SOCIOECONOMIC STATUS AND EXECUTIVE FUNCTION

EXPLORING THE ROLE OF HOME COGNITIVE STIMULATION IN THE ECLS-K:2011

A Dissertation

presented to

the Faculty of the Graduate School

at the University of Missouri-Columbia

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

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MAY 2023

APPROVAL

The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled:

SES AND EXECUTIVE FUNCTION: EXPLORING THE ROLE OF HOME COGNITIVE STIMULATION IN THE ECLS-K:2011

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ACKNOWLEDGEMENTS

First and foremost, I would like to thank my academic advisor, Dr. Matthew Easter who has been supportive of my research ideas from the beginning. You have contributed time and immense knowledge throughout the entire dissertation project. It would not have been complete without your endless support and encouragement.

My appreciation also goes to the rest of my dissertation committee members, Dr. Stephen Whitney, Dr. Wesley Bonifay, and Dr. Sara Gable. I thank you for your valuable input, insightful comments, and limitless encouragement. Without all of you, this dissertation would not have been successfully completed.

To my beloved husband, thank you for always believing in me and supporting me despite the great distance between us. Your support and prayers for me have sustained me this far. I would also like to thank my family for being a constant reminder that I am loved and supported even when I am halfway across the world.

To my best friend and sister, Fatin Asnan, thank you for always having my back during the tough times of completing this dissertation. You have seen me at my lowest and yet you still believed in me. To my family in St. Louis, you have been there through tears and laughter, you have given me a home away from home, and I am grateful for having you all throughout this extraordinary journey.

Finally, I thank my fellow Educational Psychology students, Shannise Jones, Precious Hardy, Lindsay Brockmeier, Alice Hung, Tayla Stephen, Michelle Oliver, and Megan Hirni for your endless continuous support, fruitful discussions, and constant encouragement especially during those difficult times. All of you are truly irreplaceable.

TABLE OF CONTENTS

List of Tables and Figures

ABSTRACT

Past findings have established that students from low SES families tend to have poorer academic outcomes in general. What is more concerning is that SES-related differences on academic outcomes between low SES children and high SES children tend to be stable throughout adulthood. Thus, current study attempted to explore the underlying mechanism between socioeconomic status (SES) and executive functioning skills (EF), which contribute to their learning. This study also aimed to examine the mediating role of home cognitive stimulation between socioeconomic status (SES) and executive functioning skills (EF) and its three components: working memory (WM), cognitive flexibility (CF), and inhibitory control (IC) among 5th grade students in the nationally representative dataset, ECLS-K:2011. Results revealed that academic-focused activities partially mediated the relationships between SES and working memory and cognitive flexibility while arts-focused activities fully mediated the relationship between SES and cognitive flexibility. Additionally, findings also indicated that there were differences in biological sex in the mediated pathways between SES and inhibitory control and between SES and cognitive flexibility through academic-focused activities. In sum, findings from the present study highlight the importance of targeting malleable factors to lessen the impact of low SES on children's cognitive development.

CHAPTER I. INTRODUCTION

Socioeconomic status (SES) refers to an individual's or group's social and economic status in relation to others in a society (Baker, 2014). In many studies, SES is generally measured as a composite measure of educational attainment, household income, and occupational prestige. Historically, during the 1960s and 1970s, SES was more commonly measured by father's education and/or occupation, leading to possible differing outcomes in previous research as it relates to educators and family (Sirin, 2005). However, current research has started using a more diverse set of SES indicators such as maternal education and income-to-needs ratio.

As a variable, SES has been widely and extensively used by educational researchers who are interested in examining contextual factors that affect students' general academic achievement (Sirin, 2005). In addition, SES is commonly investigated within various fields such as health, neuroscience, and psychology. Some factors often related to SES include structural elements like housing, neighborhoods, access to nutritious foods and access to health care providers (Baker, 2014). According to Herd, Goesling, and House (2007), higher income families generally have access to better housing and neighborhoods, health care, and nutritious foods which may mitigate the effects of stress and hardship. Similarly, education is tied to SES through the idea that as one possesses a higher level of education, the more access they will have to better occupations, which leads to higher income, more educational resources for their family, better housing, access to health care, and nutritious foods.

In the educational context, educational researchers have often focused on SES-related academic "gaps" that highlight the impact on student's success and performance in school. Children from low SES backgrounds are commonly associated with poorer academic skills at school entry compared to their high SES peers including poorer math skills (Galindo &

Sonnenschein, 2015). In fact, SES and academic achievement positive correlation persists throughout adolescence and is consistent across races (Mpofu and Van de Vijver, 2000; Wössmann, 2005; Aikens and Barbarin, 2008; Caro et al., 2009; Kieffer, 2012). Researchers have also discovered a strong association between SES-related adversity and executive functioning skills, in the sense that low SES children often begin school with poorer executive functioning skills (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005).

Executive function (EF) is a set of higher order cognitive processes that support goal-directed behaviors (Zelazo & Muller, 2012). EF consists of three distinct but related components: working memory, cognitive flexibility, and inhibitory control. These components are important for children's learning in terms of decision-making skills, critical thinking, regulating emotions and behaviors, as well as holding attention and focusing on a specific task. As expected, EF skills are often correlated with higher academic achievement (e.g., Lan et al, 2010) and specific domains of academic areas including literacy, numeracy, and science (e.g., Blair & Razza, 2007; Spiegel, Goodrich, & Morris, 2021; Pascal, Muñoz, & Robres, 2019). However, previous findings have also shown that there are significant differences in EF skills between children in lower SES and higher SES, with the gap being stable throughout life (e.g., Sirin, 2005).

Therefore, while such findings have been enlightening to educators about the reality of SES impacts on student achievement, it may be more productive for researchers to move beyond emphasizing these gaps and focus on potential factors that could help narrow them instead. Therefore, the purpose of the current study is to determine whether cognitively stimulating home environments explain the mechanism between SES and students' executive functioning (EF) skills. The literature review section begins with a detailed review of how EF is defined, following discussions about how home cognitive stimulation influences cognitive outcomes, how SES influences academic outcomes through home cognitive stimulation, how SES influences EF skills in children, how different aspects of cognitive activities influence EF skills, and mechanisms that have been explored by other researchers in determining the effects of SES on EF skills. In addition, the literature review also discusses the justification of using home cognitive stimulation as a mechanism that explains the SES-EF relationship through the idea of structural neuroplasticity.

The present study made use of the nationally representative sample, *Early Childhood Longitudinal Study, Kindergarten Class of 2010-11* (ECLS-K:2011) to determine the role of home cognitive stimulation in explaining the relationship between SES and EF skills in 5th grade students. Moreover, since home environment and stimulation are often measured using the HOME scale (Bradley & Caldwell, 1984) in many previous studies, the current study offered a different perspective of home cognitive stimulation measure using the ECLS-K:2011 dataset.

In summary, the literature review suggested 1) there is a lack of research that explores the mechanism between SES and EF skills and more research has been focusing on academic achievement as an outcome, 2) while home cognitive stimulation has been explored as a mediating factor that links SES and EF skills, many studies emphasize the role of parenting practices or parent-child relationships (e.g., Kuhn & Baker, 2017; Lohndorf, Vermeer, de la Harpe, & Mesman, 2021; Vrantsidis et al., 2019) and 3) home cognitive stimulation is often measured using the HOME scale (Bradley & Caldwell, 1984) in studies exploring the SES-EF relationship. Given this information, we attempted to answer the following research questions:

1) What is the factor structure of home cognitive stimulation in the ECLS-K:2011?

2) Are the relationships between SES and EF components mediated by home cognitive stimulation?

3) Are relationships in the structural model proposed in 2) different or equal across biological sex groups?

By attempting to answer the questions above, the present study may inform educators, researchers, and policymakers on how SES may impact executive functioning skills, which play a crucial role in the learning process. In the framework of structural neuroplasticity, the structural connections of the brain can change as a result of the environment, or more specifically, learning activities, which is explained in more detail in the literature review. Thus, this idea influences how stakeholders think about the impacts of low SES and provide appropriate educational and material resources for students, their families, and schools to improve executive functioning skills.

CHAPTER II. LITERATURE REVIEW

Executive function (EF)

"Executive function (EF) skills are a set of neurocognitive skills that support the conscious, top-down attentional control of thought, action, and emotion" (Zelazo & Carlson, 2020). These cognitive processes include planning, shifting, problem-solving, goal-directed activity and self-control. According to their seminal work in the field of executive function, Miyake, Friedman, Emerson, Witzki, Howerter, and Wager (2000), EF, among many other things, involves three distinct but interrelated components: working memory, cognitive flexibility, and inhibitory control. Miyake et al. (2000) also referred to EF components as the "unity and diversity of EF", which means that despite existing as discernable components, the three EF components share some underlying commonality and are not considered completely independent. *Working memory (WM)* is defined as an individual's cognitive ability to keep information updated during a task (Bull & Scerif, 2001). Cognitively speaking, as information from the sensory register enters the working memory, we as humans store, rehearse, and update that information for processing. Due to this, WM is said to be one of the most important parts of learning and the human memory. *Cognitive flexibility (CF)* refers to the ability to flexibly shift between tasks (Heaton, Chelune, Talley, Kay, & Curtiss, 1993) and *inhibitory control (IC)* is known as the ability to sustain attention and filter out external distractions from entering working memory (Baddeley, Emslie, Kolodny, & Duncan, 1998; Bull & Scerif, 2001).

According to Miyake et al. (2000), our central executive system is unitary in nature during the early stages of human development, with no distinct components. However, later in the development stages, around children's preschool years, the unitary EF begins to become more distinct in nature. Many other studies have also similarly found that EF manifests as a unitary factor during early childhood and gradually diverges into three distinct but related components around the end of pre-kindergarten and the beginning of elementary school (Baggetta & Alexander, 2016; Garon, Bryson, & Smith, 2008; Xu, Han, Sabbagh, Wang, Ren, & Li, 2013). Once they become distinct, EF is said to be relatively stable throughout adulthood (Baggetta & Alexander, 2016).

The following section will provide a brief definitional review of the three components, including how they are commonly measured in studies. From there, the discussion will progressively shift to more contextual review of EF that includes its relationships with SES, academic outcomes, and home cognitive stimulation.

Working memory (WM). Working memory (WM) or also known as updating, is the process of dynamically manipulating relevant information that enters the working memory storage (Miyake et al., 2000). This is to say that updating is not merely storing information in the WM system, but the ability to actively manipulate that information. In their study, Miyake et al. (2000) found that brain areas associated with passive storage of information was different than the brain areas associated with active updating. To be more specific, the active updating activity was stronger in dorsolateral prefrontal cortex area (DFPLC) rather than the premotor areas of the frontal cortex and the parietal lobes, which showed stronger activities during passive memory storage (Miyake et al., 2000).

Additionally, WM performance is commonly assessed using tasks such as the Numbers Reversed Task or sometimes referred to as the Backward Digit Span Test (Woodcok, McGrew, & Mather, 2001). The test requires individuals to verbally repeat a presented sequence of numbers in the reverse order of the presentation. In other words, participants are required to recall a string of digits and verbally present them in reverse order. Therefore, not only the individual is required to store the presented information, but there is an active cognitive demand that occurs through the manipulation of the presented information. The longer digit strings are, the more challenging the task becomes.

Cognitive Flexibility (CF). Another essential aspect of EF is cognitive flexibility (CF), also known as “shifting”, “attention switching” or “task switching”. Cognitively, CF is referred to as the ability to shift back and forth between cognitive tasks or mental sets (Miyake et al., 2000). During a cognitively demanding task, an individual must show the ability to shift from current irrelevant task to a new, more relevant task. For instance, during a mathematical task, an instructor will ask a student to add 15 on a list of 10-digit numbers. Then, once the instruction changes, for example, to “subtract 10 from the number list”, the student must overcome any interference from having previously performed a different operation (Miyake et al., 2000).

However, Miyake et al. (2000) argued that the “shifting” that occurs in a task like this is different than visual attention shifting. In other words, neural circuits that are involved in visual attention switching and more executive-oriented, instruction fulfilling shifting, are quite different yet the networks seem to interact with each other (Miyake et al., 2000; Posner & Raichle, 1994). Specifically, executive-oriented shifts primarily occur within the frontal lobes, as opposed to visual attention shifts that occur primarily within the parietal lobes.

In terms of assessment, CF is commonly assessed using the *Dimensional Change Card Sort (DCCS) Task* (Zelazo, 2008; Zelazo, Anderson, Richler, Wallner-Allen, Beaumont, & Weintraub, 2013). In the DCCS Task, the participant will be presented with two target cards and is asked to sort the cards based on one dimension and then another. For instance, if a participant is being presented with a blue fish and a red apple card, they are asked to sort the cards by color first, ignoring the shape, and then by shape, ignoring the color.

Inhibitory Control (IC). The last component of EF is inhibitory control (IC) or more simply "inhibition". IC is referred to as the ability to deliberately suppress unnecessary and irrelevant stimuli. According to Morasch and Bell (2011), IC is defined as the ability of an individual to inhibit a prepotent response to achieve a goal. In everyday life, IC manifests as behavioral regulation in terms of responding to external demands such as waiting, stopping current activities, having to clean up after a play session, and handling everyday conflicts. Like the other two components of EF, IC undergoes rapid development during a child's toddlerhood and preschool years, which mirrors rapid maturation of the PFC at that age (Morasch & Bell, 2011). Therefore, IC can be considered as an EF component that is not only task-specific but is also more apparent in everyday behavioral regulation of a child compared to WM and CF.

In terms of assessment, many researchers measure IC in the laboratory by using the well-known Flanker Test (Zelazo et al., 2013) that was adapted from the original Attention Network Task (ANT) by Eriksen and Eriksen (1974). During the task, the participant is required to inhibit an automatic response tendency by using selective attention in order to achieve a goal. More specifically, the participant will be asked to focus their visual attention on an image of fish in the center, while the "flankers" act as distractor arrows pointing toward the same direction (congruent), or the opposite direction (incongruent). Following these visual presentations, the participant will respond by pressing a button that indicates the direction of the fish.

Prior research on EF. Thus, the brief definitional review above shows the cognitive role of each EF component. Even though EF components are sometimes discussed in the literature as both distinct and united constructs, there is a theoretical basis that supports both positions. Historically, EF was more commonly researched within the context of individuals with developmental issues. This is because the knowledge about damaged PFC had been established many years ago, such that individuals with a damaged PFC often lack EF skills while still having normal IQ (Stuss & Benson, 1994). Researchers have been able to establish this by using brain imaging and neuroscience techniques such as the functional magnetic resonance imaging (fMRI) (e.g., Kesler et al., 2011; Scheibel et al., 2009) and event-related potential (ERP) (e.g., Downes et al., 2017). With these techniques, researchers can observe underlying neural mechanisms of EF. Therefore, today, there are many more advanced and nuanced studies that focus heavily on the relationship between developmental disorders and EF skills (e.g., Craig et al., 2016; Kira et al, 2022; Nunõ et al., 2021) but there is also an increasing demand for EF research within the learning, school, and educational context.

