Executive Function and Academic Achievement:

Differential Relations Across Socioeconomic Status

by

Manna Shintani

A Thesis Submitted in Partial Fulfillment of the

Requirement for the Degree of Bachelor of Arts

With Honors in Psychology from the

University of Michigan

2017

University of Michigan

Advisors:

Frederick Morrison, Ph.D.

Sammy Ahmed, M.S.

Abstract

Executive functions (EF) are a powerful predictor of children's academic success. Yet, there is a lack of literature exploring how executive functions can serve as a protective factor for socioeconomically disadvantaged children's academic achievement. Specifically, whether the relation between EF and academic achievement varies across social class is less understood. The current study examines the moderating role of working memory on the association between socioeconomic status (measured by household income and maternal education) and math achievement in a sample of 81 kindergarten children. Regression analyses revealed that the interaction between both SES variables and working memory was not significant, which might suggest that EF is equally important for all children's academic success. Limitations and implications are discussed.

Keywords: executive functions, working memory, math achievement, SES, early childhood

Executive Function and Academic Achievement:

Differential Relations Across Socioeconomic Status

Persistent disparities in academic achievement among US children are often understood as a product of a variety of demographic factors, one of which is socioeconomic status (SES). According to the report by the U.S. Department of Education, National Center for Education Statistics (2002), only 14% of children from low-SES households and 29% of those who were from middle-SES households had earned a bachelor degree or higher in comparison with 60% of those who were from high-SES household.

Today, there exists a burgeoning literature on protective factors that disadvantaged students can utilize to resist socioeconomic barriers and succeed in school. Many of them emphasize the importance of early interventions given that plasticity in biological, social, and psychological development is much higher in infancy and early childhood than in any other periods (Ramey & Ramey, 1998). While existing studies have revealed some protective factors including parental and social support (i.e., Davis-Kean, 2005; Milne & Plourde, 2006; Malecki & Demaray, 2006), there is a lack of literature addressing how cognitive traits can be a protective factor for early achievement. Given the crucial role of executive functions on academic achievement (Van der Ven, Kroesbergen, Boom & Leseman, 2012; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Best, Miller, & Naglieri, 2011; St Clair-Thompson & Gathercole, 2006; Lawson & Farah, 2015; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014) and their high plasticity in early childhood (Zelazo & Carlson, 2012; Carlson, Zalezo, & Faja, 2013), research is needed to address the utility of executive functions as a protective factor in overcoming socioeconomic disadvantages in school. Therefore, the aim of the current study is to investigate whether or not low-SES children, when compared to high-SES children, benefit more from possessing higher executive functions to succeed in school.

Socioeconomic Status and Academic Achievement

Socioeconomic status (SES) is a powerful contextual variable that has been attracting substantial research interest from educational and developmental scientists. SES is a multi-faceted construct which consists of education, income, occupation, and social privilege. Such social contexts set the stage for children's academic performance. As well as aggregated SES, each aspect of SES has been shown to predict academic attainment in early childhood, with maternal education being a stronger predictor than paternal education, parental occupation, and parental income (Sirin 2005; Alexander, Entwise, & Bedinger, 1994; Alspaugh, 1991; Christian, Morrison, & Bryant, 1998; Greenberg, Langau, Coie, & Pinderhughes, 1999; Jimmerson, Egeland, Sroufe, & Carlson, 2000; Walker, Greenwood, Hart, & Carta, 1994; Davis-Kean, 2005).

A significant amount of researchers' current understanding on the mechanism of how SES influences children's achievement has been credited to the study by Davis-Kean (2005) with a large national sample of 868 children aged from 8 to 12. The study first revealed that parental education influenced child performance on standardized achievement test through parental belief of achievement and their behaviors that facilitate learning and play at home. The study also indicated this mechanism slightly differed between Caucasian Americans and African Americans, suggesting the process of SES affecting achievement varies in different racial or cultural context. The findings, thus, overturned a general belief that economic disadvantages and a lack of material resources are the indirect factors that constrains child achievement by rather suggesting the importance of parental behaviors and attitudes on achievement that promote better learning environment at home.

