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Using Chess as an Intervention to Improve Executive Functioning Among Youth

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Walden University
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Abstract

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Anandita Oberoi

MA, University of Houston—Clear Lake, 2001

BA, Houston Baptist University, 1998

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Human and Social Services—General

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Abstract

Youth represent a vulnerable segment of the population and may have underdeveloped levels of executive functioning (EF), which is important in both daily life and is shown to have far-reaching effects. This research study aimed to decipher if lessons in the game of chess could be used as an efficacious intervention for accelerating EF development in youth. The three research questions focused on determining whether there was a difference in the chosen indices of EF before and after a 14-session chess intervention. The theoretical framework used for this study was Piaget's cognitive development theory. This quantitative, single group pretest–posttest design measured three indices of EF: decision making measured by Iowa's gambling task, working memory measured by the digit span backward task, and impulsivity measured by the Barratt Impulsiveness Scale—Brief. The 39 participants included youth (8 to 17 years old) in the beginner groups of chess training from chess academies across the United States. Results were analyzed using a paired-samples *t* test and indicated (a) a statistically significant positive difference in decision making after the chess intervention [$t(38) = 3.37$, $p = .002$], (b) a statistically significant positive difference in working memory after the chess intervention [$t(38) = 3.18$, $p = .003$], and (c) no statistically significant difference in impulsivity after the chess intervention [$t(38) = -1.62$, $p = .114$]. These results point to how chess may be used as a valuable tool to improve EF development in youth. This can significantly alter academic, health, and work-related outcomes for youth. It may impact social change by helping educators and social workers by providing them with an effective and easily accessible tool.

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Dedication

This research study is dedicated to my father, Balram Kohli, who always wanted to get a doctorate himself but was unable to due to life circumstances. To be fulfilling his dream through myself means a lot to me. I wish he were alive to see this day, but wherever he is in Heaven, I know this would be a special moment for him.

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Chapter 1: Introduction to the Study

This research study aims at deciphering if the game of chess may influence the development of executive functioning in youth. Youth may have suffered delays in their executive functioning development due to the external circumstances and life events encountered by them, such as the inconsistency of basic needs being met, exposure to crime and violence, and being entrenched in disorganized microsystems (Campos-Gil et al., 2020; Rosen et al., 2019). Youth represent one of the most vulnerable groups in society (Campos-Gil et al., 2020). Executive functions are defined as the cognitive and emotional capacities that are essential for goal-directed behavior and appropriate social conduct (Lemberger et al., 2015). These functions are malleable and begin to develop in early childhood and mature in the early 20s (Lemberger et al., 2015). Executive functions have a broad reach and serve as a predictor for various life outcomes such as academic achievement, socioeconomic status (SES), and physical health (Karbach & Unger, 2014). Given all these factors and their implications (Campos-Gil et al., 2020; Karbach & Unger, 2014; Lemberger et al., 2015; Rosen et al., 2019), one can see why this research study is needed. This study has the potential to provide information about the game of chess as a possible intervention to change the trajectory of executive functioning development for youth.

In this chapter, I will give the background research for the topic, illuminating the gap that exists in the current literature and providing the need for the current study. I will then highlight the purpose of the study and specify the research questions and hypotheses. The theoretical framework on which the study rests will be explained, along with the

nature of the research design, definitions, assumptions, scope, limitations, and delimitations. Finally, the significance of the research study will be highlighted. A brief summary will be provided along with what to expect in the next chapter.

Background

There are numerous definitions of executive functioning. Karbach and Unger (2014) defined executive functioning as the use of a set of higher order cognitive abilities that are instrumental in supporting action control and flexible adaptation to a changing environment. The authors further noted that executive functioning was not a singular trait but included domains of inhibition, working memory, and cognitive flexibility (Karbach & Unger, 2014). Other researchers (Grau-Perez & Moreira, 2017) described executive functioning as the amalgamation of complex processes that included decision making, concept formation, abstract reasoning, working memory, processing speed, interference control, inhibition of impulses, planning, evaluation errors, and cognitive flexibility.

Executive functioning has a significant effect on many arenas in life, such as academic functioning, SES, and physical health (Karbach & Unger, 2014). It also influences one's psychological well-being and response to stressful situations (Nieto et al., 2019). Additionally, poor executive functioning often results in youth externalizing behavior such as aggression, delinquency, and heavy risk-taking (Modecki et al., 2017). Executive functioning is often delayed for lower SES individuals due to the harsh conditions and experiences they are faced with (Haft & Hoeft, 2017; Rosen et al., 2019). Recent researchers have underscored the need for "help" for lower SES individuals by demonstrating the link between SES and executive functioning and prefrontal cortex

development (Rosen et al., 2019). Besides, other factors such as school and community experiences (Cumming et al., 2020), early mother–child attachment security, and maternal autonomy support (Regueiro et al., 2020) were influential in the trajectory of development of executive functioning skills.

Numerous strategies have been researched to improve executive functioning in youth. They include meditative training (Kaufman & Jensen, 2018), computer gaming intervention (Dovis et al., 2015), and yoga to build self-efficacy (Kwasky & Serowoky, 2017). Further, some of these strategies have focused on special populations such as those with attention deficit hyperactivity disorder (Chimiklis et al., 2018), Syrian refugees (Sirin et al., 2018), and those with cocaine dependence (Goncalves et al., 2014).

Even though these strategies have been beneficial, there is much room for growth in services and new avenues (Hernandez & Rios, 2014). Gibbons and Poelker (2017) ascertained that for any direct interventions to be successful, disadvantaged youth must be involved in a meaningful and empowering way. Learning the game of Chess presents as an option with its focus on deliberately thinking through choices before making a decision (Peters, 2016; Thiers, 2014). Thiers (2014) went a step further to suggest that chess is particularly suited to youth because they have critical life-changing decisions to be made at every stage. Jordan et al. (2017) discussed how chess has many parallels to life, and this is a helpful analogy for youth where different chess puzzles represented problems in life and the challenge was to find alternative solutions by exercising infinite options in one’s mind.

Neuroscientific evidence supports that chess improves academic performance in school (Ortiz-Pulido et al., 2019) with the most benefited areas being math and reading. Besides gains in cognitive and academic spheres, chess has been shown to have an impact on students' self-efficacy, self-esteem, and social anxiety (Peng et al., 2019).

Problem Statement

Although the aforementioned research regarding avenues to bolster executive functioning in youth illuminates important findings, I have found no research that has examined the changes in executive functioning potential in youth when chess is used as an intervention. Given such, further research was warranted that could examine the influence of chess on executive functioning in an effort to address the documented problem of youth's poor levels of executive functioning (Haft & Hoeft, 2017; Rosen et al., 2019).

Purpose of the Study

The purpose of this quantitative study was to determine whether there are differences in executive functioning in youth when the intervention of chess is used. Healthy executive functioning translates into better decision-making regarding issues in many arenas that youth are faced with in disproportionate amounts as compared to adults (Thiers, 2014). This is of huge significance to individuals, families, and society because poor executive functioning not only results in poor immediate decisions, but also perpetuates other long-term issues (Karbach & Unger, 2014). I proposed using a single group pretest–posttest design with the assessment of executive functioning indices done before and at the conclusion of the chess club/intervention. Results were analyzed using

the repeated measures *t* test, also known as paired sample *t* test. Here, the independent variable was the learning of chess over time, whereas the dependent variables were the chosen indices of executive functioning (decision making, working memory, and impulsivity).

Research Questions and Hypotheses

First Research Question: Are there differences in the decision making of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention?

First Null Hypothesis (Ho): μ1 = μ2. There are no significant differences in the decision making of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

First Alternative Hypothesis (H1): $\mu 1 \neq \mu 2$. There are significant differences in the decision making of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Second Research Question: Are there differences in the working memory of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention?

Second Null Hypothesis (Ho): $\mu 1 = \mu 2$. There are no significant differences in the working memory of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Second Alternative Hypothesis (H1): $\mu 1 \neq \mu 2$. There are significant differences in the working memory of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Third Research Question: Are there differences in the impulsivity of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention?

Third Null Hypothesis (Ho): $\mu 1 = \mu 2$. There are no significant differences in the impulsivity of the youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Third Alternative Hypothesis (H1): $\mu 1 \neq \mu 2$. There are significant differences in the impulsivity of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Theoretical Framework for the Study

The theory providing the lens for this study was Jean Piaget's theory of cognitive development (1936). According to Piaget (1936), cognitive development is a progressive reorganization of mental processes that occurs due to biological maturation and interaction with the environment. Humans process the information that they receive rather than simply responding to stimuli, and they relate it to what is already known. These building blocks of knowledge are called "schemas." When existing schema are used to deal with a new object or situation, assimilation occurs and there is an equilibrium created. When existing schema cannot be used, disequilibrium follows, and the process of accommodation occurs wherein there is adjustment made to the existing

schema. Equilibration is the force by which the learning process is driven because people do not like to be frustrated and seek to maintain equilibrium through accommodation. Once schemas are constructed, they become automated, and little conscious effort is needed to operate them (Kuldas et al., 2015). Therefore, once the schemas of planning and decision making are learned through chess, they become easy to use in daily life. I will provide a more detailed explanation in Chapter 2.

In this study, the purpose was to determine if there were differences in executive functioning in youth when the intervention of learning chess was used. Piaget's theory of cognitive development is grounded in the measures used to determine executive functioning. The youth in the research study were between the ages of 8 and 17 years. According to Piaget's theory, 12 years marks the beginning of the formal operations stage wherein abstract ideas and hypotheses may be entertained. Therefore, the chess intervention may help facilitate the "push into" this stage and/or accelerate development during this stage. For example, impulsiveness is measured using the Barratt Impulsiveness Scale by rating statements such as "I say things without thinking." and "I plan tasks carefully." It was hypothesized that there may be changes in schemas through the learning of chess that may be reflected in these executive functioning measures.

Nature of the Study

The method that I chose for my study was quantitative. The purpose of my study was to determine if there were differences in executive functioning in youth when the intervention of chess was used. The design that I planned to employ was the single group pretest–posttest design, with testing of measures done before beginning chess training

and after 14 sessions of chess training. Results were analyzed using the repeated measures *t* test, also known as the paired sample *t* test. This was a suitable method for the study because I was interested in examining the effect of chess, which lends to "hard facts" that can be measured. Further, the design of single group pretest–posttest was very simple to administer as well as analyze, and it gave one a quick at-a-glance idea of how changes in executive functioning happened over time (Campbell & Stanley, 1963). Additionally, fewer participants were needed because there was no need for a control group. This also led to the control of the natural variation that occurs between subjects/individuals (Howell, 2009).

The independent variable in this study was learning of chess over time. Chess is a two-person strategy/skill game and in my study was used as an intervention. The students were taught the principles of the game of chess. The students were encouraged to engage in chess puzzles and play games between sessions. They also had access to play in tournaments online. The three dependent variables reflected the indices of executive functioning, which is defined as the capacity for cognitive and emotional response that is essential for goal-directed behavior and appropriate social conduct (Lemberger et al., 2015). It includes the domains of decision making, working memory, and impulsivity (Karbach & Unger, 2014). Because there was not one single instrument to measure executive functioning, different neuropsychological assessments were employed to get an understanding of executive functioning using its indices. The three dependent variables were decision making, working memory, and impulsivity.

The researcher administered the pretests virtually to determine the indices of executive functioning to the youth who had volunteered to be part of the research study. This battery of three tests took less than 30 minutes to complete. These students were from the beginner groups (unrated through U.S. Chess Federation [USCF] 1200 rating) of scholastic chess academies in the United States and were between the ages of 8 and 17 years. Convenience sampling was used so as to facilitate the execution of the study because in convenience sampling, individuals who fit the criteria of a study are found in any way possible (Emerson, 2015). Chess was taught by instructors whom the academies had hired for the purpose of chess coaching. The lessons were either in person or carried on virtually through different platforms such as Zoom or Skype. At the end of 14 sessions, the tests on the indices of executive functioning were repeated again virtually. Results were tabulated for each individual student as results at first time interval, T1, and results at second time interval, T2, and kept together. Results were analyzed using repeated measures *t* test, also known as paired sample *t* test. The paired sample *t* test is a statistical procedure used to determine whether the mean difference between two sets of observations is zero. A total sample size of 41 was found to be appropriate using G Power sample size calculation. I chose an effect size of 0.4, an alpha of 0.05, and power of 0.80.

Definitions

Independent variable: The learning of chess over time.

Dependent variables: Decision making, working memory, and impulsivity.

For the purposes of this research study, the three executive functioning measures discussed were decision making, working memory, and impulsivity. These indices of executive functioning were picked because these components could greatly influence youth (Vogel & Ham, 2018).

Decision making: Defined as the cognitive process by which a preferred option or a course of actions is chosen from amongst a set of alternatives based on certain criteria (Wang & Ruhe, 2007). In the research study, it was measured using the Iowa gambling task (Bechara et al., 1994).

Working memory: Defined as the retention of a small amount of information in a readily accessible form that facilitates planning, comprehension, and problem solving (Cowan, 2014). In the research study, it was measured using the digital span backward task (Wechsler, 1997).

Impulsivity: Impulsivity may be defined as characterized by unplanned risky behaviors and making up one's mind quickly (Eysenck, 1993). In the research study, it was measured using the shortened version of the Barratt Impulsiveness Scale or BIS-11 (Patton et al., 1995), a 30-item self-report instrument.

Assumptions

Certain assumptions were made so as to make the study feasible. It was assumed that students were focused and engaged during the learning of chess. Further, it was also assumed that there was not "too much attrition." This could potentially happen due to technology issues or family issues. With respect to the youth, it was assumed that they had the cognitive ability and language skills to understand what was being taught during

the lessons and to take the tests used to assess executive functioning. Another important consideration or assumption was that students had given their "true" answers to the different tests, given that some of them were self-report questionnaires. If students had not given their true answers, it could have affected the scores on executive functioning indices.

Scope and Delimitations

First and foremost, it is pertinent to understand that three aspects of executive functioning were chosen for this research study. These three aspects were decision making, working memory, and impulsivity, and they were chosen due to the significant influence they can have on youth (Vogel & Ham, 2018). There are, in essence, many more components of executive functioning that other researchers outline (Grau-Perez & Moreira, 2017).

