulty detecting a significant relation between hot EF-related abilities and academic achievement in early childhood (e.g., Duncan et al., 2007). In sum, cool EF appears to be directly associated with first graders' behavior and achievement outcomes whereas hot EF shows a pattern of similar relations dependent upon context.

Practical Implications

Findings from this and other studies (Blair & Razza, 2007; Diamond et al., 2007) begin a compelling argument for articulating EF development as a goal of early childhood education. The current trend in education policy is to focus efforts toward measuring student gains in basic skills and content knowledge (No Child Left Behind Act, 2001; The School Readiness Act, 2005). An expanded definition of the goals of the classroom, one that includes EF, may invite practitioners and researchers to embed opportunities for EF development into the classroom.

Moreover, results implicate both hot and cool EF in children's behavior and achievement dependent upon teachers' choice of instructional practices. These findings suggest that elementary teacher preparation programs should emphasize the important role of individual differences in children's EF ability in determining optimal activity settings with attention to the amount of time allocated to different settings. In so doing, teachers will be able to maximize learning time and support the needs of diverse learners in the classroom.

Limitations and Future Directions

Three avenues for future research are suggested. First, due to time and testing constraints hot and cool EF constructs rely on one EF task each. EF measurement is a relatively new area in the field of psychology (Carlson, 2005). The tasks selected for this study show both reliability and validity (Archibald & Kerns, 1999; Hongwanishkul et al., 2005). Yet, it may be that the complexity of EF is not fully captured by these tasks. Future analyses that incorporate multiple measures of EF are suggested in order to make more robust predictions about the relation between EF, child outcomes, and classroom processes.

Second, Sameroff and Mackenzie's (2003) transactional model of development proposes analyses take into account the bidirectional effects of the child and environment. It is conceivable that teachers altered their choice of activity settings or that quality was influenced by the hot and cool EF abilities of children in the classroom. Within this data set, this hypothesis is untestable because hot and cool EF scores were collected for four to five children per classroom. Future studies designed to collect scores for every child in the classroom are suggested in order to examine the potential for a reciprocal relation.

Lastly, findings from this study indicate certain activity contexts serve to ameliorate the behaviors of children with low hot and cool EF ability over the course of first grade. Specifically, settings where teachers manage children's attention appear to bolster classroom behaviors and settings where children manage their own attention can be detrimental to behavior ratings. What is not clear is the long-term impact of exposure to classrooms that externally regulate children's behavior and versus classrooms that offer opportunities to exercise self-regulation. Other research has found that although teacher-managed classrooms tend to support children's behavior and achievement outcomes, these same children show less independence, less self-reliance, and less self-confidence (Goldbeck, 2001; Stipek et al., 1998). Longitudinal research is proposed to examine children with low EF may benefit from more teacher support initially, with increasing opportunities for less teacher-managed instruction over time.

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Table 1

Means, Standard Deviations, and Correlations

Variables	1	2	3	4	5	6	7	8	9	10
Mean	77.34	.52	3.69	12.86	18.8	2.98	3.98	447.61	457.42	414.36
Standard Deviation	3.59	.50	1.92	2.56	3.32	2.06	2.06	14.89	15.96	25.57
Minimum	68	0	1	4	5	0	0	393	417	364
Maximum	86	1	8	16	23	6	6	485	498	491
1. Age	—									
2. Gender (male = 1)	-.04	—								
3. Family Income	-.07	.08	—							
4. Fall Cool EF	.05	-.11	.03	—						
5. Spring Cool EF	.10	-.06	-.12	.16*	—					
6. Fall Hot EF	.13	.02	-.13	-.01	.12	—				
7. Spring Hot EF	.21**	.09	.16*	-.07	.21**	.39**	—			
8. Fall WJ Math Scores	.23**	-.05	.22**	.16*	.07	.09	.24**	—		
9. Spring WJ Math Scores	.09	-.02	.27**	.22**	.09	.10	.16*	.71**	—	
10 Fall WJ Reading Scores	.16*	-.14	.24**	.14	.07	-.02	.04	.43**	.48**	—
11. Spring WJ Reading Scores	.10	-.11	.20**	.16*	.11	-.05	.00	.41**	.52**	.86**
12. Academic Performance	.16*	-.20**	.25**	.22**	.13	.03	.00	.55**	.54**	.70**
13. Learning-Related Behaviors	.18*	-.29**	.16*	.27**	.24**	.05	.07	.38**	.41**	.42**
14. Observed Classroom Engagement	.07	-.22**	.06	.12	.22**	.07	.10	.12	.21**	.19*
15. CLASS Quality	.03	-.03	.09	-.12	.16*	-.01	.20**	-.04	.03	.01
16. Time in Teacher-Managed Instruction	-.10	-.00	-.10	-.05	.01	.04	.16	-.07	.04	-.11
17. Time in Child-Managed Instruction	.11	.05	.05	-.05	.04	-.04	-.03	.09	.01	.11
18. Time in Orient-Organize	-.07	-.03	.04	-.06	-.13	.02	-.10	.07	-.00	.02
19. Time in Non-Instruction	.01	-.11	.05	.16*	.00	-.01	-.07	-.09	-.06	-.11