More recently, research attention has been directed toward the relationship between socioeconomic disadvantages and academic outcomes during early childhood because of its developmental implications. First, it is assumed that early low SES environment before formal education restricts successful development of academic-related skills that predispose them to later academic success in school. For example, regarding literacy skills, the National Center for Education Statistics (NCES) survey indicated only 38% of low-SES children could recognize letters of the alphabet compared with 86 % of high-SES children at kindergarten entry (West, Denton, & Germino-Hausken, 2000). Furthermore, studies on mathematical development demonstrated that low-SES children perform poorly on tasks measuring verbal calculation ability and intuitive understanding of numeric system, which are considered to underlie math achievement (Geary, 1998; Griffin, Case, & Siegler, 1994). Second, children who enter school with less developed skillsets are more likely to fall further behind those who enter school with better literacy and math abilities. The achievement gap will then be exacerbated throughout middle childhood and adolescence (Caro, McDonald, & Willms, 2009; Morgan, Farkas, & Wu, 2011) because socioeconomic advantages on learning are shown to be cumulative (DiPrete & Eirich, 2006). Therefore, academically at-risk children are detectable at early developmental stages based on socioeconomic status and require special attention considering the enduring effect in later education.

However, SES does not seem to be a definite determiner of academic outcomes. The correlation between SES and academic achievement is only weak, indicated as .299 in Sirin (2005) and .343 in White (1982). These findings suggest that some children are still able to achieve in school even with such powerful socioecological disadvantages. Then, a question arises: What distinguishes high achieving low-SES children from low achieving low-SES children? To answer this question, most existing literature has been focused on social factors, such as parental support (i.e., Davis-Kean, 2005; Milne & Plourde, 2006; Malecki & Demaray, 2006). On the other hand, there is a lack of literature exploring cognitive factors that serve as a protective factor. In particular, executive functions have received increasing attention as a critical mechanism shaping academic trajectories and potentially mediating the link between SES and academic achievement.

Executive Functions

A crucial base for academic achievement is cognitive abilities. It is very likely that high achieving low-SES children possess high cognitive abilities that help them overcome social disadvantages. One of the cognitive abilities that are shown to be a powerful contributor to academic achievement is executive functions (e.g., Van der Ven, Kroesbergen, Boom & Leseman, 2012; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Best, Miller, & Naglieri, 2011; St Clair-Thompson & Gathercole, 2006; Lawson & Farah, 2015; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014). Executive functions encompass a complex cognitive skillset which enables an individual to perform goal-oriented tasks. This multi-componential construct includes response inhibition, working memory, and attentional control. Response inhibition refers to the ability to suppress partially prepared responses. Working memory, also called updating, is a memory system with limited capacity which allows us to transiently store and manipulate information. Attentional control enables us to regulate attention and ignore the distractor, which is often understood as the ability to concentrate (e.g., McClelland, Cameron Ponitz, Messersmith,

& Tominey, 2010). These individual components of executive functions are shown to become functionally dissociable before the age of three (Garon, Bryson, & Smith, 2008).

Evidence is mixed upon how each component of executive functions contributes to different domains of academic achievement. Some researchers have shown that inhibition and working memory are related to performance in mathematical and reading skills while there is inconsistency in literature about the relationship between attentional control and academic achievement (Van der Sluis et al., 2007; Bull & Scerif, 2007; Protopapas et al., 2007; St Clair-Thompson & Gathercole, 2006; Espy et al., 2004; Van der Van, Kroesbergen, Boom, & Leseman, 2012). On the other hand, many studies have substantiated the strong link between working memory and math achievement (Van der Ven, Kroesbergen, Boom, & Leseman, 2012; Monette, Bigras, & Guay, 2011; Swanson & Beebe-Frankenberger, 2004). Van der Ven, Kroesbergen, Boom, and Leseman (2012), in a longitudinal study of mathematical ability and executive functions, found that working memory is a stronger and unique predictor of the development of mathematical performance from first grade to second grade compared with inhibition and attentional control which are not distinguishable from each other.

Additionally, executive functions provide a crucial insight in understanding academic achievement in this age group. First, the association between executive functions and academic achievement was shown to be stronger in early childhood than older age groups in a large national sample of children aged from 5 to 17, suggesting the possibility that executive functions serve as a key factor for academic achievement particularly in early childhood (Best et al., 2011). Moreover, although the relationship between SES and academic achievement has been shown to depend on third factors, such as race (Davis-Kean, 2005), executive functions and academic achievement has shown to be directly related with each other regardless of cultural or racial context (Lan, Legare, Ponitz, Li, & Morrison, 2011). One study, for example, tested how different components of executive functions predicted different domains of academic achievement in Chinese and American preschoolers. Their findings indicated, although Chinese children outperformed American counterparts in the inhibition and attentional control tasks, there was no significant difference in the relation between components executive functions and academic achievement. Thus, executive functions constitute an important domain-general skill contributing to academic success across racial and cultural contexts

Socioeconomic Status, Academic Achievement, and Executive Functions

Evidence suggests that executive functions are associated with socioeconomic status (e.g., Rhoades, Greenberg, Lanza, & Blair, 2011; Ardila, Rosselli, Matute, & Guajardo, 2005; Hackman & Farah, 2009). A longitudinal study from Evans and Schamberg (2009) found children who are exposed to poverty longer experience higher cortisol level, which is associated with poorer performance on the working memory task in adulthood. In addition, parental income and educational level are positively related with executive functions (Rhoades, Greenberg, Lanza, & Blair, 2011; Ardila, Rosselli, Matute, & Guajardo, 2005).

