ABSTRACT

TURNER, KIMBERLY ANN. Understanding Socioeconomic Differences in Kindergarteners’ School Success: The Influence of Executive Function and Strategic Memory. (Under the direction of Lynne Baker-Ward, Ph.D.).

Because academic achievement is one of the most important accomplishments of childhood, understanding the sources of variability in students’ school performance has both theoretical and applied significance. One of the most widely used predictors of individual differences in school success is socioeconomic status (SES). SES, however, is a nebulous construct that is influenced by many other variables. Hence, there is much need to identify behaviors and skills that enable children to achieve in academic settings regardless of SES.

At present, however, much more is known about what children know (domain-specific knowledge) than about how children learn (domain-general processes). This research, therefore, was conducted in order to investigate the influence of the domain-general cognitive processes of attention shifting (Flexible Item Selection Task; Jacques & Zelazo, 2001), inhibitory control (Day/Night Task; Gerstadt, Hong, & Diamond, 1994), working memory (Backwards Digit Span; McCarthy, 1972), and strategic memory (Object Memory Task; Baker-Ward, Ornstein, & Holden, 1984) on academic achievement in kindergarteners, while accounting for the relative limitations in academic success that are traditionally associated with socioeconomic status, race, and language. Academic achievement was operationalized in terms of standardized reading and mathematics performance (Woodcock Johnson Tests of Achievement’s Letter-Word Identification and Applied Problems subscales;
Woodcock, McGrew, Mather, 2001) and teachers’ subjective assessments (Academic Performance Rating Scale; DuPaul, Rapport, & Perriello, 1991). The sample (N=138) was economically and racially diverse sample. Results indicated that children’s cognitive control processes explained a significant amount of variability in standardized reading and mathematics scores even when accounting for variability in SES, race, and vocabulary. In addition, children’s use of strategic memory approaches uniquely predicted teachers’ ratings of early academic success. Consequently, it is suggested that cognitive processes may serve as a source of resilience for children who do not have the advantages arising from high levels of maternal education over time. The contributions and limitations of this research and suggestions for future investigations are discussed in relation to the growing body of research that emphasizes the importance of cognitive abilities in early academic success.
Understanding Socioeconomic Differences in Kindergarteners’ School Success:
The Influence of Executive Function and Strategic Memory

by
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Understanding Socioeconomic Differences in Kindergarteners’ School Success: The Influence of Executive Function and Strategic Memory

Academic achievement is one of the most important accomplishments of childhood. It is a cumulative process; students must continuously learn new knowledge and skills and refine existing conceptualizations and abilities (Pungello, Kupersmidt, Burchinal, & Patterson, 1996). Consequently, there is much need to identify the early behaviors and skills that enable children to learn in educational settings. The present study was conducted to contribute to the understanding of how kindergarteners’ self-controlled cognitive processes add to predictions of school achievement, while accounting for the relative limitations in academic success that are traditionally associated with socioeconomic status, race, and language ability. The cognitive processes examined in this investigation were children’s executive function abilities of attention shifting, inhibitory control, and working memory and children’s use of deliberate memory approaches.

One of the most widely used contextual factors to predict individual differences in school success is socioeconomic status (SES; Sirin, 2005). Numerous studies have shown a strong association between SES and various measures of academic achievement (e.g., Gottfried, Gottfried, Bathurst, Guerin, & Parramore, 2003; Bradley & Corwyn, 2002; Liaw & Brooks-Gunn, 1994; Baydar, Brooks-Gunn, & Furstenberg, 1993). The significance of SES differences in school success is illustrated by the continued support for the national Head Start program. With an annual budget of $6.8 billion in 2008, the Head Start program has provided comprehensive support to economically disadvantaged children and families in an
attempt to increasing school readiness and success (U.S. Department of Health and Human Services, 2008).

The association between SES and academic achievement cannot be addressed without acknowledging the nebulous nature of SES. SES is a complex construct that has been shown to be influenced by other variables. A particular difficulty in examining the relation between SES and academic outcomes in the US is the extent to which race is confounded with SES when predicting child outcomes (e.g., Pungello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009; McLoyd, 1998). In addition, SES may indirectly influence academic achievement, and thus researchers are challenged to identify and examine the effects of other variables that could influence and underlie the status variable and its association with academic achievement. Much has been learned from research that has examined the unique effects of factors external to the child (e.g., family’s access to resources, teacher attitudes, stress) on SES and child development (see Bradley & Corwyn, 2002). Less is known, however, about the potential effects of child characteristics. Research that has looked at early child attributes as predictors of school success has traditionally concentrated on what children know not how children learn. Hence, the focus has been on domain-specific knowledge, such as letter and number recognition (Duncan et al., 2007), rather than domain-general processes. The present research investigated the influences that children’s cognitive processes, specifically executive function (i.e., attention shifting, inhibitory control, and working memory) and strategic memory skills, have on the academic achievement in kindergarten above and beyond the effects that are associated with SES and language ability. Further addressing a limitation in the literature,
higher levels of SES were represented among both the European and African American families who participated in the research.

**Executive function**

Executive function is the overarching term used to describe the set of higher-order processes that aid in the regulation of cognition in the service of planning, problem-solving, and goal-directed actions (Miyake et al., 2000). Executive function is typically thought of as comprising three specific cognitive abilities: attention shifting, working memory, and inhibitory control. Attention shifting is defined as the ability to adapt or shift actions to changing situational demands (Zelazo, Frye, & Rapus, 1996). Working memory is the ability to keep and manipulate information in the mind to guide ongoing behavior (Baddeley & Hitch, 1974). Inhibitory control is the ability to impede prepotent responses or irrelevant information that could interfere with completing a goal (Baddeley, 1996; Diamond, 1990).

Cognitive control has garnered much recent attention due to its association with early school success. Survey results have indicated that kindergarten teachers perceive approximately 50% of the children in their classrooms as experiencing problems that limit their ability to achieve in school, with the inability to regulate behavior as the most frequently reported reason for these problems (Rimm-Kaufman, Pianta, & Cox, 2000). These findings have spurred a growing interest in understanding how regulatory processes influence individual differences in school success in hopes of preventing school failure (e.g., Blair & Diamond, 2008). Studies have indicated that young children’s executive control is positively associated with early math and reading abilities, such as mathematics knowledge, letter
knowledge, and phonemic awareness (Blair & Razza, 2007; Bull & Scerif, 2001; Espy et al., 2004). Further, Blair and Razza (2007) have found that executive functioning predicts success in math and reading at the end of kindergarten, above and beyond the effects of general intelligence.

In addition to the associations among measures of executive function and school success, the relations among indicators of executive function and SES are increasingly of interest. Most of the work on SES and executive function has been conducted by Farah, Noble and their colleagues (e.g., Hackman & Farah, 2009; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005). These researchers suggest that brain systems with prolonged postnatal development, including the prefrontal/executive system, are more susceptible to the effects of poverty than are earlier developing systems. Farah and associates have found that among early elementary school children, SES was associated with lower performance on a composite of executive function tasks and that this relation was statistically mediated by children’s language ability (Noble, et al., 2007). Therefore, as with early school achievement, it appears that the environmental factors associated with low SES influence the development of some cognitive abilities.

Adding complexity to the understanding of the linkage between SES and executive function, there is some debate among researchers regarding the interrelatedness of the executive control abilities. Specifically, they question whether the abilities described above constitute three uniquely independent processes (Miyake et al., 2000) or form a unitary construct (Wiebe, Espy, & Charak, 2008; Duncan & Owen, 2000). This quandary is
magnified in the study of young children (i.e., 3- to 6-year olds) who are in a developmental period during which the ability to regulate their behavior and cognition becomes increasingly important and prevalent (Blair & Diamond, 2008). Inconsistencies in evidence for the interrelatedness of executive function abilities are common (for comparison, see Schneider, Lockl, & Fernandez, 2005 and Carlson & Moses, 2001). Differential patterns also emerge when examining executive function components’ association with other constructs. Especially pertinent to the current investigation, the associations between the specific abilities of executive function and SES are inconsistent and are more likely to be found with inhibitory control measures (c.f., working memory; Noble, et al., 2005). A different pattern of influence also emerges for academic achievement, with inhibitory control abilities (c.f., attention shifting) exerting the most consistent and predictive influence (Blair & Razza, 2007). Therefore, research that utilizes statistical methods for parsing unique and shared variance is needed.

