CHESS PRACTICE AND EXECUTIVE FUNCTIONING IN A POST-SECONDARY STUDENT DIAGNOSED WITH ADHD: A SINGLE CASE STUDY

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By

Douglas Nechio

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ABSTRACT

This single-case study explored how the influence of chess practice on working memory and other executive functions was perceived by an adult diagnosed with attention deficit hyperactivity disorder (ADHD). Cognitive science has used chess in the study of memory, concentration, attention and expertise (Charness, 1992; Gobet, 1998). The game of chess has also been used in clinical and educational contexts both to enhance cognitive abilities and to change academic outcomes (Hong, 2005). The chess program I designed consisted of a weekly, one hour chess practice for ten weeks during which the participant solved chess puzzles. The selected participant underwent a semi-structured interview pre- and post- the chess intervention and answered the Barkley Adult ADHD Rating Scale (BAARS-IV) and the Barkley Deficit in Executive Function Scale (BDEFS) at the beginning and end of the chess program. Furthermore, the participant answered opened-ended questions about her perceptions of the effects of the chess program after each of eight training sessions. Thematic analysis was performed in an inductive search for general descriptors within the data. The chess training intervention resulted in the participant's perception of an overall decrease in ADHD symptoms, especially inattentiveness, and improvement in working memory and other executive functions. Implications for further research and practice are identified.

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Chapter 1: Introduction

I am profoundly intrigued by the extent to which chess practice can improve executive functions, especially working memory. This study explored how the effectiveness of chess problem-solving on working memory and executive functions was perceived by a female university student diagnosed with attention deficit hyperactivity disorder, inattentive type (ADHD). This line of inquiry was guided by the following research questions:

1. Is solving chess puzzles perceived as a contributing factor to the improvement of working memory of an adult diagnosed with ADHD?

2. Can solving chess puzzles be an effective intervention to improve executive functions of an adult diagnosed with ADHD?

3. Does the self-perception of an adult diagnosed with ADHD on her inattentiveness, impulsiveness and hyperactive behaviors change with chess practice?

Attention deficit hyperactivity disorder is among the most commonly diagnosed neurodevelopmental disorders in North America. The number of children affected by ADHD has grown over the last two decades in several countries outside North America including Germany, Australia and Brazil (Spencer, Biederman & Mick, 2007). The authors of the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association [APA], 2013) have changed the age threshold for the onset of childhood symptoms of ADHD increasing the numbers of people who have been and will be identified as having ADHD, especially adolescents and young adults (Voort, He, Jameson & Merikangas, 2014).

The DSM-5 (APA, 2013) defines ADHD as a neurodevelopmental disorder characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity that negatively affects a person's development and functions including, but not limited to, the capacity to perform daily

life activities and sustain attention. According to the new DSM-5 criterion, the onset of symptoms is experienced at or prior to 12 years of age.

Attention deficit hyperactivity disorder in North America is estimated to affect 5-10 % of school-age children, and 5% of adults (Faraone, 2007), a number that urges professional attention to the current array of available treatments (Kiely & Adesman, 2015). Even though research on the effectiveness of pharmacological intervention is in progress, many non-pharmacological treatments for ADHD have yet to be explored (Biederman & Spencer, 2000).

The few studies which have researched the effects of chess practice on university students diagnosed with ADHD have suggested that the game represents a viable intervention for ADHD and other disorders. Chess has been used to improve cognitive deficits of people diagnosed with schizophrenia and Alzheimer's. Some of these same cognitive deficits are present in the cognitive profiles of people diagnosed with ADHD (Demily, Cavézian, Desmurget, Berquand-Merle, Chambon & Franck, 2008). Additionally, recent studies have shown that chess practice has the potential to improve executive functions including organization, time management, planning and concentration (Scholz, 2008). Moreover, chess practice has been successfully used as a protective factor against both degenerative neurological illnesses (Morley, 2011) and educational failures (Hong, 2005).

Furthermore, for decades, cognitive science has benefited from chess research in testing human memory, problem-solving skills and expertise, even though chess has never become a mainstream intervention within this field (Charness, 1992; Gobet, 1998). In fact, Alfred Binet was one of the first psychologists to study memory using chess. He found that chess practice could favour memory recall, improving both one's memory and chess performance (Binet, 1966).

Therefore, rather than a novelty, the use of chess in the treatment of ADHD symptoms can be considered an application of its already known therapeutic effects on human cognition. The unique contribution of this project is that it explored an adult's perceptions of the efficacy of chess as an intervention for either ADHD symptoms or executive function enhancement. This type of research has not been conducted in Canada over the last few years. However, the knowledge about efficacy of intervention to ADHD with adults is paramount because the number of adults diagnosed with this disorder, as aforementioned, has increased but there are fewer studies on ADHD in adults than there are on ADHD in children (Voort et al., 2014).

Many university students experience symptoms of ADHD and struggle both socially and academically. For example, a pilot study exploring the working memory capacity of college students found that the overall grades of students diagnosed with ADHD were lower than their peers (Grooper & Tannock, 2009). The number of students failing their classes and dropping out of school or who have general academic problems was also higher among the ADHD group.

There already exist institutional recommendations and accommodations available for university students through university disability services that aim to remediate issues caused by ADHD. However, as Barkley (2008) claimed, multiple interventions can help students overcome the barriers put forth by ADHD. An advantage of chess practice over several other interventions is that it has been historically associated with intelligence, not with mental illness or any type of psychiatric disorder (McLeod & Gobet, 2007). Because of this, I believe chess could be a suitable intervention in academic settings where the construct of intelligence is generally valued and facilitating student success is increasingly important.

Additionally, chess as an intervention for ADHD may decrease the risk of social stigma, which is often associated with psychiatric or psychological diagnoses, because chess can be

recommended for any person, and not only for medical or psychology patients (Hansan, Burgouis & Drucker, 2014). In an educational setting, avoiding the potential stigma related to a psychiatric diagnosis is critical as it affects both students' self-esteem and educational outcomes (Hunt, Eisenberg & Kilbourne, 2010).

Theoretical Underpinnings

During this study our understanding of cognitive abilities, intelligence and executive function is guided by the Cattell-Horn-Carroll theory (CHC). Cross-Battery assessment approach (XBA), is typically used to measure executive functions and cognitive abilities. The XBA approach was introduced by Flanagan, Ortiz and McGrew (Flanagan & McGrew, 1997). It is a systematic way of assessing cognitive skills and neuropsychological processes. The approach is guided by the CHC cognitive theory (Flanagan, Ortiz, & Alfonso, 2013).

Flanagan, Ortiz, and Alfonso (2013) explained that different psychometric intelligence theories have recently merged, forming a complex, research-based classification of intelligence. This process synthesized several intelligence factors based on extensive research accumulated throughout the last 70 years. Cattell-Horn-Carroll represents the most contemporaneous and evidence-based intelligence definition. In Flanagan's words, "CHC theory is an integration of Cattel and Horn's Gf-Gc theory and Carrol's three stratum theory of the structure of cognitive abilities" (p.7).

The use of the cross-battery approach became well known in the cognitive assessment field after the CHC theory gained visibility and started being used by professionals conducting cognitive assessments (Flanagan et al., 2013). The cross-battery approach is based on the assumption that the use of multiple assessment tools contributes to a more accurate

representation of an individual's cognitive pattern of strengths and weaknesses compared to the use of single assessment batteries (Flanagan et al., 2013).

The XBA theory uses assessment and achievement tests to measure broad and narrow CHC abilities. Within the CHC conceptual framework, working memory is one amongst seven cognitive abilities, also known as CHC factors, which are responsible for overall intelligence (Flanagan & Alfonso, 2010). Even though cognitive abilities were not measured during this study but were guided by the participants' perceptions of a chess program, the definitions of working memory and other cognitive abilities used are based on a CHC approach to intelligence.

Significance of the Study

The results of this study illuminates what chess practice can offer when used as an intervention to improve working memory and executive function skills of adults diagnosed with ADHD from the point of view of one participant. Executive functions refer to the skills required to adequately solve problems and to use intelligence. According to Braaten and Willoughby (2014), "these skills include abilities such as goal-setting, planning, organizing, prioritizing, remembering information in working memory, monitoring one's behavior, and shifting back and forth between different tasks or activities" (p. 79) and are paramount to one's ability to function and adequately meet age-appropriate expectations, in and out of educational settings. Approached this way, executive function skills are just as important as an individual's overall intelligence.

The aforementioned understanding of executive function skills highlights how one's personal and educational development can be impaired by ADHD. Because interpersonal interactions and academic success rely on behavioural self-regulation, deficits in these skills can

be a source of distress. The majority of people diagnosed with ADHD experience impairments in executive functioning (Barkley, 2008).

We explored the self-perceptions of an adult diagnosed with ADHD of the effects of chess practice on her inattentiveness and impulsivity and restlessness. I gathered information on how the participant diagnosed with ADHD approached and experienced tasks requiring complex problem-solving skills. Additionally, the participant explained what she considered helpful while trying to overcome the difficulties associated with the disorder. The case study design provides an in-depth information on the coping skills, strategies and mechanisms put in place by the participant to solve the chess puzzles, as well as the difficulties the participant experienced. Rather than idiosyncratic, random information, the knowledge produced during this study shed light on how individuals diagnosed with ADHD approach complex problem solving situations, such as those presented by a game of chess.

Chapter 2: Literature Review

This chapter presents and discusses the literature on the effects of chess practice on human cognition and academic performance. The relationships between cognitive aptitude and chess practice discussed are limited to how the game affects cognitive functions such as working memory and enhances other executive function skills such as planning, organizing and prioritizing. A brief summary of the history of ADHD and how it affects cognitive functioning is also included. Finally, the use of chess practice as an intervention for people diagnosed with ADHD is discussed.

The Game

Chess is an ancient game and its origins are much older than the age of FIDE (International Federation of Chess), a French organization responsible for ranking and classifying chess players according to their abilities demonstrated in tournaments, or the beginning of scientific studies on human cognition. In fact, even the geographic origins of the game are disputed by historians (Murray, 1913).

Chess is a strategic board game in which the primary goal is to capture the opponent's king. The game is played on a board with 64 squares and by the use of a chess set containing 16 pieces and 16 chess pawns. Each player starts the game with eight different pieces and eight pawns. Each piece has an assigned movement which remains the same throughout the game and an abstract value which changes according to the specific position of the pieces on the board. The pawns move in an identical fashion. However, the role performed by each piece or pawn depends on the positions created during the game, which varies according to the player's strategy (Fischer, Margulies & Mosenfelder, 1982).