Based on this evidence, the interaction between SES and executive functions must be considered within the same framework in understanding academic achievement. Yet, surprisingly few studies have investigated the interactive relationship of SES and executive functions on academic outcomes. According to the existing literature, the complex relations linking SES, executive functions, and academic achievement have largely been seen as a mediation model, such that executive functions mediates the association between SES and academic achievement. Dilworth-Bart (2012), for example, examined if executive functions mediated the relationships of SES and home quality with academic readiness in a sample of 49 children aged from four to five. The findings supported executive functions significantly medicated the link between SES and mathematical skills, but not literacy skills, when verbal ability is controlled. Furthermore, Lawson and Farah (2015) investigated if executive functions and verbal memory play a mediating role in the association between SES and academic achievement among 336 children between the ages of six and 15 years. Consistent with Dilworth-Bart (2012), they found that executive functions partially mediated the SES-math performance association, but not reading ability.

However, researchers have not yet reached enough understanding upon whether the effect of executive functions on academic achievement is differential by children's socioeconomic status. Most recently, Duncan, McClelland, and Acock (2017) examined differential associations between executive functions measures, classroom behavioral regulation, and academic achievement including math, literacy and vocabulary skills by household income in 100 prekindergarten children. Their findings indicated both EF measures and classroom behavioral regulation influenced academic achievement regardless of household income, except for inhibition control that was related to math and vocabulary skills less in low-SES children than in high SES-children. Duncan, McClelland, and Acock (2017) discussed the weaker association between inhibition and these achievement variables in low-SES children was due to lack of learning opportunities, where they can utilize their inhibition skills to navigate academic learning (Morrison, Ponitz, & McClelland, 2010). This consequently creates much less variations in achievement outcomes than in high-SES children. Yet, researchers cannot conclude from this evidence that the effect of executive functions on academic achievement is no different between high- and low-SES children. The reason of that is because Duncan, McClelland, and Acock (2017) only tested the moderation model using household income for SES measure. Cumulative evidence has shown that maternal education, instead of household income, is the aspect of SES that is the most relevant to academic achievement (Davis-Kean, 2005; Sirin 2005). Thus, this moderation model needs to be tested with the addition of maternal education.

Therefore, I argue that the effect of executive functions is differential by SES when maternal education is incorporated in this framework due to its relative importance on academic achievement over household income (Davis-Kean, 2005; Sirin 2005). If achievement gap is a product of limited access learning-related resources or learning-facilitating environment in low-SES household (Davis-Kean, 2005), possessing a cognitive trait that is closely tied to academic success should benefit more to low-SES children than to high-SES children. Reasoning of this proposed framework is that the cognitive asset is the only or at least one of few resources that directly and most powerfully contributes to academic achievement in low-SES children while to high-SES children, in contrast, executive functions are one of many factors that aid learning. According to this reasoning, the predictive power of executive functions for achievement will be stronger in low-SES children because of the lack of other factors that can buffer the link between SES and achievement. The implication of this is that possessing high executive functions in school might enhance academic achievement in low-SES children more than in high-SES children. Yet, there is no existing literature that has explored cognitive traits as a protective factor for academic achievement in socioeconomically disadvantaged children.

Exploring the possibility of executive functions as a protective factor in early childhood is beneficial due to the potential implications for early interventions. While longitudinal studies indicate executive functions tend to remain stable over the developmental course (Casey et al., 2011; Polderman et al., 2007), executive functions are shown to be malleable (Zelazo & Carlson, 2012), particularly during the preschool years (Carlson, Zalezo, & Faja, 2013). In fact, early interventions to improve executive functions brought about promising results (Diamond, Barnett, Thomas, & Munro, 2007; Thorell, et al., 2009), whose change was evident in the corresponding neural functions in one study (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). Therefore, understanding whether executive functions can serve as a buffer for socioeconomically disadvantaged children has implications for early educational interventions.