Second, participants of the study were from the beginner groups of chess only and were limited to chess players in the United States. Further, children under 8 years old were not included in the study. This may influence the generalizability of the results.

Limitations

One of the limitations of the single group pretest–posttest design is that during repeated testing, there may be a practice effect or a fatigue/boredom effect, both of which could lead to skewed results at repeated assessments (Howell, 2009). Another issue is the failure to control history because it is obvious that the students are exposed to many stimuli during and prior to the period of the chess training (Campbell & Stanley, 1969). Related to this is the issue of maturation, which is not related to specific external events

but includes changes in biological and psychological processes over time, such as growing older, growing hungrier, and so forth. Some other sources of limitations to this design include “instrument decay” and statistical regression toward the mean (Campbell & Stanley, 1969).

Further, the attitude of the subjects could be a limitation if the students are being “pushed” by the parents to attend chess lessons. Some additional challenges may have been that some youth had greater opportunities to play and practice chess with others during the intervention period. Additionally, others may have not found chess as interesting as they thought they would, and yet others might have found it too challenging and/or complex. This may have led to mortality issues with students not showing up to chess lessons or dropping out of the research study itself. This could pose a huge issue.

Significance

This study has the potential to unearth a valuable tool, the game of chess, for improving the executive functioning of youth. While many other avenues have been explored to improve executive functioning (Kwasky & Serowoky, 2017); chess has not been investigated as a tool to bolster executive functioning. Executive functioning has implications in many areas of daily living, and the impact of affecting executive functioning has far-reaching consequences (Karbach & Unger, 2014; Rosen et al., 2019).

Besides affecting the lives of youth in critical life-altering ways, my study may give hope to the numerous families that are affected by the issues of their loved ones being entrenched in harsh circumstances. In addition, the educators, criminologists, social workers, and researchers who have been dealing painstakingly with the multiple co-

occurring issues that youth face (Burton et al., 2016; Machell et al., 2016) may be helped with this effective tool.

Summary

This chapter has provided an introduction to my research study, in which I aimed to investigate using chess as an intervention to improve executive functioning in youth. Executive functioning has been deemed more important than even intellectual and social functioning (Karbach & Unger, 2014), and therefore, interventions to improve it are critical. It was shown that executive functions are malleable and that they are often lowered for children and youth due to the external circumstances and stressors (Cumming et al., 2020; Rosen et al., 2019). A considerable amount of research has been done on interventions to improve executive functioning, but the game of chess has not been used as an intervention. Reasons were elucidated for its consideration as a potential avenue and a research study was designed to investigate this.

This chapter specifically gave background on the issue leading to the problem statement and purpose. The research questions and hypotheses were outlined along with providing a theoretical lens and giving a description of the nature of the study. Definitions of constructs were given, and assumptions, scope, delimitations, limitations, and significance were provided. Chapter 2 provides a thorough literature review of relevant articles related to the significance of executive functioning, its relationship with SES, its impact on different arenas, history and relevant research on the game of chess, and how it has been used.

Chapter 2: Literature Review

Introduction

The executive functioning of youth may be adversely affected by the external circumstances and life events that they are faced with as they struggle to meet basic needs, are exposed to crime and violence, and are entrenched in disorganized microsystems (Campos-Gil et al., 2020; Rosen et al., 2019). The purpose of this research study was to determine whether there were differences in executive functioning in youth when the intervention of chess was used.

Executive functioning has a broad and long-lasting reach, even more so than the facets of intelligence and emotional stability (Karbach & Unger, 2014; Rosen et al., 2019). Given the problem of lowered executive functioning in youth (Haft & Hoeft, 2017; Rosen et al., 2019) as well as the numerous critical decisions that this population is "forced" to make (Thiers, 2014), it seems fitting to explore efficacious interventions to bolster executive functioning in this population. In this research study, the game of chess was considered as a tenable option for an intervention that might be efficacious in improving the development of executive functioning.

This chapter will include a discussion of the existing research on executive functioning and how it has been adversely affected in youth. It will then explore the research on the affects and consequences of healthy executive functioning and lack thereof. The link between SES and executive functioning will be delved into, underscoring the need for interventions for ameliorating executive functioning for this

specific population. In addition, the connection between executive functioning and other stressors will be explored to broaden the field to encompass all youth.

The interventions that have been used to improve executive functioning will be outlined. Further, the interventions used for special populations will be discussed. The game of chess will be explored as a viable intervention due to its special properties as well as involvement of youth in a meaningful, activity-based way. Some of the existing research on the effects of learning chess will be examined. A case will be made for the consideration of chess as an intervention to improve the executive functioning of youth.

Literature Review Search Strategy

The databases used for researching this topic were PsycINFO, PsycARTICLES, Social Work Abstracts, SocINDEX, ERIC, Education Source, CINAHL, and Academic Search Complete. Google Scholar was also used to find any articles that may have been missed. Alerts were set up on the most relevant databases so as to receive the newest articles on the topic of study. The keywords used to investigate the topic included *executive functioning*, *effects of executive functioning*, *decision-making and youth*, *working memory and youth*, *impulsivity and youth*, *socioeconomic status and executive functioning*, *prefrontal cortex development and executive functioning*, *chess and executive functioning*, *chess and cognitive ability/cognitive control*, *benefits of chess*, *malleability of executive functioning, interventions and strategies used to improve executive functioning, special populations and executive functioning*, *decision-making and executive functioning*, *working memory and executive functioning*, *impulsivity and executive functioning*, and so forth. These keywords were often combined in different

permutations and combinations to get the most relevant research. Research was limited to peer-reviewed journals and to the previous 5 years.

Theoretical Foundation

The theoretical framework used for this research study was Jean Piaget's (1936) theory of cognitive development. According to this theory, humans are not passive receivers of information and stimuli. They actively engage in processing the information received and reorganize, connect, discover discrepancies, and adjust accordingly as they go through different environmental experiences and biological maturation. Piaget discussed four different cognitive developmental stages: sensorimotor stage, preoperational stage, concrete operational stage, and formal operational stage. These stages of development were thought of as universal and corresponded to different age groups. Piaget acknowledged individual differences in the rate at which children progress through these stages (Wadsworth, 1996).

Piaget's theory of cognitive development introduced the concept of *schemas* or the building blocks of knowledge (Wadsworth, 1996). When existing schemas are used to deal with a new object or situation, assimilation occurs and there is an equilibrium created. When existing schema cannot be used, disequilibrium follows, and the process of accommodation occurs wherein there is adjustment made to the existing schema. Equilibration is the force by which the learning process is driven because people do not like to be frustrated and seek to maintain equilibrium through accommodation.

Piaget's theory has been influential in developing educational policy catapulting the idea of *discovery learning*. This is the idea that most is learned through doing and

exploring, advancing the concept of *readiness*, which proposes that one should not be taught certain constructs until one is at the appropriate developmental stage. Additionally, one needs to be engaged and active in the process of learning (Wadsworth, 2004). This is extremely relevant to my research study because chess was taught to the youth through play and "not just lecture." Further, only slightly mature children (between 8 and 17 years old) were included in the sample to adhere to the readiness concept. In addition to this, all students who were part of the research study voluntarily joined chess training, thus fulfilling the "active learner" requirement.

Besides the reasons stated above, Piaget's cognitive development theory seems to provide a valuable explanation for how changes in executive functioning can take place when the intervention of chess is used. According to Kuldas et al. (2015), once schemas are constructed, they become automatic, and very little effort is needed to operate them. This seems to explain how once the schemas of planning, decision making, and inhibitory control are learned through chess, they might become easy to use in daily life because they have been assimilated.

In this study, the purpose was to determine whether there were differences in executive functioning in youth when the intervention of chess is used. Piaget's theory of cognitive development is grounded in the measures used to determine executive functioning. For example, impulsiveness was measured using the Barratt Impulsiveness Scale by rating statements such as "I say things without thinking." and "I plan tasks carefully." It was hypothesized that there may be changes in schemas through the learning of chess and these may be reflected in the executive functioning measures.

Literature Review

First and foremost, it is important to understand what is meant by executive functioning. Lemberger et al. (2015) defined executive functioning as those cognitive processes that are critical to goal-directed behavior and appropriate social conduct. They further outlined some of these processes to include working memory, shifting focus, planning, organizing, and attentional and behavioral control. These processes begin to develop in early childhood and mature in the early 20s, with adolescence marking a dramatic period of change. From a neurological perspective, executive functioning is malleable, and changes as neural composition and activity evolve (Lemberger et al., 2015). Karbach and Unger (2014) discussed the critical role that the prefrontal cortex plays in mediating executive control/functioning but also reported that neuroimaging and lesion studies demonstrate that executive functioning tasks involve the activation of a larger set of brain regions, including the parietal and motor areas as well as subcortical structures such as basal ganglia and thalamus. Karbach and Unger (2014) believed in the "unity/diversity" framework of executive functioning, reporting that even though correlations between different core components of executive functioning are unusually high, they can be clearly separated into subcomponents. The subcomponents identified by Karbach and Unger were cognitive flexibility/shifting, working memory/updating, and inhibition.

Other researchers have identified yet more and different subcomponents of executive functioning. For example, Grau-Perez and Moreira (2017) asserted that executive functioning encompasses complex processes such as decision making, concept

formation, abstract reasoning, working memory, processing speed, interference control, inhibition of impulses, planning, evaluation of errors, and cognitive flexibility. Knouse et al. (2014) defined executive functioning as self-regulation to achieve future goals and included a broad array of self-directed cognitions and actions such as problem solving, working memory, impulse control, self-motivation, and emotion regulation. Even though researchers have included and excluded different subcomponents of executive functioning, there seems to be consensus on the view that executive functions can be thought of as the "conductor of the orchestra" (Grau-Perez & Moreira, 2017; Karbach & Unger, 2014; Lemberger et al., 2015).

History and Development of Executive Functioning

The first use of the word "executive" to allude to complex psychological abilities as those encompassed by executive functioning was by Herbert Spencer in his classic book *Principles of Psychology*, published first in 1885 and then subsequently in 1870-1872, 1881, and 1887. At the time, Spencer referred to executive processes as those representing inner, self-directed, mental activity, including a special form of memory that is called "working memory" today, along with the reasoning, will, problem solving, and self-control of emotions (Barkley, 2016). Much later, Luria (1966) was credited with giving detailed descriptions of patients with frontal lobe injuries and classifying them on the nature of their psychological deficits. Finally, Karl Pribram (1973, 1976) coined the term "executive functioning," with the primal frontal lobes being the "executive" of the brain. Lezak et al. (2014) added that as long as executive functioning stays intact, a person can continue to be an independent and functioning adult. The previous three

decades have seen a surge in research and writing on this topic, with a multitude of definitions emerging and executive functioning including as many as 30 abilities (Barkley, 2016).

Executive functions emerge in childhood and change over the lifespan, with these developments paralleling the anatomical changes of the frontal lobe and its connections with other brain areas (Jurado & Rosselli, 2007). The first executive function area to emerge is the ability to inhibit overlearned behavior, and the last is verbal fluency. During old age, inhibition of irrelevant information declines first, followed by task shifting and verbal fluency.

Executive Functioning and Socioeconomic Status

It is widely believed, and research has consistently shown that SES is linked with executive functioning, with lower SES correlating to poorer executive functioning, but the mechanisms and underpinnings of this linkage are nuanced (Haft & Hoeft, 2017; Rosen et al., 2019; St. John et al., 2019). Besides, this association does not exist only for the poor or economically disadvantaged but rather is present along the entire spectrum of SES (Rosen et al., 2019). Further, there are changes in the structure and function of the prefrontal cortex (the region primarily associated with executive functioning) corresponding to SES (Johnson et al., 2016). Some of the neural markers of poor executive functioning that are evident in lower SES children are reductions in prefrontal cortex volume and surface area, volume reductions in the orbitofrontal cortex, altered cortisol production (Johnson et al., 2016), and lower gamma power (Tarullo et al., 2017).

The harsh and adverse circumstances that economically disadvantaged youth face, including the struggle to meet basic needs, exposure to crime and partner violence, and constant chaos and disorganization, seem to affect executive functioning deeply, even more than any other cognitive abilities (Rosen et al., 2019). Vernon-Feagans et al. (2016) asserted that household chaos and disorganization play an important role in predicting executive functioning. They defined household chaos and disorganization as including inconsistency in routines and described household instability as referring to frequent changes in household composition and environment, frequent moves to different residences, and frequent changes in the people who inhabit the household. Their hypothesis was confirmed through their longitudinal study of 1,292 children born to mothers who lived in low-wealth rural America who were followed from birth to early elementary school. Yet others have argued that stress mediates the relationship between SES and prefrontal cortex function, with high stress levels leading to poor executive functioning (McKlveen et al., 2019). Parent adverse childhood experiences and caregiver reports of harsh parenting were examined in relation to executive functioning abilities in young low-income children (Treat et al., 2019). It was found that harsh parenting attitudes predicted lower inhibitory control in children and that parent adverse childhood experiences predicted lower working memory scores. This may be explained by the fact that adverse early life experiences lead to later negative parenting practices, including increased stress, role reversal, increased permissiveness, and the use of harsh discipline (Treat et al., 2019).

Additional evidence of the role of parent adverse life experiences was shown in a study by Guss et al. (2018) wherein parents reported on their adverse experiences, executive functioning, and relationship with their child. The more parent adverse childhood experiences, the poorer the relationship with the child, and this is mediated by the executive functioning of the parent (Guss et al., 2018). Some researchers (Fishbein et al., 2019) have gone "even further" than this, delineating specific home conditions. Fishbein et al. (2019) asserted that a nurturing environment in the home can mitigate some of the untoward effects of poverty. A seminal study by Brody et al. (2016) provided additional support for this speculation by reporting that family intervention can significantly improve brain functioning for high-poverty children. Neighborhood influences and external milieu also play a role in determining executive functioning, especially during the early and middle adolescent years, when peer relationships get significant (Fishbein et al., 2019). This has been demonstrated specifically in the realms of rule-breaking and aggression (Fishbein et al., 2019).

Researchers such as Rosen et al. (2019) and Johnson et al. (2016) postulated that cognitive stimulation drives lower level sensory and perceptual processes that may impact prefrontal cortex development and executive functioning through reciprocal connections between the ventral visual stream and prefrontal cortex. Cognitive stimulation refers to having access to a complex environment that includes appropriate learning materials, stimulation in the form of experiences, a sophisticated linguistic environment, and the presence of a caregiver who interacts consistently and guides learning through the process of scaffolding (Rosen et al., 2019). Werchan and Amso

(2017) added that cognitive stimulation supports the development of the feed-forward and feedback loops between sensory processing regions and the prefrontal cortex, laying the foundation for the development of executive functioning.