Learning how to play chess (i.e., the rules of the game and the movements of each piece), is a relatively easy task compared to what it takes to reach master-level. This ease of learning is because inside the 64 squares in which the game is played millions of moves are possible. The game requires the creation of short and long-term plans, assessment of the existing dynamics of the board based on previously learned theory, and the capacity to foresee and anticipate future positions (Fischer et al., 1982).

Because of its complexity, the study of chess is usually divided into three different phases: opening, middle game and endgame. Each of these phases has its own goals and theories. Accordingly, these theories are usually described and demonstrated by category in chess books, separately addressing each phase of the game (Good, 1962).

The systematic study of chess demands that a player become familiar with several tactical and strategic elements of the game. Even though strategy is not a concept specific to chess (Drogoul, 1995) it is almost impossible to talk about strategy without mentioning chess. Drogoul defined strategy as a set of planned actions that serve as a means to an end, that is reaching a pre-established specific goal. In this sense, any strategy implies the capacity to comprehensively analyze a current configuration and the availability of resources to execute the desired plan of action. This definition holds true on the chess board. As it is well known in the chess world and experienced by beginners and grand masters, the adventure of a chess game without a sound plan can be a very short one.

Tactics in chess, on the other hand, refer to short-term plans and the exploitation of weaknesses in the opponent's position (Reek, Uiterwijk, & van den Herik, 1996). A sharp understanding of a concrete position can immediately reward or punish. Tactics are carried out by a forced combination of moves in which the ultimate goal is to acquire a material advantage,

for example, gaining one of the opponent's pieces or pawns or checkmating the opponent's king, thus finishing the game. However, tactical opportunities appear only when an advantage has already been acquired through the correct implementation of a strategic game plan. Therefore, both forms of planning are complementary and indispensable skills of a chess player (Pachman, 1971).

Planning in chess is a process that requires interpretation, recognition of patterns and problem-solving skills (Reek et al., 1996). The correct plan in chess is objective, leading either to a victory or defeat or in some cases, to a draw. However, choosing the correct plan is a complex process. The first step usually involves looking at the predetermined piece locations on the board and their roles. Then a player must visualize the ideal position that should be achieved to win the game. Among other things, this analysis requires previously learned chess concepts and theory (Pachman, 1971).

The recognition of recurrent chess patterns is facilitated by game experience and by the number of typical positions that a player can retrieve from long-term memory. However, neither theory nor exceptional memory is enough for success. The capacity to solve new problems and determine an advantageous path while facing unexpected moves, novelties or positions not previously known, are equally important skills (Pachman, 1971). Consequently, nonverbal intelligence skills have been identified by several studies as having crucial roles in the performance and proficiency of chess players (Hong, 2005). For instance, if fluid reasoning is the capacity to understand how things go together without the use of a manual, then there is a heavy demand on the fluid reasoning abilities of successful chess players while facing unknown positions.

Currently, the game is professionally regulated by the World Chess Federation/Federation International des Echecs (FIDE). The rating scale used by FIDE is called the Elo system, named after Arpad Elo, its creator; the higher the player's rating, the stronger his or her ability to play chess (Gobet & Simon, 1996). According to Charness (1992), the Elo rating system offers a strategic opportunity to study cognitive differences among individuals because the system ranks players based on their chess skills, providing the conditions for the study of cognitive functions used in the game.

For instance, the use of working memory in chess is central as a player must assess the current formation of the pieces on the board and, at the same time, analyze several possible continuations, forced combinations, and maneuvers, a process that is known as line analysis (Pachman, 1971). To further complicate matters, chess players need to be able to analyze several lines during a game, and also entire sets of variations, which are alternatives included within a specific line (Fischer, 1982). Before we discuss the use of working memory in chess, we need to define working memory.

Working Memory

Working memory is a subdivision of executive functioning abilities. According to Gioia, Isquith, Kenworthy and Barton (2010), working memory has currently been researched more than any other executive function. The more comprehensive concept of executive function is defined differently within an array of emergent models, ranging from a set of basic cognitive processes to being central in higher-order cognition. Although the variety of existing executive function models has specificities, Gioia et al. (2010) claimed that they share a common understanding, that is executive functions encompass distinct abilities that somehow are related to each other. Those abilities are goal-driven and responsible for intentional problem solving.

Thus, the concept of executive functioning should include self-regulatory and supervisory skills (Gioia et al., 2010).

Working memory, on the other hand, is a more specific term, used to describe the cognitive functions required to manipulate or perform operations with information temporarily held in immediate awareness. This process requires attention, concentration and mental control skills. According to Baddley (1992), working memory is required whenever a person is involved in an interference task and must retrieve stored information.

Oberauer, Wilhelm and Wittman (2003) claim that several theoretical models have associated working memory with basic cognitive functions and have emphasized its importance on higher-order cognition, while others have tried to fragment working memory into smaller cognitive processes such as visual and spatial working memory. Today, the conceptual scope of working memory remains under discussion, including which cognitive functions should be assigned under it. Despite the fact that the debate continues, the importance of working memory on higher-order cognition is more prevalent and accepted than before, which is evidenced by the extensive use of the concept (Baddeley, 2010).

For the purpose of this study, we did not intend to engage in a theoretical debate regarding which cognitive functions working memory should encompass. Instead, we understand working memory as an essential component of any learning experience. Therefore, deficiencies or other problems with working memory may result in impaired learning including, but not limited to, processing new information, accurately taking notes or mentally manipulating academic knowledge, leading potentially to academic and professional failure if not addressed properly (Grooper, 2013).

The technological progress during the last twenty years, coupled with an exponential increase in the interest in neuroscience and neuropsychology, has boosted research on working memory (Dehn, 2015). At the same time, it has created a paradoxical situation. On one hand, the resources and information available for educator about how to early identify working memory issues is not. On the other hand, working memory training in the lab, for example computerized training, is a reality. However, as Dehn (2015) claimed, the task of relating assessment knowledge to identify and improve working memory deficits in daily classroom activities is timely.

Working memory training

There are several computer-based programs for working memory training developed throughout the past two decades. Among them, Cogmed is the most frequently researched and recommended by professionals in the field (Holmes, Gathercole, Place, Dunning, Hilton & Elliott 2010; Shipstead, Redick & Engle, 2012). This program was developed by Klingberg et al., (2005) to test the effects of computerized training on working memory. Fifty-three children diagnosed with ADHD participated in the study. The training program that was tested during the study included verbal and visuospatial working memory tasks. Participants' performance were measured during and after the program.

Participants who met the compliance criteria trained with working memory tasks provided by Cogmed, such as the span board task and digit span for at least twenty days. The results showed that the working memory of people diagnosed with ADHD can be improved by training with Cogmed, but as a secondary outcome, it created a positive effect on participants' reasoning skills and response inhibition (Klingberg et al., 2005). Additionally, parents reported a remission of ADHD symptoms following the completion of the program. For example, there was

a reduction of parent-rated symptoms of inattention in the posttreatment interval that was still present at a follow-up assessment.

The enthusiasm generated from the results of this initial Cogmed training experiment was reinforced by the importance given to working memory by a vast number of other studies, which, at that time, were starting to consider working memory (WM) as an essential factor of general cognition. As Shipstead et al. (2012) stated, "taking advantage of this perspective, many modern training programs are thus designed to specifically target WM" (p. 628). The assumption underlying those programs was that by enhancing working memory other cognitive abilities would also improve, including general intelligence.

The generalizability of acquired skills during working memory training is another assumption behind the endorsement of working memory enhancement programs. However, as Chein and Morrison (2010) stated, "practice can yield remarkable levels of achievement but little generalization" (p. 193). According to these authors, many classical studies found that expertise and skill gains were specific to the task being trained, which would have led to the conclusion of the non-generalizability of improvements obtained by the practice of a given task. For example, if one practiced digit span recall and mastered the ability to remember number sequences, such a skill would not necessarily be transferable to similar activities such as remembering the names of countries. Because of the influence of these classical studies, whether or not working memory training can be helpful for people with cognitive deficits has been a subject of continued debate.

This study used chess practice as a tool to improve cognitive abilities and shed light on the aforementioned debate. Chess can be used to explore the transferability of skills gained through a specific practice to other similar activities and domains (Charness, 1992; Gobet, 1998). This research allowed me to explore whether chess practice can improve not only chess skills but

also working memory and other executive functions. The perception of the participant and her self-measures of ADHD symptoms and executive functions proved to be a strategic data source that may inform further research on the transferability of skills gained through working memory training.

The claim of the transferability of skills acquired through the exercise of a specific task to other similar activities is supported by more recent studies on working memory training. Several recently conducted studies have suggested that mental exercises in working memory, if consistently repeated, can enhance one's cognitive performance in a variety of cognitive domains and tasks (Buschkuehl, Jonides & Perrig, 2008; Chein & Morrison, 2010;; Klingberg et al., 2005; Persson & Reuter-Lorenz, 2008). This hypothesis is primarily based on the fact that working memory requires a variety of basic cognitive functions and that its underlying processes broadly influence general cognition.

Numerous researchers have either replicated or designed different computer software based on the theoretical principles under which Cogmed was built, obtaining positive results (Bedard , Chacko, Chimiklis Feirsen, Marks & Uderman, 2013; Holmes et al., 2009; Cogmed, 2006). Nonetheless, far from unanimous consensus, there has been an ongoing debate on the efficacy of Cogmed and other computerized programs for working memory enhancement (Shipstead et al., 2012; Hulme & Melby-Lervag, 2012). Therefore, testing the efficacy of other interventions, such as chess practice, for the improvement of ADHD symptoms and working memory enhancement is warranted.

Shipstead et al. (2012) claimed that the transferability of training achievement to working memory capacity is not simple to measure, requiring pre-tests and post-tests of untrained tasks to ascertain how significant the improvement of working memory provided by the tested program

may have been. Therefore, “when transfer of training is measured via single tests (as is generally the case), post-test improvements represent the possibility that an underlying ability has changed but do not provide definitive evidence” (p. 633). Chess practice seems to be an advantageous option for both training working memory and testing the transferability of skills acquired through practice because playing chess requires a complex set of cognitive and executive function skills. For instance, chess involves more than manipulation and retention of information in immediate awareness; it demands recognition of previously learned positions, visualization and anticipation of known and unknown positions at the board, planning, goal setting and organizational skills, all of which are impacted by working memory skills (Unterrainer et al., 2006).