Within the context of learning, researchers have been studying all three EF components and found EF in general to be a supreme influence of academic achievement and performance. This includes research involving children with learning disabilities, language and comprehension problems, attention deficit hyperactivity disorder (ADHD), autism, and behavioral problems (e.g. Adams, Bourke, & Willis, 1998; Best, Miller, & Naglieri, 2011; Swanson, Ashbaker, & Lee, 1996; Visu-Petra, Cheie, & Benga, 2011; Wang & Zhou, 2019). Additionally, EF has also gained its reputation in studies related to learning performance such as numeracy skills, literacy skills and science in school-aged children (e.g., Blair & Razza, 2007; Spiegel, Goodrich, & Morris, 2021; Pascal, Muñoz, & Robres, 2019).

To better elucidate the relationship between EF and learning performance, a cross-cultural study conducted by Lan, Legare, Ponitz, Li, and Morrison (2010) on 119 Chinese and 139 American preschoolers revealed that for both countries, each component of EF uniquely predicted academic achievement. More specifically, one of their goals was to investigate the relationships of each EF component with three aspects of academic achievement: simple math (counting), complex math (calculation), and reading achievement. Their findings showed that inhibitory control uniquely predicted simple math while working memory and attentional control predicted all three aspects of achievement in the Chinese sample (Lan et al., 2010). In the American sample, inhibitory control and working memory significantly predicted simple math and complex math, but not reading while attentional control significantly predicted reading and complex math, but not simple math (Lan et al., 2010). In another study, Willoughby, Kupersmidt, and Voegler-Lee (2012) examined the causal associations between children's performance on EF tasks and academic achievement tests on preschool children. The study found that inhibitory control (pencil tapping task) and pre-test motor control (balance beam task) performances significantly predicted all three achievement scores in applied problems (math), letter-word identification, and sound awareness (rhyming) (Willoughby et al., 2012). Additionally, many other researchers have also discovered similar findings about the associations of EF performances in children with academic achievement (e.g., Bierman, Torres, Domitrovich, Welsh, & Gest, 2009; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Smith-Donald, Raver, Hayes, & Richardson, 2008; Thorell & Wahlstedt, 2006).

Given this information, it is apparent that EF skills support children's learning and academic abilities. However, it is worthwhile to note that the above studies portray EF skills and learning context within institutional settings like school. This is certainly understandable, as the learning and educational context is almost always discussed within the framework of schools, yet the home learning environment is a powerful foundation that shapes children's cognitive development before they even begin attending schools.

Home cognitive stimulation and cognitive outcomes

During the early childhood years before children begin formal schooling, home environments are key aspects of early cognitive stimulation. Even after children begin formal schooling, home remains a major component of learning where parents and caregivers provide cognitive support. Common home learning activities include reading books with parents, playing cards or board games together, telling stories, working on homework assignments, and going to the library or museum (Biedinger, 2011). While these may seem trivial compared to formal schooling, the time that children spend outside of school can sometimes tell a more complete story of a child's cognitive development.

Not surprisingly, there exists a considerable body of literature on the role of home cognitive stimulation on children's outcomes in many different contexts. For instance, Carlson and Corcoran (2001) utilized the *National Longitudinal Survey of Youth (NLSY)* dataset to study the effect of different types of family structures in 1,809 school aged children on their behavioral and cognitive outcomes. One of their findings was that children with higher home quality environment in terms of cognitive stimulation and parental emotional support were less likely to manifest behavioral problems and scored higher on cognitive tests. In another study by Rosen, Sheridan, Sambrook, Meltzoff, and McLaughlin (2018), they examined the effects of home and family SES on children and adolescents' neural development and achievement and found that that SES by itself did not significantly influence cortical thickness, but children who grew up in more cognitively stimulating home environments were found to have thicker cortical structure compared to children in less cognitively stimulating homes and thus had higher achievement scores.

Many other researchers have discovered similar findings about the influence of cognitively enriching home environment on children's cognitive development. For example, Sui-Chu and Willms (1996) assessed the relationship of parental involvement with parental background and children's academic achievement in a large representative sample of middle school students in the U.S. They found that parents who spent more time doing school-related activities at home tended to have children with higher academic achievement. Similar findings were unearthed by other studies (e.g., McNeal, 1999; Scribner, Young, & Pedroza, 1999; Trusty, 1998; Yan & Lin, 2002).

Moreover, researchers have also determined the role of home cognitive stimulation on children's specific academic domains such as math and literacy (e.g., De Florio & Beliakoff, 2014; Foster, Lambert, Abbott-Shim, McCarty, & Franze, 2005). Research suggests that home learning activities related to numeracy skills are associated with children's mathematical knowledge (Blevins-Knabe & Musun-Miller, 1996; LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010) and home linguistic interactions with parents are associated with children's language development and literacy competence (Dickinson & Tabors, 2001). It is well known that there is a wide range of variability in early numeracy and literacy competence among children who enter school in the United States (e.g., Dubowy, Ebert, von Maurice, & Weinert, 2008; Magnuson, Meyers, Ruhm, & Waldfogel, 2004; Weinert, Ebert, & Dubowy, 2010), which creates inequality in academic outcomes. Academic disparities may be apparent as early as kindergarten entry among children with poor numeracy and literacy skills versus children with adequate numeracy and literacy skills (Larson, Russ, Nelson, Olson, & Halfon, 2015; Lee & Burkam, 2002).

Therefore, it is evident that children's disparities in school readiness may largely be influenced by the quality of home cognitive stimulation. With that said, children who enter formal schooling with better cognitive skills are often associated with having higher cognitive stimulation at home such as exposure to literacy and numeracy activities outside of school (e.g., Larson et al., 2015).

However, while children's cognitive outcomes may generally be influenced by their home learning environment quality, it is almost impossible to discuss the home environment without considering the discussion of family SES. Many studies, including the ones described above, have included some notion of family or parental resources when discussing educational inequalities and achievement gaps. This is because a cognitively stimulating home environment largely depends on the availability of educational and familial resources, which begins with a structural characteristic of the family – SES.

SES, home cognitive stimulation, and academic outcomes

Over the years, it is well documented that child SES is a compelling predictor of academic achievement (Crane, 1996; Davis-Kean, 2005; Eamon, 2002; Larson, et al., 2015; Sirin, 2005). In fact, academic inequalities are often observed among low-SES children and high-SES children in terms of their academic preparedness and outcomes (Larson et al., 2015). For instance, some researchers have discovered that children from low SES background tend to perform worse on reading performance compared to high SES children (Aikens & Barbarin, 2008). Moreover, it is worth mentioning that these SES-related differences in academic outcomes also tend to be immovable throughout a child's life (Sirin, 2005). Thus, the next few paragraphs will discuss home cognitive stimulation as a factor that may mediate the relationship between SES and child academic outcomes.

According to Merlo et al. (2007), while SES is said to be an influential predictor of academic outcomes, it is debatable that family income alone directly influences academic achievement. Rather, SES-related differences in academic outcomes are more associated with differences in the quality of home environment. The reason family income can sometimes be associated directly with achievement is because the quality of home learning experiences may be judged by the availability of material resources such as number of books available in the home, possession of library membership and electronic devices. Thus, one must be careful in making such statements as it can be misleading in describing the achievement gap.

To clarify this idea, there are studies investigating the effects of SES on the home environment activities without directly determining the impacts of SES on academic achievement (e.g., Bornstein & Bradley, 2014; Bradley & Corwyn, 2002). As an example, Sandy, Muliawanti, and Aisyiyah (2020) conducted a qualitative study in Indonesia on the relationship of SES with early childhood literacy experiences at home and discovered that mid-level income parents provided higher support to their children in terms of read aloud, formal reading, and formal writing activities compared to low-income parents. In another study, Neumann (2016) explored the SES-related differences of home literacy activities in Australian preschoolers aged 3 to 5 and found that lower SES parents provided fewer literacy related activities to their children compared to higher SES parents. In terms of numeracy, a study that investigated the effects of SES on home math activities in Beijing, China, found that higher SES parents were more likely to provide home math activities to their children compared to lower SES parents (Pan, Yang, Li, Liu, & Liu, 2018). Additionally, it was also discovered in a study which determined the effects of SES on motor affordances at home that SES had a significant influence on the availability of physical space and play materials at home (Freitas, Gabbard, Caçola, Montebelo, & Santos, 2013). Similar findings were unearthed in a study that investigated the relationships of home environment with children's physical activity, sedentary time, and screen time which found that low SES children had more access to electronic media devices in their bedroom but lower access to portable play equipment such as bicycles and scooters and were significantly more sedentary compared to high SES children (Tandon, Zhou, Sallis, Cain, Frank, & Saelens, 2012).

Thus, as described earlier, it is important to emphasize that SES influence on academic achievement is not necessarily straightforward. Researchers have found home environment quality to be one of the mechanisms that links SES-related differences in academic achievement (e.g., Rosen et al., 2018). In fact, a few researchers have studied these relationships specifically on children's literacy skills. In a recently published study, Lurie, Hagen, McLaughlin, Sheridan, Meltzoff and Rosen (2021) determined the environmental mechanisms that linked SES and academic achievement, and language development in 101 children aged 60 to 75 months old and discovered that home cognitive stimulation mediated the relationship between SES and language development and academic achievement. In another example, Merlo et al. (2007) looked at the effects of parental nurturance on reading skills development among low SES children, specifically 77 students attending Head Start. They learned that parental involvement and nurturance significantly predicted their children's reading development. Similar findings were unearthed by other studies that investigated SES and home environment effects on literacy and numeracy skills development (e.g., DeFlorio & Beliakoff, 2014; Foster et al., 2005; Kluczniok, Lehrl, Kuger, & Rossbach, 2013Niklas & Schneider, 2017; Susperreguy, Lira, Xu, LeFevre, Vega, Pando, & Contreras, 2021).

However, not all studies looking at SES, home environment and academic outcomes solely focus on literacy and numeracy skills development. For instance, an interesting study that explored the role of home learning environments and family SES among naturalized refugees, rural, and urban groups in terms of their children's learning in Tanzania, Ndijuye (2020) found that there were no significant differences in terms of literacy and numeracy skills development between low SES family groups (naturalized refugees and rural groups) and high SES urban family groups. Rather, the significant differences between the SES groups were instead found in parental beliefs about education and expectations on their children (Ndijuye, 2020). More specifically, parents in the rural groups believed that education was just "another government initiative", in other words, not entirely important for their children. In contrast, education was believed to be a child's right within the urban groups and a way to move up the social ladder among naturalized refugee groups (Ndijuye, 2020). A few other studies have also mentioned parental beliefs in different SES groups in terms of how important education was to their children as they found SES discrepancies. Specifically, discrepancies showing low SES parental beliefs towards how school contributed more than the home environment in helping their child succeed in math compared to middle SES parents who thought the opposite (DeFlorio & Beliakoff, 2015).

In short, it is apparent that SES may not have a direct relationship with academic outcomes. The examples above were excellent in emphasizing the role of SES and home cognitive stimulation in predicting child academic outcomes. However, at present, not as many studies emphasize the effects of these factors on a child's EF skills.

The reason that the current study puts such an emphasis on EF skills is the fact that each EF component works together in helping the learning process, including the mastery of literacy and numeracy skills. As previously discussed by Miyake et al. (2000), working memory (WM) component holds and manipulates information that enters the short-term memory, cognitive flexibility (CF) component flexibly switches between tasks and adapts to new environments, and inhibitory control (IC) components helps regulate impulsive responses (Miyake et al., 2000).

Hence, before diving into the discussion of the relationship between cognitively enriching environments and EF skills, the next section will first shed light on the relationships between SES and EF skills. This relationship is in fact a key component that inspires the entire current study.

SES and EF skills

It has been well established that children in SES predicts student outcomes such as mental and physical health, academic achievement, and cognitive ability (Adler & Rehkopf, 2008; Gottfried, Gottfried, Bathurst, Guerin & Parramore, 2003; Matthews & Gallo, 2011; Sirin, 2005). More specifically, children in low SES families are known to perform more poorly on EF tasks compared to their middle and high SES counterparts (Noble, McCandliss, & Farah, 2007). Farah, Shera, Savage, Betancourt, Giannetta, Brodsky, Malmud, and Hurt (2006) specifically discovered that children from high SES families generally performed better on working memory, cognitive flexibility, and inhibitory control tasks. Additionally, prior research has also found that there was a positive correlation between SES and EF skills in early childhood (Clearfield & Niman, 2012; Lipina, Martelli, Vuelta, & Colombo, 2005) and the gap remains sturdy throughout childhood (Hackman, Gallop, Evans, & Farah, 2015).

More interestingly, a meta-analysis that observed the associations between SES-related differences and EF skills among thousands of children aged 2 to 18 years old discovered a small-to-medium association between SES and EF and even a stronger association among studies with multiple measures of EF (Lawson, Hook, & Farah, 2018). Not only that, findings from neuroscience research also suggest that children in low SES have different brain structures and functions than children in higher SES (Noble, McCandliss, & Farah, 2007; Rosen, Lurie, Sambrook, Meltzoff, & McLaughlin, 2021).

In a study conducted by Hughes and Ensor (2005), 140 children aged 2 from predominantly disadvantaged families were given batteries of EF and Theory of Mind (ToM) tasks to observe differences in family factors such as parent-child relationships and siblings relationships. Their findings suggested that family factors, particularly social disadvantage, significantly predicted both EF skills and ToM (Hughes & Ensor, 2005). In a longitudinal study, Raver, Blair, and Willoughby (2013) followed 1,259 children from low-income families from birth to age 4 and administered working memory, attentional set shifting, and inhibitory control tasks. They reported that, at 48 months of age, chronic exposure to poverty and strains of financial hardship significantly predicted performance on EF measures. In another longitudinal study, Evans, Farah, and Hackman (2021) investigated 245 adult participants who participated in the fourth wave of the childhood poverty study revealed that the duration of poverty from birth to age 9 was associated with poorer inhibitory control and working memory performances in adulthood. Interestingly, these effects were largely due to lack of maternal responsiveness and elevated allostatic load. Finally, findings from a study that collected samples of salivary cortisol from 310 preschoolers attending Head Start programs in the United States suggested that higher cortisol levels were associated with poorer teacher-report EF skills (Brown, Weaver, Streich, Shivde, and Garnett, 2023). However, assumptions made about children facing poverty-related stress were unclear because those children could have been facing other kinds of stressful situations unrelated to poverty.