**Strategic memory**

Like executive function, strategic memory requires the activation of self-regulatory cognitive process in the service of completing a goal. In the case of strategic memory, the goal is to increase memory performance via the use of memory strategies, defined as “cognitive or behavioral activities that are under the deliberate control of the subject” (Naus & Ornstein, 1983, p. 12). Strategies include such tactics as searching for objects, rehearsal, organization, selective attention, elaboration, and visual imagery. The work of John Flavell and his associates has led to the conclusion that memory development in children can be
understood largely as the transition from nonstrategic to strategic behavior (for review, see Schneider & Pressley, 1997). Moreover, Flavell’s work inspired more than three decades of research examining the use and significance of strategies, including assessments of the relation between knowledge and strategies (e.g., Bjorklund & Buchanan, 1989; Schneider & Bjorklund, 1992) and the relation between strategies and metamemory (e.g., DeMarie & Ferron, 2003).

The use of memory strategies has been shown to increase declarative memory performance at all three stages of remembering: encoding, storage, and retrieval. Students who employ strategies are more likely to recall information learned in the context of school and hence to succeed in the academic environment (Anderson, 1995). The use of strategies is fairly limited in the early elementary years. However, many researchers have provided evidence that kindergarten children do possess some tactics for deliberate remembering. At age four, children make a transition from being passively drawn to an object’s novelty or salience to actively and strategically scanning their environments (i.e., demonstrating selective attention; Schneider & Pressley, 1997). Research by Baker-Ward, Ornstein, and Holden (1984) showed that children as young as four displayed different behaviors depending upon whether they were asked to either remember or play with a set of stimulus objects that they would subsequently be asked to recall. When given the instruction to try to remember the objects, children spent more time engaging in on-task or study-like behaviors with the objects, compared to the task approaches of children instructed to play. Moreover, during memory activities kindergarteners exhibit deliberate, intentional, and purposeful
behaviors, such as organizing physical objects and rehearsing verbal materials for memorization (for review, see Wellman, 1988).

A main limitation of young children’s use of memory strategies lies not in their ability to produce but rather in the ability to utilize these strategies for successful recall, a phenomenon described as a utilization deficiency (Bjorklund, Miller, Coyle, & Slawinski, 1997). This developmental lag is a robust finding that traditionally accompanies the learning of a new strategy (e.g., Bjorklund & Buchanan, 1989; DeMarie, Miller, Ferron, & Cunningham, 2004; Lange & Pierce, 1992). For example, Baker-Ward and colleagues (1984) found that there were few links between the use of overt strategic behaviors and children’s subsequent recall of the objects among the groups of children younger than six years of age. However, such deficiencies are associated with learning new strategies, and as such deliberate memory behaviors could have developmental and predictive significance even before they benefit recall. Strategic memory is a goal-oriented behavior, which requires children to maintain and manipulate information (working memory), to focus attention and inhibit their prepotent responses (inhibitory control), and to adapt or shift actions (attention shifting). Hence, it is reasonable to predict that cognitive control capabilities might contribute to individual differences in memory strategy usage.

**Present study**

Given the nebulous nature of SES and the number of investigations that have shown strong associations between SES and various measures of academic achievement (see Bradley & Corwyn, 2002), it is important to examine how factors more proximal to a child
might contribute to the understanding of the SES and school success relation. Therefore, the overarching goal of the present study was to understand the unique effects that children’s cognitive processes have on standardized tests and teachers’ ratings of early academic achievement in an economically and racially diverse sample of kindergarten children. As noted above, the sample included a range of African American children from families across the socioeconomic strata, thus avoiding a confound that typically exists when the academic performances of European American and African American children are compared. This is especially important given that previous research has shown substantial racial differences on standardized measures of educational achievement even when controlling for socioeconomic status (Brooks-Gunn & Duncan, 1997; 2000). Minority status, therefore, has a unique effect on achievement beyond the effect of family SES and could be a product of prejudice, discrimination, and increase stress (McLoyd, 1998). As such, it seems likely that the relation between SES and school achievement could be influenced by a child’s race.

As indicated above, recent work has indicated the significant effect that children’s early cognitive regulation can have on early school success (e.g., Blair & Razza, 2007; Bull & Scerif, 2001; Diamond, Barnett, Thomas, & Munro, 2007; Espy et al., 2004) and additional research work that has indicated a significant relation between SES and measures of cognitive control (e.g., Hackman & Farah, 2009; Noble et al., 2007; Noble et al., 2005). The cognitive processes examined in previous research were those that represent regulation and control - attention shifting, inhibitory control, and working memory. To date, strategic
memory approaches have not been considered as an aspect of cognitive regulation. However, given the importance of strategic memory and mnemonic skills to academic success and the fact that strategic memory involves goal-oriented behavior that requires regulation, an aim of this study was to examine the relation among children’s executive function and deliberate memory approaches, while accounting for socioeconomic diversity, race, and language ability. It was expected that measures of executive function would positively predict children’s use of deliberate memory or study-like approaches.

Lastly, given the extent to which measures of cognitive regulation have been shown to be interrelated (e.g., Carlson & Moses, 2001), another aim of this research was to determine the extent to which child-level variables of cognitive flexibility, inhibitory control, working memory, and deliberate memory approaches related to standardized measures and teachers’ ratings of academic achievement when accounting for differences in SES, race, and language abilities. It was expected that children’s performance on cognitive regulation measures would uniquely and positively predict measures of academic achievement even when accounting for differences in family economic status, race, and child language ability.

Method

Participants

All participants were recruited from a largely urban community as part of a longitudinal study of child health and development, the Durham Child Health and Development Study. Participants were recruited in accordance with a stratified sampling plan designed to reflect the recruitment city’s demographic diversity (ethnicity and income).
Families were recruited at a child’s birth and were examined multiple times over early childhood. For recruitment purposes, attempts were made to have approximately equal representation of below poverty African Americans, below poverty European Americans, above poverty African Americans, and above poverty European Americans. The study examined variables that were assessed when the families’ target children were approximately 60-months old. A total of 138 families participated in the 60-month visit. The sample had an approximately equal representation of female and male children, 73 versus 65, respectively, \( \chi^2 (1, N = 138) = 0.46, p = .496. \). To ensure sample diversity, African American families were oversampled at recruitment; as a result, the 60-month sample included more African American families than European American families, 81 versus 57, respectively, \( \chi^2 (1, N = 138) = 4.17, p = .041. \) At the 60-month visit, family income-to-needs ratios ranged from 0.05 to 24.33 with an average of 4.41 (SD = 3.39). Mother’s years of education for the sample ranged from 5 to 20 years with an average of 15.09 (2.61) years or at least some college education. It should be noted, however, that the European American families on average had higher income-to-needs ratios (\( M = 5.64, SD = 4.23 \)) than the African American families (\( M = 3.54, SD = 2.29 \), \( t(136) = 3.74, p < .001 \). Additionally, European American mothers on average had more years of education (\( M = 16.28, SD = 2.05 \)) than African American mothers (\( M = 14.25, SD = 2.64 \), \( t(136) = 4.87, p < .001 \). The distributions of income-to-needs ratios and maternal years of education as a function of target children’s race can been seen in Figure 1.


Procedures and measures

**Overview of 60-month visit.** The 60-month assessment took place in one visit that on average required one and a half to two hours for completion. All tasks involving the child participants were administered at the DCHD Study’s playroom by research assistants employed by the DCHD project. The tasks comprising the assessment were administered in a standard order across participants.