* $p < .05$ ** $p < .01$

11	12	13	14	15	16	17	18	19
450.07	3.34	0	4.53	3.84	179.69	204.56	41.62	168.2
22.54	1.05	3.66	0.96	0.60	95.17	111.02	32.86	68.91
397	1	-8.03	2.42	3	0	5	0	38
504	5	5.84	6	6	461	475	174	396
—								
.74**	—							
.44**	.64**	—						
.25**	.25**	.54**	—					
.11	.01	.12	.26**	—				
.02	-.08	-.05	-.01	.25**	—			
.03	.06	-.01	-.02	-.04	-.73**	—		
-.06	-.01	-.01	-.09	-.05	-.05	-.26**	—	
-.13	-.04	.04	.11	-.11	-.11	-.49**	-.02	—

Table 2

The Contribution of Hot and Cool EF to Academic Outcomes

	WJ Applied Problems			WJ Letter-word ID			Academic Performance		
Fixed Effects	Coeff.	*df*	t	Coeff.	*df*	t	Coeff.	*df*	t
Intercept	457.39	36	298.6 ***	449.70	36	405.46 ***	14.22	36	43.58 ***
Fall WJ Scores	0.70	163	11.03 ***	0.76	165	23.71 ***	~		~
Age	-0.22	163	-1.11	-0.23	165	-1.33	0.18	164	2.52 *
Gender (male=1)	0.35	163	0.18	0.81	165	0.50	-1.76	164	-3.78 ***
Family Income	0.84	163	1.55	-0.29	165	-0.78	0.64	164	4.51 ***
Hot EF	0.47	163	1.23	-0.57	165	-1.26	0.10	164	0.82
Cool EF	0.80	163	2.94 **	0.45	165	1.38	0.29	164	2.31 *
Random Effects	*Var.*	x^2	*p*	*Var.*	x^2	*p*	*Var.*	x^2	*p*
Intercept	12.260	55.54	.020	14.53	55.92	.018	0.35	38.55	.355
Level-1 effects	104.00			11.67			14.63		

*p $\leq$.05 **p $\leq$ .01 ***p $\leq$ .001

Note. Coeff. = Fixed effect HLM coefficient estimate; *Var.* = variance component; ~ denotes predictor not in model

Table 3

The Contribution of Hot and Cool EF to Classroom Behavior

	Learning-Related Behaviors			Observed Engagement		
Fixed Effects	Coeff.	*df*	t	Coeff.	*df*	t
Intercept	1.00	36	2.45 *	20.12	36	43.93 ***
Age	0.17	164	2.55 *	0.06	161	0.55
Gender (male=1)	-1.91	164	-3.68 ***	-1.59	161	-2.06 *
Family Income	0.38	164	2.76 **	0.19	161	1.04
Hot EF	0.14	164	1.10	0.20	161	1.09
Cool EF	0.30	164	3.40 ***	0.13	161	0.83
Random Effects	*Var.*	x^2	*p*	*Var.*	x^2	*p*
Intercept	0.53	44.60	.154	1.18	45.58	.132
Level-1 effects	10.67			19.27		

*p ≤.05 **p ≤ .01 ***p ≤ .001

Note. Coeff. = Fixed effect HLM coefficient estimate. *Var.* = variance component.

Table 4

The Contribution of CLASS quality to Hot and Cool EF Gains

	Hot EF			Cool EF		
Fixed Effects	Coeff.	*df*	t	Coeff.	*df*	t
Intercept	3.84	35	19.53 ***	18.91	35	64.30 ***
Age	0.07	166	1.83	-0.03	151	-0.47
Gender (male=1)	0.31	166	1.17	-0.12	151	-0.27
Family Income	0.22	166	3.52 ***	-0.24	151	-1.86
Fall EF scores	0.38	166	6.90 ***	0.18	151	1.64
CLASS Quality	0.57	35	2.89 **	1.00	35	2.64 **
Random Effects	*Var.*	x^2	*p*	*Var.*	x^2	*p*
Intercept	.002	31.13	>.50	.012	28.26	>.50
Level-1 effects	3.28			10.34		

*p ≤.05 **p ≤ .01 ***p ≤ .001

Note. Coeff. = Fixed effect HLM coefficient estimate. *Var.* = variance component.