The research regarding the linkage between SES and executive functioning has mainly focused on Western, high-income countries and not on low- and middle-income countries in the rest of the world (Haft & Hoeft, 2017). Haft and Hoeft (2017) reported that the link between SES and executive functioning is found to be global and that the considerations are similar, except they are exacerbated in low- and middle-income countries. Having said that, they also recommended that cultural practices, especially in the field of parenting and education, be considered when building on interventions for improving executive functioning. For example, Tarullo et al. (2017) found that elevated gamma power, a neural correlate, serves a protective factor and may be more important in girls in certain countries wherein there is gender discrimination. With regard to teasing out some of the effects of SES on the different components of executive functioning, it was found that for younger children (ages 4.5–5.5 years), lower SES corresponded to lower working memory, inhibition control, and vigilance but did not have much effect on higher cognitive load or performance over time because those skills are still developing (St John et al., 2019).

Other Factors Affecting Executive Functioning

Besides SES, there are many other factors that affect executive functioning. Some of these factors are tied into SES while others may operate independently. One of the most controversial debates in this arena is regarding the effects of bilingualism on

executive functioning. Earlier studies showed that bilingualism greatly enhanced executive functioning (Bialystok et al., 2009; Prior & Gollan, 2011) with the proposition being that managing two or more languages puts demands on the executive functioning system when switching between languages and suppressing the language not in use. This handling of excess cognitive load is presumed to generate transfer effects when tasked with other executive functioning tasks. Neurological association has been demonstrated with bilinguals possessing increased white matter integrity and gray matter density in the frontal lobe areas (Gold et al., 2013; Ma et al., 2014). However, authors of newer studies have criticized the previous ones for not controlling for confounders such as SES, intelligence, culture, and immigration status (Lehtonen et al., 2018); for having small sample sizes (Paap et al., 2015; Sorman et al., 2019); and for using measures and tasks that have not demonstrated convergent validity (Paap et al., 2015). Sorman et al. (2019) proposed considering different features of bilingualism in relation to executive functioning when examining this debate. They suggested considering when in an individual's lifespan the second language was acquired, the proficiency of the second language, the linguistic distance between the two languages, and whether the executive functioning task measured is verbal or nonverbal in nature (Sorman et al., 2019).

Another factor that affects executive functioning or has associations with it is motor control (Gonzalez et al., 2014; Houwen et al., 2017; Ludgya et al., 2018). There is a broad consensus in the literature regarding this overlap although there is still dearth of research on the topic. Additionally, most of it has been concentrated on children five-year-old and over even though the younger ages are when the rapid developments in both

motor skills and executive functions occur (Houwen et al., 2017). Gonzales et al. (2014) discussed how executive functioning deficits can be detected through motor deficits such as lateralization of hand and space use. This is especially critical since motor deficits can be observed earlier than executive functioning skills. This suggests the possibility of using motor interventions to remediate executive functioning deficits (Gonzales et al., 2014). Houwen et al. (2017) studied the relationship between motor performance and executive functioning in preschool children and found that motor performance is coordinated with the working memory and planning components of executive functioning in preschoolers. Ludgya et al. (2018) studied the association with preadolescent children and found that executive functions are selectively related to different facets of motor functioning in this age group. They found that working memory has associations with locomotor skills and inhibitory control is directly related to object control. In a research study by Leonard et al. (2015), which assessed a comprehensive range of executive functions in children with a diagnosis of developmental coordination disorder and those with motor difficulties; children in both groups performed poorer in nonverbal measures of working memory, inhibition, planning, and fluency; but not on tests of switching. As we can see, even though there is broad consensus regarding the association between motor and executive functioning, there are a lot of confounding variables that should be further researched so best interventions may be used.

A ‘very hotly debated’ arena is the effect of exercise on executive functioning. There are many research studies that demonstrate the positive effect of exercise on executive functioning (Falck et al., 2019; Guiney & Machado, 2013; Helmes & Harris,

2017; Verburgh et al., 2014). Some have done research on comparing different forms of exercise (Kaushal et al., 2018; Verburgh et al., 2014) whereas others have attempted to study specific age groups such as the aging population (Helmes & Harris, 2019); preadolescents, adolescents and young adults (Verbugh et al., 2014). Positive benefits of exercise have been proven in numerous of these studies with the researchers (Falck et al., 2019; Guiney & Machado, 2013; Helmes & Harris, 2017; Verburgh et al., 2014) pointing out that exercise has benefits for both physical and cognitive health. Diamond (2015), Diamond and Ling (2016) contested this viewpoint and presented that the studies done have been purely correlational, have no comparison groups, have 'mixed' results, etc.; and are inherently faulty in design. They proposed instead the implementation of mindful physical activity instead of mindless physical activity arguing that subjects who were randomly assigned to cognitively engaging physical activities such as taekwondo, basketball, and soccer showed great improvements in executive functioning unlike those who were subject to mindless physical activity such as aerobic exercise. They suggested that these activities not only train diverse motor and cognitive skills but also provided joy and self-confidence and a sense of social belonging (Diamond & Ling, 2016). Other researchers (Hillman et al., 2018) thought that Diamond and Ling (2016) had misrepresented the state of the science by omitting relevant literature, misinterpreting study results, and mischaracterizing study methods. Diamond and Ling (2019) offered their own rebuttal stating that the 'weakest evidence' does not mean 'no evidence' regarding exercise affecting executive functioning; that their focus is on executive functions, and not the entire cognitive domain; and that their statement mainly

characterized that research has not proven the link, even though one would think there is an association.

There is some speculation that the reason physical exercise affects executive functioning is because it helps in stress regulation besides other hypotheses such as regulating physical functioning (Diamond & Ling, 2016). Neurologically speaking, when a person is stressed, the prefrontal cortex specifically gets overwhelmed with excess dopamine plus there is heightened adrenoceptor stimulation in the norepinephrine system of the prefrontal cortex. Additionally, in response to stress, the adrenal cortex releases cortisol and there is disruption of the functional connectivity between the prefrontal cortex and other brain regions.

There have been numerous studies relating stress to low SES and how this affects executive functioning (Blair & Raver, 2016; Watson et al., 2019) but stress can occur without the co-occurrence of poverty or poor SES. Stress may be defined as when one's life circumstances maybe considered uncontrollable, unpredictable, and/or overly burdensome (Crandall et al., 2019). Children brought up in chaotic family environments, those that have suffered trauma, those that have dealt with maternal psychopathology in early childhood years, or those that are institutionally reared display biological markers of stress such as high cortisol levels, alterations to the volume of the amygdala and hippocampus and total gray and white matters in the brain areas that underlie executive functioning and emotion regulation (Blair & Raver, 2016; Piccolo et al., 2016). Perceived stress also has associations with smaller hippocampal, amygdala and prefrontal cortex volume in adults (Piccolo et al., 2016) as well as in adolescents (Piccolo & Noble, 2018).

Poorer working memory and overall levels of executive functioning are shown as visible manifestations of stress (Blair & Raver, 2016; Crandall et al., 2019; Piccolo et al., 2016). Stress also affects cognitive flexibility (Goldfarb et al., 2017) with cortisol increases being associated with enhanced updating but impaired switching. Researchers, Seehagen et al. (2015), studied how stress affects cognitive flexibility in infants. They found that stress impairs infants' ability to adjust to changing circumstances (Seehagen et al., 2015).

Some other external factors have been researched in the field of executive functioning. One of them is the effect of dietary consumption on executive functioning (Cohen et al., 2016). Researchers, Cohen et al. (2016), conducted a systematic review of databases to investigate how executive functioning was influenced in children and adolescents by examining food quality, macronutrients, acute and long-term diet. While the results of acute impact were inconsistent; studies examining longer-term diet effects showed positive associations between healthier overall diet quality and executive functioning. The food groups that showed a positive association were whole grains, fish, fruits and/or vegetables whereas less-healthy snack foods, sugar-sweetened beverages, and red/processed meats were inversely associated with executive functioning (Cohen et al., 2016). The potential adverse effect of energy drinks on executive functioning was looked at in early adolescence (Van Batenburg-Eddes et al., 2014) and it was found that consuming one or more energy drinks a day resulted in problems in executive functioning, both on self-reports and as indicated by parent reports on the Behavior Rating Inventory of Executive Functioning (BRIEF).

Another factor is the effect of sleep deprivation on executive functioning (Aidman et al., 2018; Fanning et al., 2016, & Hoyniak et al., 2018). There is wide consensus among the researchers that sleep issues including deprivation, quality, etc. hamper executive functioning in children, adolescents, and older adults. The executive functions of vigilance, inhibitory control, and task switching are poorest after 24 hr of sleep deprivation (Aideman et al., 2018). Complex decision-making shows a decline too but this may be more due to metacognitive factors than cognitive mechanisms (Aidman et al., 2018).

The effect of screen media content on executive functioning delivers an important lesson. It is not just 'screen time' that needs to be considered but the content and interactivity of what is being watched (Huber et al., 2018). For example, in a study done on 96 toddlers, children's working memory improved after playing an educational app as compared to viewing a cartoon. Further, children were more likely to delay gratification after playing the educational app (Huber et al., 2018). Besides being exposed to screen media, some scholars have studied the effect of exposure to nature on executive functioning (Bourrier et al., 2018). It was determined that exposure to nature has a direct and positive influence on executive functioning adding evidence to the claim of attention restoration theory that postulates that natural environments tend to make fewer 'harsh' demands for attention and can be considered 'softly fascinating' allowing for processing with less effort (Bourrier et al., 2018).

The phenomenon of bullying has been studied with respect to executive functioning with the goal of studying hot and cold executive functions as compared to the

usual emotional and social aspects of bullying (Medeiros et al., 2016). It was found that bullies had lower scores on decision-making whereas victims had lower scores on cognitive flexibility (Medeiros et al., 2016).

Recent researchers have focused on self-directed executive functioning as compared to externally-driven executive functioning (Barker et al., 2014; Barker & Munakata, 2015). Less structured time in children's daily lives seemed to foster self-directed executive functioning. It appeared that children developed more self-directed executive functioning when they had a good idea of options to choose from and also when they played a large role in directing activities that they participated in. This allowed for opportunities to plan, mind-wander and play which are considered as critical in creating plans and organizing toward own goals as compared to those that are imposed on by the adults in their lives. It was hypothesized that in today's world with increased focus on acquiring skills early and parent hyper-vigilance, there was less time for unsupervised play. Further, time spent in media consumption had increased manifold with the removal of outside play. This bolstered passive behavior in children with less opportunities for decision-making (Barker & Munakata, 2015). The assertion was made that in today's world self-directed executive functioning is important to inculcate even more than 'regular' executive functioning since some of the means by which self-directed executive functions develop have been stripped away (Barker & Munakata, 2015).

Impacts of Executive Functioning

One of the initial 'felt' impacts of executive functioning was on school readiness with higher levels of executive functioning predicting better school readiness (Micalizzi

et al., 2019). School readiness maybe defined as the behavioral, emotional, and academic preparedness of young children to learn in school. School readiness, in turn, forecasted later academic achievement, employment, and health (Micalizzi et al., 2019).

In a systematic review of literature studying pedagogical practices to alleviate poverty's effects on academic performance, it was found that interventions that help with executive functioning greatly influenced academic performance since executive functioning is highly malleable in early childhood and is strongly predictive of academic success (Allee-Herndon & Roberts, 2019). These results were also borne out in higher education wherein self-report measures of executive functioning determined academic performance in first-year students at a university (Baars et al., 2015) with those with higher executive functioning showing more study credits at the end of the year. In a related study by Knouse et al. (2014), the link between actual GPA and executive functioning in college students was demonstrated with lower executive functioning scores being predictive of lower GPA. The authors (Knouse et al., 2014) discussed how self-motivation played a huge part in the GPA obtained. Low self-motivation led to poorer GPA because of lower setting of goals; but that was not the only factor. There was poorer achievement of those low set goals indicating that there was another factor operating which may be perhaps, executive functioning (Knouse et al., 2014). These studies definitely point to the fact that executive functioning is developing and influential through adolescence and early adulthood.

Some of the specific cognitive skills that showed marked improvement with executive functioning included mathematics and spelling outcome regardless of child's

IQ level (Dekker et al., 2017). Dekker et al. (2017) further asserted that any changes in working memory influence academic achievement. Besides giving children the necessary cognitive skills, executive functioning along with metacognition fueled agency in learning (Marulis et al., 2020). Metacognition maybe defined as the knowledge, monitoring, and control of one's cognition (Marulis et al., 2020). Therefore, Marulis et al. (2020) recommended combining metacognition and executive functioning skills training in early childhood to enhance active learning and engagement.

Executive functioning had impact on one's psychological well-being and adaptation to stressful situations (Nieto et al., 2019). The relationship between executive deficits and depression was pointed out in the study by Nieto et al. (2019) comparing executive functioning, short term memory, and coping in a sample of young and older adults with no prior diagnosis of depression and with normal cognitive function (N = 216). They hypothesized that the link between executive function and depression was related to avoidant coping strategies. In addition, executive functioning was related to emotional regulation demonstrating the link between cognition and emotion (Ferrier et al., 2014; Sudikoff et al., 2015) with negative emotionality being linked to lower executive functioning. Emotional regulation may be defined as the "process of initiating, maintaining, modulating, or changing the occurrence, intensity, or duration of internal feeling states and emotion-related physiological processes, often in the service of accomplishing one's goals" (Ferrier et al., 2014). Poor emotional regulation, in turn, led to negative consequences at school and in life with increased pathology, anhedonia regarding school, peer rejection, lower academic outcomes, and diminished social

competencies (Ferrier et al., 2014). Further, the coexistence of both emotional dysregulation and poor executive functioning could be seen in many psychological disorders such as ADHD, mood disorders, and anxiety disorders (Sudikoff et al., 2015). Temperament has been linked to anxiety disorders; and it appears that the expression of temperament may be linked to executive functioning (Affrunti & Woodrow-Burden, 2015). In a study done by Affrunti and Woodrow-Burden (2015), combined and separate effects of temperament and executive functioning were studied in the relationship between parent and child anxiety. It was found that both executive functioning and temperament separately played a role in parent and child anxiety but also that executive functioning mediated the effect temperament had on child anxiety. From this, one can infer that temperament and executive functioning may represent a specific pathway of risk on the familial transmission of anxiety (Affrunti & Woodrow-Burden, 2015). Additional research has been done investigating the relationship between temperament, executive functioning, and anxiety in school-age children who stutter (Rocha et al., 2019). The researchers found that temperament and executive functioning abilities may contribute to the development of stuttering (Rocha et al., 2019).