**Academic ability.** Academic ability was assessed by standard reading and mathematics achievement tests and teachers’ ratings of academic performance. Specifically, the Woodcock Johnson Tests of Achievement (WJ-III ACH; Woodcock, McGrew, Mather, 2001) was used to measure ability. The WJ-III is a battery of 22 subtests that assess children’s and adults’ academic achievement. Each subtest is considered qualitatively different and as such each subtest can be used individually to assess distinct abilities. For the current study, two of the subscales are utilized: *letter-word identification (Subtest 1)* and *applied problems (Subtest 10)*. These two subscales were chosen to index the central components of academic success, children’s basic reading skills and mathematic reasoning. These subscales are correlated with children’s abilities in reading decoding, reading speed, and the ability to comprehend connected discussion while reading (letter-word identification) and abilities in problem solving, number facility, automaticity, and reasoning (applied problems). Each subscale takes about 5 to 10 minutes to administer.

Extensive psychometric data are available for the WJ-III ACH. It strongly correlates with other achievement measures in both normative and clinical samples. Concurrent validity
for the WJ-III ACH has been established with the Weschler Individual Achievement Test and the Kaufman Test of Educational Achievement (Woodcock, McGrew, Mather, 2001). The letter-word identification and applied problems subscales both indicate good inter-item and test-retest reliability for children 2- to 18-years of age (.80 and higher; Bradley-Johnson, Morgan & Nutkins, 2004). The dependent measure for the task are children’s grade-based standardized scores (M = 100, SD = 15) on the two subscales.

Teachers’ ratings of academic performance were obtained through the use of the Academic Performance Rating Scale (APRS; DuPaul, Rapport, & Perriello, 1991), a 19-item teacher-rating scale designed to assess children’s classroom performance via Likert-ratings (range = 1 to 5). Validity of the measure has been established with other measures of academic performance, observational classroom behaviors, and assessments of Attention/Deficit-Hyperactivity Disorder (DuPaul et al., 1991). The 19 items load onto three statistically unique student abilities/factors: 1) academic success, 2) impulse control, and 3) academic productivity. Congruent coefficients within factor items ranged from .84 and .98 with a mean of .92. The academic success subscale measures the quality of a student’s classroom work, the impulse control subscale indicates a student’s ability to control his/her behaviors in academic situations, and the academic productivity subscale assesses a student’s ability to complete work regardless of quality. Strong intercorrelations also exist between subscales. The intercorrelations among Academic Success and Impulse Control, Academic Success and Academic Productivity, and Impulse Control and Academic Productivity are .69, .88, and .63, respectively. Due to the high intercorrelations among subscales, the present
study used the APRS Total Score (sum of all items) as the independent variable of standardized academic achievement.

**Executive function.** Executive function was assessed using three measures in order to tap the three specific cognitive abilities widely assumed to comprise the construct: attention shifting, working memory, and inhibitory control. Attention shifting was measured using the Flexible Item Selection Task (FIST; Jacques & Zelazo, 2001), which is an assessment of children’s cognitive flexibility or their ability to shift attention in order to reach a goal. Following successful completion of criterion trials that assesses children’s ability to understand the instructions, children were presented with 12 trials in which they were given three items that vary along some combination of two of three dimensions: size, shape, number, and color. Children were instructed to point to two objects that go together in one way. Children were then instructed to point to two objects that go together in another way. The task requires children to identify two of the three objects that are similar along one dimension (i.e., size) but then to shift and identify two of the three objects that are similar along a second dimension (i.e., shape). Jacques and Zelazo (2001) have found that 2- to 5-year-old children’s performance on the FIST converges well with other executive functioning measures that assess attention shifting. They have also demonstrated scoring reliability on the task. The dependent measure is the number of correct responses divided by the total number of trials (range = 0 to 1).

Inhibitory control was measured via the Day/Night task (Gerstadt, Hong, & Diamond, 1994), which requires a child to respond counter to the prepotent tendency of saying “day”
when a white card with a yellow sun drawing on it is presented and saying “night” when a black card with a white moon is presented. Thus, a response is marked as correct when the child says the opposite of what the picture shows. Practice trials were administered until the child successfully labeled each card correctly once. If a child was unable to demonstrate success after 5 trials, the task was stopped. If the child was successful, 10 “day” and 10 “night” cards were shown to the child in a predetermined random order. Gerstadt et al. (1994) have extensively studied task performance in children 3.5- to 7-years of age and have demonstrated individual and age-related differences in children’s ability to inhibit their prepotent responses. The dependent measure is the number of correct responses divided by the total number of trials (range = 0 to 1).

Lastly, working memory was measured by means of a backward version of the Digit Span. The backward series is a measure of working memory span due to the added need to manipulate information stored in memory. The task procedures were based on the procedure used in the McCarthy Scales of Children’s Abilities (1972). As such, backward span was assessed along with forward digit span, which is a measure of short-term memory. In total, the task was composed of two forward series and two backward series. All children were presented with the same series of number. Beginning with forward series, children were instructed to repeat a series of numbers, starting with two digits, in the same order that it is given. The child had up to two opportunities at a given set size to respond correctly. If correct, the child proceeded to the next set that provided children with a new set of numbers that is increased by one digit. Each series ended when the child failed to respond correctly.
on both trials of a given set size. Following the completion of the forward span children completed the backwards span, which requires children to repeat a series of numbers, starting with two digits, in backwards order that are presented. Backwards series were presented in the same manner as forwards. The dependent measure for the task was a child’s backward digit span, which is defined as the largest set of numbers that could be successfully reported (range = 0 to 4).

**Strategic Approaches.** Strategic memory approaches were examined using an Object Memory Task based on previous work by Baker-Ward et al. (1984) and used more recently by Haden, Ornstein, Eckerman, and Didow (2001) and Rudek and Haden (2005). The task assesses children’s behavioral task approaches during a 2-minute study period prior to recall performance. In the administration of this task, children were seated at a table upon which there were 10 small, relatively unrelated objects (e.g., ball, hat, cup). The children were told that they should try to do anything that they could to help them remember the objects. They were then given a 2-minute activity period after which a cloth was used to cover the objects and the children were asked to recall as many items as they could. All interactions with the stimuli were videotaped for subsequent analysis.

The task performance is coded based on the work of Baker-Ward et al. (1984), Haden et al. (2001), and Rudek and Haden (2005). The scheme was designed to capture both physical interactions with the stimuli such as playing and manipulation, visual inspection of the array, and language used in the performance of the task, such as object naming. The 2 min study period was divided into 5 s blocks that were coded separately for the occurrence of
verbal and non-verbal task approaches. Verbal task approaches used in each block were recorded as a raw count of the number of times the approach was used in a 5 s block; however, non-verbal task approaches used in each block were recorded as either occurring or not occurring during the interval. Interrater reliability was established on 25% of the study’s cases by two independent coders. Participants’ data were collected and coded in two waves. One researcher was a coder for both waves, yet her counterpart was different between the two waves. In order to correct for agreements based on marginal rates, agreement was established via kappa. For wave 1, agreement for nonverbal task approaches was .95 and .92 for verbal task approaches. For wave 2, agreement for nonverbal task approaches was .95 and .94 for verbal task approaches. The kappa coefficients thus indicated “substantial” agreement (Landis & Koch, 1977).

Task approaches were selected based upon previous work examining the behaviors children utilized during the Object Memory Task. Baker-Ward et al. (1984) found that the most prevalent task approaches exhibited by five-year-olds were manipulation (manual contact with the objects that does not involve the unique properties of the object such as lifting or touching the objects), playing (engagement with an object’s unique basic properties such as rolling a vehicle, wearing sunglasses), visual inspection (scanning the objects without touching them), and naming (providing a label—conventional or personal—for an object without further description). Moreover, children who were instructed to “remember” the objects were more likely to exhibit visual inspection and naming and were less likely to exhibit play compared to children who were instructed to “play” with the objects. Receiving
remember versus play instructions did not influence how much children manipulated the objects. Among the behaviors that were more likely to occur for remember instructions compared to play instructions, visual inspection was the only significant predictor of subsequent target item recall. Hence, visual inspection among five-year-olds can be assumed to be an early and beneficial strategy for remembering. Consequently, the number of intervals characterized by visual inspection was used as an indicator of deliberate remembering in this research.