Table 5

The Contribution of Activity Setting to Gains in EF

	Hot EF			Hot EF		
Fixed Effects	Coeff.	*df*	t	Coeff.	*df*	t
Intercept	3.88	36	18.83 ***	18.96	36	58.41 ***
Age	0.11	162	2.52 *	-0.01	148	-0.01
Gender (male=1)	0.29	162	1.04	-0.23	148	-0.47
Family Income	0.26	162	4.08 ***	-0.19	148	-1.40
Fall EF scores	0.37	162	6.37 ***	0.15	148	1.40
Time in Child-Managed Instruction	-0.004	162	-1.48	-0.003	148	-0.34
Time in Teacher-Managed Instruction	-0.001	162	-0.36	-0.003	148	-0.42
Time in Orient-Organize	-0.011	162	-2.26 *	-0.014	148	-1.09
Time in Non-Instruction	-0.005	162	-2.01 *	-0.004	148	-0.50
Random Effects	*Var.*	x^2	*p*	*Var.*	x^2	*p*
Intercept	.003	29.08	>.50	.058	30.77	>.50
Level-1 effects	3.25			10.73		

$*p \leq .05$ $**p \leq .01$ $***p \leq .001$

Note. Coeff. = Fixed effect HLM coefficient estimate. *Var.* = variance component.

Figure 1
The Contribution of Time Spent in Non-Instruction to Math Outcomes for Children with Varying Levels of Hot EF

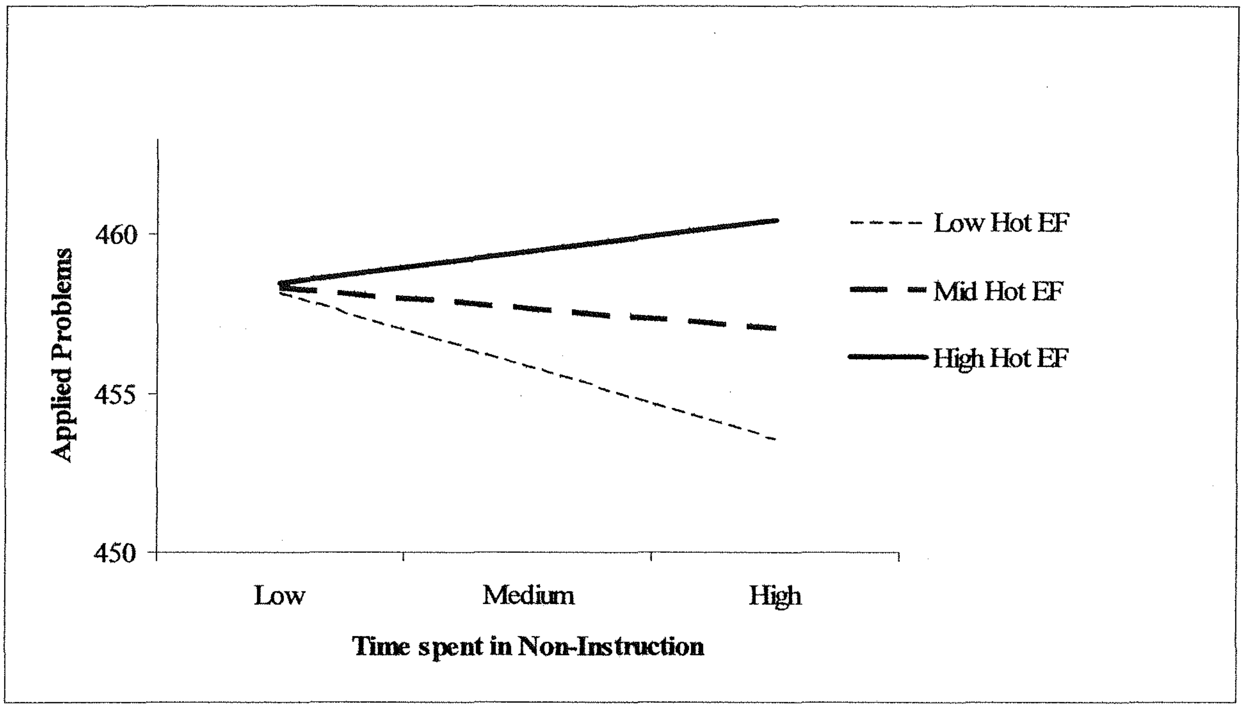


Figure 2
The Contribution of Time Spent in Non-Instruction to Teacher-Rated Academic Performance for Children with Varying Levels of Hot EF