Researchers have indicated that executive functioning has an impact on health behaviors (Allan et al., 2016; Hall & Marteau, 2014; Reimann et al., 2018). While some researchers argued a causal relationship wherein executive functioning influenced positive health behaviors (Hall & Marteau, 2014) others suggested a more bidirectional relationship wherein both executive functioning and positive health behaviors influenced one another (Allan et al., 2016). In the study by Reimann et al. (2018), a total of 114

articles meeting the criteria for the relationship between health behaviors associated with the leading causes of death in the United States and executive functioning were systematically reviewed and it was found that at least one executive functioning component was associated with every health behavior (Reimann et al., 2018). The Center for Disease Control and Prevention identified heart disease, cancer, accidents, chronic lower respiratory diseases, stroke, Alzheimer's disease, diabetes, influenza and pneumonia, nephritis and suicide as the leading causes of death in the United States in 2016 (National Center for Health Statistics, 2017). Some of the key health behaviors associated with the leading causes of death include dietary behaviors, physical exercise, substance use, risky driving, and medication and treatment adherence. Hall and Marteau (2014) argued, in the Temporal Self-Regulation Theory, that behavioral intentions were not suffice in predicting actual health behaviors; and proposed that executive functioning moderates the relationship between behavioral intentions and health behaviors. They explained that the different facets of executive functioning help an individual to resist temptation, avoid distractions, and plan better (Hall & Marteau, 2014). This solidified the critical role of executive functioning in determining health (Reimann et al., 2018).

Another arena that takes center stage with regards to impact of executive functioning is youth externalizing behavior such as aggression, delinquency, and heavy risk-taking (Modecki et al., 2017). The three capacities that these researchers outlined to prevent externalizing problems in adolescence were emotion regulation, coping, and decision-making; all of which fell under the general umbrella of executive functioning/control. Luciana (2013) pointed to how executive functioning deficits

underlie neurodevelopmental models of adolescent problem behaviors. It is explained that numerous demands are made on the developing prefrontal cortex during the rocky adolescent period. The youth who engage in externalizing behaviors burden the prefrontal cortex even more due to their high emotional reactivity as well as creation of external situations that demand decision-making and intensive processing. Therefore, relative to their high-functioning peers, youth with externalizing issues create more demands on the executive functioning system (Luciana, 2013). Risk taking behaviors were also indicated in the area of self-reported driving behaviors with those adolescents having poorly developed executive functioning engaging in high levels of risky driving due to the slow maturation of the prefrontal cortex of the brain (Starkey & Isler, 2016).

Executive functioning has been found to have clear associations with work-related rumination which in turn was related to productivity at the workplace (Cropley et al., 2016). Work-related rumination refers to perseverative thinking or dwelling about issues and problems at work (Cropley et al., 2016). Planning, being focused, and problem solving are critical elements in the workplace. Therefore, one can infer that executive functioning deficits led to lower workplace productivity. Work-related rumination, though, adds another layer; and it was unclear whether work-related rumination affected executive functioning or vice versa or both; but work-related rumination was said to influence or disinhibit the circuits that coordinate the multiple brain regions and pathways active in executive functioning (Cropley et al., 2016).

Making the Connection

The previous three sections have discussed the all-encompassing effects of executive functioning and the relationship between executive functioning and influencing factors. They have also raised the idea of the malleability of executive functioning during the childhood and youth years; much more than the flexibility of the other domains of cognitive functioning (Rosen et al., 2019). Additionally, the point is made that many children grow up in conditions that lower executive functioning and are faced with many more life-changing decisions as compared to adults (Thiers, 2014). Putting all this together, one can see the dire need for understanding what factors affect executive functioning and creating interventions that can impact these factors, especially in youth.

Executive Functioning and Interventions

The most direct interventions to improve executive functioning come in the form of programs that are geared to offer cognitive training specifically for that purpose. Most of them focus on a specific component of executive functioning (Crespi et al., 2018; Volckaert & Noel, 2015) but some claim to affect the entire paradigm of executive functioning (Lemberger et al., 2015; Wass, 2015). Some of these trainings were computerized trainings (Diamond & Ling, 2016; Takacs & Kassai, 2019) while others engaged parent/teacher/counselor interaction to teach executive functioning skills (Lemberger et al., 2015). Computerized training programs such as CogMed, Braingame Brian focused on different pieces such as working memory, inhibition control, etc. In CogMed, children practiced working memory tasks in both the verbal and visuospatial domains whereas in Braingame Brian, inhibitory control and cognitive flexibility were

targeted (Takacs & Kassai, 2019). Noncomputer training programs involved practice of inhibitory control through games such as circle time with inhibitory control practice, etc. (Takacs & Kassai, 2019). The research from these trainings showed that the cognitive training helped in the executive functioning skill that was tapped but did not transfer to other domains (Kassai et al. 2019). In addition, it helped those that were 'behind' in executive functioning skills to a much greater extent than those who had 'normal' executive functioning skills (Melby-Lervag et al., 2016).

Classroom curricula and add-ons to classroom curricula had great ecological validity since they were embedded in children's everyday lives and considered their socio-emotional and physical development (Blair, 2017). Some examples of this were programs such as Tools of the Mind, Montessori, PATHS, etc. These programs had activities that encouraged pretend play, waiting on one's turn, planning one's schedule independently; and practicing these skills enabled children to transfer these abilities to other domains. Further, these programs did not require additional material and could be given easily to large numbers under the guidance of regular teachers.

Playing cognitively demanding games had also been used as an intervention to improve executive functioning (Parong et al., 2017; Ramos et al., 2019). Some of these games had a digital/video game component to it (Parong et al., 2017; Sirin et al., 2018) whereas others had an exercise component (Alvarez-Bueno et al., 2017; Diamond & Ling, 2016; Verburgh et al., 2014) and yet others had an educational component (Ramos et al., 2019). Most of the research done in this area had shown to have positive effects on executive functioning while some of it affected specific domains only.

Researchers, Parong et al. (2017) developed a custom video game to teach the executive functioning skill of shifting between competing tasks; and it was found that practice of a cognitive skill in game context transferred to performance on the same skill in a non-game context. A computer-based, playful learning approach (Project Hope) was used in trying to meet the educational and learning needs of Syrian refugee children staying in the country of Turkey and it was found that the intervention group demonstrated improvement in language learning, coding, executive functioning, and an overall sense of hopefulness (Sirin et al., 2018). Those interventions that had an educational component included using cognitive games with small groups in an intentional and mediated way to purposefully enhance executive functioning (Ramos et al., 2019). The researchers found improvements in operating memory, processing speed, and attention when teachers used Brain School's digital games that focused on challenges, decision-making, etc. (Ramos et al., 2019).

Physical exercise or activity had been studied extensively as an intervention to improve executive functioning (Gatz et al., 2019; Helmes & Harris, 2017; Nakutin et al., 2019; Verburgh et al., 2014). Studies had focused on different populations (Helmes & Harris, 2019; Nakutin et al., 2019) while others had focused on different forms of exercise (Kaushal et al., 2018; Verburgh et al., 2014). The general consensus in most studies had shown positive correlations between exercise and executive functioning. Diamond and Ling (2016) had criticized these studies for faulty designs and had raised the idea regarding combining physical activity with cognitive activity and social

engagement to produce the most extensive and long-lasting benefits to executive functioning.

Mindfulness-based interventions had become increasingly popular the last few years. Mindfulness may be defined as the psychological capacity to stay willfully present with one's experiences with a non-judgmental stance, engendering openness and curiosity (Kabat-Zinn, 2005). Systematic reviews of mindfulness-based interventions at schools had yielded mixed results with the mindfulness-based interventions producing positive cognitive and socio-emotional outcomes but those results not being translated into academic and behavioral outcomes (Maynard et al., 2017; Zenner et al., 2014). In addition, there was great heterogeneity in the practices implemented for the interventions and the studies were underpowered; thus, making it quite complex to claim mindfulness-based interventions as a panacea (Maynard et al., 2017). In a recent study, mindfulness-based interventions were used with primary school children, and it was found that the inclusion of targeted mindfulness activities interspersed through the day in the regular school curriculum bring about positive changes in executive functioning and attention (Janz et al., 2019). Another study used mindfulness-based interventions among college students integrated into scheduled classroom activities (Kaufman & Jensen, 2017). Kaufman and Jensen (2017) found that meditative training improved executive functioning regarding stress, cognitive flexibility, and insight. The point to be made was that the research designs had to be made more robust for understanding the key mechanisms underlying mindfulness interventions that contribute to improved executive functioning (Maynard et al., 2017). Therefore, this is an area for further research. Having

said that, some of these interventions have yielded positive results without much financial burden and while being convenience-based (Janz et al., 2019; Kaufman & Jensen, 2017).

Yoga and martial arts had been specifically studied as forms of exercise or mindfulness-based interventions with regard to ameliorating executive functioning. The theory is that yoga moderates the stress response by restoring the body's sympathetic-parasympathetic balance; and therefore, results in improved executive functioning (Chimiklis et al., 2018; Gothe et al., 2016). In a recent study, a comparison was made between yoga and physical exercise as interventions on executive functioning, attention, and memory in adolescent children across schools (Vhavle, et al., 2019). It was found that yoga improved executive functioning, attention, and working memory as effectively as physical exercise intervention in adolescent school children (Vhavle et al., 2019). With regards to martial arts training, researchers (Douris et al., 2015) investigated the effects of 2 types of martial arts training to aerobic exercise on cognitive performance in middle-aged adults. The 3 treatments conditions studied were a typical martial arts class, an atypical martial arts class, and a one-hour walk at a self-selected speed. The researchers found that while all conditions improved attention and processing speed, only the 2 martial art conditions improved executive functioning. This was attributed to the increased cortical demand required by the more complex martial arts exercise as compared to the repetitive action of walking (Douris et al., 2015).

Creativity training had been studied as an intervention to improve executive functioning with mixed results (Bott et al., 2014; Meinel et al., 2019; Vally et al., 2019). Creativity may be defined as the ability to generate ideas, solutions, or insights that are

novel yet feasible (Stevenson et al., 2014). Creativity has long been thought to be associated with executive functioning and people with higher creative potential exhibiting enhanced executive functioning (Bott et al., 2014). This was borne to be true in a study by Bott et al. (2014) where in the researchers studied the effects of a 5-week creativity training intervention on both low and high-level executive functions. Low-level executive functions such as goal-directed attention and information processing showed improvements in the group that received the creativity intervention as compared to the control group whereas high-level executive functions such as inhibition, fluency, and cognitive flexibility showed no between-group differences. Valley et al. (2019) did a study with 133 students who completed a semester long course in creativity as part of their undergraduate studies. Creative production, creative self-efficacy, and neuro-executive functioning were measured before and after the training. Improvements were found both in creative production and self-efficacy but not in neuro-executive functioning. In another study by Meinel et al. (2019), creativity training bolstered creative production, but no effect was seen on creative self-efficacy. Therefore, this may be an area of further research.

Along the lines of creativity training, other creative avenues have been researched as interventions for bolstering executive functioning. Art of Learning (an art-based intervention) was researched in children ages 6 to 9 years to study the effects of an arts-based curriculum (music, theatre/drama, dance, literature/poetry, visual arts, and photography/digital art) on global executive functioning, behavioral self-regulation, and metacognition (Andersen et al., 2019). A pretest-posttest methodology was used

comparing the intervention group to a control group. It was found that the intervention group displayed a much more significant change in global executive functioning and Behavior Rating Inventory of Executive Functioning (BRIEF) plus the teachers reported positive effects on collaboration, conflict management, inclusion, vocabulary, and confidence in the semi-structured interviews performed. Other researchers investigated the effects of fantasy-oriented pretend play on children ages three- to five-year-old with respect to executive functioning (Thibodeau et al., 2016). The researchers found that even with a 5-week intervention, children in the fantasy-oriented group showed improvement in executive functioning as compared to those in the group of non-imaginative play intervention and business-as-usual control group. Further, those that were highly engaged in the play and those who were highly fantastical showed the most improvement in executive functioning (Thibodeau et al., 2016).

Music training had been investigated as an avenue for improving executive functions in all age groups considering that playing a musical instrument requires a lot of sub-skills that are linked with executive functioning such as sustained attention, inhibitory control, task switching, and goal-driven behavior (Slevc et al., 2016; Zuk et al., 2014). Previous studies had been criticized for not controlling for confounding variables and methodological issues (Zuk et al., 2014). Therefore, Zuk et al. (2014) decided to study the behavioral and neural correlates of executive functioning in musicians and non-musicians (both adults and children) while matching for general cognitive abilities and socioeconomic variables. Adult musicians showed enhanced performance on executive functioning measures of cognitive flexibility, working memory, and verbal fluency as

compared to non-musicians. Musically trained children showed greater performance in verbal fluency and processing speed compared to musically untrained children. It was thought that executive functions mediated the relationship between music training and cognitive skills/academic achievement (Zuk et al., 2014). Researchers, Slevc et al. (2016) decided to study the specific executive functioning skills that showed improvement with musical training. They studied three different components of executive functioning (inhibition, updating, and switching) along both the auditory and visual modalities. They found that musical training showed improvement in both auditory and visual updating tasks but did not show strong correlations with either inhibitory control or task switching. Therefore, Slevc et al. (2026) recommended a process-specific relationship between musical ability and executive functioning. Specifically, Lesiuk (2014) recommended music-based activities as an intervention for working memory. Music training is highly recommended for noting executive functioning improvements in the aging population (Alain et al., 2014; Gooding et al., 2014). The research done by Alain et al. (2014) demonstrated that early to mid-life musical training is associated with improved late-life episodic and semantic memory as well is a marker for cognitive reserve. Gooding et al. (2014) reviewed many studies all pointing to the conclusion that engagement in musical activity can offset age-related decline in cognitive skills through enhancing hearing ability for musical and non-musical tasks, processing speech amid noise, etc.