**Vocabulary.** The Expressive Vocabulary Test (EVT; Williams, 1997) is a standardized language measure designed for children aged 2 1/2 years through adults aged 90 years. It is used as an assessment of expressive vocabulary and word retrieval for the English language, and it is co-normed with the PPVT-III. In general, the test measures expressive vocabulary knowledge with two types of items: labeling and synonym production. The EVT reliability analyses indicated a high degree of internal consistency. Split-half reliabilities ranged from .83 to .97. Test-retest studies with four separate age samples resulted in reliability coefficients ranging from .77 to .90.

**Socioeconomic status.** The present study utilized two mother-reported indicators of SES; a family’s needs-to-income ratio as a measure of financial capital and maternal years of education as a measure of human capital. Two measures were used in the present study because previous research has shown that multiple measures represent SES better than any alone. The variables were examined individually, rather than as a composite, because of evidence that different measures of capital might assess different underlying phenomena and
have unique effects on outcome measures (White, 1982). A family’s needs-to-income ratio was computed by dividing the total family income by the poverty threshold for the appropriate family size, as determined by the U.S. Department of Health and Human Services. Maternal education was the number of years of education completed by the target child’s mother.

**Missing data**

All 138 target children completed the subjective measures of academic achievement (WJ-III Letter-Word Identification and Applied Problems). Of the 138 children, 1 child was missing his/her family’s income-to-need ratio, 4 children were missing Object Memory data, 9 were missing FIST data, 4 were missing Day/Night data, 1 was missing Digit Span data, and 4 were missing EVT data. For the tasks characterized by higher rates of missing information (Object Memory, FIST), technical problems with video recording were the primary source for incomplete data. There were no differences in performance on either measure of subjective academic achievement as a function of incomplete data status for any study variable. For the teacher ratings of academic performance (APRS), however, only 58 target children had teachers who completed the survey. There were no differences in Letter-Word Identification and Applied Problems scores between children whose teachers completed the survey and those who did not. There were differences, however, between children who had APRS data and children who did not, as a function of their family’s income-to-needs ratios, $t(78.87) = 2.65, p = .010$. Hence, teachers who completed the survey had students who on average came from higher income families ($M = 5.38, SD = 4.33$) than
did teachers who did not complete the survey ($M = 3.72$, $SD = 3.32$). Children did not differ on any other variable. For children who had APRS data, 1 child was missing his/her family’s income-to-need ratio, 2 children were missing Object Memory data, 5 were missing FIST data, 1 was missing Day/Night data, and 1 was missing EVT data. There were no differences in the teacher ratings of academic performance scores for children who were missing data and those who were not for any measure.

To prevent the reduction in sample size that would result from completing regression analyses with listwise deletions, full information maximum likelihood (FIML) estimations were utilized. The FIML estimator utilizes all available raw data to estimate a model’s parameters and standard errors. FIML estimation has been shown to be superior to other ad hoc missing data techniques (e.g., listwise deletion, and mean imputation) by reducing regression coefficient bias, $R^2$ bias, and regression coefficient sampling variability than other ad hoc methods (Enders, 2001).

**Results**

The first step in determining the unique effects that children’s cognitive processes have on standardized measures and teachers’ ratings of early academic achievement was to examine the zero-order correlations among the independent variables: income-to-needs, maternal education, deliberate memory approaches, cognitive flexibility, inhibitory control, working memory, and vocabulary. Table 1 presents these correlations, along with means and standard deviations for each variable. Note that racial differences are not presented in this table; the main effect of race is presented below in the examination of its moderating effect.
on SES and academic achievement. As indicated, higher vocabulary scores were positively related to both indicators of SES variables and to each of the three executive function abilities (attention shifting, inhibitory control, and working memory). Also indicated in Table 1, SES as measured by income-to-needs ratio was positively related to the backwards digit span but was not associated with performance on the FIST and Day/Night task and the use of visual examination memory approaches. Maternal education, however, was positively related to both backwards digit span and Day/Night performance. The correlations between SES and executive function are no longer significant when vocabulary is controlled, $rs \leq .10, ps \geq .275$.

As further indicated in Table 1, backward digit span was positively related to the performance on the FIST and Day/Night tasks, and these measures were unrelated to each other. Controlling for vocabulary rendered the association between working memory and attention shifting no longer significant ($r = .07, p = .425$), whereas the correlation between working memory and inhibitory control remained significant ($r = .22, p = .011$). There was also a negative relation between performance on the FIST and children’s use of visual examination memory approaches.

Before examining the unique effect of SES and child cognitive measures on the academic assessments, zero-order correlations among these variables were calculated. Table 2 presents these correlations along with means and standard deviations for the academic measures. As indicated in the table SES as measured by income-to-needs ratio was positively related to the standardized measures but not teachers’ ratings of academic achievement. SES
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as measured by maternal education, however, was positively related to both standardized measures and teachers’ ratings of academic achievement. More maternal education was also related to higher teachers’ ratings of general academic success. It was also shown that vocabulary was positively related to all three measures of academic achievement. With regard to child cognitive processes, children’s use of visual examination memory approaches and greater performance on the Day/Night task and larger backwards digit spans were associated with better performance on the both standardized measures of achievement. Moreover, larger backwards digit spans were also predictive of the higher teacher ratings of academic performance. Lastly, better performance on the FIST was related to better performance on standardized mathematics performance.

**Relation between SES and academic achievement**

To examine the unique relation of measures of SES on standardized measures and teachers’ ratings of academic achievement, multiple regression was used. In the regression equation, income-to-needs ratios and maternal education were entered simultaneously. The coefficients associated with Type III sums of squares were interpreted in order to estimate the unique effect of each SES variable on the standardized reading ability and mathematic ability, teacher- ratings of general academic success. To reduce the risk of alpha error, the standardized measures of achievement were analyzed in the same regression equation.

With regard to standardized reading ability, analysis indicated that the two SES variables combined accounted for 14% of variance in WJ Letter-Word Identification scores, $F(2, 135) = 10.92, p < .001$. The regression estimate indicated that maternal education ($\beta =$
.35, $t = 3.61, p < .001$) was a significant positive predictor, whereas income-to-needs ratio was not a unique predictor of reading ability. A commonality analysis indicated that the two measures of SES shared 6% of the variance in reading ability. Income-to-needs ratio uniquely explained less than 1% of the variance, while maternal education uniquely explained 8% of the variance in reading ability. Moreover, the two SES variables combined accounted for 25% of variance in scores, $F(2, 135) = 22.77, p < .001$ in WJ Applied Problems performance. Both maternal education ($\beta = .32, t = 3.50, p = .001$) and family’s income-to-needs ratios ($\beta = .25, t = 2.81, p = .006$) were unique and positive predictors. A commonality analysis indicated that the two measures of SES shared 14% of the variance in mathemetic ability. Income-to-needs ratio uniquely explained 4% of the variance and maternal education uniquely explained 7% of the variance.

As for the teacher ratings of academic success, analysis indicated that the two SES variables combined accounted for 15% of variance in APRS ratings, $F(2, 55) = 4.76, p = .012$. The regression estimate indicated that maternal education ($\beta = .35, t = 3.61, p < .001$) significantly and positively predicted teachers’ ratings, but income-to-needs ratio was not a unique predictor. A commonality analysis indicated that the two measures of SES shared less than 1% of the variance in subjective achievement. Maternal education uniquely explained 14% of the variance, yet income-to-needs ratios uniquely explained 1% of the variance.

**Relation between SES, race, and academic outcomes**

Analyses were conducted to determine if race moderated (as defined by Barron & Kenny; 1986) the relation between the family SES and academic achievement. Specifically, a
regression model was conducted to include variables race and a composite SES variable
(i.e., the average of a standardized income-to-needs ratio and standardized maternal
education) and their two-way interaction. Zero-order correlation indicated that the composite
SES variable was positively related to a child’s WJ-III Letter Word Identification and
Applied Problems scores, \( rs(137) > .34, ps < .001 \), and teacher’s APRS ratings, \( r(57) = .27, p = .045 \). The composite was also related to the target child’s race, such that on average
European American children had a larger SES composite \( (M = 0.41, SD = 0.91) \) than African
American children \( (M = -0.29, SD = 0.75) \), \( t(137) = 4.91, p < .001 \). On average European
American children also had higher Applied Problems scores \( (M = 123.12, SD = 14.00) \)
compared to African American children \( (M = 103.53, SD = 20.47) \), \( t(137) = 6.26, p < .001 \).
However, there were no race differences for Letter Word scores, \( t(137) = 1.45, p = .149 \), and
APRS teacher ratings \( t(57) = 0.91, p = .368 \).