Nevertheless, the impact of SES on EF skills is apparent in the studies described above. Early adversity related to SES could be seen manifesting through reduced cognitive skill performance even in adulthood. Being the current study's essence, we will revisit this relationship later in the literature review that includes the discussion of home cognitive stimulation as a potential mechanism that explains the relationship between SES and EF skills.

Home cognitive stimulation and EF skills

Outside of school, children spend most of their time at home with parents, siblings, or other caregivers. There is an abundance of research that suggests children who achieve better academically tend have stimulating home environments (e.g., Tamis-LeMonda, Luo, McFadden, Bandel, & Vallotton, 2017). However, less is known about how a stimulating home environment influence a child's EF skills which benefit their learning. In this section, we review literature that explains the relationship between the two variables before diving into a more complete discussion which includes SES in the subsequent section.

As with everything else, the development of a child's brain is impacted by the interaction of genetic and environmental factors (Gao, Grewen, Knickmeyer, Qiu, & Salzwedel, 2019; Lenroot & Giedd, 2008). Similarly, the maturation of the prefrontal cortex (PFC), which houses EF components, is also impacted by the same interaction. While children spend a significant amount of time in school, the home environment sets the stage for school readiness and their preparedness to receive more stimulation. Thus, typical home activities such as parent-child interaction, solving puzzles, and reading bedtime stories may not only improve general cognitive skills, but give way for EF skills to develop accordingly (Stucke, Stoet, & Doebel, 2022).

Research on home cognitive stimulation or home environment and EF skills has been growing in the recent years. However, much research on this topic is focusing more on parenting influences that affect children's EF skills. In the first example, Korucu, Litkowski, and Schmitt (2020) investigated the relationships between home literacy environment, EF skills, and school readiness among 102 preschool children in the U.S. Their results showed that home environment was not significantly contributing to social-emotional competence and academic readiness, but more significantly associated with children's EF skills. More specifically, Korucu et al. (2020) concluded that home literacy activities with parents might promote children's EF skills, which in turn could promote school readiness. In another study, Bernier, Carlson, Deschênes, and Matte-Gagné (2012) explored early caregiving environment and its influences on the development of early EF skills at 3 years of age. Their findings suggested that children who had better attachment with their parents were more likely to perform better on conflict EF skills at 3 years old. Next, a study conducted by Bernier, Whipple, and Carlson (2010) investigated similar parental variables such as maternal sensitivity, mind-mindedness, and autonomy support in 80 children aged 12 to 15 months old. Their study found that all three parental variables were significantly related to children's EF skills with parental autonomy support having the most substantial contribution (Bernier et al., 2010). Finally, a study that explored the effects of early intervention influences on verbal intelligence, performance intelligence, and EF skills in 1,302 children in rural Pakistan discovered that their stimulation intervention directly influenced EF skills and performance intelligence (Obradović, Yousafzai, Finch, & Rasheed, 2016).

Moreover, some other studies have also included home literacy environment (HLE) as another aspect of potential predictor of children's EF skills. For example, Altun (2022) investigated HLE within the home activities on 201 preschool children's EF skills in Middle Anatolia, Turkey. Their study found that HLE activities such as indoor and outdoor playtime, receptive vocabulary, and active screen time were in fact positively associated with EF skills while passive screen time was negatively associated with EF skills (Altun, 2022). Similar findings were discovered in other studies that explored the effects of home environment and parental influences on children's EF skills. (e.g., Haft, Gys, Bunge, & Uchikoshi, 2021; Devine, Bignardi, & Hughes, 2016; Hughes & Devine, 2019; Korucu, Litkowski, Purpura, & Schmitt, 2019).

Thus, given what we know about cognitive home stimulation and EF skills, it shows that the literature puts a greater emphasis on parental roles when discussing home environment and stimulation. These roles include mother-child talk, parenting styles, maternal depression, and parents' EF skills (Altun, 2022). There are fewer studies that discussed how different aspects of home cognitive stimulation impact children's EF skills.

To our knowledge, physical activity has generally been associated with EF skills in the literature but is defined as more structured, physically active, intervention-based play that focus on increasing motor skills (e.g., Ishihara, Sugasawa, & Matsuda, 2017; Shaheen, 2014) as opposed to simple everyday play or physical activity. In one study, Schmidt, Jäger, Egger, Roebers, and Conzelmann (2015) compared the effects of different levels of cognitive engagement during play (high cognitive engagement, high physical exertion, vs. low cognitive engagement, high physical exertion, vs. low cognitive engagement, low physical exertion) on each domain of EF skills and found that the change in cognitive flexibility performance significantly differed among the three conditions with post hoc tests revealing a stronger improvement in shifting performance in the "high cognitive, high physical exertion" condition than in the "low cognitive, high physical exertion" and the control condition. Thus, their results suggested physical activities that are cognitively engaging such as sports-based team games that require complex eye-hand coordination are better for improving EF skills compared to more aerobic-oriented physical activities such as running a marathon (Schmidt et al., 2015). A meta-analysis review on the effects of physical activity on EF skills, attention, and academic performance in 31 interventions by de Greef, Bosker, Oosterlaan, Visscher, and Hartman (2017) showed that longitudinal physical activity programs (physical activity done over a long period of time) had positive impacts on working memory (Hedges' $g = 0.36$; $p < 0.01$) and cognitive flexibility (Hedges' $g = 0.18$; $p < 0.05$). There were no significant effects of longitudinal physical activity programs found on inhibitory control and planning skills (de Greef et al, 2017). Additionally, within the longitudinal programs, both aerobic and cognitively engaging physical activity were significant in predicting cognitive performance but cognitively engaging physical activity had a higher effect size (Hedges' $g = 0.53$; $p < .05$) compared to aerobic physical activity (Hedges' $g = 0.29$; $p < .05$).

Indoor games have also been investigated in terms of their impacts on children's EF skills. Gashaj, Dapp, Trninic, and Roebers (2021) determined the effects of electronic video games, exergames, and board games on children's EF skills in kindergarten to 2nd grade and found that exergames had a positive impact on switching ability. Moreover, board games were positively associated with inhibition skills, exergames negatively associated with updating skills, and the use of 3D games was positively associated with switching ability (Gashaj et al., 2021). In another example, a study that explored the effects of playing chess on school aged children's EF skills found that compared to non-chess players, chess players had significantly better planning skills (Grau-Pérez & Moreira, 2017). This result may be explained by the high complexity of games such as chess which require excellent planning ability in order to win the match.

In terms of numeracy activities, the literature shows abundant research on how EF skills predict math ability in children (e.g., Clark, Pritchard, & Woordward, 2010; Espy, McDiarmid, Cwik, Stalets, Hamby, & Senn, 2004; Ribner, 2020) but very few on how early numeracy activities may be associated with EF skills. In a review article by Clements, Sarama, and Germeroth (2016), it was suggested that the relationship of math and EF skills was bidirectional (van der Ven, Kroesbergen, Boom, & Leseman, 2012) and researchers found that working memory and attentional control significantly predicted growth in numeracy skills in preschool (Welsh, Nix, Blair, Bierman, & Nelson, 2010). However, they also found that preschool numeracy skills significantly predicted later EF growth (Welsh et al., 2010). Additionally, Clements et al. (2016) suggested that mathematical activity may benefit EF growth in children. The reason behind this suggestion was grounded by the fact that mathematical thinking allows children to develop EF skills (Clements et al., 2016). Similarly, other aspects of activities that have been recently reported to improve children's EF skills include arts-focused activities such as creative drama activities, creative movement, & playing musical instruments (e.g., Ciftci & Aykaç, 2020; Park, Lee, Baik, Kim, Yun, Kwon, Jung, & Kim, 2015).

In short, it is apparent that researchers have explored the impacts of different activities on children's EF skills. Moreover, it is more common to find studies discussing parental roles and parent-child relationships when discussing home environment. There are also very few studies that combined these different aspects in one study in terms of predicting EF skills. Hence, in the next section, we will justify the importance of home cognitive stimulation in the current study through the framework of structural neuroplasticity.

Structural Neuroplasticity

Why might differences in SES manifest in children's cognitive abilities, particularly EF skills? Before going further, it may be beneficial to understand the characteristics of our brain. Our brain is referred to as plastic—the ability to alter its form according to its surroundings and experience (James, 1890; Zelazo & Carlson, 2020). There are several types of neuroplasticity: evolutionary, reactive, adaptive, and reparation plasticity (Trojan & Pokorny, 1999). The current study will however focus on adaptive neuroplasticity, which generally refers to changes in the brain that reflect long-term or repeating stimulation (Trojan & Pokorny, 1999). This will then branch into two more types – functional and structural neuroplasticity (Trojan & Pokorny, 1999).

Functional neuroplasticity is defined as the brain's capability to shift localized functions from a damaged area to other undamaged areas of the brain (Trojan & Pokorny, 1999). As an example, a person who experiences a stroke and loses some brain functions may re-gain the functions through a re-wiring of the brain taking over the functions of damaged areas. The word "functional" puts an emphasis on how the brain can change to preserve functions that are lost. *Structural neuroplasticity* refers to the ability of the brain, specifically its spines and dendrites to change the physical structure of the brain as a result of learning. Thus, the present study will particularly focus on the notion of *structural neuroplasticity* as it is the most relevant to the proposed model. However, it is important to note that the term "structural" does not mean that the resulting morphometric changes in the brain do not provide functional benefits as functional neuroplasticity does. The term "structural" is used to emphasize new connections in the brain upon learning a new skill.

One of the most common brain stimulations occurs in our everyday lives – our daily experiences. According to Zelazo & Carlson (2020), experience contributes to changes in cortical networks development. According to Rampon, Jiang, Dong, Tang, Lockhart, Schultz, Tsien, and Hu (2000) and van Praag, Kempermann, and Gage (2000), cognitively enriching environments are associated with improved learning and memory, as well as decreases in age-related memory decline. At the structural level, the volume and density of grey matter and white matter are not the only observed changes in an enriching environment, but changes can also be seen in the density of receptors for neurotransmitters such as dopamine (Zelazo & Carlson, 2020). Others have also found various cognitive stimulations that changed the structural shape of the brain, which will be discussed below.

Groussard, Viader, Landeau, Desgranges, Eustache, and Platel (2014) investigated the effects of musical practice on the dynamics of grey matter changes in 44 participants who had no musical experience and who were amateur musicians. They discovered that repeated musical training significantly increased grey matter volumes, suggesting that musical training induced structural changes to the brain. Additionally, Michelli, Crinion, Noppeney, O'Doherty, Ashburner, Frackowiak, and Price (2004) investigated second language acquisition on the density of grey matter in the brain among 25 monolinguals, 25 early bilinguals, and 33 late bilinguals and found significant differences in grey matter density in both bilingual groups compared to monolinguals. In another study, longitudinal magnetic resonance image (MRI) data was collected throughout a 9-month social and cognitive mental training intervention among adults aged 20 to 55 years old (Valk, Bernhardt, Trautwein, Böckler, Kanske, Guizard, Collins, & Singer 2017). Their findings revealed that short daily mental training significantly resulted in prefrontal regions, frontoinsular regions and inferior frontal and lateral temporal cortices plasticity (Valk et al., 2017). Finally, a study was conducted to investigate the effects of a 2-week Go/NoGo training designed to promote frontal top-down EF inhibitory control mechanisms and results showed increases in grey matter volume in specific parts of the brain (Chavan, Mouthon, Draganski, van der Zwaag, & Spierer, 2015). Similar findings on structural brain changes were discovered in various brain-related training (e.g., Bailey, Zatorre, & Penhune, 2014; Bengtsson, Nagy, Skare, Forsman, Forssberg, & Ullén, 2005; Klöppel, Mangin, Vongerichten, Frackowiak, & Siebner, 2010; Lee, Park, Jung, Kim, Oh, Choi, Jang, Kang, & Kwon, 2010; Steele, Bailey, Zatorre, & Penhune, 2013; Spierer, Chavan, & Manuel, 2013).

Therefore, the above studies are evidence that the brain is able to change its structural shape and connections in stimulating environments. In other words, structural neuroplasticity is experience-dependent (May, 2011). On the basis of this evidence, enriching environment seems to be key to increased neural connectivity. Next, we will discuss the dataset that will be used in the current study in terms of its unique home cognitive stimulation measure.

Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 (ECLS-K:2011)

The present study will make use of the nationally representative sample from the *Early Childhood Longitudinal Study, Kindergarten Class of 2010-11* (ECLS-K:2011). Participants in the dataset consist of children who were followed from the first year of kindergarten to the last year of fifth grade. Additionally, children in the ECLS-K:2011 are diverse in terms of SES and ethnic/racial backgrounds. Not only that, the dataset is inclusive in the sense that parents, teachers, school administrators, and before- and after- school care providers also participated in providing information about children's socioeconomic backgrounds, social, cognitive, emotional, and physical development, as well as home activities, school activities, home and school environment, classroom environment, and classroom curriculum (NCES, 2019). Hence, we think that the present study benefits from the all-inclusive aspects of child development in terms of exploring the role of home cognitive stimulation in the SES-EF relationship.

Thus, in terms of measuring home cognitive stimulation for the current study, we will utilize participants in the last wave in Spring 2016 (5^{th} Grade) within the Parent Interview in the Home Environment, Activities, and Cognitive (HEQ) section to be included as a measure of home cognitive stimulation. The ECLS-K:2011 itself provides a wide range of home activities and cognitive stimulation that encompasses literacy, play, physical activity, monitoring online activity, tutoring, and outside of home activities such as visiting the library or museum. To be more specific, there are 40 parent interview questions in the HEQ section that targets various aspects of home cognitive stimulation and activities.

In addition, it is important to acknowledge that the HEQ section in ECLS-K:2011 does not restrict these activities to be provided by parents only, but with any family members in the home. For instance, the section begins with, *"Now I'd like to talk to you about {CHILD}'s activities with family members. A family member refers to any person who lives in the child's household and any relative of the child living outside the child's household."* In other words, the provider of stimulation could be coming from family members other than the child's parents. While some may argue that this muddles the effects of the study, we are taking this opportunity to clarify that the present study focuses on the home cognitive stimulation aspects regardless of who provides the stimulation. In other words, we are more interested in whether there is a presence of cognitive stimulation in the home.