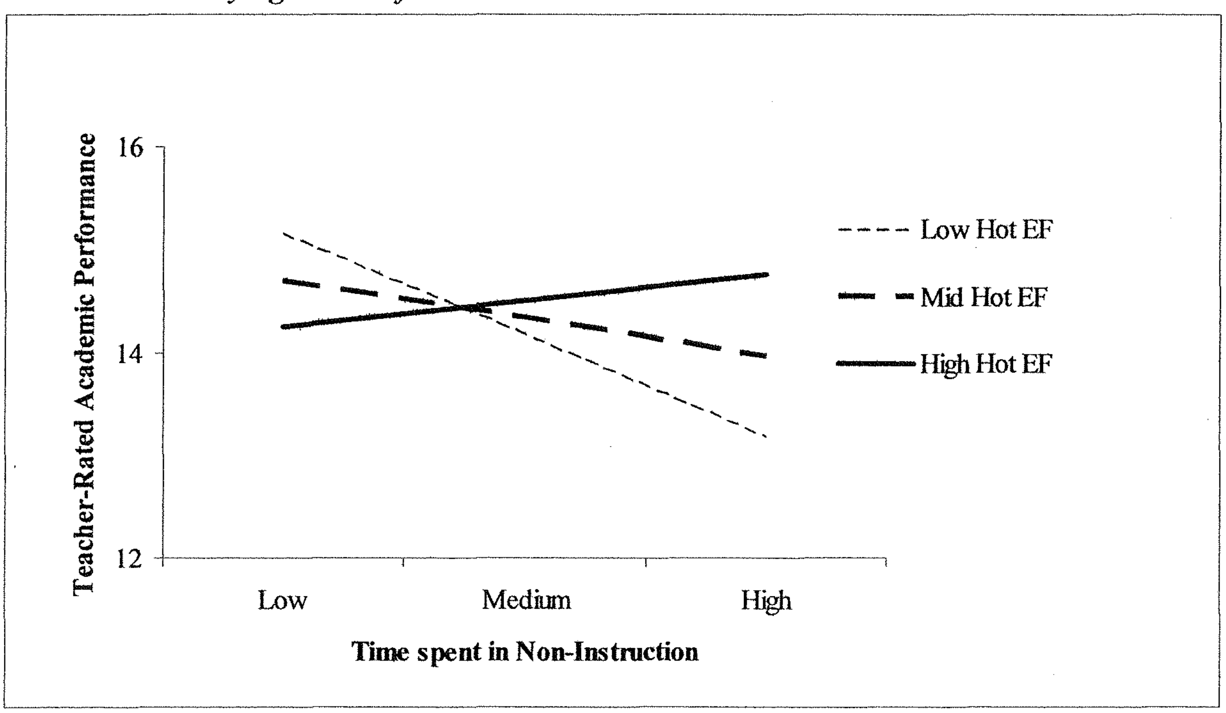


Figure 3

The Contribution of Time Spent in Non-Instruction to Learning-Related Behaviors for Children with Varying Levels of Hot EF