To reduce the risk of alpha error, the standardized measures of achievement were
analyzed in the same regression equation with race, composite SES, and the interaction
between the two variables entered into one step. The regression revealed that for Letter-Word
Identification there were no main effects of race and SES; however, there was a significant
two-way interaction between race and SES \( (\beta = .37, p = .001) \). In contrast, for Applied
Problems there were significant main effects for both race \( (\beta = -.34, p < .001) \) and SES \( (\beta = .25, p = .019) \) as well as a trend for a two-way interaction between race and SES \( (\beta = .17, p = .091) \). The overall model accounted for significant variance in both standardized reading
ability \( (F(3,134) = 10.01, p < .001) \) and mathematic ability \( (F(3,134) = 24.76, p < .001) \). In
addition, approximately 18% of the variance in reading ability and 36% of the variance in mathematic ability was explained.

As seen in Figure 2, the simple slopes revealed that that for European American children, there was no relation between standardized reading performance and SES, \( t(134) = 0.05, p = .962 \). However, for African American children there was a significant positive relation between standardized reading performance and SES, \( t(134) = 2.50, p = .014 \). Simple slopes also revealed that for European American children, there was trend for a relation between standardized mathematics performance and SES, \( t(134) = 1.75, p = .082 \). However, for African American children there was a significant positive relation between standardized mathematic performance and SES, \( t(134) = 4.45, p < .001 \). Therefore, the analysis revealed that SES was only significantly predictive of standardized reading and mathematics performance for African American children, not European American children.

To examine if race moderated the relation between teacher’s ratings of achievement and the standardized SES composite, a regression was conducted on APRS scores, with the variables race and composite SES and their interaction entered into one step. The regression revealed that there were no main effects of race (\( \beta = -.02, p = .897 \)) or SES (\( \beta = .04, p = .823 \)). There was, however, a trend for a two-way interaction between race and SES (\( \beta = .30, p = .096 \)), and a trend for the overall model (\( F[3,54] = 2.26, p = .093 \)) that explained approximately 11% of the variance in teacher’s ratings. Simple slopes revealed that for neither European American nor African American children was the SES composite related to the teacher ratings of children’s academic success, \( ts(54) < 1.12, ps > .266 \).
Relation between SES and children’s cognitive abilities

To examine the unique relation of SES to the child measures of executive function (attention shifting, inhibitory control, working memory), while controlling for language, a series of hierarchical regression analyses were conducted. Specifically, the two SES variables were entered in the first block and then the measure of language was entered in the second block, and the coefficients associated with Type III sums of squares were interpreted in order to estimate the unique effect of each SES variable on each of the study’s cognitive measures. Because the use of the visual examination memory approaches were not significantly related to either of the SES variables or to the EVT scores (see Table 2), it was not included in this set of analyses.

As presented in Table 3, analysis indicated that combined income-to-needs ratio and maternal education (block 1) accounted for approximately 3% of the variance in FIST performance when vocabulary was not in the equation, which was not significant, $F(2, 135) = 1.74, p = .180$. With the addition of EVT scores in the second block, the amount of variance explained increased significantly to 6% and the overall model approached significance, $F(2, 135) = 2.61, p = .054$. Moreover, EVT scores were a significant positive predictor of FIST performance, such that high vocabulary scores were associated with greater attention shifting even when accounting for differences in SES. A commonality analysis indicated that SES and vocabulary shared 2% of the variance in attention shifting. SES uniquely explained less than 1% of the variance, which was not significant. Maternal
education, however, was a significant predictor and uniquely explained 3% of the variance in attention shifting.

In predicting Day/Night performance, income-to-needs ratio and maternal education (Table 3, Block 1) jointly explained approximately 5% of the variance when vocabulary was not in the equation, $F(2, 135) = 3.36, p = .034$. Income-to-needs ratios though did not predict Day/Night performance when accounting for maternal education. With the addition of EVT scores in the second block, maternal education was no longer a statistically significant predictor of Day/Night performance, suggesting that child vocabulary mediated the effect of maternal education on inhibitory control. Results from a follow up Sobel test (1982) confirmed this effect, $t = 45.75, p < .001$. Interestingly, EVT scores were a uniquely significant predictor indicating that not only did it mediate the effect of maternal education but uniquely and positively predicted Day/Night performance, such that better vocabulary performance was associated with better inhibitory control. A commonality analysis indicated that the two measures of SES and vocabulary performance shared 3% of the variance in inhibitory control. SES explained approximately 1% of the variance, whereas vocabulary uniquely explained 7% of the variance in inhibitory control.

Lastly, in regards to backwards digit span, income-to-needs ratio and maternal education combined (Table 3, Block 1) explained approximately 11% of variance when EVT scores were not in the equation. The variables together explained a significant amount of variance, $F(2, 135) = 8.70, p < .001$. The regression estimates indicated that without accounting for EVT Scores, maternal education was a unique positive predictor of backwards
digit span. Income-to-needs ratios did not predict backwards digit span when accounting for maternal education. With the addition of EVT in the second block, maternal education was no longer a statistically significant predictor suggesting that child vocabulary mediated the effect of maternal education on backwards digit span. Results from a follow up Sobel test (1982) indicated that in fact vocabulary established this mediation, $t = 7.11, p < .001$.

Interestingly, EVT scores were a uniquely significant predictor indicating that not only did it mediate the effect of maternal education but uniquely and positively predicted backwards digit span, such that better vocabulary performance was associated with better working memory. A commonality analysis indicated that the two measures of SES and vocabulary performance shared 11% of the variance in working memory. SES explained approximately 1% of the variance, while vocabulary uniquely explained 19% of the variance in working memory.

**Relation between executive function abilities and strategic memory approaches**

Hierarchical regression was also used to examine the potential relations between children’s executive function and their use of visual examination memory approaches while accounting for socioeconomic diversity and language ability. Specifically, the regression equation entered the SES variables and EVT scores in block 1 and the three executive function measures (FIST, Day/Night, and backwards digit span) were entered in block 2. The coefficients associated with Type III sums of squares were interpreted in order to estimate the unique effect of each of the executive function measures on independent variable of strategic memory approaches. As seen in Table 4, the SES variables and EVT scores when entered in
block 1 did not explain a significant amount of variance in children’s use of visual examination task approaches, $F(3, 134) = 0.74, p = .529$. The addition of the executive function abilities in step 2 increased the amount of variance explained by 4%, which was not significant. The overall model was also not significant, $F(6, 131) = 1.64, p = .140$. However, the regression estimates indicated that FIST performance was a unique predictor of children’s use of visual inspection memory approaches, but in contrast to expectations, better attention shifting performance was associated with less use of deliberate strategy usage. A commonality analysis indicated that attention shifting uniquely explained 3% of the variance in children’s use of strategic memory approaches, which was significant.