Moreover, the HEQ section also provides extensive description of each activity in clarifying the types of activities that occur. For instance, *"In a typical week, how often do you or any other family members play games or do puzzles with {CHILD}? This includes indoor "quiet" games like board games or puzzles, or more active indoor games like Ping-Pong", "In a typical week, how often do you or any other family members play a sport or exercise together with {CHILD}? This includes calisthenics (e.g., jumping jacks, sit-ups), riding bicycles, rollerblading, individual or team sports, games like hide-and-go-seek, or other outdoor activities were activity or exercise is involved. Do not include times when the child does the sport or activity by him or herself."* Thus, not only the ECLS-K:2011 provides a rich variety of home cognitive stimulation, but the present study also benefits from the fact that the home stimulation measure does not restrict parents to be the only provider of stimulation.

Furthermore, the home cognitive stimulation measure in ECLS-K:2011 has generally been used by other scholars in various studies. For example, Padilla and Ryan (2020) explored the role of cognitive stimulation, early care, and education in determining its impact on school readiness among children of Hispanic immigrants. In their study, cognitive stimulation was measured as a composite of eight items assessing how often families read books, told stories, sang songs, played games, did arts and crafts, talked about nature or science, built things, and practiced reading, writing, or working with numbers. The composite score was the average of the frequencies (Padilla & Ryan, 2020). In another example, Byrnes, Wang, and Miller-Cotto (2019) investigated how children's propensities (i.e., prior knowledge, self-regulation, and executive function) mediated the relationship between the role of family and classrooms factors with cognitive development using home cognitive stimulation from the ECLS-K:2011 dataset. Responses to each item were multiplied by the factor loading for that item and then summed to index literacy cognitive stimulation and non-literacy cognitive stimulation (Brynes et al., 2019).

Hence, the current study aims to focus on utilizing the different aspects of everyday home cognitive stimulation from the ECLS-K:2011 dataset in our analyses. Next, we will discuss how researchers have explored some aspects of home cognitive stimulation along with other mediating factors as a mechanism that explains the relationship between SES and EF skills.

Mediating factors of SES and EF

Many researchers have established the relationship between SES and EF skills through research in cognitive and brain outcomes (Noble et al., 2007). For instance, children from low SES backgrounds are often associated with poorer EF abilities such as working memory (Noble et al., 2007) whereas children from middle and high SES families tend to demonstrate better EF skills (Dilworth-Bart, 2012; Hackman & Farah, 2009; Noble et al., 2007; Rosen et al., 2018). Given the evidence, this could mean that children in low SES families are at risk for negative outcomes when differences in EF disparities are observed.

However, recent efforts have increased toward exploring potential mediating factors that may further explain the SES-EF linkage in an effort to identify targets for interventions and programs. This section will provide a literature review on studies that have attempted to explore various potential mechanisms explaining the linkage between SES and EF. To our knowledge, few scholars have looked at potential mechanisms including parental education (Ardila, Rosselli, Matute, & Guajardo, 2005; Noble et al., 2005; Noble et al., 2007), child's health status and parenting style (Guo & Harris, 2000), environmental housing conditions and mother-child interactions (Duncan & Brooks-Gunn, 2000), characteristics of the neighborhood (Brooks-Gunn & Duncan, 1997; Duncan & Brooks-Gunn, 2000; Leventhal & Brooks-Gunn, 2000) and home cognitive stimulation (Guo & Harris, 2000).

Looking at a few more instances, Arán-Filippetti, Cristina, and de Minzi (2012) conducted a study to explore the role of several cognitive factors in mediating the SES-EF relationship by collecting data from 254 children in Santa Fe, Argentina aged 7 to 12 years old. The children were then separated into two SES groups; low SES and middle SES. They reported that maternal education level and housing conditions were significant predictors of EF skills (Arán-Filippetti et al., 2012). Additionally, Rosen, Lurie, Sheridan, Hagen, Miles, and Meltzoff (2019) also investigated the role of home cognitive stimulation as a potential mediating factor linking SES and EF skills. They collected longitudinal data from 101 participants in Seattle, Washington, aged 60 to 75 months and found that cognitive stimulation at home, a subscale taken from the Home Observation of the Environment (HOME) assessment (Bradley & Caldwell, 1984) such as number of books, parent-child interactions, parent's language use and parent's encouragement of cognitive activities fully mediated the relationship between SES and EF (Rosen et al., 2019). In this study, a subscale from the HOME items was extracted and cognitive stimulation was made up of 20 items assessing different aspects of cognitive stimulation. The mediation model however includes home cognitive stimulation as a single construct after confirmatory factor analyses (CFA) was performed. Thus, while the study may seem related to the idea of the current study, it is worth clarifying that we attempt to explore the ECLS-K:2011 home cognitive stimulation measure as possible multiple constructs in determining their roles in the SES-EF relationship.

More interestingly, Vrantsidis, Clark, Chevalier, Espy, and Wiebe (2019) investigated potential mediators of SES-EF linkage through two models; the family stress model and the family investment model among 151 infants aged 6 to 36 months. The potential mediating variables were maternal psychological distress, harsh parenting, and cognitive stimulation, which was also taken from the EC-HOME scale (Bradley & Caldwell, 1984). Particularly for cognitive stimulation measure, scores from each subscale were tallied and the weighted average of their sums was used as a measure of home cognitive stimulation (Vrantsidis et al., 2019). Briefly, the family stress model (Conger & Conger, 2002) refers to the detrimental effects of parental stress on parent-child relationships and child development in low SES households (Vrantsidis et al., 2019). To be more specific, parents in low SES households tend to experience more stress related to finance and social life, which can potentially affect their psychological health and thus affecting their relationships and interactions with their children (Vrantsidis et al., 2019). In contrast, the family investment model (Conger & Donnellan, 2007) refers to the emphasis on cognitive stimulation as a crucial factor for children's neurocognitive development. Particularly, parents in low SES households may have fewer material resources to invest in their children's development compared to parents in middle and high SES households (Vrantsidis et al., 2019). Therefore, within the family stress model, their findings revealed that increased maternal psychological distress mediated the linkage between lower parental education (low SES) and EF skills (WM and IC) (Vrantsidis et al., 2019). In addition, they did not find cognitive stimulation to be a significant mediator of SES and EF skills (Vrantsidis et al., 2019), suggesting that family functioning is a more supreme factor that explains the SES-EF linkage than material resources in this study. It should be noted that the non-significant results of this unique study exploring both family functioning and material aspects were the opposite of what we see in the previously mentioned studies (e.g., Rosen et al., 2019).

Hence, given this information, it is evident that mediating factors have been explored in the literature. However, we acknowledge that there are more studies focusing on exploring mediators between SES and academic outcomes (e.g., Rosen et al., 2018; Rosen et al., 2021) than SES and EF skills. We also acknowledge that cognitive stimulation has been explored as a mediating factor that links SES and EF skills (e.g., Rosen et al., 2019; Vrantsidis et al., 2019), albeit rather recently and that parent-child relationships have been the focus of many studies.

In sum, the literature review has generally shown that 1) there is a lack of research that explores the mechanism between SES and EF skills and more research has been focusing on academic achievement as an outcome, 2) while home cognitive stimulation has been explored as a mediating factor that links SES and EF skills, many studies emphasize the role of parenting practices or parent-child relationships (e.g., Kuhn & Baker, 2017; Lohndorf, Vermeer, de la Harpe, & Mesman, 2021; Vrantsidis et al., 2019) and 3) home cognitive stimulation is often measured using the HOME scale (Bradley & Caldwell, 1984) in studies exploring the SES-EF relationship and often included in analyses as a single construct. However, this is not to say that the ECLS-K:2011 measure of home cognitive stimulation includes entirely different types of home activities than the HOME scale, but some of the response scales in ECLS-K:2011 contain frequencies of involvement in home practices while the HOME only contains a binary response of "yes" and "no". Therefore, differences of effects may exist in regard to the response scales between the two measures.

The Present Study

Considering the above literature review, the present study sought to explore the role of different aspects of home cognitive stimulation as a potential mechanism that explains the relationship between SES and distinct EF skills – working memory, cognitive flexibility, and inhibitory control. We utilized the nationally representative sample from the *Early Childhood Longitudinal Study, Kindergarten Class of 2010-11* (ECLS-K:2011) dataset and extracted all measures of SES, three distinct components of EF skills, and home cognitive stimulation in 5^{th} grade students.

Our justification for studying the 5^{th} grade sample in the ECLS-K:2011 was due to the fact that past literature often focused on younger children when examining the effects on cognitive abilities as school readiness is seen as important in predicting academic achievement (e.g., Bierman et al., 2011; Evans et al., 2021; Rosen et al., 2021). Furthermore, psychologist Susan Harter suggested that children at this age may have developed a self-system that is more stable and consistent, including a more complex understanding of themselves and their relationship with others (Harter, 2012). In other words, they also become more aware of their own weaknesses and strengths and are able to engage in self-reflection and self-expression.

Harter (2012) also argued that during middle childhood, children's self-concept becomes more differentiated as they develop a clearer understanding of their unique qualities and abilities. They also become more able to differentiate their self-concept based on different domains, such as their academic, social, and athletic abilities (Harter, 2012). Thus, we believe that this developed sense of self may have an influence on the activities that they engage in outside of school.

In addition, one unique feature of the current study is our attempt to examine distinct but relevant aspects of the home cognitive stimulation taken from the ECLS-K:2011 dataset, allowing us to inform educators on potential stimulations in the home that may mitigate the well-known impact of SES on students' EF skills. Furthermore, studies that have looked at this specific relationship often made use of the HOME scale (Caldwell & Bradley, 1984) (e.g., Rosen et al., 2019) to index home cognitive stimulation, which allowed us the opportunity to explore the relationship using the ECLS-K:2011 dataset instead. As previously mentioned, the home cognitive stimulation measure in the ECLS-K:2011 dataset provides a rich variety of home cognitive stimulation ranging from literacy activities, academic-focused activities, games, tutoring frequency, sports, to outside of home stimulation. Hence, the inclusion of the ECLS-K: 2011 measure of home cognitive stimulation in our analyses may accommodate for different perspectives of the SES-EF linkage.

Therefore, based on the literature review, we generally hypothesized that the ECLS-K:2011 measure of home cognitive stimulation mediated the effect of SES and EF components. In addition, we also sought to explore whether biological sex had a significant effect on SES and EF components via home cognitive stimulation. With that in mind, the present study sought to answer the following questions:

1) What is the factor structure of home cognitive stimulation in the ECLS-K:2011?

a. We hypothesized that 7 items, namely the frequency of playing games and puzzles, talking about science and nature, practicing reading, writing, and math, reading outside of school, frequency of participation in academic activities outside of school, and getting regularly tutored would load onto the "academic" latent factor.

b. We hypothesized that 3 items, namely the frequency of exercising, participation in athletic activities, and attending sporting events would load onto the "physical" latent factor.

c. We hypothesized that 5 items, namely the frequency of going to concerts, shows, or plays, involvement in music lessons, drama lessons, art lessons, and performing arts programs would load onto the "arts" latent factor.

2) Are the relationships between SES and EF components mediated by home cognitive stimulation?

a. We hypothesized that academic stimulation would mediate the effects between SES and working memory (WM), cognitive flexibility (CF), and inhibitory control (IC).

b. We hypothesized that physical stimulation would mediate the effects between SES and working memory (WM), cognitive flexibility (CF), and inhibitory control (IC).

c. We hypothesized that arts stimulation would mediate the effects between SES and working memory (WM), cognitive flexibility (CF), and inhibitory control (IC).

3) Are relationships in the structural model proposed in 2) different or equal across biological sex groups?
    a. Based on Harter's (2012) idea that children become more developed in their sense of self in middle childhood, we hypothesized that biological sex would moderate the mediated effects of SES and all aspects of EF skills through home cognitive stimulation factors.

CHAPTER III. METHODS

Participants

Data for the present study was drawn from the nationally representative sample, the *Early Childhood Longitudinal Study, Kindergarten Class of 2010-2011* (ECLS-K:2011). Children who participated in data collection conducted by the National Center for Education Statistics (NCES) were longitudinally followed from the first wave of kindergarten in Fall 2010 to the last wave at the end of fifth grade in Spring 2016. However, participants in the present study only included children in the last wave when most of them would be in fifth grade.

4,613 participants were included in the data after performing listwise deletion. 2,726 participants were White (59%), 263 participants were Black or African American (6%), 933 participants were Hispanic (20%), 428 participants were Asian (9%), 22 participants were Native Hawaiian/Pacific Islander (0%), 29 participants were American Indian/Alaska Native (0%), and 212 participants were of other ethnicities (5%). Additionally, 2,304 participants were male (50%) and 2,309 were female (50%). Table 1 provides the frequencies and percentages of participants' race/ethnicity and biological sex before and after listwise deletion.

Table 1

Demographic Information of Participants

Number of Participants	n = 18,174 (Before listwise deletion)		n = 4,163 (After listwise deletion)	
Race/Ethnicity				
White	8,026	47%	2,726	59%
Hispanic	4,324	25%	933	20%
Asian	1,410	8%	428	9%
Black/African American	2,152	13%	263	6%
American Indian/Alaska Native	140	1%	29	0%
Native Hawaiian/Pacific Islander	97	1%	22	0%
Other	819	5%	212	5%
Biological Sex				
Male	9288	51%	2304	50%
Female	8847	49%	2309	50%

Procedure

The data collection instruments for the fifth-grade round included computer assisted interviews and assessments (CAI) and hard or physical copy questionnaires. Particularly, direct child assessments and parent interviews were conducted using CAI and the data collected from teachers and school administrators were conducted using physical copy questionnaires (NCES, 2019). Note that the current study did not include any teacher level or school level data. Generally, the instruments and assessments used for fifth grade students were the same in the earlier rounds of data collection. However, some assessments and instruments from the earlier rounds were either revised or added to fit the fifth-grade sample (NCES, 2019). For example, the direct EF skills measure (direct cognitive EF measure) did not comprise all three components until fourth grade, when inhibitory control measure was added to the battery of assessments.

Similarly, while questionnaires regarding home cognitive stimulation were the same as the earlier rounds of data collection, some activities were revised to fit children as they grow older.

In addition, sampling weights were utilized in our analyses in order to achieve national-level estimates and capture a nationally representative sample. Particularly, the ECLS-K:2011 data was weighted "to account for differential probabilities of selection at each sampling stage and to adjust for the effect nonresponse can have on the estimates" (NCES, 2019, p. 4-28). The appropriate sample weight used in data analysis was selected based on the number of sources of data and survey components, for which nonresponse adjustments were made. For instance, fifth grade sampling weight for child and parent questionnaire/response from fall kindergarten would be different from the fifth-grade sampling weight for child and parent questionnaire/response from fall kindergarten all the way through spring fifth grade. Therefore, the most appropriate weight variable chosen for the present study was w9c29p_9a0.