Current Study

Based on this knowledge, the current study aimed to gain a deeper understanding of how executive functions influence academic achievement in different socioecological contexts. The study focused on specific components of executive functions and academic achievement whose association has been substantiated most widely; working memory and math achievement (Van der Ven, Kroesbergen, Boom, & Leseman, 2012; Monette, Bigras, & Guay, 2011; Swanson & Beebe-Frankenberger, 2004). Given that the models by Dilworth-Bart (2012) and Lawson and Farah (2015) only supported the mediation of executive functions between SES and math performance, it is reasonable to assume that the interaction among SES, executive functions, and academic achievement is most evident in working memory and math achievement. Furthermore, this study aimed to extend the moderation model by Duncan, McClelland, and Acock (2017) with the different framework by suggesting differential effects of executive functions on achievement by maternal education. Therefore, the current study will examine the moderating role of executive functions in the association between SES and math achievement using household income and maternal education in a sample of 81 kindergarteners. I hypothesize (1) academic performance of children from low SES households is lower than of children from high SES households, and (2) possessing high working memory is more beneficial for children form low SES households.

Method

Participants

Participants were a total of 81 preschoolers recruited from four local preschools in Eastern Michigan. In the moderation model using household income, there were 74 children with 54% being male. In the moderation model using maternal education, there were 72 children with 57% being male. The mean age of the total sample was 5.7.

Measures

Socioeconomic Status (SES). Sociodemographic information, preschool information, household income, and maternal education were obtained through Parent Questionnaire.

Household income. Children's parents indicated household income in the questionnaire by choosing from 1 = under $5,000; 2 = $5,000-$9,000; 3 = $10,000-$14,999; 4 = 15,000-$19,999; 5 = $20,000-$29,999; 6 = 30,000-$39,999; 7 = $40,000-$49,999; 8 = $50,000-$59,999; 9 = $60,000-$79,999; 10 = $80,000-$99,999; 11 = $100,000- $124,999; 12 = $125,000-$149,000; or 13 = 150,000 and over.

Maternal education. Maternal education was also reported by parents in the questionnaire (i.e., 1 = some high school, no diploma; 2 = high school graduate diploma or the equivalent (e.g., GED); 3 = some college credit, no degree; 4 = Trade/technical/vocational training; 5 = associate degree; 6 = bachelor's degree; 7 = master's degree; 8 = professional degree; or 9 = doctorate degree).

Executive Functions.

Working Memory. Working memory or updating was assessed using the Digit Span subset from the Wechsler Intelligence Scale for Children (WISCIII) (Wechsler, 1991). The assessment consists of two components. The first component is Forward Digit Span, in which participants are instructed to repeat a sequence of digits following a task administrator. The second component is Backward Digit Span, which requires participants to repeat a sequence of digits in reversed order. A sequence is given twice, and longer sequences will be given if participants successfully repeat the digits in one of two trials for each sequence length. Scores are calculated by the total number of sequences participant repeat correctly. For the sake of the current study, I only used Backward Digit Span as measure for working memory since it better represents the ability of both maintaining and manipulating information.

Academic Achievement.

Mathematical Achievement. Mathematical achievement was measured through the Applied Problems task from Woodcock-Johnson III standardized tests (WJ-III) (Woodcock, McGrew, & Mather, 2001). In applied problem subset, children were asked to solve math problems with pencil and paper that were presented orally and visually as a way to assess mathematical ability.

Procedures

Each child was assessed using the full battery of executive functions measures. Children participated in each task only one time during each year of the investigation, however, these assessments took place across multiple brief sessions. After this, we obtain child assent before proceeding. Assessments, including behavioral executive functions and achievement tasks, were conducted separately in a brief 30-minute session for each child. The classroom-based tasks were scheduled at the convenience of the teacher, and were conducted across three separate sessions during the year. Measures of the children’s working memory were collected in individual assessments with a trained research assistant. Testing sessions were scheduled at the school before, during, or after school hours in consultation with the participant's teacher and parents.

Statistical Analysis

The first question will be answered by performing the linear regression analysis, which tests the correlation between socioeconomic status and math achievement. For the second question, the criteria of Baron and Kenny's (1986) moderation method will be carried out to assess whether working memory moderates the relation between socioeconomic status and math achievement. A multiple hierarchical regression was performed (as outlined by Baron & Kenny, 1986). Sex and age will be entered in the first step as controls, to eliminate the effects of confounds. Additionally, the predictor and moderator variables (household income/maternal education and working memory) will be entered in the second step. Finally, an interaction term will be created (household income/maternal education x working memory) and entered in the last step. The significance of the last step (interaction term) will be the statistical test of the moderation.

Results

Descriptive statistics for gender, age at testing, maternal education, household income, Backward Digit Span (WISCIII) and Applied Problems (WJ-III) are summarized in Table 1. Prior to testing the primary questions of the study, independent samples t-tests was performed to test the effect of gender on the dependent variables of interest, which are Backward Digit Span (working memory) and Applied Problems (math achievement). The result indicated no significant gender difference on performance on Backward Digit Span and Applied Problems (Table 2). Furthermore, regression was performed in order to test age effects on working memory and math achievement. There was a significant age difference on applied problems

(*F*(df) = 9.09, p = .01), but not on working memory (*F*(df) = 3.30(1), p = .074). Based on these preliminary analyses, age at testing was controlled for all subsequent analyses.