Additionally, Redick et al. (2013) argued that the majority of problem-solving activities used during Cogmed training sessions are not strictly working memory tasks. Furthermore, because these authors do not agree that Cogmed reproduces real-life types of situations in their training program, they reject the transferability of improvement in tasks that demand working memory to real-life situations. Similarly, Hulme and Melby-Lervag (2012) affirmed that evidence from their meta–analysis did not support the results regarding working memory enhancement made by Cogmed. Among other critics, these authors affirmed that their research findings did not support the claim that Cogmed increases intelligence scores, improves attention, lessens ADHD symptoms or enhances working memory capacity.

Current research on the effectiveness of computerized training on working memory has found mixed results. Therefore, more studies on the subject as well as on alternative ways of enhancing working memory are warranted. Some of the major criticisms of Cogmed and other computerized training programs are their high cost and lack of real-life situations. The sessions occur out of the context where inattentive behaviour tends to manifest and are isolated from

social interactions. These variables make the transferability of gains acquired within the artificial context of a lab experiment and training to be questionable (Chein & Morrison, 2010; Shipstead et al., 2012).

Based on the issues related to computerized training, chess may prove to be a viable option for the enhancement of working memory and reduction of ADHD symptoms for at least two reasons. First, the costs to learn and play chess are lower than purchasing a computerized working memory training program. Second, chess promotes real life social interactions and can be easily included in any educational setting. Before discussing why chess might be a complementary or substitute intervention for working memory enhancement and help with the remission of ADHD symptoms, it is necessary to analyze one more element of the Klingberg study design.

Another limitation of the Klingberg et al. (2005) study, cited by the authors themselves, refers to its generalizability. The study excluded children with oppositional defiant disorder (ODD), thus limiting the generalisability of the findings. This limitation is significant in that children diagnosed with ADHD often have ODD symptoms (Barkley 2001; Swanson et al., 2001). A chess program designed to enhance working memory and other executive functions could potentially extend beyond people with ADHD, increasing the number of people it might help. In the next section, we discuss the effects of chess on cognitive abilities and executive functions.

Chess and Cognitive Abilities

The idea of using chess to enhance cognitive skills is not a novelty per se, but an extension of known positive effects of chess on cognitive functions. Several studies have tested the effects of chess on a variety of cognitive domains, including visual processing, fluid

reasoning and memory (Charness, 1992; McDonald, 2010). Likewise, researchers have had an interest in the potential of chess to improve executive function skills, concentration, attention span, and generally enhance cognitive skills (Berger, 1989; Ferguson, 1983; Ferguson, 1986; Mechner, 2010). Chess has also been tested as a supplementary treatment to improve cognitive abilities of patients with health conditions as serious as schizophrenia.

In an experiment conducted with patients who were hospitalized, treated with anti-psychotic medication, and met DSM-IV criteria for schizophrenia, Demily et al. (2009) found that after ten hours of chess practice, there were significant improvements on standardized measures of executive function skills. The patients' improvements were found in the analysis of a cross-battery neuropsychological assessment. Participants were randomly assigned to one of two groups: game of chess (GC) and treatment as usual (TAU). Pre- and post-tests were administered to statistically determine the effect of the experimental factor: the practice of chess impact on participants' executive functions. Neuropsychological measures used in Demily et al.'s (2009) study included standardized tests such as the Wisconsin Card Sorting Test, the Tower of London Test, both parts of the Trail Making Test and the Stroop Colour Test. A physician analyzed the pre-test and post-test results to determine the potential of chess to promote changes in the participants' executive functioning skills.

One limitation of this study is that the requirement of normality and variance homogeneity could not be met, so statistical analyses were conducted by the use of nonparametric tests. This limits the ability to establish differences and make comparisons between the two groups as not enough parameters are available.

Nevertheless, during the pre-test GC participants made more perseverant errors in the Wisconsin Sorting Test, (U=46; Z=2.02; pb.05; +161.54%). After the chess intervention this

difference was no longer present. Additionally, GC participants showed an increase in the number of sentences read in the Stroop Colour Test during the post-test, which was not observed among TAU participants. If combined, these results indicate the positive effects of chess on the performance of participants in the collected measures of executive function. As the authors reported, the game provided an opportunity for participants to practice their planning and prioritizing skills, and their memory capacity. This training taught them strategies to better plan and prioritize tasks that could be implemented in similar activities.

The results of this study indicated positive effects of chess practice for patients with executive impairments. Additionally, it showed that chess was an economically viable option for the treatment of executive dysfunctions. If the purpose of training is not to become a Grand Master, but to sharpen cognitive and executive functions, an internet connection is all that is required for intervention as there are multiple free websites for practicing and playing chess. The ten weeks duration of the chess program in the current study was meant to determine whether the participant would notice differences in her executive function skills similar to those found by Demily et al. (2009).

Chess practice has also been used as a protective factor against degenerative illnesses such as Alzheimer's disease and dementia. According to Morley (2011), the chances of developing dementia decrease when a person pursues meaningful activities such as chess. The description of meaningful activities used in this study were medically oriented and referred to the potential of a task to develop and strengthen healthy, functional neuronal connections. Chess practice, like other activities such as dancing or playing an instrument, activates the brain and produces neuronal connections. This would decrease the likelihood of developing degenerative neuropsychological illnesses such as Alzheimer's.

Chess was instrumental in a study that explored the link between expertise and mental imagery in problem solving situations. In two experiments using chess masters, Campitelli and Gobet (2010) studied how the brains of expert chess players separated relevant from irrelevant information. Their experiments investigated the relationship between imagery and visual perception in blindfold chess. Players were presented with chess moves on a board where relevant and irrelevant information, from the point of view of the game, was available. Participants were supposed to remember positions they were previously shown in the presence of interfering stimuli.

The moves were presented one by one. However, the chess board purposefully contained more pieces than it was supposed to according to the game's description. Participants were only allowed to see the current move as it was being narrated on a computer screen. All previously mentioned moves were supposed to be remembered without being shown on the board. Chess masters' performances were only affected by irrelevant information as the game was narrated, which indicated the positive effects of chess practice on working memory and retrieval fluency.

Campitelli and Gobet (2010) concluded that "novelty information is used by the mind's eye to select incoming visual information and separate 'figure' and 'ground'" (p. 41). More importantly, they found that chess players developed memory strategies to overcome the difficulties presented by concurrent stimuli. If playing chess helps one develop memory strategies to take in novel information, then it is reasonable to suppose that the game could potentially help people diagnosed with ADHD to enhance their working memory, ability to sustain attention and successfully learn new content without going off-task or losing their concentration.

Blindfold chess has been used in the study of memory for a long time, attracting researchers in psychology since Binet. The modality of blindfold chess demands several cognitive functions, especially visuospatial working memory. With practice, an experienced chess player can recall orally presented games in their entirety without needing to refer to the chess board (Campitelli & Gobet, 2010). In fact, several studies have used chess to study memory capacity, retrieval and storage.

In a classic study, Chase and Simon (1973) found that experienced chess players had an advantage over beginners in recalling briefly presented chess positions. Two experiments were conducted to understand how chess players perceived positions and recalled them from memory. In the first experiment, participants had to reproduce a chess position in plain view, and in the second, they had to reproduce the chess position after a five-second delay. Both tasks were videotaped to record piece placement and time. In both experiments, level of expertise had a positive correlation with performance. This suggested that chess training had the potential to improve one's ability to retrieve positions and retain information in immediate awareness for a longer period of time.

In this same study, Chase and Simon (1973) used a general cognition theory known as chunking theory. Its main assumption revolves around the hypothesis that chess expertise is due to a process of encoding complex positions in memory by "chunking" information into significant blocks making it easier to retrieve the information contained in a given position. Gobet (1998) commented that the chunking theory was used to explain how expert-level players overcame the limits of short-term memory and remembered more information (i.e., chess piece positions) than did the beginners. However, there was insufficient evidence as to the size of a chunk in terms of how many pieces it could contain, as well as how many chunks a chess player

could retain after having briefly seen a position (Chase & Simon, 1973). Since then, other theories have been tested, producing an array of data on the impact of chess on memory.

In an attempt to understand what makes experts successful in their realms of expertise, Gobet (1998) used empirical data from different cognitive studies to test three leading theories on expert memory. The chess domain was chosen by Gobet (1998) for a variety of reasons, among which were its strong external and ecological validity and the possibility of using chess to study both low-level cognitive processes such as reaction time (e.g. by timing how long it takes for a chess player to perceive the position of one piece on the board) and high-level processes such as move choice.

The theories Gobet (1998) tested were "the chunking theory (Chase & Simon, 1973), the knowledge-based paradigm (e.g., Chi et al., 1982), and the skilled-memory theory (Chase & Ericsson, 1982), which has recently been extended in the long-term working memory (LT-WM) theory (Ericsson and Kintsch, 1995)" (p. 116). For the purposes of this study, it is not relevant to extensively review each of these theories. However, I shall comment on some aspects of Gobet's (1998) paper. First, if chess, in fact, has a strong validity, the benefits of chess practice could theoretically be transferred to other domains, making it a viable intervention to improve working memory deficits of people diagnosed with ADHD. Second, from Gobet's (1998) review of the leading expert theories, it is possible to conclude that chess practice has contributed to success and improvement in memory capacity.

For instance, the two theories that relate chess and memory, the working memory theory and the skilled memory theory, provide explanations as to how experienced chess players are able to remember larger amounts of information than what is expected based on research on short-term memory capacity. According to the skilled memory theory, experienced players

remember better than beginners because they use cues based on previously acquired knowledge to encode information; they encode and retrieve information quicker through practice and develop retrieval structures that enable large chunks of positions to be remembered. Such ability could be transferred to domains other than chess. Mental calculation and mnemonics are just two examples of its applications (Chase & Ericsson, 1982; Gobet, 1998).

Finally, chess has been used to improve executive functions of children diagnosed with ADHD. A pilot study was recently conducted in Spain investigating the efficacy of chess as an alternative treatment for children and adolescents diagnosed with ADHD (Blasco-Fontecilla et al., 2013). Forty-four children and adolescents between the age of six and 17 participated in an 11 week chess course.

Parents completed the Swanson, Nolan and Pelham Scale in its Spanish version (SNAP-IV) and the Abbreviated Conner's Rating Scale (CPRS-HI). The data was then submitted to a paired t-test to compare the outcomes of the chess interventions. The magnitude of effect was measured by Cohen-d calculations. The results indicated that the severity of ADHD symptoms in measures of both the SNAP-IV (t= 6.23; df = (41) (P smaller than .001) and in the SPRS-HI (t=5.39; df=33 P smaller than .001) were largely reduced in the post-intervention.