Measures

SES and Demographics. Socioeconomic status (SES) was computed using parent interview data at the household level. With that, the five components used to measure SES include: parent 1/guardian's education, parent 2/guardian's education, parent 1/guardian's occupational prestige score, parent 2/guardian's occupational prestige score, and household income (NCES, 2019). Additionally, the current study also included fifth grade students' other demographic information such as race/ethnicity and biological sex.

Cognitive Flexibility. To assess children's cognitive flexibility, the *Dimensional Change Card Sort (DCCS)* (Zelazo, 2006; Zelazo, Anderson, Richler, Wallner-Allen, Beaumont, & Weintraub, 2013) was used. This task was developed as part of the National Institutes of Health

Toolbox Cognitive Battery (NIHTB-CB) to assess three distinct components of EF skills as proposed by Miyake et al. (2000).

The standard DCCS is a well-known task used to measure a child's ability in task switching or set shifting. In this task, children were presented with two target cards and were asked to sort the cards based on one dimension and then another. For example, if a child was presented with a blue rabbit and a red apple card, they were asked first to sort the card by color, ignoring the shape, and then by shape, ignoring the color. Additionally, more challenging versions of this task were developed to assess older children, adolescents, and young and old adults (Zelazo et al., 2013). It was reported that the standard version of the DCCS and the more challenging versions had impressive test-retest reliability in childhood, with an intraclass correlation coefficient (ICC) of .90 to .94 (*ICCs* = .90-.94) (Beck, Schaefer, Pang, & Carlson, 2011).

The ECLS-K:2011 measured cognitive flexibility using the computerized version of the DCCS, also known as the Toolbox (DCCS) Test (Zelazo et al., 2013), which was included in the current study. According to the ECLS-K:2011 manual, this task consisted of four components: practice, preswitch, postswitch, and mixed. Children were presented with practice trials before they are given the real switching tasks on a touch screen monitor. More specifically, they were presented with two images, such as a white rabbit and a green boat, and then asked to match the object by color or shape by touching the target object on the screen. Instructions of the task appear on the screen and a research assistant assisted them to make sure they understood the task. During the task, the word "shape" or "color" appeared on the screen to prompt the child to sort by that specific dimension. The overall score was computed by taking into account children's reaction time and accuracy. The reported ICC of this modified version of cognitive flexibility measure was .92 (*ICC* = .92).

Inhibitory Control and Attention. To measure children's inhibitory control and attention, the ECLS-K:2011 made use of the modified version of the flanker test from the Toolbox Flanker Inhibitory Control and Attention Test measure (Zelazo et al., 2013). It was adapted from the original Attention Network Task (ANT) which was based on the Eriksen flanker test (Eriksen & Eriksen, 1974). Furthermore, the Toolbox Flanker test measures a child's inhibitory control in the context of selective visual attention (Zelazo et al., 2013). In other words, children need to inhibit an automatic response tendency to achieve a goal by using selective attention (NCES, 2019).

For example, children were asked to focus their attention on a stimulus, usually placed in the center of the screen, while ignoring the stimuli presented on the left or right of the central stimulus. They would have to focus on the central image, sometimes a fish or an arrow, while the "flankers" were distractor arrows pointing toward the same direction of the central arrow, also known as "congruent" (NCES, 2019). If the arrow was pointing toward the opposite direction of the central arrow, it would be "incongruent". Following these visual presentations, they responded by pressing a button that indicated the direction of the central arrow. The overall computed score took into consideration both the accuracy and reaction time, a different approach than the original Flanker test which only considered accuracy score. Finally, the computerized version of the Toolbox Flanker test reported an ICC of .92 as well (*ICC* = .92) (Zelazo et al., 2013).

Working Memory. Children's working memory performance in the ECLS-K:2011 dataset is assessed using the Numbers Reversed subtest of the WJIII Tests of Cognitive Abilities

(Woodcock, McGrew & Mather, 2001) or sometimes known as the Backward Digit Span Test. In this task, children were asked to verbally repeat a presented sequence of numbers in the reverse order. For instance, if the researcher says "3…9," the child will have to say "9…3," as a response, if they were able to recall it.

Additionally, the task progressively became more challenging as the digit strings became longer with each correct trial. Thus, children's ability to recall a string of digits would also have to match the increasing difficulty level in each trial. However, if the child failed to repeat the numbers in reverse order three times in a row, the task would end. Then, the score was computed based on the number of correct trials as a measure of working memory ability. The reported internal reliability for the Numbers Reversed Test was .90 (α = .90) (Arrington, Nikki, Kulesz, Francis, Fletcher, & Barnes, 2014).

Home Cognitive Stimulation. The home cognitive stimulation measure for the fifth-grade round was part of the Spring 2016 Parent Interview within the Home Environment, Activities, and Cognitive Section (HEQ). The interview contained questions about the frequency of children's wide range of activities with family members in a week, a month, and the past year, such as playing puzzles or games, reading, playing sports, going to the library or museum, interacting with computer or electronic device, and getting tutored in school subjects. For instance, "*In an average week, how often does child use a home computer or other electronic device to play with programs that teach him/her something, like math or reading skills? Would you say… (1) Never, (2) Once or twice a week, (3) 3 to 6 times a week, or (4) Every day?*" There are also questions which include binary responses such as *"In the past month, that is, since {MONTH}{DAY}, has anyone in your family done the following things with child – visited a zoo,* *aquarium, or petting farm? (1) Yes (2) No"*. The questionnaire had a total of 40 questions related to such home cognitive stimulation and activities.

Analytical Plan

All analyses for the current study were performed in statistical software R and R Studio, as well as an R package (*lavaan*) (Rosseel, 2012) that was specifically developed for latent variable modeling. The current study utilized Structural Equation Modeling (SEM) technique and framework to answer all research questions. Thus, all relevant assumptions were tested before performing analyses such as the normality for endogenous variables, outliers, influential observations, and missing data patterns.

Research Question 1: Does home cognitive stimulation contain 3 latent factors: "academic", "physical", and "arts"?

To answer this question, confirmatory factor analysis (CFA) was conducted to establish the latent factors for home cognitive stimulation. It was hypothesized that home cognitive stimulation consisted of three latent factors, namely the "academic", "physical", and "arts" factors. These latent factors were assessed using CFA for adequate model fit. Model fit, which assesses whether our model fits the observed data, of the measurement model is normally assessed using the chi-square test. However, a statistically significant chi-square would be expected for the ECLS-K:2011 dataset regardless of the fit as it had a large sample size. Thus, other model fit indices such as the comparative fit index (CFI) with cut-off criterion ≥ 0.90 indicating an acceptable fit (CFI; Bentler, 1990), the Tucker Lewis index (TLI) with cutoff value $> .90$ indicating an acceptable fit (TLI; Bentler & Bonett, 1980; Tucker & Lewis, 1973), the standardized root mean square error of approximation (SRMR) with values less than .05 (Byrne & Bentler, 1998) or as high as .08 are acceptable fit according to Hu and Bentler (1999), and the root mean square error of approximation (RMSEA) with cutoff values between .05 to .08 (RMSEA; Steiger, 1990) were examined. Additionally, items with considerably low factor loadings would be deleted. Any modifications made to the measurement model would have theoretical justification.

Due to the fact that the current model contained a mixture of categorical and continuous variables, the diagonally weighted least squares (DWLS) estimator was used to obtain more accurate parameter estimates. According to Mîndrila (2010) and Li (2021), DWLS is robust to non-normality and yields more accurate factor loadings when a mixture of continuous and categorical variables is present in the model compared to robust maximum likelihood (MLR). Additionally, robust standard errors of parameter estimates obtained by DWLS are said to be reliable once sample size exceeds n = 500 or 1000 (Li, 2021).

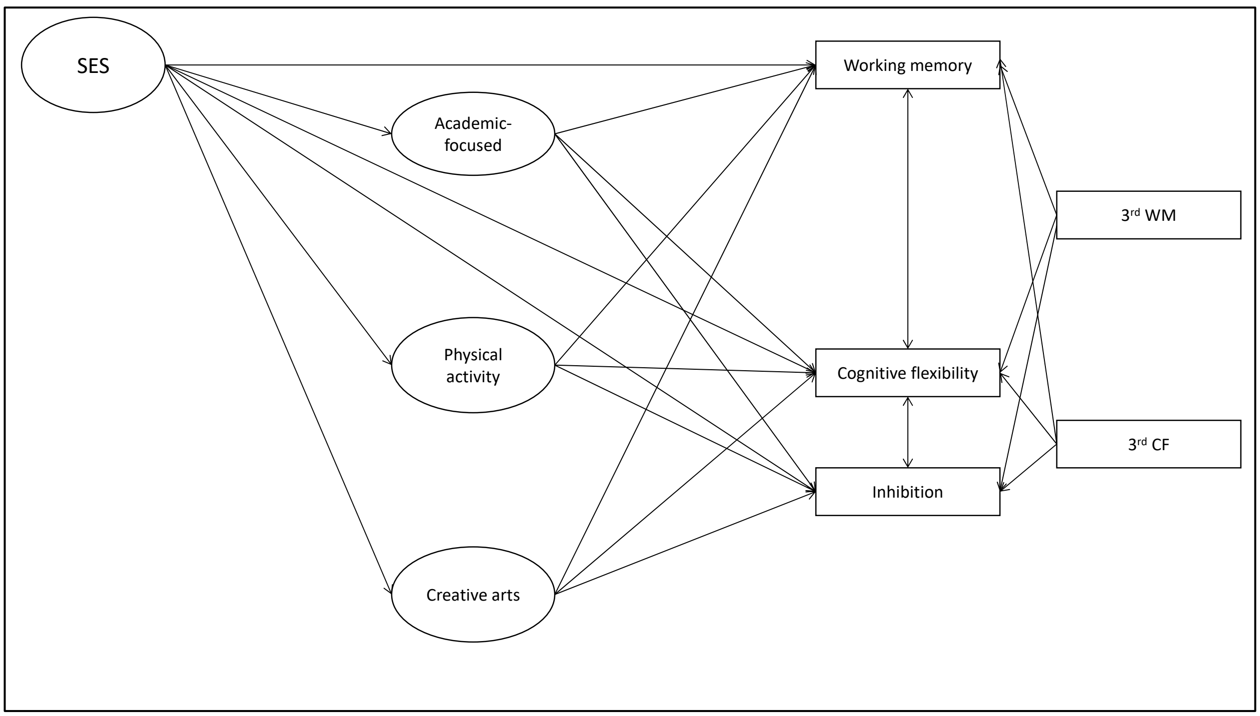
Research Question 2: Are the relationships between SES and EF components mediated by home cognitive stimulation?

Then, given a well-fitting measurement model, the structural model was assessed to observe the effects of different aspects of home cognitive stimulation on EF skills and the mediated effects of SES on EF through home cognitive stimulation. 3rd grade working memory and cognitive flexibility performance would be included as covariates to account for the influence of prior EF skills. A full mediation effect would be achieved when path c’ (SES-EF skills) loses significance while path a (SES-home cognitive stimulation) and path b (home cognitive stimulation-EF skills) are statistically significant. In contrast, a partial mediation effect would be achieved when path c’ decreases in magnitude after the mediator variable (home cognitive stimulation) was inserted but still statistically significant, while both paths a and b also remained statistically significant.

Therefore, based on the literature, we hypothesized that the relationship between SES and EF components would be mediated by all three latent factors of home cognitive stimulation. Again, model fit indices such as comparative fit index (CFI), Tucker Lewis index (TLI), the standardized root mean square error of approximation (SRMR), and the root mean square error of approximation (RMSEA) were examined.

Figure 1

The Proposed Conceptual Model



Research Question 3: Are relationships in the structural model proposed in 2) different or equal across biological sex groups?

There were two parts in attempting to answer this research question: measurement and structural parts. A multiple group analysis or a multi-group SEM would be conducted to detect differences in groups (1 = male, 0 = female) within the structural model proposed in 2). Therefore, before examining whether group differences existed in the structural model, a certain level of measurement invariance would have to be established. To be more specific, configural, metric (weak invariance), and scalar invariance (strong invariance) would be examined before proceeding with structural invariance testing. Measurement invariance testing is often required to establish that the instrument measures the same trait, in the same way, across different groups (Kline, 2016, p. 396).

Upon testing measurement invariance, it is recommended to estimate models for each group separately and observe the model fit indices (Kline, 2016, p. 400). Then, if all fit indices were within reasonable conventional cutoff ranges, both groups would be estimated in one model with all freely estimated parameters (unconstrained), and this model would serve as the baseline model. Next, factor loadings would be equally constrained across both groups to observe whether metric invariance could be achieved. Finally, factor loadings and intercepts would be equally constrained across groups to observe whether scalar invariance was present. A chi-square difference test would be conducted to compare the nested models and significant chi-square test would indicate that the more complex model (unconstrained) was supported whereas a non-significant chi-square test would indicate that a more parsimonious model (constrained) was supported. However, since we were only concerned with examining the structural relationships across groups and not comparing latent means, the minimum level of measurement invariance needed would only be metric invariance (Steenkamp & Baumgartner, 1998). Thus, once metric invariance was established, it would be appropriate to proceed with structural invariance testing.

After establishing measurement invariance, parameters for each group would be specified in *lavaan* to obtain regression slopes for male and female separately while all parameters were unconstrained, and model fit indices would be observed. Next, regression slopes between the two groups would be constrained to detect group differences within the structural model. A significant chi-square difference test would indicate that the more complex (unconstrained) model was supported while a non-significant result would indicate that the more parsimonious (constrained) model was supported.