To begin the primary analysis, correlations among the main variables of interest were examined. As presented in Table 3, household income was significantly associated with both outcome variables, working memory and math achievement. On the other hand, there was no significant correlation between maternal education and either outcome variables.

The first primary research question was whether the interaction between household income and working memory significantly predicts math achievement. A multiple hierarchical regression was carried out based on Baron and Kenny's (1986) moderation method (Table 4). After age was controlled, the analysis showed a significant main of working memory on math achievement (β = 4.30, t = 4.62, p = .00). The effect of household income on math achievement was not significant (β = .4.65, t = 1.54, p = .13). The interaction term (income x working memory) was not a significant predictor of math achievement (β = .59, t = .32, p = .75).

To answer the second question, whether maternal education interacts with working memory in predicting math achievement, a multiple hierarchical regression was performed (Table 5). After age was controlled, there was a significant effect of working memory on math achievement (β = 4.32, t = 4.67, p = .00). On the other hand, maternal education did not significantly predict math achievement (β = 1.80, t = 1.03, p = .38). When interaction term (maternal education x working memory) was entered, the result revealed the association between maternal education and math achievement was not moderated by working memory (β = 1.67, t =1.60, p = .12).

Discussion

The current study aimed to deepen the understanding of the association between executive functions and academic achievement differentiated by SES in early childhood. The model tested the moderation of working memory in the relationship between SES and math achievement in kindergarteners using two SES measures - household income and maternal education. I hypothesized low-SES children performed poorly on math tasks than high-SES children, and the importance of working memory on math achievement differs by maternal education, but not by household income, such that children whose mother had lower education benefit more from possessing better working memory. Contrary to expectation, my findings indicated no significant main effect of both SES measures on math achievement. Furthermore, the interaction of working memory with household income and maternal education did not significantly predict math achievement, which partially supported the hypotheses.

The two main contributions of this study is replications of the association between working memory and math achievement and the non-differential effect of working memory on math achievement by household income. First, consistent with existing literature, the result indicated that working memory is a powerful predictor of math achievement in early childhood (Van der Ven, Kroesbergen, Boom, & Leseman, 2012; Monette, Bigras, & Guay, 2011; Swanson & Beebe-Frankenberger, 2004). My findings confirmed the importance of working memory on math achievement is independent from socioeconomic status of children. This supports the previous research by Duncan, McClelland, and Acock (2017), who revealed working memory and attentional control mattered similarly for academic success of children from family with high and low income. On the other hand, the hypothesis for maternal education was not supported. This hypothesis was originally developed based on the findings by Davis-Kean (2005), who illustrated that maternal education has a stronger correlation with direct predictors of academic outcomes (e.g., parental educational expectations on children, parental warmth, and intellectual stimulation provided at home) than household income. Therefore, differential effects of working memory on math achievement by SES may become visible if researchers use maternal education in the model instead of household income, whose role is simply not powerful enough in academic achievement. However, the null results for both household income and maternal education suggested a different possibility. The lack of moderation by household income in the study by Duncan, McClelland, and Acock (2017), therefore, may not be because household income does not mater enough in early learning to create differential effects of working memory on math achievement compared with maternal education. Instead, it could be because of working memory whose role in math achievement is equally powerful across different SES groups, independently from access to learning resources and parental supports.

On the other hand, my study failed to replicate the association between SES and math achievement that has been substantiated in many previous studies (e.g., Sirin, 2005). Interestingly, maternal education was not significantly related with any outcome variables, which contradicts previous findings (Davis-Kean, 2005; Sirin, 2005). The lack of main effects of both SES measures may be due to limitations of the study design. The study used a relatively small sample size, which may limit the sensitivity to detect the effect of independent variables. More accurate differences can be found using a larger sample size. Second, the distribution of SES of the sample was not equal across groups. There was a much higher variation in SES variables in low SES group than in high SES group. In addition, the sample had an issue of overrepresentation of high-SES subjects. Therefore, the lack of association between SES and math achievement may potentially be a product of the small sample size and uneven distribution of SES.

In addition to the issues with the sample, there are several limitations in this study that have to be addressed. First, the study employed the non-longitudinal design. Since the study only analyzed performance in working memory and math tasks in kindergarten, it cannot tell us how having high working memory can impact the growth of math skills.