Given all these creative avenues that have shown to bolster executive functioning, it appears fitting to try the game of chess as an avenue. Chess, with its emphasis on logical thinking, cautious planning, and deliberate moves seems naturally fitted to

improve executive functioning (Grau-Perez & Moreira, 2017; Ortiz-Pulido et al., 2019). In the next sections, I will attempt to give the history of this game; describe the existing research on different facets of chess and its uses; outline the few studies done on chess and executive functioning; and therefore, make a push for my research on the use of chess as an intervention for improving executive functioning in youth.

History of Chess

Chess was first documented in a recognizable form in North India in 6th century (Eales, 1993). It was considered an Indian war game (chatarunga) possibly derived from other board games played along the Silk Road to China. The Sanskrit word, chatarunga refers to the four branches of the military: foot soldiers or infantry who were represented by pawns; soldiers on horseback, the cavalry who were represented by the knights; elephant divisions represented by the rooks; and charioteers, represented by the bishops. The movements of the pieces on the chessboard aligned to the way each of the different forces moved on the battlefield. From there it spread to China and Japan, Central Asia, and west through Persia and the Islamic World (chatrang) reaching Western Europe around 1000AD. By the 12th century, the game of chess had spread to North Africa, Iceland, Spain, and Constantinople. A major rule change occurred just before 1500 in Spain and Italy, and then spread through Europe and the rest of the world through modern colonization (Eales, 1993). In medieval Europe, it wasn't considered as seriously as in Islamic territory but by the Renaissance period, chess began to develop into its modern dynamic form. During the Enlightenment period, chess began to be played in Parisian cafes combining logic and pleasure. The war simulating game seemed to promote

cosmopolitan tolerance and civility during the 18th and 19th centuries despite being fiercely competitive. Until the late 19th century the game was known as "the game of kings" because of its popularity amongst the upper classes. However, in the 20th century, ordinary people started taking it up by the thousands. The 20th century allowed politics into it with Nazis and Communists competing for supremacy through grotesque chess propaganda (Shenk, 2006).

The game is thought to have bewitching power and is sometimes alluded to as a metaphor for life, as an addiction, as a window into the workings of the human brain, even as a hope for mankind (Shenk, 2006). Chess is also said to take on a metaphysical aura as it draws you into a self-enclosed world of infinite possibilities, forking paths, deadly traps and escapes with an uncanny labyrinthine elegance. Benjamin Franklin, an avid player, wrote "For Life is a kind of Chess" and described how the complex structures and strategies of chess are profoundly related to the complexities of human thought and decision-making.

Chess and Existing Research

Most of the research done with regard to chess has focused on the effects on cognitive ability and academics (Burgoyne et al., 2016; Ortiz-Pulido et al., 2019; Rosholm et al., 2017; Sala et al., 2017). There are numerous results that show positive gains in these areas through the use of chess (Ortiz-Pulido et al., 2019; Rosholm et al., 2017) and others that show 'not so positive results' making one question the concept of transfer of learning (Jerrim et al., 2018; Sala & Gobet, 2017;).

Researchers, Nicotera and Stuit (2014) commissioned by the Chess Club and Scholastic Center of Saint Louis (CCSCSL) performed a thorough and critical literature review of chess studies available with the goal of investigating whether chess programs (at-school or after-school) lead to improved outcomes for school aged-children in academic, cognitive, and/or behavioral spheres. It was found that in-school chess interventions had a positive and statistically significant impact on both mathematical and cognitive outcomes and after-school chess interventions showed positive and statistically significant outcomes on mathematical outcomes (Nicotera & Stuit, 2014). This literature review used very rigorous search, coding, and analytic strategies along with following the protocols and quality standards set up by the United States Department of Education's Institute of Education Sciences. Gliga and Flesner (2014) demonstrated the cognitive benefits of chess training in novice children when post-test scores improved significantly for the school performance test (Math and Romanian language) as compared to those in the control group wherein students participated in fun math lessons. Other researchers (Bart, 2014; Rosholm et al., 2017; Trinchero, 2013) had all shown positive effects in mathematical abilities when chess was used as an intervention. Rosholm et al. (2014) specifically pointed to how bored and/or unhappy children showed larger impacts in their scores. Trinchero (2013) asserted that larger amounts of time spent on chess instruction correlated with bigger improvements.

Ortiz-Pulido et al. (2019) went a step further demonstrating differential brain activation through magnetic resonance imaging when novice, intermediate, and advanced chess players played the game. fMRI detects brain activity by measuring tissue perfusion,

changes in blood volume, and changes in oxygen concentration. The brain regions that were activated during the analysis of chess game positions were premotor areas, frontal lobes, parietal lobes, occipital lobe, and the left hemisphere of the cerebellum (Ortiz-Pulido et al., 2019). Hanggi et al. (2014) described the architecture of the chess player's brain with reduced grey matter volume and reduced cortical thickness in the occipito-temporal junction; negative correlation between caudate nucleus volume and chess experience; increased mean diffusivity in the left superior longitudinal fasciculus in chess players; negative correlation between mean diffusivity of the right superior longitudinal fasciculus and the Elo score (chess tournament ranking). Li et al. (2015) similarly asserted that the bilateral caudate nucleus is significantly smaller in grandmasters and masters. In addition, Li et al. (2015) pointed out that the functional connections between basal ganglia, thalamus, hippocampus, and several parietal and temporal regions were increased in chess masters and grandmasters. The researchers stated that whether these changes in the brain are the cause or consequence of intensive chess training was still to be determined (Hanggi et al., 2014; Li et al., 2015). Having said that, one could not undermine the effects of changes in the actual structure and physiology of the brain.

The researcher, Sala has done enormous work on the association between chess and cognition. In his earlier works, Sala joined forces with Gorini and Pravettoni (2015) to study the potential benefits of in-presence chess lessons and on-line training on mathematical ability in students aged 8 to 11 years old. The control group had normal school activities. It was found that the experimental group showed a higher improvement in mathematical abilities than the control group advancing the thought that the practice of

chess can enhance mathematical abilities in children. Sala and Gobet (2016) investigated through a meta-analysis whether the skills learned through chess transferred to mathematics, reading, and general cognitive abilities. The results showed moderate overall effect size ($g = 0.338$); the tendency for a stronger effect on mathematics ($g = 0.382$) than reading ($g = 0.248$); and a significant positive effect on duration of the intervention. However, all the studies used had a deficiency in design whether it be including pre- and post-test measures, random allocation of participants, or the presence of a do-nothing control group and an active control group (Sala & Gobet, 2016). In response to this criticism, Sala and Gobet (2017) decided to focus on chess instruction and mathematical problem-solving using two experimental studies with an active control group (one using checkers and the other using the Oriental game Go). The results demonstrated that the chess-treated group only slightly outperformed in mathematical ability and that the differences were not statistically significant. Sala and Gobet (2017) decided to take it a step further and investigate whether chess, music, and working memory training have an impact on children's cognitive and academic skills. The results showed small to moderate effects pointing to the limitations of far transfer in learning. Far transfer may be defined as the transfer of learning that occurs when a set of skills generalizes across two or more domains that are 'loosely related' to one another (Sala & Gobet, 2017). Trinchero and Sala (2016) showed the role of teaching problem-solving heuristics in aiding far transfer of skills. In an experiment done on 931 primary school students, there were two experimental groups attending chess lessons (one where the trainers taught the students heuristics to solve chess problems and the other in which no

heuristics were used) plus a control group. It was found that the students who were in the group where they were taught problem-solving heuristics did much better than the other groups.

Even though there were many research studies that showed sobering results, there were a multitude that looked very promising. When comparing the scores on standardized tests of 'chess kids' versus their peers, it was demonstrated that chess kids did better overall on standardized tests (Poston & Vandenkieboom, 2019). This could "simply mean" that chess kids were smarter. But this study went further to demonstrate that the learning of chess increased a student's academic performance by comparing score gains to non-chess peers (same grade and academic percentile). Additionally, through a variety of comparisons, this research study showed that the more chess played; the more the benefits. Children who came to chess club occasionally received about 5% to 10% benefit in Math, whereas those kids who played in rated tournaments gained substantially in Math (30 % to 50%) and significantly in Reading (10% to 20%). This benefit kept increasing as the students played in more tournaments and increased their chess rating (Poston & Vandenkieboom, 2019).

Young chess players showed advanced visual perspective taking in laboratory tasks as compared to their non-chess counterparts demonstrating that even though both egocentric and altercentric intrusions affected both groups, chess players were more efficient in taking another's perspective as taking their own perspective, especially when constant switching was required (Gao et al.,2019). Chess is a game that requires taking on another's perspective while planning one's own move and countermove from one's

own perspective; and over time this extensive training yields better perspective taking (Gao et al., 2019). Expert chess players showed better auditory memory function as compared to non-chess players (Fattahi et al., 2015). The auditory-verbal memory is a type of memory that involves auditory reception of orally presented information. It is a component of working memory which essentially holds information and keeps it temporarily accessible. This kind of memory is extremely critical for learning language skills (Fattahi et al., 2015). Chess, thus presents, as a tool for improving cognitive performance and as a rehabilitative mechanism for those with memory impairment and learning difficulties. This is echoed in the study done by Eldaou and El-Shamieh (2014) wherein the effects of chess were studied on the concentration of ADHD students and results showed a significant increase in the concentration skill and duration along with improvement in listening language scores.

With regard to the effects of chess on social-emotional issues, many researchers reported positive benefits of chess (Aciego et al., 2013; Jianguo et al., 2019; Romanova et al., 2018). Self-rated questionnaires and teacher reports showed an increase in self-confidence and self-efficacy for children who played chess (Aciego et al., 2013; Jianguo et al., 2019) as compared to their peers. Teachers also reported a better adjustment with school, more coping skills, and increased problem-solving capacity (Aciego et al., 2013). The use of chess as a therapeutic and rehabilitative tool had been investigated and "pushed" by researchers for many years (Romanova et al., 2018). Chess with its unique abilities to bolster consecutive thinking, logical methods, imaginative and operational memory, internal plan of action, and reflection lent itself as an effective resource for

activating human mental activity (Romanova et al., 2018). Chess therapy was referenced by Reider in 1945 when a man who was suffering from schizophrenia was able to use chess as an outlet for his hostile impulses. Demily et al. (2009) demonstrated improvement in voluntary processing, inhibitory capacity, and planning abilities through using chess to restore cognitive functions for schizophrenic patients. Dr Rhazes, as chief physician at Baghdad hospital, used chess strategies and tactics as metaphors for real life to help patients heal through the game of chess (Fadul & Canlas, 2009). Julian Way (2015) used chess in the treatment of clients with mental disorders arguing that traditional medicine disempowered patients by relying on medication and taking responsibility away. He promoted independent and responsible thinking through lessons from chess. In Bulgaria, Chovekolubie (association for social rehabilitation and integration of people with mental disorders) under the direction of Dr. Emil Markov, a psychiatrist, had used chess as a method for solving human problems and strengthening mental health thereby developing human potential (Romanova et al., 2018).

Chess may be used in working with Alzheimer's patients wherein research had demonstrated that people who were cognitively active had fewer chances of developing cognitive impairment and dementia as compared to those who were less cognitively active (Wilson et al., 2007). Chess had also been used successfully in the development of motor skills for children with cerebral palsy (Panush, 2000). In Warsaw (Poland) chess was successfully used for the rehabilitation of children with motor and emotional disorders (Warszawska Biuro Educakacji, 2016) in a collaborative project between the Chess Federation of Poland and Warsaw Center for Educational Innovation. The results

showed a significant improvement in decision-making skills, concentration, patience, perseverance, formation of motivation and determination to achieve goals and fight against disease (Warszawska Biuro Educakacji, 2016). Chess had been used as intervention for children diagnosed with attention deficit hyperactivity disorder (Blasco-Fontecilla et al., 2016) wherein it was confirmed that chess had reason to be included in the multimodal treatment of attention deficit hyperactivity disorder (ADHD) with improvements demonstrated in improved attention, behavior, grades, and social relationships.

Chess had been reported to have been employed successfully in patients with addiction issues with reports from Philippines, Brazil, and Germany (Romanova et al., 2018). Dr. Angelo Subida from Manila used chess therapy with addiction patents whereas Dr. Sabine Vollstadt-Klein (2015), a professor from the University of Heidelberg insisted that chess be used as an effective and inexpensive treatment modality for some addiction patients (Romanova et al., 2018). The researchers, Goncalves et al., (2014), used motivational chess, an innovative intervention that combined chess and motivational interviewing in the treatment of cocaine-addicted patients with results indicating a boost in executive functioning skills especially working memory for the group that received this combination (chess and motivational interviewing) as compared to the active control group.

Chess had been used in the rehabilitation of prisoners with advocates such as Portman (2017) offering practical guidance through his book “Chess Behind Bars” (Portman, 2017) and his successful program in Great Britain known as “Chess in

Prisons". He supported the idea that chess brought both pleasure and purpose to the life of inmates transforming their lives for the better. In addition, Moreno (2015), a school counselor from Maryland, USA used chess as an instrument for counseling new migrants focusing on improving social and emotional processes resulting in acculturation (Moreno, 2015).