Could the positive effects of chess practice transfer to an educational setting though? Next, I discuss research that has explored the relationship between chess practice and academic achievement.

Chess Practice and Education

Research on the influence of chess on human cognition has not been limited to its application as an alternative treatment for severe mental and neurological issues. Various studies

have suggested that the positive results of regular chess practice can predict and help change educational outcomes (Barret & Fish, 2011; Berkley, 2013; Dullea, 1982).

Hong (2005) analyzed how chess instruction administered to students at risk of academic failure affected their academic performance. Thirty-seven students from three elementary schools in Korea participated in the study. The experimental group underwent a weekly, 90-min chess training for three months, while the control group attended their regular school activities. Then, both groups underwent cognitive and achievement tests.

The experimental and control group's performance on the tests did not significantly differ after chess instruction as the length of the program was too short to promote any significant results. Nevertheless, the author of the aforementioned study found chess skill rating to be a key predictor for the improvement of student cognitive skills. The foundation for this affirmation was based on the observation that the players' ratings in this study predicted the chances for the improvement of cognitive abilities. The higher a player's rating, the better his or her performance on the standardized measures collected in the post-test (Hong, 2005).

Partly, as Hong (2005) discussed, the lack of a significant difference in test performance pre- and post-chess intervention was caused by the length of the chess intervention rather than by the game's potential to enhance one's academic achievement. To determine the latter, a longer and more comprehensive instructional program is necessary. Additionally, it is necessary to determine that chess practice was responsible for improvements in academic achievement, rather than other variables such as individual cognitive abilities or natural cognitive development. In fact, several studies in which longer chess programs were tested have been conducted in and outside of North America.

Ferguson (1983) conducted a federally-funded, four-year study in Pennsylvania called Explore. The purpose of the study was to determine effective tools and conditions for the development of critical thinking skills. Gifted elementary students were placed in groups and offered a variety of cognitive development programs. Among other activities, students switched every four to six months between the following programs: creative writing, problem solving with and without computers, future problem solving and chess. The control groups varied in duration, size and hours per week. Annually, the results of this experiment were analyzed by the use of the Watson-Glaser Critical Thinking Appraisal. Students also completed the Torrance Tests of Creative Thinking when the project started. Additionally, students completed a modified version of these tests at the end of the study.

Ferguson's (1983) objective was to monitor the academic performance throughout each program to determine which tools were most effective in the development of critical thinking. To meet this goal, Ferguson and his team administered critical-thinking tests before and after the different programs. To avoid biases regarding preferences for specific critical-thinking developers, neither hypotheses nor expected results were created. Nevertheless, the results of this four-year experiment determined that chess boosted cognitive efficiency and critical thinking more than any other tool. While exposed to the chess programs, children improved their critical thinking at an average rate of 17.3 percent annually, but less than five percent when participating in the other groups. Ferguson's (1983) work is important in that his experiment design showed that chess was a contributing factor to increased academic achievement, rather than just intelligence and natural cognitive development.

Years later, another Pennsylvania study also conducted by Ferguson confirmed the findings from the Explore program. In 1986, he conducted a two-year pilot study to understand

the effects of chess on memory and reasoning skill development. As predicted, all the participants, sixth grade students from a rural school, achieved higher than expected levels of executive functions such as organization, memory, fluid reasoning.

More recent studies have found similar results. Unterrainer, Kaller, Halsband and Rahm (2006) compared the planning abilities of chess and non-chess players using the Tower of London Test, a psychometric tool that requires well-developed planning skills for the completion of its tasks. Additionally, Unterrainer et al. (2006) assessed fluid reasoning using the Raven Test and verbal and visuospatial working memory. Chess players exhibited planning skills at a higher level than non-players, especially during the completion of highly complex tasks.

The Unterrainer et al. (2006) study emphasized another well-known potential of chess, that is, the development of planning skills. Historically, as the authors stated, chess has been used as a tool for the study of overall intelligence and several different cognitive abilities. It has also been used in the development of superior planning skills. However, my interest in chess for the purposes of this research study was specifically centered in the experience of an adult with the game. I wanted to explore whether chess practice is perceived as improving executive functions and cognitive abilities in a university student diagnosed with ADHD.

Cognitive and educational research using chess, as discussed, have been conducted primarily with children. The advantage of exploring the perceptions of an adult as was the case in this study is that my participant had the language skills necessary to elaborate on her experiences. She provided a detailed description of how chess practice affected her working memory and other executive functions, thus providing invaluable feedback about how chess as an intervention might impact adults with ADHD.

Chess has the potential to help people diagnosed with ADHD because its practice both requires and exercises executive functions and other cognitive abilities usually impaired in people diagnosed with ADHD. Additionally, chess is accessible and provides social interactions and opportunities for relationship building among players. Furthermore, playing chess is recommended to people of all ages, gender and is not restrictive to someone struggling with a mental disorder or psychiatric condition. An understanding of what ADHD is and how it affects peoples' lives may provide more clarity on how chess can be helpful in decreasing symptoms and improving the quality of life of people experiencing issues with attention, concentration or hyperactivity.

ADHD as an Evolving Concept

Current understanding of ADHD continues to evolve. According to Taylor (2011), two different extreme theoretical poles coexist and guide practitioners' understanding of ADHD. Some see ADHD as a biological condition, which Taylor (2011, p.69) calls a "mindless" understanding of ADHD, referring to the fact that defenders of this approach do not usually accept ADHD as a primarily psychological construct. However, there are others who consider ADHD to be a psychological variant and reject classifying it either as a psychiatric or medical disorder. Taylor calls this approach "brainless" because there is an overreliance on sociological explanations in comparison to medical ones.

For the first group, the effects of ADHD can be seen in the brain and are measurable. Here the etiology of ADHD is pinned on genetic aspects of brain constitution and on the physical environment that may trigger some dysfunctional or maladaptive behavior due to brain disposition. Accordingly, within this theoretical framework, treatment may require diet and/or medication, as well as behavioral modification. The scientific justification used by defenders of

the “mindless” position is based on neuroimaging evidence of brain activity, clinical trials, research on molecular genetics and experimental psychology (Taylor, 2011).

The second extreme pole described by Taylor (2011) is the “brainless” approach. This group represents those who see ADHD as a psychological variant and not as a disorder. Behavioral and emotional issues are explained as a result of societal intolerance, thus requiring educational and emotional support rather than medical assistance. The evidence for this position comes from changes over time in the prevalence of ADHD, “the very great differences between countries, the presence of emotional upsets and the inconstancy of changes in performance” (p.69).

To clarify my position and for a better understanding of this ever-present polemic surrounding ADHD, I now make a brief digression to the first conceptualizations that are usually associated with what is known as ADHD. This digression is especially important because the current understanding of ADHD as a medical issue includes some of the aspects present in its original definition (Barkley, 2006).

According to several historians and experts, the first systematic description of what is now called ADHD appeared in England in 1902 during the lectures of pediatrician Dr. George Still (Taylor, 2011). At the time, the term “mental pathology” was used to describe deficiencies in moral control. Descriptions of his 43 patients during his lectures at the Royal College of Physicians have been considered by many historians as likely prototypes of what now is diagnosed as ADHD (Barkley, 2006).

Still (1902) conceptualized the dysfunctional behaviors presented by his patients in moral rather than biological terms. He introduced the topic of his first of three lectures at the Royal College of Physicians saying that the physical conditions he would be talking about were “those

which are concerned with an abnormal defect of moral control in children." (p.108). Still then compared this moral defect experienced by his patients with that observed in people with intellectual deficiencies. Disabilities related to intellectual capacity were at that time called "idiocy, imbecility, or insanity," which Still supposed would be undoubtedly marked by moral deficiencies (p.155).

However, rather than simply reducing moral defect to an intellectual deficiency, Still (1902) stated that the most intriguing cases of lack of moral control, expressed through behavioral problems, were those in which an intellectual disturbance was not present. Furthermore, he established that the symptomatic behaviors exhibited by those patients were not exclusively related to intelligence, but also affected by volition.

Still (1902) stated that volition had little to do with intellect. He said that "volition… in so far as it is concerned in moral control, may be regarded as inhibitory; it is the overpowering of one stimulus to activity" (p.60). In other words, volition would be our consciously chosen inhibition of certain stimuli or actions that are opposed to a moral idea. Thereby, Still anticipated various contemporary models in which inhibitory dysfunctions are a major factor of ADHD.

Still (1902) used a definition of moral control in which the social implications implicit to any choice of action are strongly stated. He defined moral control in terms of a process that necessarily had to take into consideration the "idea of the good of all" (p. 160). By doing so, he accomplished a twofold objective. He explicitly stated his assumption that lack of consciousness and self-awareness was behind those actions usually classified as problem behaviour based on their consequences.

It is important to mention that moral control was not merely described by Still (1902) as an altruistic behavior. For him, moral control was also an essential part of self-preservation and

self-regard, thereby making moral control a suitable a pathway to medical exploration. Hence, the idea of moral control preceded the more recent notion of executive function, in which self-regulation is similarly not reduced to an intellectual ability, even though it requires cognitive skills.

Barkley (2006) also claimed that Still correctly predicted several contemporary formulations on the mechanism of self-regulation and sustained-attention issues experienced by people diagnosed with ADHD. Thus, many of his theories are still considered valid, including the high percentage of comorbidity between different disorders, the higher prevalence of males diagnosed with ADHD compared to females, failure to postpone gratification, and low tolerance to frustration. All of these were included, conceptualized by Still as core factors of what he called moral control defect.

In fact, Still's (1902) initial formulations had a strong impact on the development of further conceptualizations that led to the classifications currently contained in the DSM-5 (Barkley, 2006). Moreover, the patients described by Still as "lacking moral control" were often stubborn, aggressive, resistant to discipline and emotionally immature, features often present in the diagnosis of ADHD comorbid with other externalizing disorders. As Taylor (2011) observed, for Still, these children had learning issues due to the consequences of their behavior.

Next, I describe some of the products of this exploration by listing and discussing what are the known cognitive deficits related to ADHD. Rather than a comprehensive list, I specifically discuss typical cognitive difficulties experienced by people diagnosed with ADHD for which I anticipate chess could be of help.