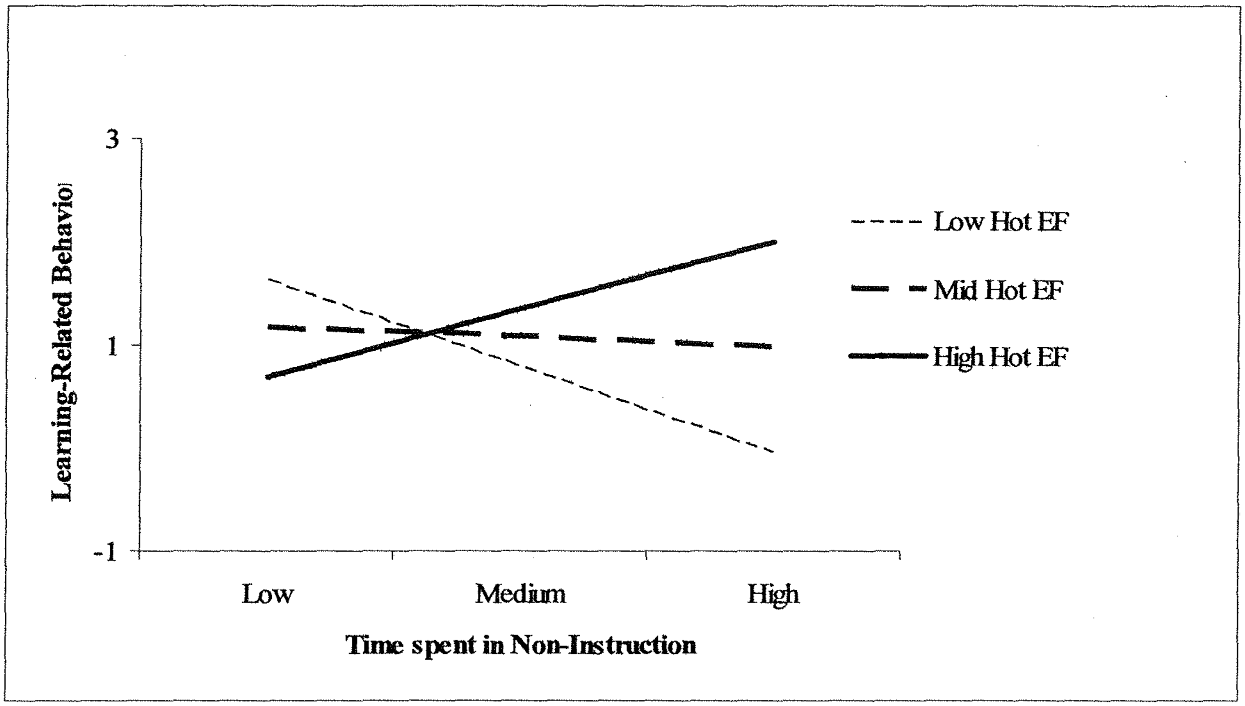


Figure 4

The Contribution of Time Spent in Non-Instruction to Observed Engagement for Children with Varying Levels of Hot EF

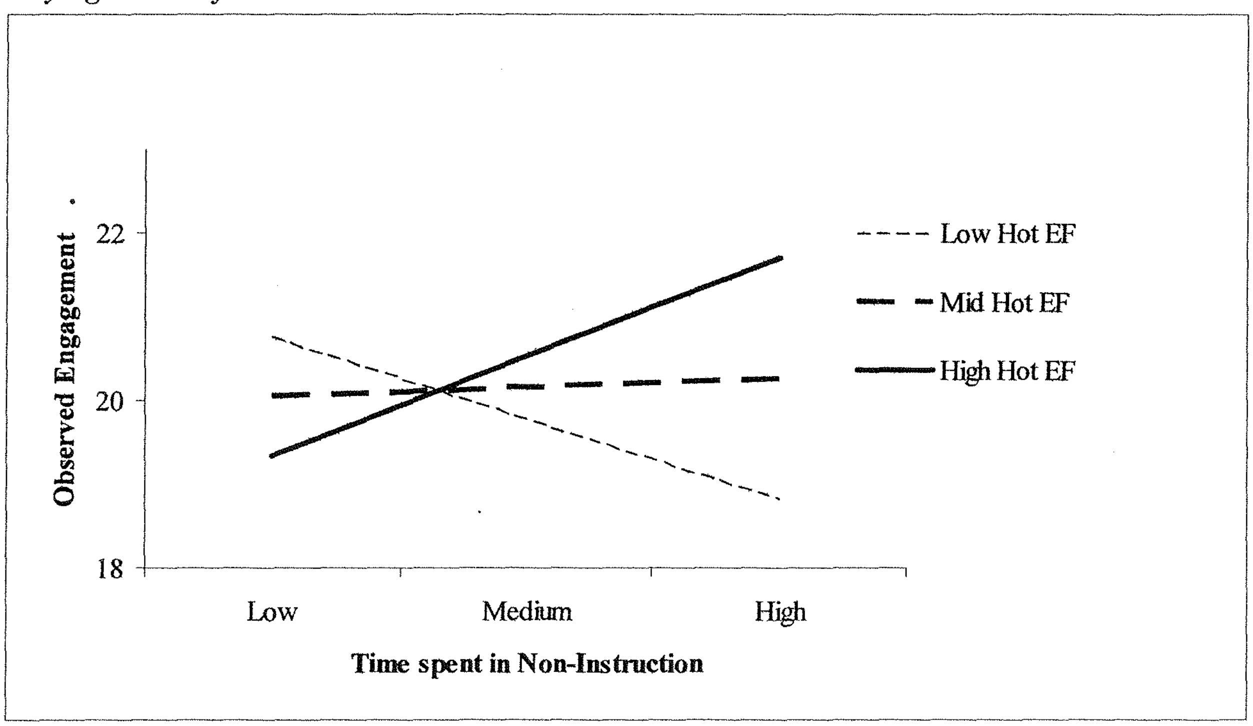


Figure 5

The Contribution of Time Spent in Orient-Organize to Reading Outcomes for Children with Varying Levels of Cool EF