Chess and Executive Functioning

There has been sparse research on using chess to improve executive functioning skills. Since this is the topic of my research, I will detail the few studies that have been done. Grau-Perez and Moreira (2017) researched the influence of chess on two executive functions (planning and cognitive flexibility) in childhood. Results pointed to improved planning and cognitive flexibility skills for the chess players as compared to the non-chess players. Planning was measured by the Tower of London test and Wisconsin Card Sorting Test was used to measure cognitive flexibility. Grau-Perez and Moreira asserted that these results rest on the framework that chess is a complex game which uses planning, monitoring, and adjusting one's course of action as needed. Therefore, these skills built through the game of chess can enhance executive functioning (Grau-Perez & Moreira, 2017). Researchers, Khosrorad et al. (2015) aimed to study the efficacy of chess practice for bolstering executive functions of students with mathematical learning disorders and reported significant pre-test and post-test differences in all executive functioning tests performed for those undergoing the intervention of chess practice as compared to those in the control group. They supported using chess for neurological interventions, education and treatment (Khosrorad et al., 2015). Another important area

that chess targets is the capacity to reason iteratively about potential intentional choices of an opponent thus building high levels of theory of mind [ToM] and empathy (Powell et al., 2017). Theory of Mind [ToM] is the ability to infer the intentions and beliefs of others in order to explain or predict behaviors. These aspects are definitely helpful in improved decision-making, which is one of the facets of executive functioning. In a study done on novice chess players by Powell et al. (2017), functional magnetic resonance imaging was used to identify cortical regions associated with chess, ToM, and empathizing. Blood-oxygenation-level dependent (BOLD) response for chess and empathizing task was extracted from each ToM region and results showed neural overlap between ToM, chess, and empathizing tasks in right-hemisphere tempero-parietal junction, left-hemisphere superior temporal gyrus and posterior cingulate gyrus (Powell et al., 2017). Researchers, Goncalves et al. (2014) tried to use chess as an intervention to help with executive functioning of cocaine-dependent patients. Cocaine- dependence is associated with neurobiological changes in the prefrontal cortex, impulsivity, and executive function deficits. Given the increasing prevalence of cocaine dependence in developing countries (Brazilian Psychiatry Association, 2012) together with a neurocognitive system that reinforces drug-related behaviors; any intervention focusing on rehabilitation of executive functioning in these individuals was warranted (Goncalves et al., 2014). They were successful in their efforts when chess combined with motivational interviewing led to an improvement in executive functioning skills as compared to just motivational interviewing. Similar improvements were made in the

executive functioning of schizophrenic patients in the realm of planning abilities and inhibitory control with the use of mere 10 hours of chess (Demily et al., 2009).

Conclusion

Even though there had been some research regarding chess and executive functioning, most of the research had focused on individuals with disabilities or co-existing issues (Demily et al., 2009; Goncalves et al., 2014; Khosrorad et al., 2015). Additionally, some of the existing research dealt with executive functioning capabilities in young children. My study aimed to target both pre-adolescents and adolescents. This is especially helpful since adolescence is a tumultuous period wherein there is great scope for growth in executive functioning (Lemberger et al., 2015). Therefore, it would be beneficial to investigate the use of chess as an intervention in a group that is vulnerable to external circumstances but one that has immense capacity to demonstrate growth. My study aimed to fill these gaps in research and provide a thorough understanding of the use of chess as an intervention to improve executive functioning in youth.

Chapter 3: Research Method

Introduction

The purpose of this quantitative study was to determine whether there are differences in the executive functioning of youth when the intervention of chess is used. This chapter will provide a detailed review of the research design and rationale, sample and sampling procedure, nature of the intervention, instrumentation and operationalization of the constructs, validity threats, and ethical procedures.

The independent variable in this study was the learning of chess over time. Chess is a two-person strategy/skill game and in my study was used an intervention. The three dependent variables in this study were the indices of executive functioning: decision making, working memory, and impulsivity. Because there is not one single instrument to measure executive functioning, different neuropsychological assessments are employed to get an understanding of executive functioning using its indices. Executive functioning may be defined as the capacity for cognitive and emotional response that is essential for goal-directed behavior and appropriate social conduct (Lemberger et al., 2015).

Research Design and Rationale

Research Design

The design that I used for the study was a single group pretest-posttest design with testing of measures done before and after 14 sessions of the chess intervention. Results were analyzed using the repeated measures *t* test, also known as the paired sample *t* test. This was a suitable method for the study because it quantified the effect of learning chess. Further, the design of single group pretest-posttest was very simple to

administer as well as analyze, and it gave one a quick, at-a-glance idea of how changes in executive functioning happen over time with the intervention of chess (Campbell & Stanley, 1963). Additionally, fewer participants were required because there was no need for a control group. This design also led to the control of the natural variation that occurs between subjects/individuals (Howell, 2009).

This design put a strain on the time needed to complete the research study because a period of 14 sessions was required for the intervention to take place. However, to advance true knowledge in this arena and for the results to reflect authentic effects, this type of research design was beneficial.

Research Questions and Hypotheses

Because I planned to study three different indices of executive functioning, there were three research questions along with corresponding null and alternative hypotheses.

First Research Question: Are there differences in the decision making of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention?

First Null Hypothesis (Ho): $\mu 1 = \mu 2$. There are no significant differences in the decision making of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

First Alternative Hypothesis (H1): $\mu 1 \neq \mu 2$. There are significant differences in the decision making of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Second Research Question: Are there differences in the working memory of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention?

Second Null Hypothesis (Ho): $\mu 1 = \mu 2$. There are no significant differences in the working memory of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Second Alternative Hypothesis (H1): $\mu 1 \neq \mu 2$. There are significant differences in the working memory of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Third Research Question: Are there differences in the impulsivity of youth who participate in the chess group intervention group intervention as measured before and after the 14-session chess intervention?

Third Null Hypothesis (Ho): $\mu 1 = \mu 2$. There are no significant differences in the impulsivity of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Third Alternative Hypothesis H1:$\mu 1 \neq \mu 2$. There are significant differences in the impulsivity of youth who participate in the chess group intervention as measured before and after the 14-session chess intervention.

Methodology

Population

The target population of this research study was students in beginner (unrated to 1200 USCF rating) chess groups at chess academies across the United States who were between the ages of 8 and 17 years old.

Sampling and Sampling Procedures

Convenience sampling was used for the study. This choice was made to facilitate the execution of the study because in convenience sampling, individuals who fit the criteria for a study are identified in any way possible (Emerson, 2015). Because of the COVID-19 pandemic, chess was taught in-person or through virtual platforms. The students ranged between the ages of 8 and 17 years old.

A total sample size of 41 was found to be appropriate using G Power sample size calculation. G Power is a data analysis tool for statistical power analyses from different tests that provides effect size calculators (Buchner et al., 2014). I chose an effect size of 0.40, an alpha of 0.05, and power of 0.80.

Procedures for Recruitment, Participation, and Data Collection

Prior to any data collection, I obtained the approval of the Institutional Review Board (IRB). I also obtained approval from chess academies across the nation that were willing to partner with me and/or distribute flyers so that I could recruit from their beginner chess groups. Informed consent was also obtained from the parent/guardian of each participating youth, and assent was obtained from the youth wherein they were made knowledgeable regarding the research process, purpose of the study, risks and

benefits, right to decline at any time, and confidentiality. In addition, I obtained permission from the appropriate sources to administer the assessments for the indices of executive functioning, explaining the purpose as a doctoral dissertation. The students and parents were also informed that the data obtained from the pretest and posttest measures would be deidentified.

I administered the pretests on the indices of executive functioning to the youth who had volunteered to participate in the research study. The study was open to all students in the beginner group of chess learning who were between the ages of 8 and 17 years old. The number of students to be recruited was 41. The intervention of chess was offered to the youth through chess academies that focused on teaching chess and allowed for play in person or virtually. Because of the COVID-19 pandemic, chess was taught either in-person or virtually through a Zoom/Skype platform, and Lichess or another chess server was used for playing games. The students were taught the principles of the game of chess and given a chance to practice/play what had been learned at every session. The instructors were active in making connections between the game of chess and problem solving in life. The students were encouraged to engage in chess puzzles as well as to play games/tournaments between sessions. At the end of 14 sessions, youth took the tests on the indices of executive functioning. Results were tabulated for each individual student as results at first time interval (T1) and results at second time interval (T2) and kept together. Results were analyzed using repeated measures *t* test also known as paired sample *t* test. The paired sample *t* test is a statistical procedure used to determine whether the mean difference between two sets of observations is zero. A total

sample size of 41 was found to be appropriate using G Power sample size calculation. I chose an effect size of 0.40, an alpha of 0.05, and power of 0.80.

Instrumentation and Operationalization of Constructs

Independent variable: The learning of chess.

Dependent variables: Decision making, working memory, and impulsivity

Decision making: Defined as the cognitive process by which a preferred option or a course of actions is chosen from amongst a set of alternatives based on certain criteria (Wang & Ruhe, 2007). It is measured using the Iowa Gambling Task (IGT; Bechara et al.,1994). The IGT was originally developed to examine the decision-making capacities in a variety of populations. It is widely used in research on cognition and emotion. The test itself features a gambling task resembling real-world situations with rewards and penalties (winning and losing of money) creating a conflict between immediate reward and delayed punishment. The task engages the participant to make advantageous choices without pinpointing them. The IGT2 version was used for this study. It is a computerized assessment and can be used for ages 8 through 79 years. It takes 5– 10 minutes to complete this assessment. Test-retest reliability of the instrument was found to be in the range of 0.35 to 0.65 when administered several weeks apart. There was great interscorer agreement.

Working memory: Defined as the retention of a small amount of information in a readily accessible form that facilitates planning, comprehension, and problem solving (Cowan, 2014). It is measured using an online tool for the Digital Span Backward test (Wechsler, 1997). This test requires the student to recall a sequence of digits in reverse

order that has been given both visually and orally. Digit sequences start from two numbers, and sequences are increased when the student completes at least one of the two trials of the same length correctly. The test is completed when the student fails both trials of the same length. The score is obtained from the number correctly recalled. The tool is set up so that digits are said at the rate of 1 digit about every 1 second; a monotonic voice is used; and digits are not repeated once a span is read. This test takes about 10 minutes to complete. The internal reliability of the test is in the range of 0.70 to 0.90; the test-retest reliability is between 0.50 and 0.70 (Conway et al., 2005). Further, the test has excellent construct validity.

Impulsivity: May be defined as characterized by unplanned risky behaviors and making up one's mind quickly (Eysenck, 1993). The Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995), a 30-item self-report instrument, is usually used to measure impulsivity. In this study, the BIS-Brief (Steinberg et al., 2013) was used, which is a shorter, unidimensional version of the instrument. The shorter version has only eight items of the BIS-11 instrument, reducing participant burden plus omitting items related to activities not typically encountered in adolescence. These items are rated on a Likert scale from 1 = *rarely/never* to 4 = *almost always/always.* Items on the BIS-Brief included "I plan tasks carefully, I concentrate easily." The test takes about 5 minutes to complete. The reliability or internal consistency coefficient for this scale was 0.78, and both construct and concurrent validity were demonstrated (Reise et al., 2013).

Data Analysis Plan

Statistical Package for the Social Sciences (SPSS) Statistics 21 was used as the data analysis tool to screen and clean the data for this research study. As previously mentioned, paired *t* test was the test performed. All relevant data were transported into SPSS, and SPSS ran the analysis. The results were then interpreted corresponding to the hypotheses.

Threats to Validity

Some internal validity threats that were associated with my research design were history threat, maturation threat, and regression threat (Campbell & Stanley, 1963). *History threat* refers to events outside the research study that may influence the subject's responses. *Maturation threat* refers to the idea that subjects may change during the course of the research not due to specific external events, but due to changes in biological and psychological processes such as growing older, growing hungrier, growing more tired, and so forth. *Regression threat* refers to the idea that when subjects are tested several times, their scores are likely to regress toward the mean (Campbell & Stanley, 1963). Another limitation called the *testing effect* comes in the form of practice and fatigue/boredom, all of which can lead to skewed results (Howell, 2009). Instrumentation or "instrument decay" is another threat, which may come in the form of the students being more test savvy by having been exposed to such testing previously (Campbell & Stanley, 1963).

Other threats include that the recruited group was self-selected; this may influence the participants of the group. Furthermore, different scholastic chess academies may

attract specific substrata of the population even though they are all youth. Some additional challenges were that some youth may have had greater opportunities to play and practice chess with others during the intervention period. Additionally, others might not have found chess as interesting as they thought they would, and yet others might have found it too challenging and/or complex. This could lead them to drop out of chess lessons and/or the research study constituting a *mortality threat.*

Ethical Procedures

The biggest step regarding ethical procedures involved obtaining IRB approval from Walden University. Because the population that I was studying is considered vulnerable (youth/adolescents), this was even more critical. Further, informed consent had to be obtained from the parent/guardian of each participating youth, along with assent from the student. In the informed consent, knowledge was disseminated regarding the research process, purpose, risks and benefits, right to decline at any time, and confidentiality.

Some ethical concerns regarding recruitment of participants involved how participants were recruited and ensuring that there was no coercion. A plan to address this issue involved clearly stating that there would be no differences in how the student would be "treated" at the chess academy. In fact, the chess academy or instructor was not made cognizant of the student's participation in the research study.

Data were collected and scored for all students at two prefixed time intervals. I deidentified the data while also keeping scores for each student at the different time intervals together. Only I had access to the data. Further, I took the steps necessary to

educate myself so as to conduct the assessments in a knowledgeable, efficient, and skilled manner. The instructors, parents, students, teachers, and school administrators did not have any access to the data themselves. All research data and signed consent forms were stored and planned to be kept in a safe place for 5 years before being shredded.

Summary

This chapter described the design used to carry forth the research study along with its rationale. It also provided an in-depth look at the methods employed. Research questions and hypotheses were stated. Operational definitions of the constructs as well as details regarding the tests/assessments performed were provided. Further, caveats and concerns were discussed along with ethical considerations. In the next chapter, I will discuss the results of the research study.

Chapter 4: Results

The purpose of this quantitative, single group pretest-posttest design study was to determine whether there were differences in executive functioning potential in youth when the intervention of chess was used. In particular, three indices of executive functioning were investigated — decision making, working memory, and impulsivity. The research questions were as follows:

- Are there differences in the decision making of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention?
- Are there differences in the working memory of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention?
- Are there differences in the impulsivity of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention?

In this chapter, I present the results of the study and review the data collection procedures. Characteristics of the final sample obtained are discussed, along with any assumptions of the statistical test performed as a foundation for the results obtained. The results are discussed in depth along with their relationships to the hypotheses. Tables and figures are used to illustrate results as needed.

Data Collection

IRB approval was obtained on October 21, 2020. The entire process of data collection took 7 months. The time period of data collection was prolonged because recruitment was staggered, plus there was a time interval between preassessment and postassessment. Due to COVID issues, the study changed a lot in nature. The population focus had to be changed from economically disadvantaged youth to all youth. More than one chess academy was partnered with to achieve the number of recruits needed. There was an alternate pathway created for data collection because the initial pathway involved "more work" from the agency, which included tracking and reporting chess attendance. Pathway B allowed for partnership with chess organizations or agencies whose sole task was the distribution of flyers. A total number of 46 participants were recruited. Seven participants dropped out of the study and only completed the preassessment. Some of the reasons cited were noncompletion of the chess lessons requirement due to change in family circumstances, academic pressure, loss of interest, and so forth. Therefore, the results were obtained from 39 participants. This was just a little short of the desired number of 41, as calculated by G Power in Chapter 3.