ADHD and Executive Dysfunctions

Contemporary research has established that ADHD is predominantly genetic. Most studies have suggested that major contributing factors are atypical brain structures, chemicals and the dysregulation of brain functions broadly known as executive functioning skills (Barkley, 2008; Uddin, Kelly, Biswal, Castellanos & Milham, 2008). Those brain functions include overarching cognitive processes such as memory, concentration, attention, organization and motivation among several others (Gioia et al., 2010).

The positive correlation between ADHD and executive dysfunction in adults has been highlighted in several recent studies (Adler, 2010; Seidman, 2006; Silva et al., 2012). Attention deficit hyperactivity disorder may cause issues in relatively simple tasks such as prioritizing daily life activities as well as impairments in activities that require more complex cognitive functioning (Levin, 1990). A few examples of the latter within an academic context would be issues when planning an extensive academic project. Planning, organizing and prioritizing are abilities usually deficient in people diagnosed with ADHD (Barkley, 1997).

Among the executive functions impaired in adults with ADHD, inattention, impulsivity and hyperactive behavior have been studied extensively over the years. However, as previously mentioned, working memory has been the most studied subdivision of executive functioning (Gioia et al., 2010). According to Gioia et al. (2010), Barkley conducted the most comprehensive assessment of executive dysfunctions in children with ADHD. In his model (Barkley, 1997; Gioia et al., 2010), issues in executive functioning were caused by an inhibitory dysfunction. As a consequence, this behavioral inhibition affects other executive functions such as working executive memory, motivation, affection regulation and problem-solving.

Therefore, I anticipated that because research has shown a positive association between chess practice and cognitive enhancement, chess could serve as an intervention to improve executive functions of an adult diagnosed with ADHD. As this literature review suggests, chess not only has the potential to improve cognitive abilities, but has also improved cognitive functions that are usually deficient in people diagnosed with ADHD. However, there is little Canadian research into adult perceptions on the effectiveness of chess as an intervention for ADHD. Therefore, research on the subject is necessary.

Chapter 3: Method

This chapter outlines the reasons for a qualitative research using a single-case study method and describes the recruitment procedures. Furthermore, the process of data collection through semi-structured interviews, application of executive function inventories and attention check-lists is detailed. Finally, the chess program implemented is presented. Ethical concerns and the steps taken to increase the validity and reliability of this study, as well as its strengths and limitations, are also made explicit.

Qualitative Research

Qualitative research is a systematic and rigorous way of producing knowledge and interpreting individual and social phenomena that encompass various methods, epistemologies and research traditions (Creswell, 1998). Qualitative researchers interpret reality through research data using a holistic and naturalistic approach. Rather than separating context from phenomena and experimenting with variables in a laboratory, qualitative researchers gather research evidence within the setting where the phenomenon being studied belongs (Yin, 2009). The subjectivity and meanings produced by researchers and participants are the cornerstone in the interpretation and production of knowledge and, as such, are explicitly stated herein this paper (Hays & Singh, 2011).

The focus of qualitative studies are usually on the construction and sharing of meanings that specific individuals or groups create in a given period and under certain conditions (Gall & Borg, 2007). Such tasks require a dynamic, collective effort between researcher and research participants throughout the various phases of the study. This mutual interaction shapes the scope and limitations of a qualitative study, its analytical generalizability as well as the required steps that are necessary to assure the validity and reliability of the findings (Yin, 2009).

The primary intention of a qualitative study is not to prove cause and effect relationships, nor is it to predict future events. Thus, there is usually no reliance on statistical generalizations. Instead, discovering the meaning of experiences and describing how participants perceive complex events from the social world are some of the distinctive characteristics of this research paradigm. Additionally, in qualitative research a complex set of information is obtained from varied sources and data collection instruments (Gall & Borg, 2007), and is not limited to the analysis of data points (Yin, 2009). However, qualitative studies can contribute to what Yin (2009) refers to as analytical generalization where "the investigator is striving to generalize a particular set of results to some broader theory" (p. 43).

A qualitative research design suited the main goal of this study for a few reasons. Understanding how the participant perceived the effects of chess practice on her behavior and cognition yielded invaluable information for refining interventions for ADHD. Furthermore, determining how effective chess can be in reducing ADHD symptoms is as important as understanding how meaningful the chess experience can be to participants. This knowledge is particularly important because meaningful experiences have the potential to boost cognitive performance, increase sustained attention and quality of life (Morley, 2011).

This study employed a single-case study method to collect, analyze and generate findings on how a university student diagnosed with ADHD experienced the impact of a short chess-practice program on her cognition and behavior. Yin (2009) defined the concept of case study research in a twofold manner. First, the context of the observation and comprehension of real-life phenomena is important. Second, the specificity of data collection and data analysis strategies for this empirical research design needs to be incorporated into the study. Next, the case under study, its design, and the procedures employed to collect and analyze the data are described.

The Case

This case study is an exploration of the perceptions of an adult diagnosed with ADHD about the effects of a chess practice program in her executive functions and as an intervention for symptoms of ADHD. The chess program consisted of weekly, one-hour chess practice for 10 weeks in which one participant, Sophie, solved chess puzzles. I delivered the program at the University of Saskatchewan campus. Chess puzzles were extracted from the book, *Bobby Fischer Teaches Chess*. The book contains several chess puzzles that are presented from lower to higher levels of difficulty. The book is used by chess masters and Grand Master teachers to develop tactical chess skills in their beginning chess students. The book is popular among chess coaches because it provides the opportunity to measure skill development. Because the difficulty of the chess puzzles increases throughout the book, it requires a constant enhancement of chess abilities, which can be easily observed by chess coaches (Fischer, 1988).

The chess program used was designed in consultation with a chess Grand Master (GM). The GM helped to monitor and assess the effects of the chess program on the participant's performance. The GM then analyzed the data and suggested how the chess puzzles should be administered to the participant in the next session. Because the book *Bobby Fischer Teaches Chess* offers a systematic method to teach chess, the number of chess puzzles solved during each session depended on how fast Sophie could find the solutions.

Having the knowledge of a professional coach was beneficial not only because it served to ascertain the progression of the participant's chess level, but it also helped determine the effectiveness and appropriateness of the chess program. Moreover, if the participant had developed a higher than expected level of proficiency in chess during the sessions, or had finished the book prior to the end of the 10 training sessions, the GM would have been consulted

about extra chess material to develop the weekly activities, thus maximizing the positive effects chess can offer. However, this was not necessary.

The participant underwent both pre- and post- semi-structured interviews, which took place at the University of Saskatchewan. The purpose of the first interview was to understand the participant's perceptions of her working memory skills, sustained attention, impulsivity and hyperactivity behaviors prior to the chess intervention. Following the completion of the program, a second semi-structured interview was conducted where Sophie answered open-ended questions. She was given the chance to describe her thoughts, feelings and observations on the experience and to state her perceptions of the effectiveness of chess practice on her executive functions and related skills.

Additionally, after every chess session Sophie answered some open-ended questions. The number and types of questions asked vary as they were designed to summarize Sophie's weekly perceptions of her experience and generate data on the effects of chess on her ADHD symptoms, executive functions and other areas of her life. During the first three sessions, while Sophie was still mastering the movements of each piece and learning basic strategic aspects of the game, the qualitative data gathered at the end of the session was mainly based on my perceptions of Sophie's verbal and nonverbal behaviors, as well as her chess performance as seen in the time required to complete problems, number of problems solved and number of problems correctly answered. However, from session four until session 10, Sophie was formally asked open-ended questions, such as: What are your overall impressions of this chess training session? Did you get anxious while solving the chess puzzles? (Please see appendix G for the complete list of questions asked).

Data generated weekly as well as through the two semi-structured interviews were compared in a search for themes that described the participant's chess experience in terms of its effectiveness in the reduction of ADHD symptoms, improvement of self-regulation behaviors, attention, concentration, working memory and interpersonal relationships. Additionally, the data collected required me to categorize its content using unexpected themes, such as self-confidence.

Self-Report Measures of ADHD and Executive Function Symptoms

Self-report measures were collected during the first and the last sessions. The participant answered the Barkley Adult ADHD Scale and the Barkley Deficit in Executive Function Scale. The BAARS-IV is a scale that was empirically developed to assess current and childhood ADHD symptoms and domains of impairment. The BAARS-IV yield scores for diagnostic purposes in the following areas: inattention, hyperactivity, impulsivity and a total ADHD score. There is also a score in a section called sluggish cognitive tempo (SCT). Symptoms in this category are similar to the inattentive subtype (formerly referred to as Attention-Deficit Disorder, ADHD).

The criteria for a diagnosis of ADHD in the DSM-5 are only merited if the symptoms experienced cause clinical levels of impairment (APA, 2013). In the BAARS-IV an adult placing at the 93rd percentile or higher, and who has reported an onset of symptoms before age 16 as affecting more than one domain (e.g. education, relationships, work) in the past and in the present (last six months) is likely to have ADHD.

The Barkley Deficits in Executive Functioning Scale- Long Form (BDEFS-LF) is a scale developed under theoretical and empirical models of executive functioning. The instrument assesses several aspects of executive functioning required in day-to-day life activities of individuals 18 years of age or older. Scores above the 93rd percentile usually indicate significant

impairment in executive functioning. The self-measures collected prior to and after the intervention were compared to Sophie's qualitative perceptions of her chess experience.

Recruitment Process

Students from the University of Saskatchewan were invited to participate in this study. An invitational advertisement was posted on campus, as well as on the university of Saskatchewan website. The chosen participant received an incentive for participation of twenty dollars per session.

The selection criteria for participation in this study included: (a) being a university student who has a diagnosis of ADHD from a family doctor or psychologist, (b) have knowledge of, or interest in, learning chess, and (c) availability. The chess program ran weekly for ten weeks, requiring a time commitment of at least one hour a week. The recruitment process was completed when one eligible person agreed to participate and met all participation requirements.

The research objectives and procedures, including the expected time commitment was explained for potential participants via email and by phone. I received 15 emails from potential participants asking for more information. The first person who met all the participation criteria was included in this study. I did not schedule interviews with all potential participants because the first person I interviewed met all participation criteria. I adopted this "first come, first served" approach for two reasons: first, I thought that if I interviewed the 15 potential participants who showed interest in my research, I would not have a way to fairly and ethically select only one in the event that they all met criteria; second, due to time constraints it seemed reasonable to make the recruitment process as short as possible once a suitable participant was selected.

The participant was made aware that she was free to withdraw her participation at any given point and advised how to do so. If for any reason she decided to withdraw her participation she was instructed to contact me either in person, via phone or by email. However, the participant was able to successfully complete the ten chess training sessions.