Given the lack of literature addressing protective roles of cognitive traits in low-SES children, research on this topic is still in the exploratory phase. Future research can consider different components of executive functions and academic achievement in association with maternal education with a larger longitudinal sample. Although the current study focused on working memory and mathematical achievement, it is possible that other components of executive functions have a more protective power in low-SES children.

While my finding did not support the stronger effect of working memory on math achievement in low SES group than in high SES group, the current study presented applied implications for early interventions. This study substantiated that possessing high working memory functioning can be highly advantageous for math achievement regardless of socioeconomic status. Because working memory has been shown to be trainable relatively easily compared with other aspects of executive functions (Thorell et al., 2009; Morrison & Chein, 2011), developing early intervention programs to train working memory capacity among low-SES children will be promisingly beneficial. Children who receive such interventions before formal schooling could potentially start their first grade without much less delay in the cognitive ability associated with math learning. This could contribute to narrowing achievement gap for math achievement in a long run.

Conclusion

This study has demonstrated that working memory plays a crucial role in math learning regardless of household income and maternal education of children. Though the moderation model using maternal education still requires further testing with better samples, the current study has made a significant contribution in replicating previous findings of the income moderation model by Duncan, McClelland, and Acock (2017). It has also set a stage for future studies that are to explore protective factors for socioeconomically disadvantaged children by examining moderation among the variables which can potentially unveil a complex mechanism of what aids learning in early childhood.

References

Alexander, K. L., Entwisle, D. R., & Bedinger, S. D. (1994). When expectations work: Race and socioeconomic differences in school performance. *Social Psychology Quarterly*, *57*(4), 283–299.

Alspaugh, J. (1991). Out-of-school environmental factors and elementary-school achievement in mathematics and reading. *Journal of Research and Development in Education, 24*(3), 53–55.

Ardila, A., Rosselli, M., Matute, E., & Guajardo, S. (2005). The influence of the parents' educational level on the development of executive functions. *Developmental Neuropsychology*, *28(*1), 539-560.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173.

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between executive function and academic achievement from ages 5 to 17 in a large, representative national sample. *Learning and Individual Differences*, *21*(4), 327-336.

Brock, L. L., Rimm-Kaufman, S. E., Nathanson, L., & Grimm, K. J. (2009). The contributions of 'hot'and 'cool'executive function to children's academic achievement, learning-related behaviors, and engagement in kindergarten. *Early Childhood Research Quarterly*, *24*(3), 337-349.

Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. *Developmental Neuropsychology*, *19*(3), 273-293.

Casey, B. J. , Somerville, L. H. , Gotlib, I. H. , Ayduk, O. , Franklin, N. T. , Askren, M. K. , et al. (2011). Behavioral and neural correlates of delay of gratification 40 years later. *Proceedings of the National Academy of Sciences of the United States of America*, *108*, 14998–15003.

Caro, D. H., McDonald, J. T., & Willms, J. D. (2009). Socio-economic status and academic achievement trajectories from childhood to adolescence. *Canadian Journal of Education*, *32*(3), 558-590.

Carlson, S. M., Zelazo, P. D., & Faja, S. (2013). Executive function. In P. D. Zelazo (Ed.), *Oxford Handbook of Developmental Psychology*. New York: Oxford University Press.

Christian, K., Morrison, F. J., & Bryant, F. B. (1998). Predicting kindergarten academic skills: Interactions among child care, maternal education, and family literacy environments. *Early Childhood Research Quarterly, 13*(3), 501–521.

Davis-Kean, P. E. (2005). The influence of parent education and household income on child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology, 19(*2), 294.

Dilworth-Bart, J. E. (2012). Does executive function mediate SES and home quality associations with academic readiness?. *Early Childhood Research Quarterly*, *27*(3), 416-425.

DiPrete, T. A., & Eirich, G. M. (2006). Cumulative advantage as a mechanism for inequality: A review of theoretical and empirical developments. *Annual Review of Sociology*, 271-297.

Diamond, A., Barnett, W. S. , Thomas, J. , & Munro, S. (2007). Preschool program improves cognitive control. *Science*, *318*, 1387–1388.

Duncan, R. J., McClelland, M. M., & Acock, A. C. (2017). Relations between executive function, behavioral regulation, and achievement: Moderation by household income. *Journal of Applied Developmental Psychology*, *49*, 21-30.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin*, *134*(1), 31.

Geary, D. C. (1998). *Children's Mathematical Development*. Washington, DC: American Psychological Association.

Greenberg, M. T., Lengua, L. J., Coie, J. D., & Pinderhughes, E. E. (1999). Predicting developmental outcomes at school re-entry using a multiple-risk model: Four American communities. *Developmental Psychology, 35*, 403–417.