All assessments were carried out as planned in Chapter 3 following both parent and child consent. The student and parent were made responsible for tracking the number of chess lessons and reaching out to me as they reached the required number of 14 chess lessons. Reminder emails were sent as needed. The online tool for Digit Span Backward test experienced some glitches in the "testing phase" with family and friends. Therefore, I

conducted this assessment myself (without the online tool) using the guidelines from the Digit Span Backward test (Wechsler, 1997).

Results

Descriptive Statistics

The participants were restricted to the beginner groups (rating under 1200 USCF) taking chess lessons through chess organizations/agencies/coaches. They could be anywhere between the ages of 8 and 17 years and either male or female. The demographic information presented in Figure 1 includes a sample population of 32 males (82.1%) and seven females (17.9%). The largest number of participants came from the state of Texas (n = 29, 74.4%), and the rest were residents of New York, California, Kansas, Massachusetts, North Carolina, South Carolina, and Pennsylvania (Figure 2). The biggest representation (as illustrated in Figure 3) was from elementary school children (n = 25, 64.1%), followed by middle school children (n = 10, 25.6%) and then high school children (n = 4, 10.3%). The SES index score of each participant was calculated using the mean of mother and father's SES index scores (as derived from Duncan's socioeconomic index, 1950). The mean SES score was 83.90, and the median was 89.25. The standard deviation was 7.60.

Figure 1

Gender Distribution

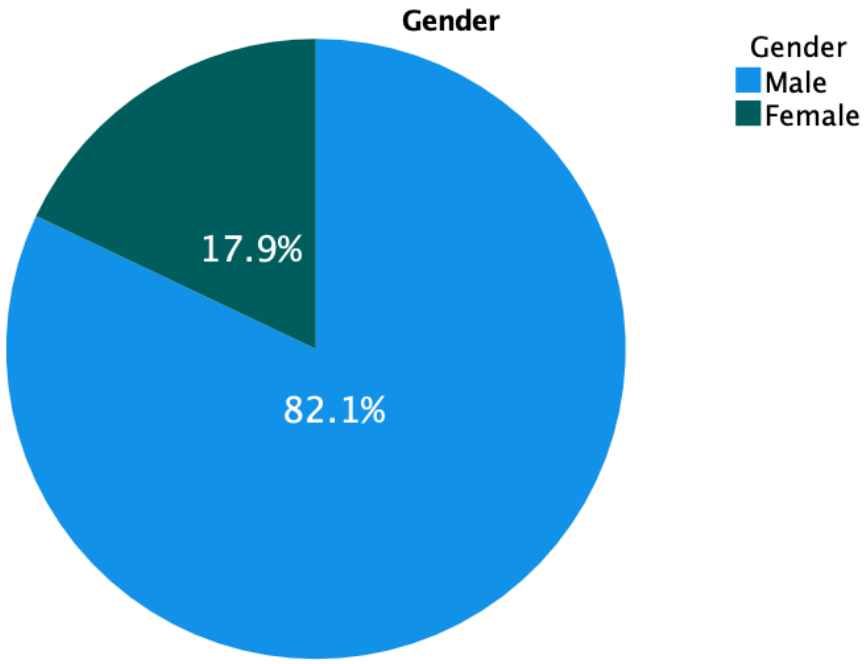


Figure 2

Geographical Distribution

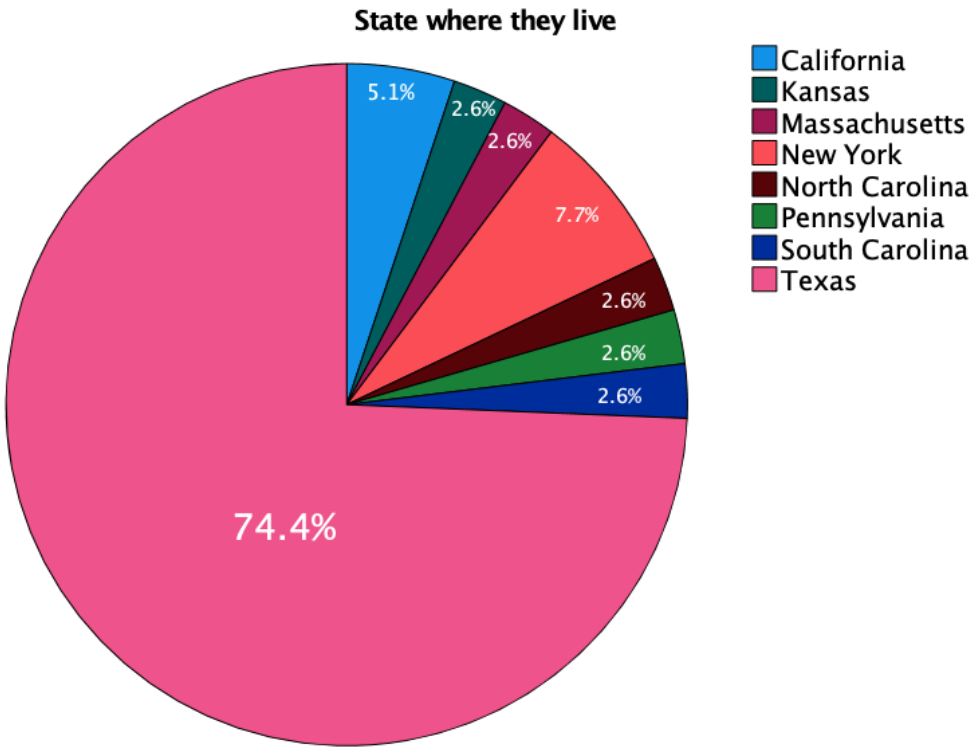
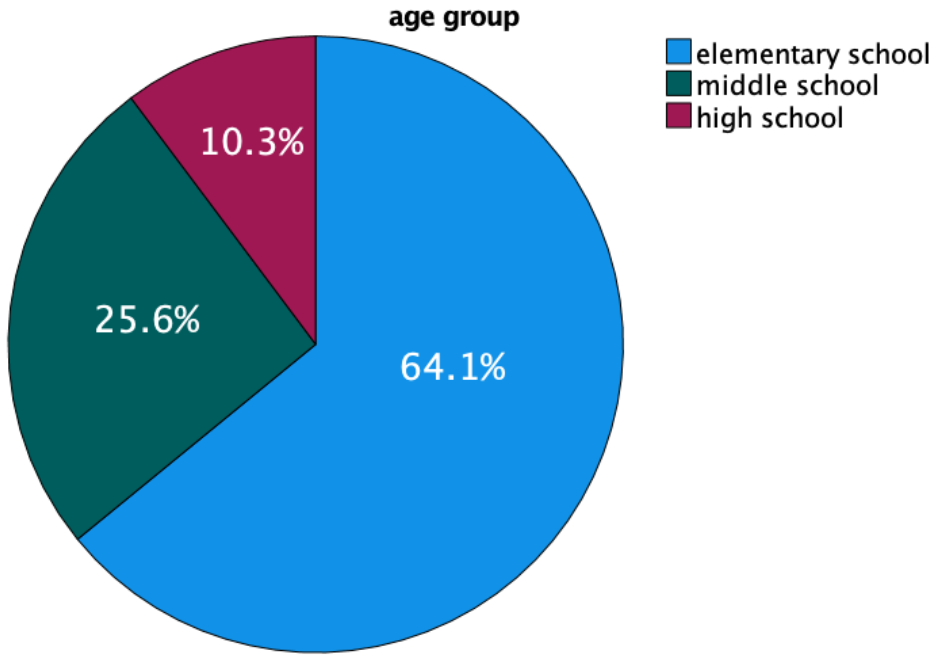


Figure 3

Age Distribution



Assumptions

There are several assumptions related to paired sample *t* test. The first assumption includes having continuous dependent variables. This assumption works because the dependent variables in this study are measured by scores on decision making, working memory, and impulsivity. The second assumption involves the independent variable being categorical (learning of chess over time) for two related groups. Herein, the first related group consisted of participants at the beginning of chess training, and the second related group consisted of the same participants after 14 sessions of chess training. The third assumption is that there are no significant outliers in the differences between the two related groups. The fourth assumption is that the distribution of the differences of the

dependent variable between the two selected groups is approximately normally distributed. The third and fourth assumptions were tested for each variable.

For decision making, one outlier was detected that was more than 1.5 box-lengths from the edge of the box in a boxplot. Inspection of its value did not reveal it to be extreme, and it was kept in the analysis. Further, the paired *t* test was carried out with removing the outlier to ensure that the results were still statistically significant. This was found to be the case. The difference between pre decision making scores and post decision making scores was normally distributed as assessed by Shapiro-Wilk's test (p = .179).

For working memory, three outliers were detected that were more than 1.5 box-lengths from the edge of the box in a boxplot. To ensure that these outliers did not affect the results unduly, the paired *t* test was carried out with removal of the outliers also. It was found that the results were still statistically significant. Additionally, the difference between pre working memory scores and post working memory scores (after removing the outliers) was normally distributed as assessed by visual inspection of a normal Q-Q plot.

For impulsivity, there were no outliers in the data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box. The difference between pre impulsivity scores and post impulsivity scores were normally distributed as assessed by Shapiro-Wilk's test (p = .239).

A paired-samples *t* test (Table 1 and Table 2) was used to determine whether there was a statistically significant mean difference between the decision making of youth who

participated in the chess group intervention as measured before and after the 14-session chess intervention. Participants obtained higher scores on decision making after the chess group intervention (M = - 247.31, SD = 1735.82) as opposed to before (M = -1183.33, SD = 1281.15), a statistically significant mean increase of 936.03, 95% CI [373.62, 1498.43], $t(38) = 3.37$, $p = .002$, $d = 0.54$. Therefore, the null hypothesis was rejected, and the alternative hypothesis was accepted. It was found that there were significant positive differences in the decision making of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention.

A paired sample t test was repeated with removing the outlier to ensure that it did not have an undue effect on the results obtained. It was found that the results were still statistically significant, with there being a statistically significant mean increase of 818.16, 95% CI [294.83, 1341.48], $t(37) = 3.17$, $p = .003$, $d = 0.51$. On looking at the Cohen's d, both with and without the outlier, one can see that there is a moderate effect size or practical significance with Cohen's d being close to 0.5.

A paired sample t test (Table 1 and Table 2) was used to determine whether there was a statistically significant mean difference between the working memory of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention. Participants obtained higher scores on working memory after the chess group intervention (M = 9.15, SD = 5.02) as opposed to before (M = 7.21, SD = 3.54), a statistically significant mean increase of 1.95, 95% CI [.71, 3.19], $t(38) = 3.18$, $p = .003$, $d = 0.51$. Therefore, the null hypothesis was rejected, and the alternative hypothesis was accepted. It was found that there were significant positive differences in

the working memory of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention.

A paired sample *t* test was repeated with removing the three outliers to ensure that they did not have an undue effect on the results obtained. It was found that the results were still statistically significant, with there being a statistically significant mean increase of 1.64, 95% CI [1.10, 2.18], $t(35) = 6.19$, $p < .001$, $d = 1.03$. On looking at the Cohen's *d*, with the outliers present, there is a moderate effect size or practical significance with Cohen's *d* being close to 0.5. On assessing with the outliers removed, this effect size or practical significance becomes large because *d* is greater than 0.8.

A paired sample *t* test (Table 1 and Table 2) was used to determine whether there was a statistically significant mean difference between the impulsivity of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention. Participants obtained lower scores on impulsivity after the chess group intervention ($M = 15.10$, $SD = 4.23$) as opposed to before ($M = 15.82$, $SD = 3.99$), a non-statistically significant mean decrease of -.72, 95% CI [-1.62, 1.8], $t(38) = -1.62$, $p = .114$, $d = -0.26$. Therefore, I failed to reject the null hypothesis. It was found that there were differences in the impulsivity of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention, but these differences were not statistically significant.

Table 1

Paired Samples Statistics

	Variable pairs	Mean	*n*	Std. deviation	Std. error mean
Pair 1	Post IGT2 (decision making)	-247.31	39	1735.82	277.95
	Pre IGT2 (decision making)	-1183.33	39	1281.15	205.15
Pair 2	Post DSB (working memory)	9.15	39	5.02	.80
	Pre DSB (working memory)	7.21	39	3.54	.57
Pair 3	Post BIS (impulsivity)	15.10	39	4.27	.68
	Pre BIS (impulsivity)	15.82	39	3.99	.64

Table 2

Paired Samples Test

Variable pairs	Mean	Std. deviation	Std. error mean	95% confidence interval of the difference Lower	Upper	*t*	*df*	Sig. (2-tailed)
Post IGT2-Pre IGT2	936.03	1734.94	277.81	373.62	1498.43	-3.37	38	0.002
Post DSB-Pre DSB	1.95	3.83	0.61	0.71	3.19	-3.18	38	0.003
Post BIS-Pre BIS	-0.72	2.77	0.44	-1.62	.18	1.62	38	0.114

Summary

I tested the hypotheses for each research question using a paired sample *t* test analysis. It was found that there was a significant positive difference in both the decision making and working memory of youth who participated in the chess group intervention as measured before and after the 14-session chess intervention. Although there was no significant difference, a practical difference was found in lowered impulsivity of the youth who participated in the chess group intervention as measured before and after the 14-session chess intervention. In conclusion, out of the three indices of executive functioning researched, decision making and working memory had a statistically significant difference when chess was used as an intervention, while impulsivity was not significant. In Chapter 5, I will discuss the details and intricacies of the results along with any limitations. Further, these will be situated within the literature and theoretical framework. Recommendations will be made for future studies.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this quantitative, single group pretest-posttest design study was to determine whether there were differences in executive functioning potential when the intervention of chess was used. In particular, three indices of executive functioning were investigated — decision making, working memory, and impulsivity. This study was conducted specifically because even though a lot of different modalities had been tried to improve executive functioning, there had been no research done on the use of chess as an intervention. Executive functioning has a broad reach and serves as a predictor for various life outcomes such as academic achievement, SES, and physical health (Karbach & Unger, 2014).