CHAPTER IV. RESULTS

Preliminary Analyses

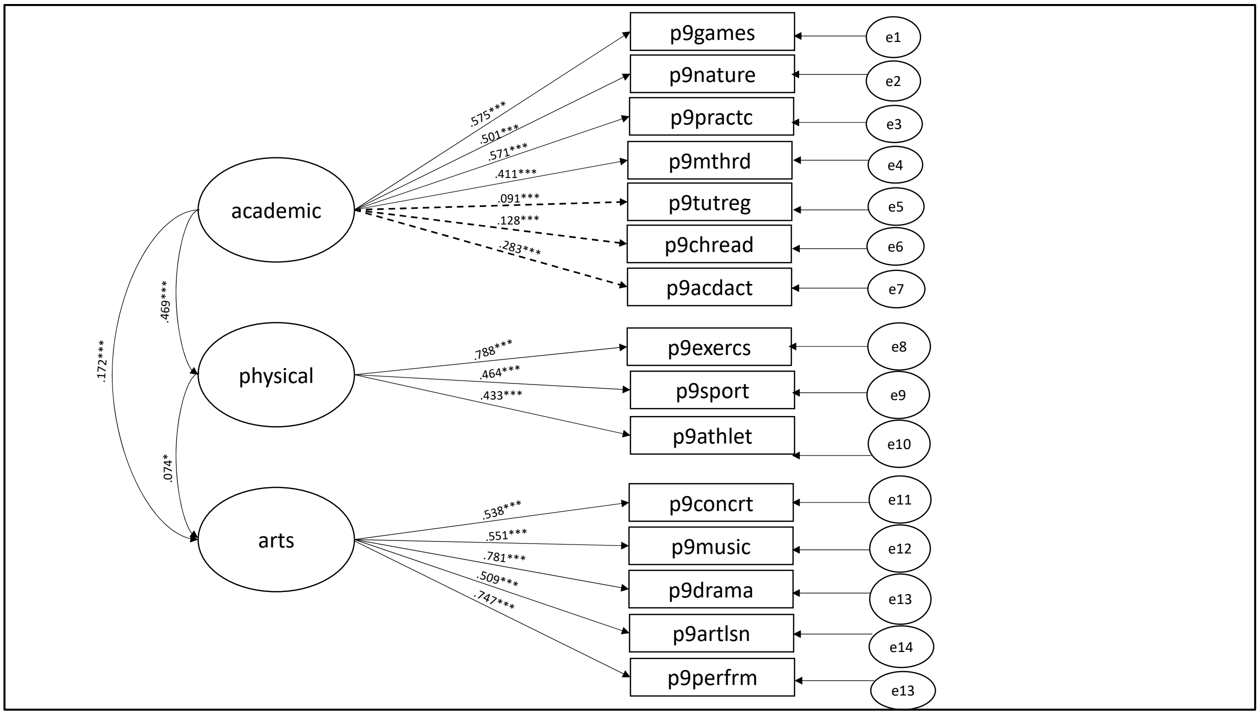
A series of preliminary analyses were performed to examine the distribution of the current study's variables. Assumptions of normality were evaluated using the multivariate Shapiro-Wilk test and all study variables did not follow a normal distribution ($p < .001$). Missing data patterns were examined using the Multivariate Imputation by Chained Equation (MICE) package in R (Van Buuren & Groothuis-Oudshoorn, 2011). Little MCAR's test (Little, 1988) within the MICE package was performed and results revealed that the data was not missing completely at random ($p < .05$). Missingness patterns within each variable were also examined. We found that 4 variables had at least 29% missing values and 16 variables had more than 44% missing values with 47% missing values being the highest percentage. Following the results, listwise deletion was performed. The decision was made based on the fact that the data was not missing completely at random (MCAR) and there was a large percentage of missing data to the extent that multiple imputation could not be performed. Alternatively, full information maximum likelihood (FIML) could have been utilized as it performs equally as well as multiple imputation in handling missing data (Huang, 2023). However, a diagonally weighted least squares (DWLS) estimator was used within an R package, *lavaan* (Rosseel, 2012) to estimate parameters for categorical variables in our dataset and FIML was not supported in DWLS, at least not currently. Thus, the only option for utilizing DWLS was listwise deletion and this yielded 4,613 complete observations in the current dataset.

<u>Research Question 1</u>: What is the measurement structure for home cognitive stimulation in the ECLS-K:2011?

The ECLS-K:2011 home cognitive stimulation measure consisted of parent interview questions that did not have clear groupings of constructs. Therefore, based on the inspection of the interview questions, we assumed that there were three latent constructs: academic-focused activities, physical activity, and arts. Confirmatory factor analysis (CFA) with diagonally weighted least squares (DWLS) estimator was performed to test the three-factor model of the home cognitive stimulation. Thus, three items from the academic construct were dropped as the factor loadings were considerably low: regular tutoring (.09), frequency of reading outside of school (.13), and participation in academic activities like science, computers, math lab, or taking a class to learn a language other than English (.28). Therefore, consistent with the assumption, the three-factor model represented an acceptable fit: $N = 4613$, $\chi 2\ (51) = 496.65$, $p < .001$, CFI = .91, TLI = .88, RMSEA = .04, SRMR = .06. All standardized factor loadings were significant and varied from .36 to .93.

Figure 2

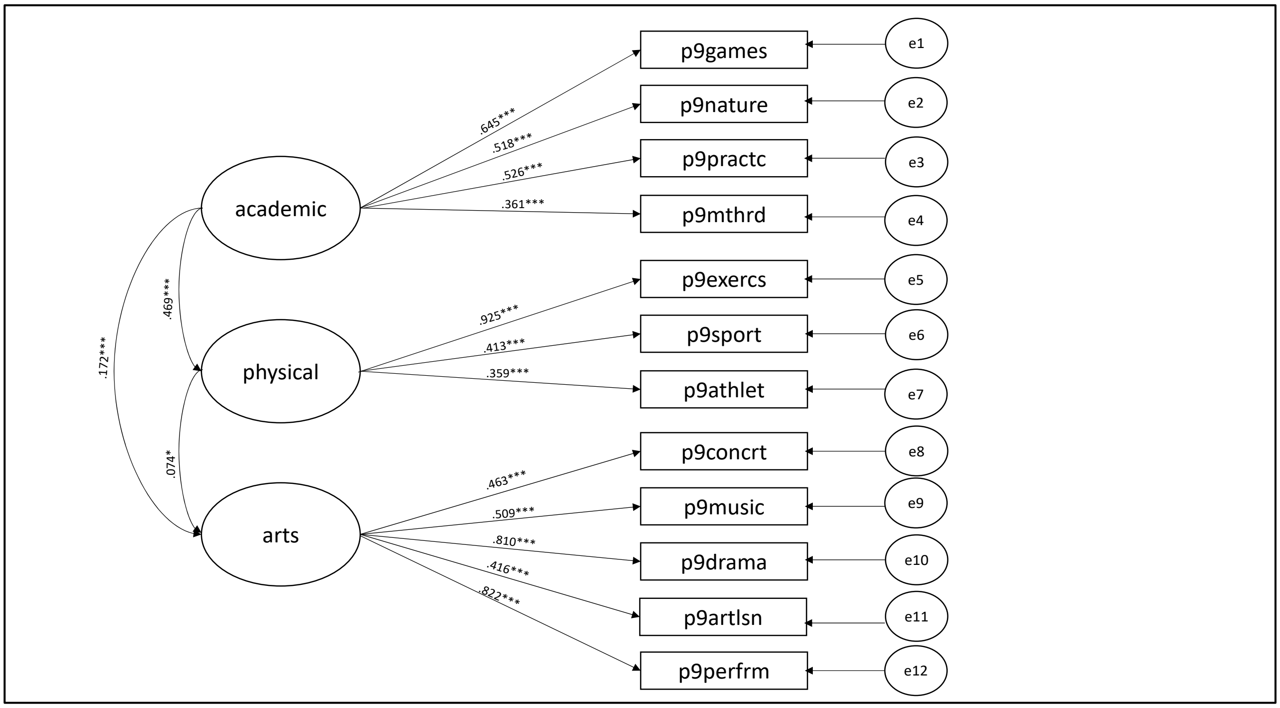
Initial Confirmatory Factor Analysis (CFA) model of Home Cognitive Stimulation



Note: Dashed lines represent lowest factor loadings to be dropped from the model.

Figure 3

Final Confirmatory Factor Analysis (CFA) model of Home Cognitive Stimulation



Research Question 2: Are the relationships between SES and EF components mediated by home cognitive stimulation?

Structural equation modeling (SEM) was used to examine the hypothesized associations between SES and each component of EF via home cognitive stimulation. Upon achieving an acceptable model fit in the measurement model, we conducted mediation analyses in the structural portion. The structural model is illustrated in Figure 4. The overall model represented a decent fit: N = 4613, $\chi 2$ (114) = 1723.82, p < .001, CFI = .91, TLI = .92, RMSEA = .06, SRMR = .08. Further, direct and indirect paths were included in the structural model to test the effects of SES on EF components via home cognitive stimulation that contained three latent factors. Additionally, third grade scores of the Numbers Reversed task (WM) and the Dimensional Change Card Sort task (CF) were statistically controlled in the model to account for any influence of prior EF skills. Scores for the Flanker test (IC) for third grade was not included as a control variable as data on inhibitory control was not collected in third grade. The appropriate weight variable (w9c29p_9a0) and estimator (DWLS) were applied to the structural model in order to obtain more accurate parameter estimates.

Direct Effects

In terms of the effects of SES on EF components, results in the model revealed that, while controlling for 3rd grade working memory and cognitive flexibility, there were significant direct effects between SES and working memory (β = .09, p < .001), and SES and inhibitory control (β = .07, p < .001). For SES effects on home cognitive stimulation activities, we observed significant direct effects between SES and academic-focused activities (β = -.03, p < .001), SES and physical activity (β = .33, p < .001), and SES and arts (β = .35, p < .001). In terms of the effects of home cognitive stimulation on EF components, significant direct effects were also present between academic-focused activities and working memory (β = -.03, p < .001), academic-focused activities and cognitive flexibility (β = -.49, p < .001), academic-focused activities and inhibitory control (β = -.03, p < .001), and arts and cognitive flexibility (β = .06, p < .001). Non-significant direct effects were observed between physical activity and working memory (β = .02, p > .05), arts and working memory (β = .02, p > .05), physical activity and cognitive flexibility (β = .02, p > .05), physical activity and inhibitory control (β = .01, p > .05), SES and cognitive flexibility (β = .01, p > .05), and arts and inhibitory control (β = .01, p > .05).

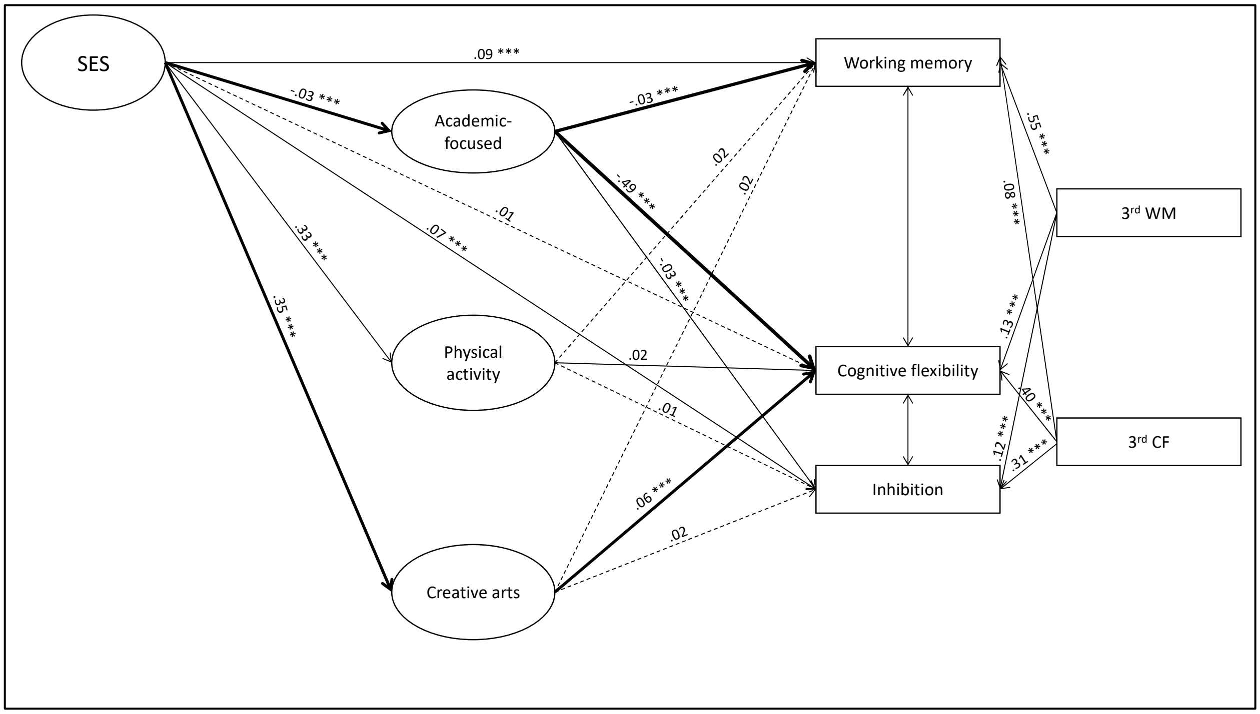
Unexpectedly, the relationships between academic-focused activities and all other variables were found to be the opposite of what we assumed. According to Cheung and Lau (2007), the inconsistencies in the regression coefficients could result from the suppressor effect; therefore, we, as suggested by the authors, examined multicollinearity issues and model fit. The variance inflation factor (VIF) test results revealed variables were in fact correlated within accepted limits, and the R package *lavaan* did not present any warnings suggesting variables were highly correlated with one another.

Indirect Effects

For all indirect effects, the presented slopes were the products of two paths (e.g., a x b). Results revealed that while effects were small, there were significant indirect effects between SES and working memory via academic-focused activities (β = .001, p < .05). This suggests that differences in working memory could partially be explained by academic-focused activities. Additionally, academic-focused activities (β = .01, p < .05) and arts (β = .02, p < .01) significantly mediated the relationship between SES and cognitive flexibility. This potentially suggests that both academic-focused activities and arts fully mediated the relationships between SES and cognitive flexibility. However, both physical activities (β = .01, p > .05) and arts (β = .01, p > .05) were not found to mediate the relationships between SES and working memory. In addition, physical activity did not mediate the relationship between SES and cognitive flexibility (β = .01, p > .05). In terms of inhibitory control, no significant indirect effects were observed through academic-focused activities (β = .00, p > .05), physical activities (β = .00, p > .05), and arts (β = -.00, p > .05). This suggests that the association between SES and inhibitory control is independent of its association with all three latent constructs of home cognitive stimulation (β = .07, p < .01).

Figure 4

Regression Coefficients of Direct and Indirect Paths



Note: Solid lines represent significant direct effects. Dashed lines represent non-significant direct effects. Bold lines represent significant indirect effects.
*** $p < .001$

<u>Research Question 3:</u> Are relationships in the structural model proposed in 2) different or equal across biological sex groups?

As an exploratory analysis, we investigated the presence of biological sex differences within the structural model proposed in 2) by using a multiple group analysis or multi-group SEM. Multi-group SEM is one method that can be used to assess whether group moderates the relationships in our model, also known as a way of assessing an interaction in the SEM framework (Kline, 2016).

First, testing of measurement invariance was conducted to establish a certain level of invariance (metric/weak or scalar/strong) before examining differences in biological sex.