Data Generation

The pre- and post-intervention interviews consisted of 21 semi-structured, open-ended questions that explored the participant's chess training experience in terms of its effectiveness in reducing inattention and/or hyperactivity symptoms, its effects on the participant's cognitive verbal and nonverbal abilities and interpersonal relationships. The weekly post-session interviews were shorter, and included six open-ended questions. Open-ended questions offer flexibility in in-depth exploration of subjects (Guthrie & Hall, 1984). Sophie gave permission to video record the entire chess program, including interviews, thus facilitating the transcription and analytic process. For instance, during every chess training session, her nonverbal behaviour was monitored. I created an observation log to track the learning strategies she used to solve chess puzzles, her verbal and nonverbal expressions during different moments of the sessions and her level of motivation to stay engaged on the task (See Appendix E).

I provided feedback to Sophie after she responded to each chess puzzle, letting her know whether her answer was correct or not and reinforcing her efforts, using phrases such as "well done, I liked how you deeply considered the problem before giving me an answer," or "yes, that is correct, it seems that your ability to solve the problems is improving," etc. More importantly, Sophie and I often talked about her feelings and reasoning process as she solved the chess puzzles, which helped to establish and maintain a positive relationship between researcher and participant. Although I followed a chess book that contained a predetermined and specific

methods of teaching chess, in my perception the positive relationship established between Sophie and I was very important and effective for the development of her chess skills.

Data Analysis

The data was analyzed using triangulation (Creswell, 1998; Yin, 2009), that is, a rigorous analysis of data from multiple instruments. In this study, findings from ADHD symptom checklists, attention checklists, executive function inventories and semi-structured interviews were merged. Krefting (1991) claimed that triangulating data in qualitative inquiries serves the purpose of promoting a deeper and richer understanding of the phenomenon being studied. It also conveys the idea that a phenomenon cannot be adequately understood by the use of a single method approach (Yin, 2009). Furthermore, the appropriate use of a triangulation increases the study's credibility (Breitmayer & Knafl, 1993).

Thematic analysis. Thematic analysis was performed in an inductive search for general descriptors. To guarantee the validity of the interpretations, the data was organized based on the questions the participant was asked, not through the use of a preexisting coding frame. Instead, I categorized the data grounded in what seemed to be relevant in the participant's opinions. The prevalence of candidate categories guided the categorization of the data. Attempting to ensure transparency and rigor in data interpretation, I followed the steps for thematic analysis in psychology discussed by Braun and Clark (2006).

First, I read the material searching for possible codes. No notes were taken and a fluent reading was performed to generate an overall understanding of the content. Second, I read the data again and made notes in the text, trying to perceive potential provisory codes. The reading process was then repeated until I was able to code the entire data set.

Third, the codes were grouped under potentially meaningful themes. These themes were constantly revised throughout the analytic process and finalized when all the codes fit into meaningful descriptors/categories. The interpretation of the codes was part of the categorization process and provided the analytical base from the beginning to the end of the thematic analysis. By delimitating how the data is analyzed and affirming the active role of myself, as researcher in this process, the results can be understood in relation to the conditions under which they were produced (Lincoln & Guba, 1985).

Trustworthiness in Qualitative Research

According to Hasson and Keeney (2011), in contrast to quantitative studies, where the concepts of validity and reliability are necessarily used to prove that the method is defensible, the methodological rigor in qualitative studies is obtained by the assessment of the study's trustworthiness, which has four elements including credibility, confirmability, transferability and dependability (Lincoln & Guba, 1985). Lincoln and Guba (1985) provided a description of the elements that compose trustworthiness in qualitative research and offered a series of strategies and techniques to increase rigor in qualitative studies.

Credibility. Credibility refers to the level of confidence that can be established in the truth of the findings. It does not refer to truth in itself, but to how credible the information gathered is. In order to guarantee credibility, I followed Yin's (2013) three principles for data collection: 1) I used different instruments to collect evidence (Interviews, self-measure checklists, etc.). 2) I created a formal and systematic "case study database" that was separate from the final case study report. This step allows other researchers to consult the evidence collected during this study. 3) I maintained what Yin (2013) called "a chain of evidence" (p. 95).

Yin (2013) explained that an external observer should be able to derive "evidence from initial research questions to ultimate case study conclusions" (p. 96).

Additionally, in order to establish trustworthiness I used a technique called prolonged engagement that consisted of an understanding of the phenomenon being studied acquired by naturalistic observation (Lincoln & Guba, 1985). Within my study, this meant establishing rapport with the participant and checking how comfortable she was on a regular basis during the chess program.

Moreover, after a preliminary version of the case study report was written, I verbally summarized the content to Sophie and asked her whether my interpretation of her perceptions were accurate. Lincoln and Guba (1985) named this procedure member-checking, as it gives the participant the opportunity to correct mistakes that were made by the researcher during the analytical process of the study, thus increasing the credibility in the truth of the findings.

Confirmability. Confirmability is the concept used to define the strategies and steps taken to assure the findings are an expression of the participant's responses rather than the researchers' interests or biases. I kept field notes to help me gain awareness on my thinking process on the chess experience, as well as to reflect on how my own subjectivity influenced each step of the research process. I also used an observation log to track behavioural observation, monitored verbal and nonverbal communication and nurtured a relationship that contributed to the development of chess practice. On one hand, the weekly open-ended questions after each chess training session generated data on the participant's perception of her behavior. On the other hand, my observations and capacity to interpret what happened during the chess sessions was combined with the participant's perceptions of the chess experience and its effects, assuring

that my interpretation was consistent with that of the participant. Furthermore, I kept a field log to record my impressions during the chess intervention to assist in data analysis.

Another technique I used to assure confirmability is referred to as peer debriefing. Lincoln and Guba (1985) defined peer debriefing as "a process of exposing oneself to a disinterested peer in a manner paralleling an analytical session" (p. 308). The purpose is to avoid researcher biases, which cause misunderstandings of the meanings implicit within the data. Additionally, this technique makes explicit data content that otherwise would not be uncovered due to the limitations of one's ability to interpret the data set. In this study, I had a peer researcher read my preliminary conclusions and provide feedback on my interpretations. Receiving feedback from a peer allowed me to understand the data in a richer and deeper way (Lincoln & Guba, 1985).

Transferability. Transferability is the effort carried out to show the findings could be applied in various contexts. Sophie's perceptions guided my understanding of how transferable the gains acquired through her chess practice are to similar activities and contexts. Even though some of her perceptions were idiosyncratic, other perceptions and understandings may yield information that transcends an individual dimension and represent a quality shared by adults diagnosed with ADHD.

Dependability. Dependability characterizes the consistency of the findings and its possible replicability. I described each step that I have made so that the research study could be carried out in different contexts with different people, so long as they share the same attributes to that of my participant (e.g. having a diagnosis of ADHD, years of education, etc.) and the steps I made during our chess program are reproduced.

Additionally, a rigorous case study design is only achieved if the instruments used for data collection are capable of connecting the data to the research questions that the study is supposed to answer (Yin, 2009). In this study, specialized literature was reviewed to identify what are the most frequently-used ADHD scales, executive functioning inventories and cognitive tests to measure working memory abilities. Then, experts in the field of cognitive assessment and ADHD identification were consulted and asked to verify whether they recommend the chosen data collection instruments and if their opinion is consistent with that predominant in the literature.

Furthermore, a set of open-ended questions was created for the pre- and post-test interviews and submitted for the approval of the thesis supervisor, the committee members and other professionals in the field. The research questions were designed to explore the participant's perceptions of her chess experience.

Ethical considerations

During this study I took measures to avoid harm and maximize the benefits for my participant, safeguarding her emotional, psychological and physical integrity. I ensured there was not a breach of confidential information throughout the study, that informed consent was a part of every step of the research process and that no psychological harm was inflicted to Sophie as a result of her participation.

Sophie's right to withdraw her consent and participation in each stage of data collection, as well as the procedures to do so, was communicated to her prior to and during the chess program. I regularly checked to make sure that her participation was voluntary and that she was comfortable participating. Before every chess session she was asked permission for the session to start. After the chess session was over, I asked Sophie to renew her consent and investigated

whether her chess experience was positive or causing her psychological distress. Sophie never reported feeling distressed or expressed a desire to stop participating.

The data and other confidential information were safely stored with the researcher and were not disclosed to third parties. The participant was informed about the chess Grand Master who assisted in the organization of the chess program and expressed excitement about it. All the information sent to the chess master was de-identified, and limited to the number of chess puzzles and chess positions the participant solved each week.

Another ethical consideration was related to the generation and interpretation of the data. I kept a log field to assure that personal biases were identified and addressed, so that the trustworthiness of the findings would not be skewed. I tried to be aware of how my communication with the participant affected her performance as well as our interpretation of events during each chess session.

The single case-study method that I used during this research study allowed me to deeply explore the self-perceptions of a university student about how chess practice affected her executive functioning skills and ADHD symptoms. The successful completion of the chess program was only possible due to the establishment of a meaningful relationship between researcher and participant. This relationship resembled, in various ways, the human connection typically seen between therapist and client within a clinical context, where the clinical work is dependent on the establishment of a therapeutic alliance.

This research design was unique in that it allowed me to explore the self-perceptions of an adult capable of using appropriate language to describe her experiences during problem solving situations. Although I could have collected collateral measures of the BAARS-IV and BDEFS-LF to compare Sophie's self-perception with the perception of people who knew her

well, I decided not to do so because my goal was to deeply explore Sophie's chess experience, not the observations of her symptoms made by others. However, if I had chosen to explore the perceptions of a child about how chess affects ADHD symptoms, I would likely have to primarily rely on nonverbal cues, the child's answers to chess puzzles and use collateral measures from parents and teachers to understand the child's experience. However, because Sophie was able to verbally elaborate on her experience with chess using her own words and perceptions, the data was solely collected from and verified by a primary source, which increased the trustworthiness of findings.

Chapter 4: Results and Discussion

In this chapter, I present and discuss the results of the chess intervention. First, I introduce the participant's profile. Second, I compare Sophie's ADHD symptoms and executive function issues in the pre and post-chess intervention period, highlighting the symptoms level of impairment in different contexts and activities.

The Participant's Profile

Sophie is a 25 year old female graduate student who has been recently diagnosed with ADHD, inattentive type (less than a year ago) by her psychiatrist. She sought professional help regarding her inattentive and restless symptoms after she moved in with her partner who also has been diagnosed with ADHD. Living with her partner made Sophie to realize that they had similar difficulties (e.g., forgetfulness, restlessness, etc.). This realization catalyzed Sophie's decision to seek professional help and to question whether her personal, professional and educational struggles could have been caused by ADHD.