Relations between children’s cognitive abilities and school achievement

Lastly, hierarchical regressions analyses were again performed to determine the extent to which child-level variables of attention shifting, inhibitory control, working memory, and strategic memory approaches uniquely relate to standardized measures and teachers’ ratings of academic achievement when accounting for differences in SES, race, and language abilities. The SES, race, and language variables were entered in block 1, the executive function abilities (attention shifting, inhibitory control, working memory) were entered in block 2, and children’s use of visual examination task approaches was entered in block 3. The coefficients associated with Type III sums of squares were interpreted in order to estimate the unique effect of the independent variables on each of the dependent academic measures. To reduce the risk of alpha error, the standardized measures of achievement were analyzed in the same regression equation.
In the analysis of WJ Letter-Word Identification scores, as seen in Table 5, the block 1 variables of SES and EVT scores predicted 17% of variance, $F(4, 133) = 6.87, p < .001$. As expected, maternal education and EVT scores were positive predictors of reading ability. With the addition of the executive function in block 2, the amount of variance explained increased significantly to 23%. This was significantly predictive of WJ Letter-Word Identification scores, $F(7, 130) = 5.66, p < .001$. The addition of visual examination task approaches in block 3 increased the variance explained to 25%, which was significant amount of variance, $F(8, 129) = 5.45, p < .001$. There was a trend for this increase to be significant. Turning to the regression estimates in the final model, backwards digit span was a significant and positive predictor of Letter-Word Identification scores indicating that better working memory was associated with higher scores on the standardized measure of reading ability. There was also a trend for a positive association between children’s use of visual inspection and Letter-Word Identification scores. FIST and Day/Night performance were not uniquely predictive of Letter-Word Identification scores. It should also be noted that with the addition block 2 and block 3, family income and race remained unrelated to reading ability. Maternal education was still significantly and uniquely associated with reading ability, though its effect was reduced. However, with the addition of the block 2, vocabulary was no longer a significant predictor of reading ability and remained non-significant with the addition of block 3. A commonality analysis indicated that working memory uniquely explained 3% of the variance in reading ability, while strategic task approaches uniquely explained 2% of the variance.
With regard to mathematics ability, as also seen in Table 5, the hierarchical analysis indicated that the block 1 variables of SES, race, and EVT scores predicted 40% of the variance in WJ Applied Problems scores, $F(4, 133) = 22.53, p < .001$. The regression estimates indicated that family income, race, and EVT scores were each positive predictors of WJ Applied Problems scores. There was also a trend for maternal education. With the addition of the executive function abilities in block 2, the amount of variance explained increased significantly to 54%. In addition, the overall model was significantly predictive of WJ Applied Problems scores, $F(7, 130) = 22.44, p < .001$. The addition of visual examination task approaches in block 3 increased the variance explained to 56%, which was significant amount of variance, $F(8, 129) = 20.39, p < .001$. There was a trend for this increase to be significant. Turning to the regression estimates in the final model, FIST scores and backwards digit span were significant and positive predictors of WJ Applied Problems scores ability indicating that better attention shifting and better working memory were associated with higher scores on the standardized measure of mathematics ability. There was also a trend for a positive association between children’s use of visual inspection and Letter-Word Identification scores. Day/Night performance was not uniquely predictive of mathematics ability. It should also be noted that with the addition of block 2 and block 3, race was still significantly and uniquely associated with mathematics ability, though its effect was reduced. However, with the addition of the child cognitive variables, the unique effect of family income and vocabulary was reduced and there was only a trend for an association between family income and mathematics ability and vocabulary and mathematics ability. Maternal
education was no longer a significant predictor after the addition of block 2. A commonality analysis indicated that attention shifting uniquely explained 3% of the variance in standardized mathematics ability, while working memory uniquely explained 11% of the variance. Strategic task approaches also uniquely explained 2% of the variance.

Finally, in the analysis of teachers’ ratings of academic performance, as seen in Table 6, the hierarchical analysis indicated that the block 1 variables of SES, race, and EVT scores predicted 16% of variance, $F(4, 53) = 3.00, p = .026$. The regression estimates indicated that maternal education was a positive predictor of APRS ratings, whereas family income and race were not significant predictors. There was a trend for child vocabulary to be related to teacher’s ratings. With the addition of the executive function abilities in block 2, the amount of variance explained increased to 21%, although the increase was not significant and the predictiveness of the overall model was reduced to a trend, $F(7, 50) = 1.86, p = .096$. The addition of visual examination task approaches in block 3 increased the variance explained significantly to 27%. Moreover, this model was significantly predictive of teachers’ ratings of academic performance, $F(8, 49) = 2.26, p = .039$. Turning to the regression estimates in the final model, visual examination task approaches were a significant and positive predictor of APRS ratings. FIST performance, Day/Night performance, and backwards digit span, however, were not uniquely predictive of teacher’s ratings. It should also be noted that with the addition block 2 and block 3, income-to-needs ratio and race remained unrelated to teachers’ ratings, whereas maternal education was still significantly uniquely associated with ratings. In addition, with the addition of block 2, vocabulary became unrelated to teacher’s
ratings. A commonality analysis indicated that children’s use of strategic memory approaches uniquely explained 8% of the variance in rated school performance.

**Discussion**

The goal of the present study was to understand the unique effects that children’s cognitive processes, specifically executive function and strategic memory, have on standardized measures and teachers’ ratings of early academic achievement in an economically and racially diverse sample of kindergarten children. In addressing this goal, findings regarding the relations among SES, cognitive processes, and academic success and relations among SES, race, and academic success were both replicated and extended.

Providing additional support for previously reported findings, the present study found that in a sample of economically and racially diverse kindergarteners, SES was predictive of early school success. In particular, the results indicated that human capital (i.e., maternal education) was a unique and positive predictor of mathematics and reading achievement test scores and teachers’ ratings of children’s academic success. Interestingly though, financial capital (i.e., family’s income-to-needs ratios) was only a unique predictor of standardized mathematics ability, but even in this case, education explained more variance than income. These findings are consistent with the argument that the effects of socioeconomic status are completely explained by differential access to economic resources (e.g., White, 1982, Bradley & Corwyn, 2002). These results also align with previous work which found that when compared to family income, education was the best predictor of intellectual attainment in 6- to 8-years olds (Mercy & Steelman, 1982). It has been proposed that associations
between maternal education and academic success are facilitated by SES differences in parenting styles. Specifically, it is suggested that better parenting is responsible for scaffolding skill-building activities and school behaviors that contribute to school achievement (DeGarmo, Forgatch, & Martinez, 1999). It could also be the case that family income was not as predictive as maternal education due to a time-of-testing effect because socioeconomic factors were measured after the economic downturn of 2007. Therefore, it is possible that income-to-needs ratios were disproportionately impacted by the economic downturn and thus less predictive.

Expanding on the relations seen among SES and academic outcomes, it was also found that this relation was moderated by a child’s race. In particular, SES was only significantly predictive of standardized reading and mathematics performance for African American children, not European American children. At present it is unclear exactly why race mediated the effect of SES and academic outcomes. It is feasible that because schools reflect middle class culture in America, low SES European American children are more acculturated to the school environment than the low SES African American children. It is also possible that African American children of more educated moms are more broadly exposed to the majority culture. Future work is needed to understand why SES predicted achievement for African American, but not European American children. For example, as suggested by Pungello et al.’s (2009) finding that the effects of negative-intrusive parenting on expressive communication growth rate differed by race, it is important to remember that there is often a dynamic interplay between parenting practices, family race, family SES, and
academic outcomes. Future investigations could productively explore the family socialization practices associated with SES and their differing effects of academic achievement among children of different races.

The present study also replicated and extended previous work by Farah, Noble and their colleagues (e.g., Hackman & Farah, 2009; Noble et al., 2007; Noble et al., 2005), who reported associations between measures of SES and executive function. A strength of the present study was the large variability in SES and the fact that the SES variables were continuous measures. Economic and social capital were also examined individually and for all three executive function abilities, in contrast to previous research that used a composite SES index and did not examine attention shifting (e.g., Noble, et al., 2007). The present study found that maternal education was a positive predictor of a child’s performance on measures of working memory and inhibitory control. Income-to-needs ratios were also found to be positively related to working memory performance. This was consistent with Noble et al. (2007), who found a positive association between an SES index and a working memory composite and cognitive control composite (i.e., inhibitory control). Also consistent with these findings, the present results indicated the relation between SES and executive function was accounted for by language ability. In particular, findings indicated that the associations between the maternal education and working memory, family income and working memory, and maternal education an inhibitory control, were due to a child’s language ability. The authors also found that language ability mediated the association between the SES index and the cognitive control index and partially mediated the association between the SES index and
the working memory index and surmised that SES differences in language independently drives executive function performance.