I examined three indices of executive functioning through three different research questions. I found that there was a statistically significant difference in the decision making of those youth who participated in the chess group intervention as measured before and after the 14-session chess intervention with an improvement in decision making after the intervention. The results also revealed that there was a statistically significant difference in the working memory of those youth who participated in the chess group intervention as measured before and after the 14-session chess intervention, with working memory being greater after the chess intervention. Finally, there was a difference in the impulsivity of those youth who participated in the chess group intervention as measured before and after the 14-session chess intervention, but this difference was not statistically significant. From these specific findings, it may be

inferred that the learning of chess influenced the executive functioning potential of the youth who participated in the 14-session chess intervention.

Interpretation of the Findings

These findings are in agreement with previous research wherein it was found that playing cognitively demanding games had positive effects on executive functioning (Parong et al., 2017; Ramos et al., 2019). Ortiz-Pulido et al. (2019) used functional mRIs to study the brain activity of chess players, and it was found that the brain regions that are activated during the analysis of chess game positions are premotor areas, frontal lobes, parietal lobes, occipital lobe, and the left hemisphere of the cerebellum (Ortiz-Pulido et al., 2019). Other researchers (Hanggi et al., 2014; Li et al., 2015) also confirmed the changes in the actual structure and physiology of the brain of the chess player. The findings of this research study seem to concur with the previous research in that it was observed that executive functioning was improved after the chess intervention. This alludes to changes that must have occurred in the brain due to the learning of chess.

The results of this research study specifically indicated a positive and statistically significant increase in decision making for those youth who participated in the chess group intervention as measured before and after the 14-session chess intervention. This seems to confirm previous findings in the literature. Grau-Perez and Moreira (2017) researched the executive functions of planning and cognitive flexibility in childhood and reported improved planning and cognitive flexibility skills for chess players as compared to non-chess players. Demily et al. (2009) demonstrated improvement in voluntary processing, inhibitory capacity, and planning abilities through using chess to restore

cognitive functions for schizophrenic patients. These are all elements involved in decision making—planning, cognitive flexibility, and inhibitory capacity. Decision making involves figuring out which course of action is better than another using planning, goal creation and maintenance, and being able to change course of action as needed (Franklin et al., 2020). Therefore, it makes sense that when these abilities are improved through chess, decision making is better. Having said that, decision-making lies at the core of pre-adolescent and adolescent life, with decisions to be made at every junction—classes to pick, extracurricular activities to join, friends to make, what risky ventures to engage in, whom to be. The onset of this period of adolescence has been stretched due to the occurrence of early puberty in nearly all populations, thus having the preadolescent period also beset with similar issues as adolescence (Sawyer et al., 2018). Therefore, it is clear that any intervention or activity that improves decision making in youth should be prized.

The results of this research study specifically indicated a positive and statistically significant increase in working memory for those youth who participated in the chess group intervention as measured before and after the 14-session chess intervention. This seems to be in line with previous research where expert chess players showed better auditory memory function as compared to non-chess players (Fattahi et al., 2015); auditory-verbal memory is a component of working memory that involves auditory reception of verbally presented information. In fact, the Digit Span Backward assessment used for this research study specifically measures auditory-verbal working memory as numbers are verbally presented and have to be recalled backward. The importance of

working memory cannot be highlighted enough. It is where information is stored temporarily and can be actively manipulated to perform cognitive operations (Spencer, 2020). Working memory changes dramatically over the course of development and is one of the last of the higher order cognitive functions to mature (Embury et al., 2019); therefore, any intervention that affects working memory is worthy of attention.

The results of this research study specifically indicated no significant difference, although a practical difference was found in the lowered impulsivity of those youth who participated in the chess group intervention as measured before and after the 14-session chess intervention. I think that if the period between preassessment and postassessment had been longer in my research study, the difference in impulsivity scores would have been statistically significant. Impulsivity is a slower trait to change, with many scholars arguing that it is a relatively stable trait (Doran & Trim, 2013). In addition, MacKillop et al. (2016) commented on the multidimensional nature of impulsivity reflecting the three broad categories of impulsive choice, impulsive action, and impulsive personality traits. The one measured by the Barratt Impulsiveness Scale—Brief, the assessment tool used for this research study, focuses on the personality traits. It could be that the other components of impulsivity might have shown a more significant change. Researchers Shahar and Avital (2020), in their research on chess play, attention deficit disorder, and impulsivity, found that chess players, in general, are less impulsive than non-chess players. I believe that some of these effects on impulsivity would have been borne out in my research study if the period between preassessment and postassessment had been slightly longer.

The findings of this research study not only confirm findings from previous literature, but also extend knowledge in the realm of executive functioning. There was much less research in the sphere of using chess as an intervention to improve executive functioning, and the sparse research that existed focused on young children and individuals with disabilities or coexisting issues (Demily et al., 2009; Goncalves et al., 2014; Khosrorad et al., 2015). My study targeted both preadolescents and adolescents. Preadolescence and adolescence are not only times when critical decisions are made, but also periods of tremendous scope in the growth of executive functioning potential (Lemberger et al., 2015; Thiers et al., 2014). This is when children decide whether to continue schooling, which friends to make, what career choices to pursue, and whether to engage in alcohol/drug use and other risky endeavors. Imagine being able to change the trajectory of all these decisions with the introduction of one single game in the formative years. In addition, youth represent one of the most vulnerable groups in society (Campos-Gil et al., 2020). They have much less control over the microsystems that they inhabit, such as housing, family dynamics, and the school environment. Campos-Gil et al. (2020) further pointed to lowered executive functioning with poorer environmental quality and stress levels. Therefore, it seems even more pertinent to help this vulnerable group of society by providing accessible modalities for improving executive functioning.

For this study, I used Jean Piaget's (1936) theory of cognitive development. According to this theory, humans are not passive receivers of information; they make connections and adjust as they go through different environmental experiences and biological maturation. Piaget's theory of cognitive development introduces the concept of

"schemas" or the building blocks of knowledge. It is said that once schemas are constructed, they become automatic (Kuldas et al., 2015). This seemed to be exhibited in my research, as when the schemas of decision making, working memory, and controlling impulsivity are learned through being engaged in chess, they become easy to use in daily life because they have been assimilated. This explains the increase in decision making and working memory shown in the results as well as the lowering of impulsivity. These constructs are extremely inherent in the learning of chess, where one has to think before one moves, one has to plan many moves ahead, one has to develop memory for opening repertoires, one has to be patient in not making a move impulsively, and so on. These lessons are learned repeatedly when the game of chess is played. Therefore, these constructs get ingrained as schemas and then can be applied in the rest of life. In addition, Piaget's theory advances the concept of readiness, which proposes that one should not be taught certain concepts until one is in the appropriate developmental stage. This was borne out in the study because all participants were voluntary, and the participants included in the sample were 8 years old and above. The other element that Piaget's theory of cognitive development stresses is discovery learning or the idea that most is learned through doing and exploring. In my study, chess was taught through both lecture and play in all the partner organizations from which recruits were obtained.

Limitations of the Study

As with any research study, there were limitations. Some of these limitations arose due to the COVID pandemic. Initially, it was proposed that all recruits would be obtained from a chess club at a particular middle school. Because of COVID and shutting

down of schools, I had to partner with more than one chess agency/organization in order to obtain the necessary number of recruits. This was an instrumentation threat because each organization had its own chess instructors who had their own way of teaching chess. Besides, the differences in content taught and stylistic issues could change what has been received in terms of "learning chess." In addition, the sample obtained allowed for a wide age range of students from 8 to 17 years. This covers a wide developmental span and could present as an issue with one age group possibly being affected in different ways than another. However, with some of the numbers being so low in each age group (elementary, middle, and high), a stratification of results was not attempted because it would not have been a fair representation of each age group. Another issue was the low numbers of females (17.9 %) obtained in the sample. Having said that, this statistic is representative of the number of females in chess (15.6%) as compared to males who participate in chess (International Chess Federation). Furthermore, most of the participants belonged to the state of Texas (74.4%). These sample constraints constituted the boundaries of my study and may have influenced its generalizability. Having said that, it was beyond the scope of my study to investigate the other factors mentioned.

Another limitation was the dropout rate of participants from the research study. As mentioned in Chapter 3, this constituted a mortality threat. Many participants may have experienced a change in external issues (family, work, technology) or have found chess too complex or not enjoyable. Seven out of 46 participants who completed the preassessments dropped out, making the final sample size 39. On studying the people who dropped out, one observes that two out of seven of these participants were high

school students. High school students, in general, have numerous demands on their time and do not have the "parental push" to complete a study. Further, when comparing their impulsivity scores, I noticed that the preassessment impulsivity score as measured by the BIS scale of those who dropped out was higher (M = 16.88, SD = 2.42) as compared to those who completed the study (M = 15.82, SD = 4.04). It seems feasible to conjecture that these participants who dropped out joined the study "somewhat impulsively."

Some other limitations came in the form of assumptions of the study wherein it was assumed that the participants had the cognitive and language resources to understand chess as well as the assessment instruments. Additionally, it was assumed that they were interested in the game and given opportunities to practice/play. In addition, a factor to be considered is that it was assumed that in the self-report assessment of impulsiveness, the participants gave a truthful response.

Besides these, there are inherent issues with the single group pretest-posttest design that need to be kept in mind as limitations. One of them is the practice or fatigue/boredom effect on repeated measurement, which could lead to skewed results at the posttest (Howell, 2009). This was my experience with a couple of participants when it was clear that they felt unmotivated to try their best on an assessment. Another limitation of this design is the failure to control history. It was obvious in this research study that the participants were exposed to many stimuli before and during the chess intervention (Campbell & Stanley, 1963). Related to this is the issue of maturation, which includes changes in biological and psychological processes over time such as growing older, growing hungrier, and so on. Last, but not least, this design poses the limitation of

"instrument decay" and statistical regression toward the mean (Campbell & Stanley, 1963).

Recommendations

I have numerous recommendations for further research in the realm of chess and executive functioning. Some of these are grounded in the limitations of this study and include recruiting participants who receive training from the same chess agency/organization, and if possible, receive instruction from the same chess instructor or instructors who teach with the same curriculum/philosophy. This would significantly reduce instrumentation threat. Another idea revolves around overcoming some of the limitations of the one-group pretest-posttest design and having some participants undergo chess as an intervention while others undergo another extracurricular activity such as robotics and yet others receive no intervention. This would help in overcoming some of the inherent flaws of the one group pretest-posttest design. Some other ideas are with regard to differences that may arise in specific populations: economically disadvantaged youth versus all youth, beginners in chess as compared to intermediate or advanced groups, females versus males, and different age groups. To know where the impact is most would be extremely beneficial in future planning for interventions. Another idea is to include other indices of executive functioning in the assessments such as cognitive flexibility, inhibitory control, and so on.

A mixed-methods study might be fascinating too wherein parents of youth, teachers, and so forth are interviewed regarding changes in executive functioning. The rich data obtained would be beneficial in supplementing "hard facts" and would provide

characterization to the changes that occur in individuals when they engage in chess. As discussed in the literature review, Romanova et al. (2018) iterated how chess should be used as a therapeutic as well as rehabilitative tool, highlighting its unique abilities to bolster consecutive thinking, logical methods, imaginative and operational memory, internal plan of action, and reflection.

Implications

This study was undertaken to determine whether chess could be used as an intervention to improve executive functioning in youth. The specific indices studied were decision making, working memory, and impulsivity. It was found that chess training had a positive and statistically significant effect on both decision making and working memory. There was an effect on impulsivity in the desired direction, but this difference was not statistically significant. These outcomes definitely point to the fact that chess may be used as an effective intervention to improve executive functioning among youth. The implications of this are numerous because executive functioning is the cornerstone for performance in many spheres such as academics, the workplace, SES, and health status (both mental and physical health). To be able to influence the trajectory of the development of executive functioning at a critical time period of development and in a vulnerable population seems priceless (Karbach & Unger, 2014; Rosen et al., 2019).

Furthermore, chess is an activity that is easy to learn, accessible, and pleasurable to engage in with relatively low cost. This might make it superior to some other modalities such as specific computer programming, music training, and so on to improve executive functioning. Besides the positive effects of improved executive functioning

showing up in cognitive benefits, one can witness the reduction in youth externalizing behaviors such as aggression, delinquency, and heavy risk-taking (Modecki et al., 2017) when executive functioning is improved. This would be helpful not only to the youth themselves, but also to parents, educators, criminologists, and researchers who have been dealing painstakingly with the multiple co-occurring issues that youth may face (Burton et al., 2016; Machell et al., 2016).

My recommendations would be that chess be integrated into the curriculum at schools. This has been done in some countries such as Armenia. Some schools provide chess as an after-school activity, but I would go a step further by integrating chess into the curriculum at schools. Despite the numerous advantages that chess has that have been previously researched and highlighted (academic achievement, self-confidence, self-efficacy, better adjustment with school, more coping skills, increased problem-solving capacity, improvement in attention); the fact that chess can improve the trajectory of executive functioning in youth lends to chess being incorporated into the daily life of youth. I would also advance the idea of educating parents, school administrators, and chess instructors on the benefits of chess and the far-reaching consequences of executive functioning since this would be pertinent in making these changes happen. Finally, I would recommend that chess be introduced in programs that serve the youth such as Boys and Girls Club, homeless family shelters, foster homes, etc.

Conclusion

The purpose of this quantitative, single group pretest-posttest design study was to determine if there were changes in the executive functioning potential of youth when the

intervention of chess was used. The focus was on three indices of executive functioning: decision-making, working memory, and impulsivity. This study found that chess had a positive and statistically significant effect on both decision-making and working memory. It altered impulsivity (lowered it) even though this difference was not statistically significant. All this points to chess being an effective intervention in improving executive functioning in youth. Youth represent a vulnerable group of society (Campos-Gil et al., 2020). Additionally, youth are faced with numerous critical decisions that can change the trajectory of their lives (Thiers, 2014). Executive functioning serves as a predictor for success in many arenas such as academic achievement, SES, mental and physical health facets (Karbach & Unger, 2014; Rosen et al., 2019). In addition, executive functioning helps lower aggression, delinquency, and risky decision-making (Modecki et al., 2017). Given all these factors, I would strongly advocate for chess being pushed as an effective intervention to improve the present and future lives of youth.

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