Sophie exercises on a regular basis. She goes to the gym a couple of times a week to do cardio, lift weight, circuits and rock climbing. Additionally, she plays baseball and frequents a fitness class once a week. She sleeps between four to 9 hours a night, depending on her level of anxiety and stress.

Sophie has been working as an administrator over the last 10 years, despite her ADHD symptoms. She perceives her professional role as a contributing factor in the way she has coped with her ADHD symptoms. Her job has forced her to learn organizational, planning and prioritizing skills, which makes Sophie believes that these "skills have been born out of necessity."(Intake interview) However, Sophie's success at work came at a price: she often had

to work extra hours and often cannot achieve her goals due to lack of focus, short- and long-term memory issues and difficulties with executive functioning (intake interview).

ADHD and Other Symptoms Prior to Intervention

During the intake interview, Sophie described several personal, professional and educational struggles that she attributed to her symptoms of ADHD. Additionally, she filled out the BAARS-IV and the BDEFS-LF scales. First, we present the results of the two self-measures (BAARS- 4 and BDEFS-LF), which showed how Sophie perceived her ADHD symptoms prior to the chess intervention. Second, we described her ADHD symptoms and perceptions of how the chess intervention affected them.

Self-Measures Pre-Chess Intervention

Barkley Adult ADHD Rating Scale-4. Sophie completed the BAARS-IV Self-Report Current Symptoms and the Childhood Symptoms forms, providing her perceptions of her past and present symptoms and how they affected her life prior to and post the chess training intervention. Overall, prior to the chess intervention Sophie endorsed scores that placed her childhood and current total ADHD scores respectively within the mildly and moderately range (≥93 and 97 percentile). This showed that Sophie's overall symptoms progressively intensified from childhood to adult life. However, Sophie's scores for inattention were consistently within the moderate range for both current and childhood symptoms (97^{th} percentile for childhood symptoms and 98^{th} percentile for current symptoms).

Additionally, Sophie's score on the hyperactivity subscale was in the borderline range (85th percentile) and her impulsivity score mildly symptomatic (94^{th} percentile). Furthermore, Sophie's sluggish cognitive tempo (SCT) score showed a moderately symptomatic level of impairment (96^{th} percentile). These results suggested that, in Sophie's perception, attention and

impulsivity had impacted her functioning in more than one domain up until the time these measures were completed.

Barkley Deficits in Executive Functioning Scale- Long Form (BDEFS-LF). Sophie's initial results on the BDEFS-LF showed, at the time, she identified as having difficulty with several areas of executive functioning. Her overall executive function score fell within the moderately deficient range (EF summary score: >98th percentile). Sophie's self-management to time and self-regulation of emotion were within the markedly deficient range (99th and 98th percentile respectively). Additionally, Sophie's self-organization/problem solving score fell within the moderately deficient range (96th percentile).

Finally, Sophie's self-restraint (self-discipline or inhibition) and motivation scores were in the borderline/somewhat deficient range. In other words, these symptoms that Sophie recognized were typically experienced either 'often' or 'very often,' suggesting a generalized difficulty in daily tasks that require executive function abilities such as organizing, prioritizing and sequencing activities of various types.

The symptoms described by Sophie had affected her functioning in various domains. Among her symptoms were: difficulties with working memory and long-term memory, severe attention issues in multiple contexts and higher than expected effort to perform educational, professional and day-to-day activities.

Memory issues. Sophie initially described herself as being "extremely forgetful," and added, "I usually lose things habitually, especially pens, small things that you just carry around and use all the time I lose constantly. Glasses, like eye glasses." Sophie tried to develop strategies to cope with her distractibility and make it easier to remember where she placed her personal objects, such as leaving her keys in the same place every day. However, prior to the

chess practice she hadn't successfully consolidated such strategies, and would get distracted by concurrent stimuli. For example, she would go play with her cat and forget that she had left her keys on the sofa where the cat was sitting.

Additionally, Sophie affirmed that her ability to retain small pieces of information in immediate awareness and retrieve them later were very poor:

> I find that I have to repeat tidbits of vital information 10+ times in my head or aloud in order to retain the information for use even when the information is to be used in as short as five minutes into the future (Intake interview).

Sophie coped with her difficulties with taking in verbal and visual pieces of information by writing down what she needed to remember as much as possible. For instance, she would set alarms and have multiple sticky notes and reminders of her weekly meetings and assignments.

Nonetheless, despite spending a lot of extra time and effort trying to remember assignments, instructions and new content at work and in school, Sophie still experienced memory difficulties: "I find all types of information difficult to memorize for a short period of time. Many attempts at memorization have to occur before something will stick" (intake interview).

Attention issues. According to Sophie's description, inattention issues have impaired her ability to learn and function in various settings more than any other symptoms, especially during activities she does not find interesting or rewarding at the outset. Sophie affirmed she found it very hard to focus and pay attention during conversations about topics perceived as not interesting. Organizing her own thoughts and ideas was also hard. She would switch back and forth among different ideas and end up lost or forget what she was thinking about.

Restlessness/hyperactivity. Although Sophie was diagnosed with ADHD inattentive type and does not perceive hyperactivity as a major problem, she mentioned on several occasions during the interviews that she does "get very restless" and experiences "a mental anguish kind of situation." As Sophie stated, she is "not physically restless" but when she "doesn't have something that I want to do and can't muster the motivation I just sit there in a state of restless discontent" (intake interview).

Anxiety and depression. Sophie was diagnosed with clinical depression by a psychologist when "she was 13 or 14" years old. She described her anxiety and depressive symptoms as related to difficult periods of her life, "brought on by major life events" or when she is under a lot of stress (e.g., huge workloads, multiple assignments, etc.). However, Sophie affirmed that she has not experienced any depressive symptom prior to or during the chess training sessions, although her anxiety level fluctuated depending on her work, personal and educational demands.

During the sixth chess training session, for instance, Sophie affirmed that having a large workload caused her to experience stress and anxiety and "instead of tackling it" she felt overwhelmed by it and it paralyzed her. When this happens, she reported a tendency to do something else, not related to the assigned tasks. She distracts, "willfully distract [herself] from the task that needs to be done" (intake interview).

Additionally, Sophie mentioned that she experiences "a lot of anxiety due to just bad short term memory and second guessing" herself because she does not trust in her ability to remember what she has been learning, important instructions she is supposed to remember or what her agenda will be like at work each week (Session 7).

Inattentiveness, restlessness and anxiety have affected Sophie's performance and achievement in different settings, such as school and work, and negatively affected her relationships and social life. The following shows how Sophie experienced these symptoms in different settings.

In school. Sophie affirmed that she never learned how to cope with her inattentiveness while she was in school. She used to "spend 40 hours studying for an exam and maybe about 8 of that would actually be productive study" because she had to read the material several times (intake interview).

At work. Sophie's inability to focus at work used to cause her to worry about losing her job. She feared, at times, that her supervisor would notice how difficult it was for her to keep up with her responsibilities due to her ADHD symptoms. She used to have several days a week in which she would "get very little work done and feel completely at a loss" because of her "inability to focus, memorize and prioritize" (intake interview). Additionally, Sophie often had to take her laptop home to maximize work productivity when she was experiencing fewer ADHD symptoms to compensate for the several hours during week days when she felt "lost" (intake interview).

Sophie's professional life as an administrator involves remembering, organizing, prioritizing, planning and dealing with concurrent tasks and projects in a timely manner and, as she described it, "juggling things when you have ADHD is nuts, it is crazy". Sophie has successfully managed her professional responsibilities, but the time, stress, anxiety and effort she puts in to accomplish it are more intense and painful than she would like it to be (intake interview).

In conversation and social life. Sophie used to have difficulties sustaining her attention during conversations, especially if the subject was not particularly interesting for her. She used to "zone out very, very badly" when someone was talking to her, regardless of how well she was trying to focus. Additionally, Sophie did not find it easy to remain social, plan group activities or simply not become reclusive (intake interview).

In sum, Sophie's inattentive symptoms have affected her level of functioning in a variety of settings, especially when learning new things that are not particularly meaningful or interesting. She tried to cope with her memory and inattentive self-perceived issues by putting in place reminders such as alarms, sticky notes and by overlearning new information. While such attempts have proven to be successful at teaching her organizing, prioritizing and coping strategies, their implementation used to be challenging for Sophie prior to the chess intervention. In her own words, "whether I can abide by my own organization structures, due to my ADHD, is another story" (intake interview).

The Chess Intervention

This section presents the quantitative and qualitative data gathered during the 10 chess problem solving sessions in a twofold way. First, I discuss Sophie's overall results during the chess-training program (how successful she was at correctly solving the chess puzzles). Second, I present her perceptions of her chess practice experience.

Chess puzzles and its mysteries: Looking at the numbers

The 10 chess training sessions lasted a period of 10 weeks, during which Sophie learned to play chess and answered a total of 148 chess puzzles. Sophie correctly answered 79.72% of the problems (118 chess puzzles), 20.27% of her answers were wrong (30 chess puzzles).

The average number of chess problems answered each week was 14.8 and varied from a maximum of 19 chess puzzles (second session) to a minimum of nine (session one). Every two weeks, the complexity of the chess problems presented as well as the chess concepts needed for Sophie to answer each chess puzzle correctly increased. The level of difficulty of the puzzles varied from very easy to very hard.

Sophie did not know how to play chess before the chess training sessions started. Thus, the majority of the first session and part of the second were dedicated to teaching her the game's basic rules and to ascertain that she was aware of how each piece moves. After Sophie learned the rules, she correctly answered 100% of problems in the first session. Each problem had a very easy difficulty level.

During the second chess training session, Sophie's answers to 17 out of 19 chess puzzles were correct (89.47%). Although the difficulty level of each problem remained roughly the same as the first session, Sophie had to recall the chess rules that she had learned in the first session, which made the complexity of the second chess session higher than the introductory one.

In the third and fourth chess training sessions, as the level of complexity of each chess puzzle increased (from very easy to easy), and basic chess concepts started to become requirements in the solution of chess puzzles, the number of problems solved decreased from 19 to 16. Furthermore, Sophie made proportionally more mistakes, correctly answering 13 chess puzzles (81.25%) in the third session and 12 in the fourth one (75%).