Questions remain, however, as to why the present study did not find an association between SES and attention shifting even though there was a significant relation between language and attention shifting. Noble et al. (2007) has hypothesized that the SES differences in executive function are due to the prolonged postnatal development of the language and executive function systems of the brain. Previous research has also indicated that during the preschool and early elementary school the prefrontal cortex undergoes a growth spurt that coincides with the development and refinement of cognitive control processes (Diamond, 2002). It could be the case that attention shifting is a later developing process and potential variability related to SES or language might not merge until later in elementary school. As such, future research should examine the development of executive function longitudinally in order to better understand how SES influences the development of self-regulatory cognitive processes, including executive function and strategic memory.

The present study was designed to extend the current understanding of strategic memory by examining the potential influence of the executive function abilities of attention shifting, inhibitory control, and working memory on deliberate strategy usage. The analysis, however, did not support the hypothesis of a positive association between the executive function abilities and strategic memory behaviors. In fact, it was found that attention shifting was a unique and negative predictor of the use of deliberate memory strategies. It is not clear why better attention shifting would be associated with less use of strategic memory.
behaviors. However, this relation could be the result of how strategic behaviors were conceptualized. In particular, children were coded as being more strategic when they relied on the use of one strategy – visual inspection – that was previously shown to be predictive of subsequent recall in five-year-olds. Therefore, children who performed better on the attention shifting task might have been children who also switched between memory strategies, which in turn lowered the amount of time they spent using visual inspection. Future work should be completed to better understand the potential association among the use of multiple memory strategies and measures of cognitive regulation to see if executive function contributes to the use of more complex memory strategies (Siegler, 1996). Moreover, these potential relations should be examined longitudinally in hopes of understanding how the development of executive function contributes to the emergence and refinement of strategic memory abilities.

The present study expanded upon the current understanding of the relations between academic achievement and self-regulatory measures of cognition. In particular, this study provided unique insight into the collective and unique effects that attention shifting, inhibitory control, working memory, and strategic memory approaches have on measures of early school success, while accounting for variability associated with differences in SES, race, and language abilities. Results indicated that children’s cognitive control processes explained a significant amount of variability in standardized reading and mathematics abilities. Moreover, it was found that working memory and strategic approaches were unique predictors of reading performance and attention shifting, working memory, and strategic approaches were unique predictors of mathematics performance. Interestingly, these findings
were not consistent with previous work that has shown inhibitory control as being a significant and unique predictor of reading and mathematics abilities in kindergarteners (Blair & Raza, 2007). There are, however, differences in the methodologies of the investigations. Specifically, the present study included measures of working memory and strategic memory. Working memory was highly correlated with inhibitory control performance; as such, it could be the case that working memory masked the influence of inhibitory control. To assess this possibility, working memory and strategic memory approaches were removed from the model predicting reading performance in a post-hoc analysis. Replicating Blair and Razza, inhibitory control emerged as a unique positive predictor ($\beta = .17$, $t = 2.09$, $p = .038$), while attention shifting was not a unique predictor.

On the other hand, when working memory and strategic memory approaches were removed from the model predicting mathematics performance, the findings of Blair and Razza were not replicated. It was found that attention shifting was a unique positive predictor of mathematics performance ($\beta = .18$, $t = 2.66$, $p = .009$), while inhibitory control was not a unique predictor. This difference could emerge, however, as an artifact of how the two studies assessed mathematics abilities. The present study used the applied problems subscale of the Woodcock-Johnson as proxy for mathematic ability, whereas Blair and Razza used a measure of mathematics developed for the Head Start National Reporting System Direct Child Assessment. It is possible that the two measures could be tapping into different aspects of mathematic knowledge. The Woodcock-Johnson Applied Problems scale was designed to measure abilities associated with problem solving, number facility, automaticity, and
reasoning, whereas the Head Start assessment was designed to measure basic numeracy, knowledge of shapes, quantity, relative size, addition, subtracting, and simple graphic relations. This distinction is notable because it might be the case that the underlying abilities being assessed by the Woodcock-Johnson Applied Problems scale are strongly influenced by fluid abilities to a greater extent than the Head Start National Reporting System Direct Child Assessment.

In addition to standardized measures that have been used in previous work examining the relation between cognitive control processes and academic achievement, this study examined the collective and unique effects that attention shifting, inhibitory control, working memory, and strategic memory approaches have on teachers’ ratings of school success, while accounting for variability associated with differences in SES and language abilities. The results indicated that that children’s use of strategic memory approaches uniquely and positively predicted teachers’ ratings. There could be limitations to the generalizability of these findings due to the fact that only 58 of the study’s 138 children had teachers who completed the survey. Moreover, children for whom teachers’ ratings were available came from families with higher income-to-needs ratios than did the children for whom the ratings were not obtained. It should be noted, however, that similar influences of maternal education and deliberate memory were found in models predicting teachers’ ratings and achievement test scores. Thus, the results with teachers’ ratings are not merely artifacts of attrition.

Despite the similarities in the models that predicted standardized and subjective indicators of academic performance, it is suggested that future research on cognitive control
processes continues to address teachers’ perceptions. Reading and mathematics test scores were only moderately correlated with teachers’ ratings in this investigations, with $r_s(138) = .35$ and .51, respectively. In addition, in contrast to standardized tests of achievement that document students’ mastery of academic knowledge, teachers’ ratings may reflect perceptions of motivation and approach-to-task behaviors that may add to predictions of future achievement. Moreover, ratings may incorporate emerging competence as well as academic mastery. Teachers’ ratings of performance, therefore, complement achievement scores in understanding how children’s control processes contribute to the knowledge and skills needed to excel in academic environments. As such, differences in cognitive control abilities might in fact contribute more to teachers’ perceptions that assess universal abilities that contribute to success.

As mentioned previously, it has been suggested that the association between SES and academic achievement might be a result of parenting practices. Therefore, future work should be conducted to examine the potential contribution that parental socialization might have on the interrelations among SES, race, executive function, strategic memory, and academic achievement. One avenue of particular promise is the potential role of mother-child reminiscing (Fivush, Haden, & Reese, 2006). Previous research has indicated that how a mother and child talk about and construct a narrative for past events influences a child’s language abilities and his or her strategic memory skills and performance. Specifically, it has been demonstrated that training low-SES mothers to use and elaborative reminiscing style actually increased their children’s print-based language skills (Reese, Stewart, & Newcombe,
It has also been found that mothers’ use of mental terms (e.g., remember, think) and elaborations during joint reminiscing was positively related to her child’s strategic behaviors and recall of sets of to-be-remembered objects (Rudek & Haden, 2005). This work also has indicated that the relations exist concurrently as well as longitudinally. Such findings suggest that joint reminiscing places relatively high cognitive and linguistic demands on children, and these co-constructions about the past might set the stage for linguistic and memory skills that are importance to early academic success.

In conclusion, the present study provides evidence that children’s ability to regulate their cognitive processes has an important impact of their early success in school, even above the well established influences of SES, race, and language abilities. These unique contributions have not been previously demonstrated. Hence, this work adds to a growing body of research that emphasizes the importance of abilities that transcend domains of knowledge and could potentially contribute to academic success globally. Further, the results suggest that cognitive processes may serve as a source of resilience for children who do not have the advantages arising from high levels of maternal education.
REFERENCES


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Table 1.