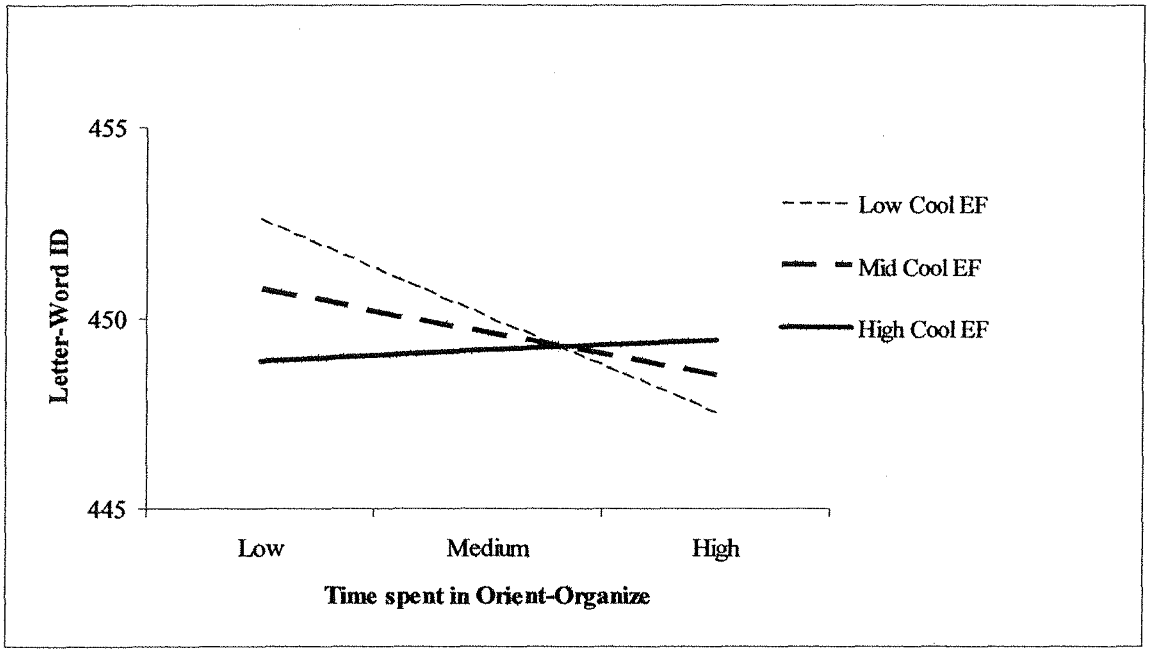


Figure 6

The Contribution of Time Spent in Teacher-Managed Instruction to Applied Problems for Children with Varying Levels of Cool EF