Therefore, models and fit indices for each biological sex group (1 = male, 0 = female) were estimated separately to serve as baseline models prior to conducting multi-group analysis. Model fit indices for the male group were within the acceptable cutoff ranges: N = 2304, $\chi 2$ (51) = 216.88, $p < .001$, CFI = .92, TLI = .89, RMSEA = .04, SRMR = .07. Similarly, model fit indices for the female group were also within the acceptable conventional cutoff ranges: N = 2309, $\chi 2$ (51) = 297.37, $p < .001$, CFI = .89, TLI = .86, RMSEA = .05, SRMR = .08. Following the initial step, the combined and unconstrained model was estimated to establish configural invariance: N = 4613, $\chi 2$ (102) = 514.24, $p < .001$, CFI = .90, TLI = .88, RMSEA = .04, SRMR = .07. Then, factor loadings were equally constrained across groups to establish metric or weak invariance (N = 4613, $\chi 2$ (111) = 521.38, $p < .001$, CFI = .90, TLI = .89, RMSEA = .04, SRMR = .07. Finally, factor loadings and intercepts were equally constrained across both groups to establish scalar or strong invariance: (N = 4613, $\chi 2$ (118) = 572.10, $p < .001$, CFI = .89, TLI = .88, RMSEA = .04, SRMR = .07. Then, model comparison using a chi-square difference test was conducted to compare the nested models. A non-significant effect was present when comparing between the unconstrained model with the factor loadings constrained model ($\chi 2$ = 521.38, $p > .05$), suggesting that the more parsimonious model, or the constrained model was preferred. However, chi-square difference test between the weak/metric constrained model with the strong/scalar constrained model yielded significant results ($\chi 2$ = 572.10, $p < .001$), which suggests that the more complex model (weak/metric constrained model) was supported.

Thus, we were able to establish configural and metric invariance but not scalar invariance. However, since our goal was not to compare the latent means between groups, establishing scalar invariance was not necessary (Steenkamp & Baumgartner, 1998). Achieving metric invariance suggests that constructs of the measures were operationalized the same way across male and female.

To assess whether relationships among factors in the structural model were different or equal across biological sex groups, every path was specified separately for male and female in *lavaan* so that regression slopes for both groups could be obtained. Specifically, separate slopes for male and female were estimated in one model. This served as the baseline model or the unconstrained model, since all parameters were freely estimated: N = 4613, $\chi 2$ (222) = 1558.92, p < .001, CFI = .93, TLI = .94, RMSEA = .05, SRMR = .07. Then, regression slopes were constrained to be equal across male and female as the next step (N = 4613, $\chi 2$ (243) = 1906.46, p < .001, CFI = .92, TLI = .93, RMSEA = .05, SRMR = .08). A chi-square difference test was conducted between the unconstrained and constrained model and results were significant ($\chi 2$(243) = 1906.50, p < .001)), showing that the unconstrained model was supported. This also suggests that there were differences in biological sex in terms of their regression coefficients in the proposed structural model.

As the next step, we were interested in whether the mediated pathways in model 2) were moderated by biological sex. Paths were sequentially constrained and relaxed to find which slopes were significantly different between males and females. We found evidence that the mediated pathways in SES-academic-cognitive flexibility were moderated by biological sex after comparing the nested models ($\chi 2$(224) = 1653.80, p < .001)). Specifically, relationship between academic-focused activities and cognitive flexibility was moderated by biological sex ($\chi 2$(223) = 1653.80, p < .001)), such that slope for female was significant and steeper (β = -.42, p < .001) compared to slope for male (β = -.19, p < .001). We also found that biological sex moderated the relationship between academic-focused activities and inhibitory control ($\chi 2$(223) = 1665.40, p <

.001)), with female's effect stronger (β = -.44, $p < .001$) than male (β = -.20, $p < .001$). Further, as a follow up analysis, we were also interested in investigating whether males and females had existing group differences in terms of their inhibitory skills that might contribute to the significant interaction effects above. Our independent sample t-test results revealed that there were significant differences between males and females in terms of their inhibitory control skills [t(4574.4) = 4.84, $p < .001$, d = .14)].

Thus, the final model was presented as the model with paths from academic to cognitive flexibility and academic to inhibition to vary across groups while other paths equally constrained across groups: (N = 4613, $\chi 2$ (228) = 572.10, $p < .001$, CFI = .92, TLI = .93, RMSEA = .05, SRMR = .08).

Figure 5

Moderated Effect of Biological Sex on Academic-CF path

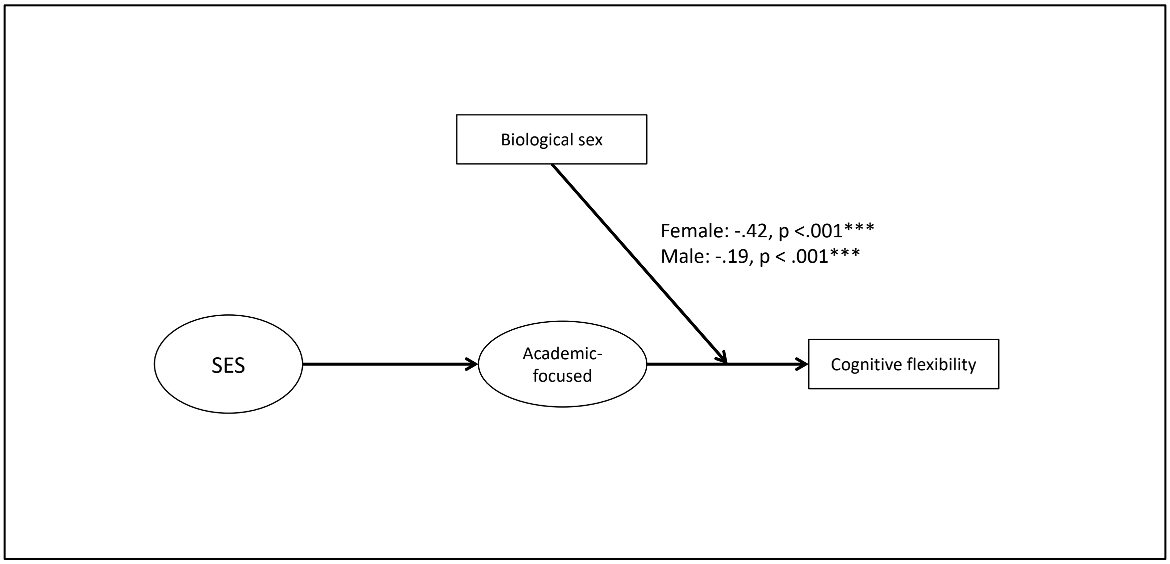
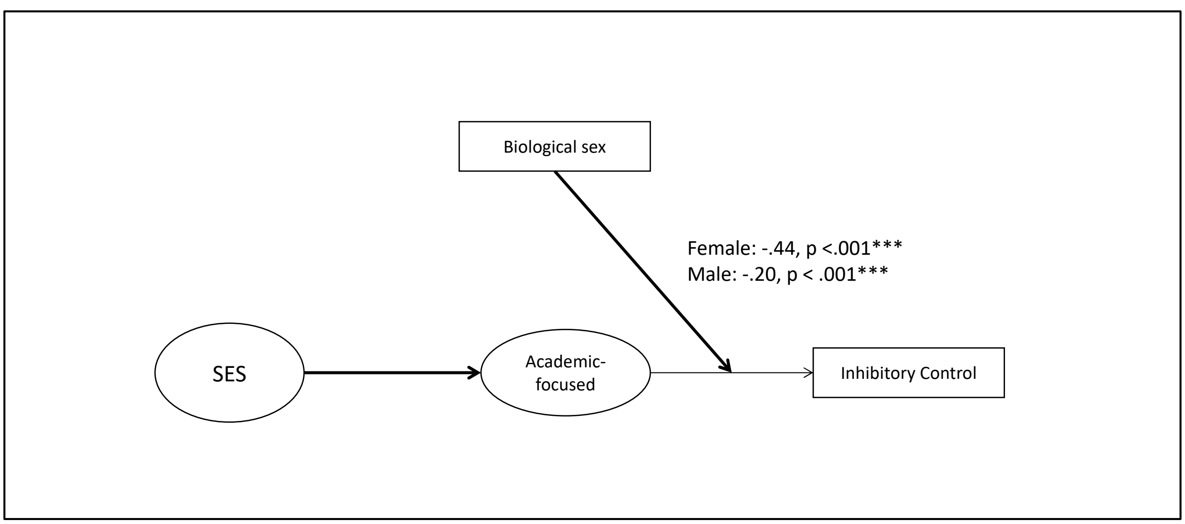


Figure 6

Moderated Effect of Biological Sex on Academic-IC path



CHAPTER V. DISCUSSION

The purpose of the current study was to explore the role of different aspects of home cognitive stimulation as a potential mechanism that explains the relationship between SES and distinct EF skills – working memory, cognitive flexibility, and inhibitory control. In addition, we also sought to establish the measurement model for home cognitive stimulation as well as exploring differences in biological sex in terms of the proposed structural model. We hypothesized that home cognitive stimulation in the ECLS-K:2011 was made up of three latent factors, namely academic-focused activities, physical activity, and arts. Based on the literature, we also hypothesized that all three latent factors of home cognitive stimulation mediated the relationships between SES and unique aspects of executive function. Finally, as an exploratory analysis, we hypothesized that biological sex moderated the mediated relationship between SES and EF components through home cognitive stimulation.

Research Question 1: What is the factor structure for home cognitive stimulation in the ECLS-K:2011?

Consistent with our hypothesis, home cognitive stimulation was a three-factor model: academic-focused activities, physical activity, and arts. Due to unclear groupings of the home cognitive stimulation measure in the parent interview, we initially assumed that regular tutoring, participation in academic activities like science, computers, math lab, or taking a class to learn a language other than English, and the frequency of reading outside of school in a week would yield higher factor loadings. However, these three items were dropped from the academic latent factor due to having significantly low factor loadings. Based on our knowledge, these results could have occurred because of how the items were measured in the parent interview, such as how they were phrased. Nevertheless, the other hypothesized items loaded as we expected, and the three-factor model was confirmed.

Prior studies utilizing the home cognitive stimulation measure in the ECLS-K:2011 have either used a composite score to index home activities by adding up and averaging the frequency scores of academic focused home activities (e.g., Padilla & Ryan, 2020), using the items individually (e.g., Kim, 2021) or combined items into latent factors (e.g., Baker & Kuhn, 2017). However, in determining the effects of maternal depression on EF skills and externalizing behavior problems, Baker and Kuhn (2017) only used five items underlying the home learning activities: reading books, singing songs, playing games and puzzles, talks about nature and science, and building with toys. Activities related to physical activity, sports, and arts were not included in the model. Therefore, while past studies have utilized the home cognitive stimulation measure in ECLS-K:2011 by mainly focusing on the academic home activities, the current findings contribute to the literature by utilizing more aspects of home activities such as physical activity and arts which we found to be separate latent constructs from the academic home focused activities.

Research Question 2: Are the relationships between SES and EF components mediated by home cognitive stimulation?

In attempting to answer this research question, we examined the direct and indirect relationships between SES and working memory, cognitive flexibility, and inhibitory control through three latent mediators: academic-focused activities, physical activity, and arts. As hypothesized, we found that academic-focused home activities fully mediated the relationship between SES and cognitive flexibility. We also found that academic-focused home activities partially mediated the relationship between SES and working memory, and this was consistent with findings from Lipina et al. (2013) who found that literacy activities mediated the relationship between SES and working memory and Rosen et al. (2019) who also discovered that home cognitive stimulation in general mediated the relationship between SES and working memory, cognitive flexibility, and inhibition. The difference between the two past findings is that Rosen et al. (2019) combined home cognitive stimulation activities into a single latent factor while Lipina et al. (2013) organized home cognitive stimulation activities by categories such as literacy activities and computer resources. The present study's home activity categories were separated into academic-focused, physical activity focused, and arts focused which allowed us to observe unique effects of these different activities on EF skills.

Hence, the present findings contribute to the existing literature in two ways: by separating home activities into unique domains and by including home activities that are not only focused on the academics as we were able to get more nuanced relationships between the domains and EF skills. For example, we found that academic-focused home activities mediated the relationships between SES with working memory and cognitive flexibility while other types of home activities did not. This may inform educators and researchers on which types of activities are useful in improving students' EF skills and which are not.

However, despite having found significant mediated effects, unexpected results from the current study indicated that the directionality of relationship between SES to academic-focused activities and from academic-focused activities to both working memory and cognitive flexibility was negative. In other words, it could be interpreted that higher SES children were less likely to participate in academic-focused home activities such as practicing reading, writing, and math, and having conversations about science and nature. Similarly, children who participated in more frequent academic-focused activities at home were more likely to have lower working memory and cognitive flexibility scores. Unquestionably, this was an unexpected finding such that no other studies in the past have found similar findings to ours regarding the directionality of these relationships. It was unclear if there were other underlying factors contributing to the current findings. We suspected that these occurrences could happen as a result of measurement error in the ECLS-K:2011 home cognitive stimulation. It is possible that these results were due to how the items in the academic latent factor were measured such as the validity of the questions or the inconsistencies in the ECLS-K:2011 home cognitive stimulation response scales. For instance, some response scales were presented as frequencies and some as binary responses.

One other possible reason could be the suppressor effect, which is when the relationships between variables in a model change significance, magnitude, or even directionality due to the presence of other variables (Cheung & Lau, 2007). According to Cheung and Lau (2007), this could be caused by an issue of multicollinearity or poor model fit. However, these issues were already addressed and were deemed unproblematic. It is also possible that the absence of certain variables was affecting the directionality of relationships in the model.

Additionally, we also believed that natural ability or aptitude such as IQ could be playing a role in explaining the unexpected relationships presented above, especially among 5^{th} grade children. To illustrate, children with higher IQ may not need additional home stimulation while children with lower IQ may need that additional support outside of school. Therefore, the occurrence of this phenomenon where children in low SES are participating in higher academic-focused activities at home and performing lower on EF skills could potentially be attributed to this reason. Similar to Harter's (2012) idea about the developmental complexity of self-system in 5^{th} grade students, gains in IQ could still developmentally change during middle childhood and potentially become higher in this age group due to various factors like educational experiences and formal schooling (e.g., Ramsden, Richardson, Josse, Thomas, Ellis, Shakeshaft, Seghier, & Price, 2011), hence explaining the differences in cognitive stimulating activities at home between lower SES and higher SES students.

Thus, although we found that academic-focused activities did significantly mediate the relationships between SES with working memory and cognitive flexibility, further discussion regarding the potential role of natural ability or IQ and how it relates to SES is beyond the scope of the current study and should be accounted for in similar future studies. Therefore, given the circumstances, it is advisable to exercise caution in interpreting these results at this moment.