*SES and Child-Cognitive Variable Zero-Order Correlation and Descriptive Statistics (N = 138)*

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Strategic Approaches</th>
<th>Attention Shifting</th>
<th>Inhibitory Control</th>
<th>Working Memory</th>
<th>Mean</th>
<th>SD</th>
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<td>.16</td>
<td></td>
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<td></td>
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<td>-.18*</td>
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<td>.08</td>
<td>.06</td>
<td>.19*</td>
<td>.35**</td>
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<td>0.25</td>
</tr>
<tr>
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<td>.28**</td>
<td>.13</td>
<td>.19*</td>
<td>.35**</td>
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<td>.07</td>
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**p < .01, * p < .05.
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<th>Income-to-Needs</th>
<th>Strategic Approaches</th>
<th>Attention Shifting</th>
<th>Inhibitory Control</th>
<th>Working Memory</th>
<th>Vocabulary</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
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<tbody>
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<td>.24**</td>
<td>.19*</td>
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<td>.28**</td>
<td>.37**</td>
<td>.31**</td>
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<td>11.49</td>
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<tr>
<td>Standardized:</td>
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<td>.20*</td>
<td>.35**</td>
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<td>.57**</td>
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<td>20.46</td>
<td>138</td>
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<tr>
<td>Mathematics Achievement</td>
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<td>.11</td>
<td>.21</td>
<td>.22</td>
<td>.21</td>
<td>.27*</td>
<td>.34**</td>
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<td>0.74</td>
<td>58</td>
</tr>
</tbody>
</table>

** p < .01, * p < .05
Table 3.

*Summary of Hierarchical Regression with SES and Language Ability Predicting Executive Function Abilities (N=138)*

| Predictors         | Attention Shifting | | | Inhibitory Control | | | Working Memory | | |
|--------------------|-------------------|---|---|-------------------|---|---|----------------|---|
|                    | Block 1           | Block 2 | | Block 1           | Block 2 | | Block 1           | Block 2 | |
|                    | b    | SE | β   | b    | SE | β   | b    | SE | β   | b    | SE | β   | b    | SE | β   |
| Income-to-Needs    | 0.18 | 0.03 | 0.06 | 0.01 | 0.03 | 0.03 | -0.01 | 0.03 | -0.05 | -0.03 | 0.03 | -0.10 | 0.18 | 0.12 | 0.14 |
| Maternal Education | 0.04 | 0.03 | 0.12 | 0.02 | 0.03 | 0.05 | 0.06 | 0.03 | 0.24 | 0.36 | 0.03 | 0.15 | 0.29 | 0.12 | 0.24 |
| Language Ability   |                  |       | 0.06 | 0.30 | 0.19 |     | 0.07 | 0.02 | 0.29 | **     |       |       | 0.61 | 0.10 | 0.48 |
| R²                 | 0.03 |     |       | 0.06 |     |     | 0.05 | **     |       | 0.12 | **     |       | 0.11 | **     | 0.30 |
| ΔR²                |      |     | 0.03 | **     |       |     | 0.07 | **     |       |     |       | 0.19 | **     |       |     |

*p < .01, **p < .05
Table 4.

Summary of Hierarchical Regression with Executive Function Abilities Predicting Strategic Approaches

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>SE</td>
</tr>
<tr>
<td>Income-to-Needs</td>
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<td>0.84</td>
</tr>
<tr>
<td>Maternal Education</td>
<td>-0.16</td>
<td>0.87</td>
</tr>
<tr>
<td>Language Ability</td>
<td>0.30</td>
<td>0.78</td>
</tr>
<tr>
<td>Attention Shifting</td>
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<td></td>
</tr>
<tr>
<td>Inhibitory Control</td>
<td></td>
<td>0.38</td>
</tr>
<tr>
<td>Working Memory</td>
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<td>0.83</td>
</tr>
<tr>
<td>R²</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>ΔR²</td>
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<td></td>
</tr>
</tbody>
</table>

*p < .05, †p < .10
Table 5.

Summary of Hierarchical Regression with Child Cognitive Abilities Predicting Standardized Measures of Academic Achievement (N=138)

| Predictors         | Reading Ability |           |           |          |           |           |           |           |          |           |           |           |           |           |           |           |
|--------------------|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                    | Block 1         | Block 2   | Block 3   | Block 1   | Block 2   | Block 3   | Block 1   | Block 2   | Block 3   | Block 1   | Block 2   | Block 3   | Block 1   | Block 2   | Block 3   |
|                    | b   | SE | β    | b   | SE | β    | b   | SE | β    | b   | SE | β    | b   | SE | β    | b   | SE | β    |
| Income-to-Needs    | 0.24 | 1.11 | 0.02 | 0.20 | 1.09 | 0.02 | 0.01 | 1.09 | 0.01 | 3.65 | 1.68 | 0.18* | 3.18 | 1.50 | 0.16* | 2.93 | 1.49 | 0.14* |
| Maternal Education | 3.55 | 1.16 | 0.31** | 3.17 | 1.15 | 0.28** | 3.28 | 1.14 | 0.29** | 2.94 | 1.76 | 0.14† | 2.23 | 1.57 | 0.11 | 2.38 | 1.56 | 0.12 |
| Race               | 2.25 | 2.13 | 0.10 | 2.67 | 2.09 | 0.12 | 3.34 | 2.11 | 0.14 | -9.56 | 3.21 | -0.23** | -7.59 | 2.87 | -0.18** | -6.68 | 2.89 | -0.16* |
| Vocabulary         | 2.44 | 1.09 | 0.21* | 0.71 | 1.19 | 0.06 | 0.80 | 1.18 | 0.07 | 6.10 | 1.64 | 0.29** | 1.60 | 1.62 | 0.08 | 1.71 | 1.61 | 0.08 |
| Attention Shifting |                   |           |           |           |           |           |           |           |           | 0.43 | 0.94 | 0.04 | 0.82 | 0.96 | 0.07 | 3.35 | 1.29 | 0.16* | 3.89 | 1.32 | 0.18** |
| Inhibitory Control |                   |           |           |           |           |           |           |           |           | 1.45 | 0.98 | 0.13 | 1.34 | 0.96 | 0.12 | 1.08 | 1.34 | 0.05 | 0.93 | 1.34 | 0.05 |
| Working Memory     | 2.64 | 1.10 | 0.23* | 2.49 | 1.09 | 0.22* | 7.94 | 1.50 | 0.39** | 7.74 | 1.49 | 0.37** | 2.32 | 1.28 | 0.11† |
| Strategic Approaches |           | 1.70 | 0.94 | 0.15† |           |           |           |           |           |           |           |           |           |           |           |           |
| R²                 | 0.17** |       |       | 0.23** |       |       | 0.25** |       |       | 0.40** |       |       | 0.54** |       |       | 0.56** |
| ΔR²                | 0.06* |       |       | 0.02† |       |       |           |       |       |           |       |       | 0.14** |       |       | 0.02† |

**p < .01, *p < .05, †p < .10
Table 6.  
*Summary of Hierarchical Regression with Child Cognitive Abilities Predicting Teacher Ratings of Academic Achievement (N=58)*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Block 1</th>
<th></th>
<th>Block 2</th>
<th></th>
<th>Block 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>SE</td>
<td>β</td>
<td></td>
<td>b</td>
<td>SE</td>
</tr>
<tr>
<td>Income-to-Needs</td>
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<td>0.09</td>
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<td></td>
<td>-0.09</td>
<td>0.09</td>
</tr>
<tr>
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<td>0.20</td>
<td>0.11</td>
<td>0.32‡</td>
</tr>
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<td>0.22</td>
<td>0.23</td>
<td>0.15</td>
</tr>
<tr>
<td>Vocabulary</td>
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<td>0.12</td>
<td>0.27‡</td>
<td>0.17</td>
<td>0.13</td>
<td>0.22</td>
</tr>
<tr>
<td>Attention Shifting</td>
<td>0.09</td>
<td>0.10</td>
<td>0.12</td>
<td>0.15</td>
<td>0.11</td>
<td>0.20</td>
</tr>
<tr>
<td>Inhibitory Control</td>
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<td>0.05</td>
<td>0.03</td>
<td>0.10</td>
<td>0.04</td>
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<tr>
<td>Working Memory</td>
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<td>0.07</td>
<td>0.03</td>
<td>0.12</td>
<td>0.04</td>
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<tr>
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<td></td>
<td></td>
<td>0.19*</td>
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<td>0.21‡</td>
</tr>
<tr>
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<td></td>
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<td>0.02</td>
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<td>0.06*</td>
</tr>
</tbody>
</table>

*p < .05, ‡p < .10
Figure 1. Distribution of income-to-needs ratios and maternal years of education as a function of children’s race.
Figure 2. Relations between SES and standardized measures of reading and mathematics ability as a function of children’s race.