Griffin, S. A., & Case, R. (1996). Evaluating the breadth and depth of training effects when central conceptual structures are taught. In R. Case & Y. Okamoto (Eds.), The role of central conceptual structures in the development of children's thought. *Monographs of the Society for Research in Child Development, 60*, 83–102.

Eccles, J. S. (2005). Influences of parents' education on their children's educational attainments: The role of parent and child perceptions. *London Review of Education*, *3*(3), 191-204.

Espy, K. A., McDiarmid, M. M., Cwik, M. F., Stalets, M. M., Hamby, A., & Senn, T. E. (2004). The contribution of executive functions to emergent mathematic skills in preschool children. *Developmental Neuropsychology*, *26*(1), 465-486.

Evans, G. W., & Schamberg, M. A. (2009). Childhood poverty, chronic stress, and adult working memory. *Proceedings of the National Academy of Sciences*, *106*(16), 6545-6549.

Fitzpatrick, C., McKinnon, R. D., Blair, C. B., & Willoughby, M. T. (2014). Do preschool executive function skills explain the school readiness gap between advantaged and disadvantaged children? *Learning and Instruction, 30*, 25–31.

Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*(2), 65-73.

Jimerson, S. R., Egeland, B., Sroufe, L. A., & Carlson, B. (2000). A prospective longitudinal study of high school dropouts: Examining multiple predictors across development. *Journal of School Psychology*, *38*(6), 525–549.

Lan, X., Legare, C. H., Ponitz, C. C., Li, S., & Morrison, F. J. (2011). Investigating the links between the subcomponents of executive function and academic achievement: A cross-cultural analysis of Chinese and American preschoolers. *Journal of Experimental Child Psychology*, *108*(3), 677-692.

Lawson, G. M., & Farah, M. J. (2015). Executive function as a mediator between SES and academic achievement throughout childhood. *International Journal of Behavioral Development*.

McClelland, M. M., Cameron Ponitz, C., Messersmith, E. E., & Tominey, S. (2010). Self-regulation: The integration of cognition and emotion. In R. Lerner, & W. Overton (Eds.), Handbook of life-span development. Hoboken, NJ: Wiley and Sons.

Milne, A., & Plourde, L. A. (2006). Factors of a low-SES household: What aids academic achievement?. *Journal of Instructional Psychology*, *33*(3), 183-194.

Malecki, C. K., & Demaray, M. K. (2006). Social support as a buffer in the relationship between socioeconomic status and academic performance. *School Psychology Quarterly*, *21*(4), 375.

Monette, S., Bigras, M., & Guay, M. C. (2011). The role of the executive functions in school achievement at the end of Grade 1. *Journal of Experimental Child Psychology*, *109*(2), 158-173.

Morgan, P. L., Farkas, G., & Wu, Q. (2011). Kindergarten children's growth trajectories in reading and mathematics: Who falls increasingly behind?. *Journal of Learning Disabilities*, *44*, 472-488.

Morrison, A. B., & Chein, J. M. (2011). Does working memory training work? The promise and challenges of enhancing cognition by training working memory. *Psychonomic Bulletin & Review*, *18*(1), 46-60.

Morrison, F. J., Ponitz, C. C., & McClelland, M. M. (2010). Self-regulation and academic achievement in the transition to school. *Child Development at the Intersection of Emotion and Cognition*, 203-224.

U.S. Department of Education, the National Center for Education Statistics (2002), Retrieved from https://nces.ed.gov/surveys/els2002/avail_data.asp

Polderman, T. J. C. , Posthuma, D. , De Sonneville, L. M. J. , Stins, J. F. , Verhulst, F. C. , & Boomsma, D. I. (2007). Genetic analyses of the stability of executive functioning during childhood. *Biological Psychiatry, 76*, 11–20.

Ponitz, C. E. C., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! Developing a direct measure of behavioral regulation in early childhood. *Early Childhood Research Quarterly, 23*(2), 141-158.

Protopapas, A., Archonti, A., & Skaloumbakas, C. (2007). Reading ability is negatively related to Stroop interference. *Cognitive Psychology*, *54*(3), 251-282.

Ramey, C. T., & Ramey, S. L. (1998). Early intervention and early experience. *American Psychologist*, *53*(2), 109.

Rhoades, B. L., Greenberg, M. T., Lanza, S. T., & Blair, C. (2011). Demographic and familial predictors of early executive function development: Contribution of a person-centered perspective. *Journal of Experimental Child Psychology*, *108*(3), 638-662.

Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development*, *72*(5), 1394-1408.

Rueda, M. R. , Rothbart, M. K. , McCandliss, B. D. , Saccomanno, L. , & Posner, M. I. (2005). Training, maturation and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences of the United States of America*, *102*, 14931–14936.