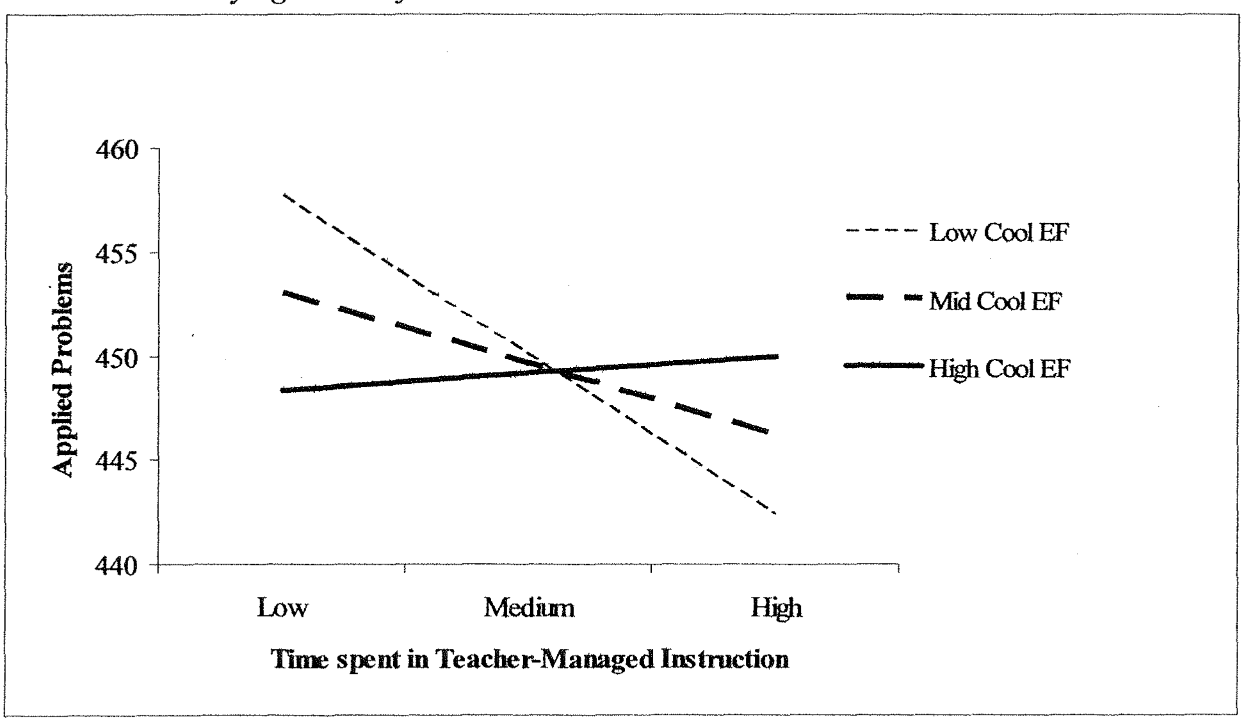


Figure 7
The Contribution of Time Spent in Teacher-Managed Instruction to Learning-Related Behaviors for Children with Varying Levels of Hot EF

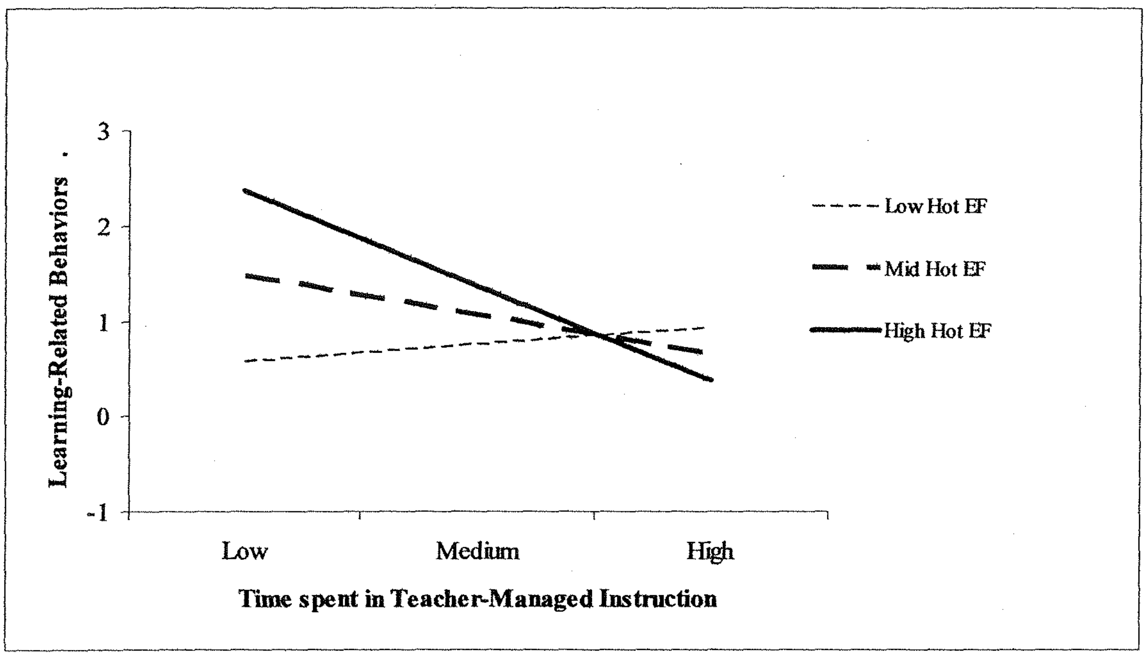


Figure 8
The Contribution of Time Spent in Teacher-Managed Instruction to Observed Engagement for Children with Varying Levels of Hot EF