Finally, we found evidence that home focused arts mediated the relationship between SES and cognitive flexibility. This was consistent with past discoveries about the positive association of arts-focused activities on children's EF skills. For example, Shen, Lin, Liu, Fang, and Liu (2019) found evidence that musical training in children in China had a sustained positive effect on cognitive flexibility after 12 weeks. Researchers also found other arts-focused activities such as creative drama activities, creative movement, & playing musical instruments to have a positive effect on EF skills (e.g., Ciftci & Aykaç, 2020; Park et al., 2015). Given these past findings, few studies have explored and reported significant mediated effects of SES on EF skills through arts-focused activities. Therefore, the present findings filled the literature gap as we found evidence for the importance of varying home cognitive activities in explaining the relationship between SES and children's EF skills. In other words, home activities that are not only academic-focused also seemed to play a role in children's cognitive development.

Interestingly, current findings revealed that while academic-focused activities mediated the relationship between SES with working memory and cognitive flexibility, we did not find evidence that it mediated the relationship between SES and inhibitory control. Our results also indicated that physical activity did not mediate the relationships between SES and any EF aspects while arts did not mediate the relationships between SES with working memory and inhibition. Undeniably, these findings violated our initial assumption. It is possible that specific activities in the home cognitive stimulation did not contribute to gains in specific aspects of EF skills, while others did. For example, while there has been evidence of improvement in cognitive flexibility skills through arts-focused activities like drama and musical training (e.g., Ciftci & Aykaç, 2020; Shen et al., 2019), other arts activities such as creative coloring tasks did not significantly improve cognitive flexibility (e.g, Crenshaw & Miller, 2022). According to Lipina et al. (2013) and Hackman et al. (2010), differences in mediation effects in the current study are consistent with the idea that specific environmental factors could be explaining some socioeconomic effects but not others, and that specific cognitive factors could be explaining specific aspects of EF skills. It is possible that the activities present in the ECLS-K:2011 home cognitive stimulation measure were not the specific activities that would tap into a child's EF skills. For instance, findings from Schmidt et al. (2015) revealed that physical activities that are cognitively engaging such as sports-based team games that require complex eye-hand coordination are better for improving EF skills, particularly cognitive flexibility, compared to more aerobic-oriented physical activities such as running a marathon. In the ECLS-K:2011, physical activities only comprised of general physical activity and attending sports and athletic events. These results shed light on the importance of acknowledging specific cognitively engaging activities that may or may not affect children's cognitive development. This may suggest that appropriate item-level analyses such as the Bradley Terry modeling could be beneficial in understanding specific effects of activities on EF skills.

Nevertheless, findings of the present study conform to the neuroplasticity idea which suggests that our brain is plastic and is able to change according to its surroundings (James, 1890; Zelazo & Carlson, 2020). According to Zelazo & Carlson (2020), experience and cognitively enriching environment contributes to changes in cortical networks development. Hence, the fact that we found evidence that some aspects of home cognitive stimulation mediated the relationship between SES and EF skills indicates that enriching environment may play an important role in lessening the impact of SES on EF skills.

Research Question 3: Are relationships in the structural model proposed in 2) different or equal across biological sex groups?

To answer our final research question, which was also intended to be more exploratory, we began with the assumption that differences in biological sex existed in the structural model. In other words, relationships in the structural model were moderated by biological sex. As hypothesized, we found evidence of moderated effects of biological sex in our model. In the mediated pathways between SES to cognitive flexibility and SES to inhibitory control via academic-focused activities, we found differences of biological sex. Specifically, we discovered that biological sex moderated the relationship between academic-focused activities and cognitive flexibility and between academic-focused activities and inhibitory control. As academic activities at home increased, cognitive flexibility performance tends to decrease significantly for males and females, with females having a stronger effect. Similarly, as academic-focused home activities increased, inhibitory control performance tends to decrease for both males and females, with females having a stronger effect. To our knowledge, no past studies have looked at the moderated effect of biological sex on the mediation between SES and EF skills through home cognitive stimulation.

One possible explanation of the current findings could be that male and female children at this age have developed a more complex understanding about themselves, and a clearer understanding of their unique qualities and abilities (Harter, 2012). This may then influence children's engagement of activities outside of school. Additionally, our results also showed that there were already group differences between males and females in terms of their inhibitory control skills which may contribute to the significant interaction effects.

Hence, these findings would be helpful for future studies to further investigate why and how differences in biological sex occurred in these relationships, and whether those differences explain Harter's (2012) notion of self-system.

Limitation

Like any other studies, the present study has its limitations. First, the study did not include race and ethnicity as a potential factor that influences the mediated relationship between SES and aspects of EF skills through home cognitive stimulation. That is, differences in home environment, more specifically, what activities are occurring at home could have been different for different ethnicities and cultures. For instance, Kim (2021), who used the ECLS-K:2011 dataset, explored the home educational contexts between Asian American children and White, Black, and Hispanic children and discovered that Asian American families were less likely to have educational materials and activities at home compared to White, Black, and Hispanic families. Instead, they were more likely to be exposed to educational and family activities outside the home (Kim, 2021). In our example, Black student sample shifted from 13% to 6% after listwise deletion (see Table 1). Compared to other groups, this was the largest shift and could potentially contribute to the unexpected results from the present study. Thus, this could be an important insight for future studies in understanding the contexts of SES and home environment on cognitive abilities like EF skills.

Second, the current study did not explore the effects of the proposed mediated relationships on children in different age and grade groups in the ECLS-K:2011. Initially, 5th grade students were chosen as population of interest to shed light on the effects of SES on EF skills in children who were not in 1st or 2nd grade, as past researchers who have used the same dataset were almost often interested in studying school readiness. However, we realize that looking at growth patterns could inform similar future studies on the sustained effects of SES and home environment on different EF skills.

Third, as an additional effort to explain the moderated effect of biological sex on academic-focused activities and inhibitory control skills, we discovered that there were in fact significant group differences in inhibitory control skills between males and females, suggesting that it may play a role in explaining the significant interaction effects. In other words, due to the fact there were already group differences of inhibitory control skills, the significant moderation effect observed of biological sex observed in this relationship may be biased.

Finally, although the ECLS-K:2011 afforded the opportunity to examine the home contexts of 5th grade students in a nationally representative sample, the measures were inconsistent relative to how the responses were presented to respondents. For instance, some activities were presented as frequencies of involvement, while others as merely “yes” or “no”. The inconsistencies of response scale could have influenced the current results and it might have contributed to the lack of diversity in types of home activities utilized by other scholars who have used the same dataset. Future researchers should explore ways to appropriately integrate the home cognitive stimulation section in the ECLS-K:2011 to utilize the entirety of the measure.

Finally, we also think the current study would benefit from children-report of home cognitive stimulation in addition to the parent interview, as parent-report measures and child-report measures can sometimes be incongruent (e.g. Guastaferro, Osborne, Lai, Aubé, Guastaferro, & Whitaker, 2021; Trang & Yates, 2020).

Implication

The present study explored the role of home cognitive stimulation as a mechanism that explains the relationship between SES and EF skills. While many scholars have presented useful findings throughout the years and shown that students from low SES families tend to have lower academic outcomes in general (e.g., Arnold & Doctroff, 2003; Duncan, Yeung, Brooks-Gunn, & Smith, 1998; Lee & Burkam, 2002; von Stumm, 2017), we believed it will be beneficial for educational researchers to move away from the deficit perspective of low-income students and target modifiable factors instead.

To be more specific, the present study may inform educators on how SES may impact EF skills, which are necessary for learning. By investigating how SES may impact different aspects of home cognitive stimulation which then impact EF skills, it may also inform educators, researchers, and policymakers to develop suitable interventions that could remedy the effects of SES-related challenges on students' academic outcomes. For instance, providing resources to families so they may increase their participations in certain activities at home.

Hence, it is important for schools, educators, and researchers to modify their perceptions of SES as a deterministic factor that contributes to academic achievement. This is owing to the fact that there are numerous targetable modifiable factors to ameliorate the impacts of SES, which in our case, is home cognitive stimulation. This of course will require some level funding by important stakeholders in order to increase appropriate material resources for families and educators.

Conclusion

In conclusion, findings of the present study accentuate the overall importance of exploring potential mediators that may affect the relationship between SES and EF skills. In our example, we presented home cognitive stimulation as a mediator that explains this relationship as an effort to lessen the impacts of SES on neurocognitive development. Specifically, we found that academic-focused activities and creative arts explained, at least partially, the relationship between SES and different aspects of EF skills. It is also imperative to acknowledge the idea of neuroplasticity, allowing researchers, educators, parents, and policymakers to believe that cognitive abilities are not rigid throughout a child’s life. Hence, with the presented findings of our study and future studies that explore similar relationships, important stakeholders may then use this information to develop suitable interventions for students.

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Appendix

ECLS-K:2011 Spring 2016 Parent Interview

Section HEQ – Home Environment, Activities, and Cognitive

Now I'd like to talk with you about {CHILD}'s activities with family members. In a typical week, how often do you or any other family members do the following things with {CHILD}?

1) Play games or do puzzles with {CHILD}? (Academic)

PROBE: Would you say not at all, once or twice a week, 3-6 times a week, or every day?
HELP TEXT:
FAMILY MEMBER: A family member refers to any person who lives in the child's household and any relative of the child living outside the child's household.
Play games or do puzzles: Includes indoor "quiet" games like board games or puzzles, or more active indoor games like Ping-Pong.

1 = Not at all
2 = Once or twice a week
3 = 3 – 6 times a week
4 = Everyday
Refused
Don't know

2) Talk about nature and do science projects with {CHILD}? (Academic)

PROBE: Would you say not at all, once or twice a week, 3-6 times a week, or every day?
HELP TEXT:
Talk about nature or do science projects: Talking about nature could include answering any questions the child may have about trees, weather, etc. or watching a television program or video about nature together and then discussing it. Science projects include any type of project designed to show the child how the world works, such as understanding how plants grow, studying rocks, using flashlights to create shadows, or mixing paints to create different colors.

1 = Not at all
2 = Once or twice a week
3 = 3 – 6 times a week
4 = Everyday
Refused
Don't know

3) Play a sport or exercise together? (Physical activity)

PROBE: Would you say not at all, once or twice a week, 3-6 times a week, or every day?
HELP TEXT:

Play a sport or exercise together: This includes calisthenics (e.g., jumping jacks, sit-ups), riding bicycles, rollerblading, individual or team sports, games like hide-and-go-seek, or other outdoor activities where activity or exercise is involved. Do not include times when the child does the sport or activity by him or herself.

1 = Not at all
2 = Once or twice a week
3 = 3 – 6 times a week
4 = Everyday
Refused
Don't know

4) Practice reading, writing, or working with numbers? (Academic)

PROBE: Would you say not at all, once or twice a week, 3-6 times a week, or every day?
HELP TEXT:
Practice reading, writing, or working with numbers: This includes time family members spend on homework, reading a calendar, practicing in an exercise or workbook.

1 = Not at all
2 = Once or twice a week
3 = 3 – 6 times a week
4 = Everyday
Refused
Don't know

In the past month, that is, since {MONTH} {DAY}, has anyone in your family done the following things with {CHILD}?

5) Gone to a play, concert, or other live show? (Arts)

1 = Yes
2 = No
Refused
Don't know

6) Attended an athletic or sporting event in which {CHILD} was not a player? (Physical activity)

1 = Yes
2 = No
Refused
Don't know

7) In the past week, how often did {CHILD} read to him or herself or to others outside of school? (Academic – this item was dropped)

1 = Never
2 = Once or twice a week
3 = 3 – 6 times a week
4 = Everyday
Refused
Don't know

8) In an average week, how often does {CHILD} use a home computer or other electronic device to play with programs that teach {him/her} something, like math or reading skills? (Academic)

HELP TEXT:
Electronic device: By electronic device, we mean any type of computer, cell phone, smart phone, iPod, reading device (such as Kindle or Nook), or game system (including those such as Wii, XBox, DS, iTouch, and Playstation).

1 = Not at all
2 = Once or twice a week
3 = 3 – 6 times a week
4 = Everyday
Refused
Don't know

9) Is {CHILD} tutored on a regular basis, by someone other than you or a family member, in a specific subject, such as reading, math, science, or a foreign language? (Academic – this item was dropped)

1 = Yes
2 = No
Refused
Don't know

10) Outside of school hours in the past year, has {CHILD} participated in:
Academic activities, like science, computers, math lab, or taking a class to learn a language other than English? (Academic – this item was dropped)

HELP TEXT: Include academic activities during the school year that take place before or after the regular school day or on weekends. Academic activities may take place inside or outside the school, and may be sponsored by the school or someone else. Some examples of academic activities are creative writing; poetry; learning about other countries; learning to use robots; using a computer; building with Legos; working on math or science projects; learning a foreign

language; and being part of a team that competes in academic subjects or does creative problem solving activities.
Do not include tutoring; recreational programs, like scouts; music lessons, such as piano, instrumental music, or singing lessons; drama classes; art classes or lessons, such as painting, drawing, or sculpture; organized performing arts programs, such as children's choirs, dance programs, or theater performances; or religious activities or instruction.

1 = Yes
2 = No
Refused
Don’t know

11) Outside of school hours in the past year, has {CHILD} participated in:
organized athletic activities, like basketball, soccer, baseball, or gymnastics? (Physical activity)

1 = Yes
2 = No
Refused
Don’t know

12) Outside of school hours in the past year, has {CHILD} participated in:
Music lessons, for example, piano, instrumental music, or singing lessons? (Arts)

1 = Yes
2 = No
Refused
Don’t know

13) Outside of school hours in the past year, has {CHILD} participated in:
Drama classes? (Arts)

1 = Yes
2 = No
Refused
Don’t know

14) Outside of school hours in the past year, has {CHILD} participated in:
Art classes or lessons, for example, painting, drawing, or sculpture? (Arts)

1 = Yes
2 = No
Refused
Don’t know

VITA

Afiah Fozi was born and raised in Kuala Lumpur, Malaysia, by loving parents, Mohd Fozi and Ruzimi Ibrahim. Her childhood was full of memory growing up alongside her chaotic yet affectionate three siblings. At the age of 19, she migrated to the United States in pursuit of higher education. Afiah graduated with her B.A. in Psychology at the University of Missouri in 2017. She then attained her M.A. in Educational Psychology at the same institution in 2020. She is currently a PhD candidate in Educational Psychology with collateral in Learning Technology. Her research focuses on the impact of SES on cognitive development through malleable and targetable interventions.