St Clair-Thompson, H. L., & Gathercole, S. E. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. *The Quarterly Journal of Experimental Psychology*, *59*(4), 745-759.

Swanson, H. L., & Beebe-Frankenberger, M. (2004). The relationship between working memory and mathematical problem solving in children at risk and not at risk for serious math difficulties. *Journal of Educational Psychology*, *96*(3), 471.

Thorell, L. B., Lindqvist, S., Bergman Nutley, S., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Developmental Science*, *12*(1), 106-113.

Van der Sluis, S., de Jong, P. F., & van der Leij, A. (2007). Executive functioning in children, and its relations with reasoning, reading, and arithmetic. *Intelligence*, *35*(5), 427-449.

Van der Ven, S. H., Kroesbergen, E. H., Boom, J., & Leseman, P. P. (2012). The development of executive functions and early mathematics: A dynamic relationship. *British Journal of Educational Psychology*, *82*(1), 100-119.

Walker, D., Greenwood, C., Hart, B., & Carta, J. (1994). Prediction of school outcomes based on early language production and socioeconomic factors. *Child Development, 65*(2), 606–621.

Wechsler, D. (1949). Wechsler intelligence scale for children.

West, J., Denton, K., & Germino-Hausken, E. (2000). America's Kindergartners: Findings from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99, Fall 1998.

White, K. (1982). The relation between socioeconomic status and academic achievement. *Psychological Bulletin, 91*, 461-481.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). Woodcock-Johnson III, Riverside. *Itasca, IL.*

Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives*, *6*(4), 354-360.

Table 1

Means, Standard Deviations, Sample Size, Minimum, Maximum, and Range for All Variables

Variable	*M*	*SD*	*N*	Minimum	Maximum
Children Characteristics					
Gender (% Male)	.54	.50	81	0	1
Age at Testing	5.70	.33	75	5.07	6.33
Socioeconomic Status Measure					
Maternal Education	2.136	2.14	72	12	20
Household Income	8.64	3.63	74	1	13
Backward Digit Span (WISCIII)	1.70	1.71	73	0	7
Applied Problems (WJ-III)	13.99	13.99	73	398	467

Note. For maternal education, 1 = some high school, no diploma, 2 = high school graduate diploma or the equivalent (e.g., GED), 3 = some college credit, no degree, 4 = Trade/technical/vocational training, 5 = associate degree, 6 = bachelor's degree, 7 = master's degree, 8 = professional degree, 9 = doctorate degree. For household income, 1 = under $5,000, 2 = $5,000-$9,000, 3 = $10,000-$14,999, 4 = 15,000-$19,999, 5 = $20,000-$29,999, 6 = 30,000-$39,999, 7 = $40,000-$49,999, 8 = $50,000-$59,999, 9 = $60,000-$79,999, 10 = $80,000-$99,999, 11 = $100,000- $124,999, 12 = $125,000-$149,000, 13 = 150,000 and over.

Table 2
Independent Sample T-test on Variables of Interest by Gender.

	Male (n = 42)	Female (n = 31)	t-test
	M(*SD*)	*M*(*SD*)	t(df)
Backward Digit Span (WISCIII)	2.57(1.76)	2.39(1.67)	.453(71)
Applied Problems (WJ-III)	436.14(16.13)	433.97(10.56)	.654(71)

Table 3
Correlation Matrix for Study Variables.

Variable	1	2	3	4	5
1. Gender					
2. Age at testing	-.142				
3. Maternal Education	-.119	-.026			
4. Household Income	-.095	.091	.759**		
5. Backward Digit Span (WISCIII)	-.054	.211	.200	.454**	
6. Applied Problems (WJ-III)	-.077	.320**	.190	.347**	.557**

** $p < 0.01$

Table 4

Summary of Regression Analysis for Predictors of Household Income Model (n = 74).

Variables	*β*	R^2	R^2-*Change*	*F(df)*
Step 1:		.08	.08	5.60 (65, 1)
Age	.28*			
Step 2:		.41	.33	14.13 (65, 3)
Household Income	.16			
Working Memory	.50**			
Step 3:		.41	.00	10.50 (65, 4)
Interaction (income x working memory)	.03			

* p < .05; ** p < .01.

Table 5

Summary of Regression Analysis for Maternal Education Model (n = 72).

Variables	*β*	R^2	R^2-*Change*	*F(df)*
Step 1:		.08	.08	5.66 (63, 1)
Age	.29*			
Step 2:		.37	.29	11.95 (63, 3)
Maternal Education	.50			
Working Memory	.13**			
Step 3:		.40	.03	9.83 (63, 4)
Interaction (maternal education x working memory)	.17			

* p < .05; ** p < .01.