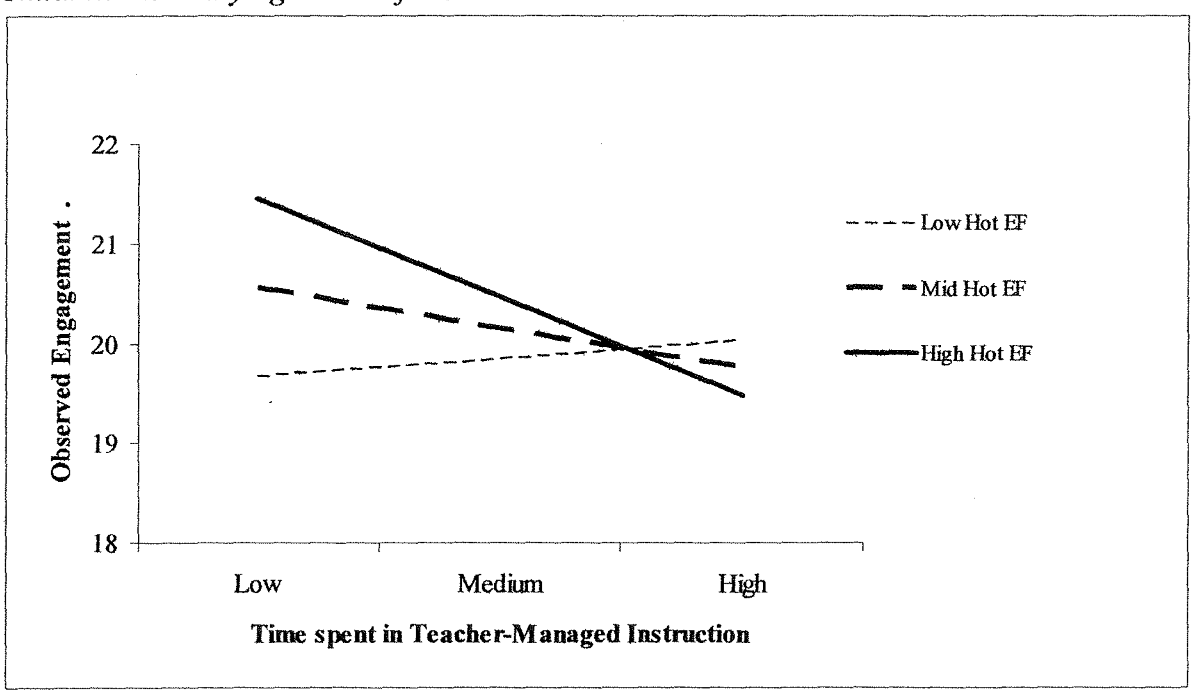
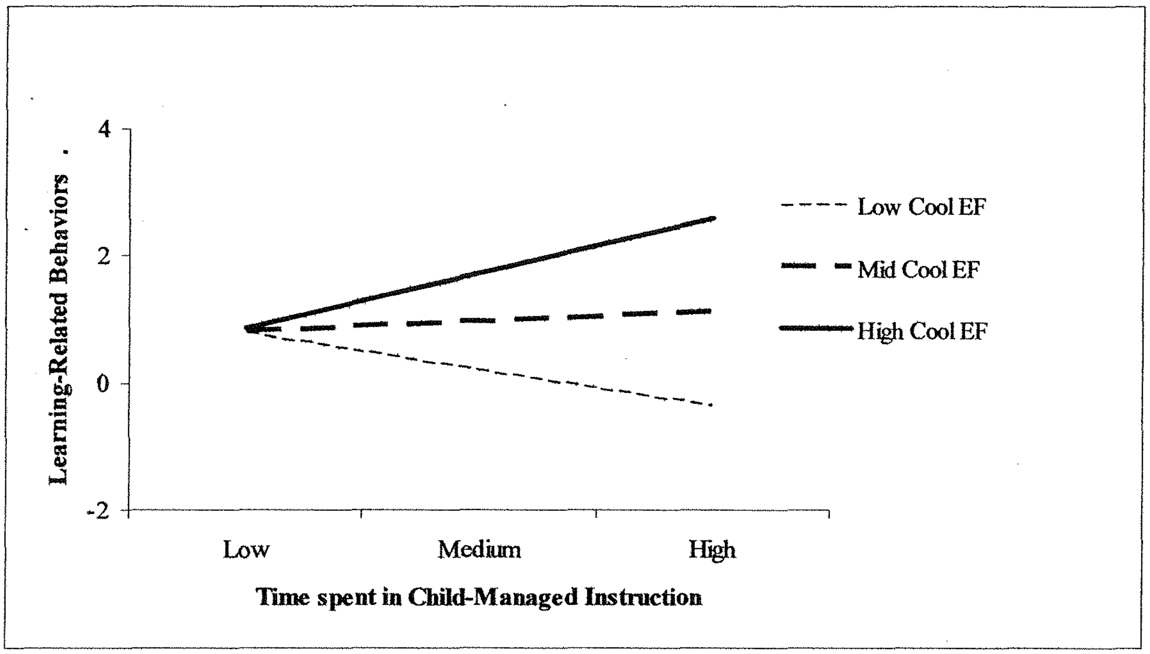


Figure 9
The Contribution of Time Spent in Child-Managed Instruction to Learning-Related Behaviors for Children with Varying Levels of Cool EF



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