During the fifth and sixth sessions, the chess program reached its halfway point in number of sessions and level of difficulty (Intermediate). During the fifth session, Sophie correctly answered eight out of 13 of chess puzzles (61%). However, Sophie successfully answered 13 out of 16 chess puzzles in the sixth session (81.5%), reaching the same level of

success of the third session, when she gave an identical number of correct answers to chess puzzles. The level of difficulty during the seventh and eighth chess sessions were hard. Nonetheless, Sophie correctly answered 10 out of 12 chess puzzles (83%) in the seventh session and 11 out of 17 in the eight session (64%).

Finally, the level of chess puzzles presented to Sophie became very hard during sessions nine and 10. Sophie correctly answered 14 out of 16 chess puzzles (87%) during the ninth session. In the final session, Sophie correctly answered 11 out of 14 chess puzzles (78%). When considering Sophie's performance in relation to the level of chess puzzles correctly answered, the percentage of accurate answers per level is as shown in the table below:

Table 1	
Level of difficulty	**Percentage of correct answers**
Very easy	94.73%
Easy	78.12%
Intermediate	71.25%
Hard	82.5%
Very Hard	82.5%

Table 1. Percentage of chess puzzles correctly answered as per level of difficulty

The results in the above table indicate that Sophie's best performances were respectively in the first and last couple of sessions (Session 9 and 10), which coincides with the period when she was learning the game and then when the program was reaching its end. Although there was some variance in Sophie's performance throughout the chess program, these results suggest that her ability to play chess and to understand the game progressively increased throughout the 10 weeks.

Next, I present Sophie's perceptions of her chess training sessions, highlighting the challenges she had to overcome to solve the chess problems, the strategies she used and her performance.

Difficulties solving the puzzles. Sophie mentioned a number of difficulties that she experienced while trying to find the right answer to each chess puzzle. Sustained attention, short-term memory, sequencing, organizing possible move continuations and choosing chess plans without touching any piece, were the major issues she had to overcome. Her cognitive difficulties are summarised by the following statement, "I would have visualized something and then forget what I had been doing and drive for a different perspective" (session 2).

Sophie initially found it hard to visualize moves in her head and got distracted. She would analyze only a few possible moves before picking one, often second-guessing her ability to find the right continuation. Besides her difficulty to retain where the pieces were over the board, choosing a move quickly was at first felt as more important than carefully considering all the nuances of each position. She described herself as a "quick answer kind of person" which she believes "is related to ADHD (Session 2).

Sophie mentioned a few times that while she was analyzing the board to find the right move, she often heard noises inside her head. The noises she heard became an internal source of distraction that she had to fight against to remain focused and successfully calculate variations. "The noise was an impact, unfortunately," she says at the end of session eight. "I had this totally inconsequential but the fact I made little noises in my head after I moved the pieces was kind of funny" (Session 8).

Finally, Sophie mentioned she had to fight the urge to choose a move impulsively without carefully assessing the requirements of the position that she was analyzing. Her impulsivity, in fact, came to the forefront of her awareness as the chess training sessions

progressed towards its end. Sophie's comments on her performance during the last chess session- where she had to solve the most difficult chess problems of the entire chess program- illustrates how she became more aware and bothered by her impulsivity when picking a chess move. Although she performed just as well as previous sessions, she says, "I was a bit impulsive this session too! I seemed to answer things before I had explored all the options." She adds, "I think I need to explore more, a little bit deeper I guess once you get into the more complex problems." This statement contrasts with her desire communicated in earlier stages of the chess program to answer the questions as quickly as possible (Session 10).

Choosing quickly but wrongly the next move during the chess training sessions made Sophie progressively more aware of how impulsivity has affected her life on and off the chessboard. She realized how anxiety and impulsivity affected her performance. For instance, while deciding which move to make during a chess training session, "rather than kind of absorb the problem, think about the solutions and then make a decision" she often times got anxious and chose quickly a wrong move before carefully analyzing the position on the board (Session 9). Nonetheless, having this insight is the first step to moving towards controlling her impulsivity.

Transferability of Chess Skills to other Domains

Throughout the chess training sessions, Sophie observed several cognitive improvements and positive changes that affected various areas of her life such as work, sports and recreational activities. Sophie attributed those positive changes to the use of skills she gained thorough her recent chess practice experience. Among the skills that she used in different domains and activities are her strategizing, prioritizing, organizing and planning abilities. Additionally, Sophie perceived improvement in her self-confidence and positive appraisal of her existing abilities,

which had a positive impact on her approach to problem solving situations at work, home and while playing sports.

Self-confidence. The theme confidence appears in Sophie's discourse in several chess training sessions. In Sophie's opinion, chess has not only increased some of her cognitive abilities, but it has also brought her confidence to trust in her already existing abilities that she may have overlooked or underestimated in the past.

Sophie's following statement is an example of how she became more confident in her cognitive abilities. In the post-training session interview, she says, "I never thought I would be able to analyze a chess board. I always thought that the game was way too complicated and learning it with you has kind of made me more confident in my problem solving and strategizing abilities."

The confidence brought on by her chess practice "translated to a lot of areas" of her life. Sophie now considers that "you don't need to automatically react to something, you can take a moment to think about it, figure out the best way forward and then move," trusting in her ability to find the right answers to her professional and personal problems. Furthermore, she realized that her performance might be more dependent on her ability to control impulsivity than any other particular skill, "it is ok to stop and analyze other things and you will probably make a better decision because of that" (Session 7).

Additionally, Sophie gained more confidence in her memory. As she comments, "if you asked me two months ago I would not trust myself at all in keeping things in my head. I set alarms for everything and had to-do lists and notes," whereas now she can trust herself "to remember them" (interview post intervention). But would Sophie's evaluation of the changes in

her own cognitive abilities be an idiosyncratic part of her personal experience or is it related to the socio-affective requirements of the game?

Commenting on the characteristics commonly found in the profile of chess player, Ramon, Lorena and Betancort (2012, p. 552), stated that besides cognitive skills, successful chess players exhibit a set of socio-affective competencies required in the game. Because of the scarcity of studies focusing on the emotional skills involved in playing chess, the authors decided to investigate it and understand whether chess practice produced benefits in personal, academic and social adjustment in children. One hundred and seventy schoolchildren aged six to 16 from eight different schools from a European Island participated in the study. Using a quasi-experimental design, the independent variable was the extra-curricular activity of chess (n=170) in contrast to other activities such as basketball and soccer (n=60). Intellectual and socio-affective competencies were the dependent variables. The dependent variables were measured using a standardized IQ test (WISC-R), a hetero-report questionnaire (teacher-tutor's criteria) and a self-report test (TAMAI).

Ramon et al. (2012) found that chess practice improved the socio-affective development of children and adolescents who consistently learned the game during the school year, both according to teacher rating scales and students' self-perception. Additionally, when compared to students who practiced soccer or basketball, those taking chess as an extra-curricular activity scored higher in the following cognitive tests: similarities, digits, block design, object assembly, and mazes. Furthermore, on a personal note, students taking chess classes were found to be more self-confident and self-assured at the end of the course. These results are consistent with Sophie's perception of how chess helped improve some of her cognitive abilities.

The self-confidence Sophie gained through learning and practicing chess has had positive effects in other sports, such as baseball. For instance, in one of the chess training sessions Sophie affirmed that she "felt a lot more confident in my ability to get things done and not shelve the wrong things or misprioritize (*sic*)" activities at work (Session 6).

The findings of this study surprisingly indicated that chess practice could promote self-confidence, which reinforces the clinical relevance of chess as a cognitive intervention. Sophie's self-reliance significantly improved, with perceived positive effects on her ability to solve problems and remember professional and personal events. Although one may argue that Sophie's self-perceived improvements may have been overstated, chess practice helped Sophie trust in her already existing abilities and exercise a positive self-appraisal.

Next, I present Sophie's self-perception of how chess improved her performance in other activities such as sports and work.

Recreational activities. Sophie is an active person, who goes to the gym and plays sports on a regular basis. Her sport of preference is baseball, which Sophie has played every week for years. Her performance in the game used to be dependent on her coach and peers' advice during each game. She would trust them to make the right decision in every moment of the game. They would shout instructions to her when it was her time to run or to stay, to throw the ball or to keep it. After she started playing chess, Sophie surprisingly realized that she was transferring some of the skills she learned on the board to the baseball field. During one of her games, she noticed that:

> I actually thought a step ahead, rather than just worrying about actually catching the ball. And it worked. I caught a ball and I threw it exactly where it needed to go and I was

surprised, I was really surprised. So I guess, that is an element of strategy that I have never used. It is not something that I have ever done before. (Session 4)

Sophie observed, after only a few hours of chess training that her approach to baseball was unintentionally strategic. She was surprised that "the one thing that I definitely have noticed is the strategizing athletic situations, which I have pretty much never done before" (session 4). Besides realizing that she became more analytical while playing sports, she noticed an improvement in her ability to refrain from simply reacting to stimuli or blindly following other people's perceptions of what need to happen in the field. After the intervention she feels more capable of analyzing what she needs to do when she is "on the field of baseball and that is something that never happened prior to our sessions together" (Session 6).

The participant attributed her improvement in baseball to her recent new chess practice. But why would that be? According to her, she improved at baseball because she tried to see a step ahead and became more analytical and confident in her own perception of the game as well as in her capacity to choose the right move. According to Urra's study (2015), regular chess practice can foster metacognition and improve one's ability to play other sports which demand similar cognitive skills.

Additionally, Sophie reported improvements in cognitive tasks such as the ability to make connections, prioritize and organize different events. Those cognitive tasks are required in most sports and are useful in a variety of problem solving situations (Urra, 2015). Halfway through the chess training sessions Sophie stated:

I think I might be getting better at prioritizing things a little better. Because I will kind of realize well, if I don't get this done first this is going to be more difficult so this is the best, most streamline direction to take in with administrating these items so that I don't

have to wait on as many people. So I might have strategized that a little bit better just based on trying to foresee what people will do (Session 5).

Work performance. Sophie observed differences in her work performance after she started practicing chess. Among those differences are included a reduction in her level of stress and anxiety and an increased ability to manage, prioritize, organize and sequence tasks, especially those that are part of large and time consuming projects. After only six hours of chess practice, Sophie noticed that she was being able to accomplish her work duties during a busy week without stressing as she used to. The following statement is an example:

> I had a crazy workload this week. It was insanely high and I managed it well without getting too stressed out because I was able to more easily prioritize and strategize what was the most important and kind of anticipating what the outcomes would be if this didn't get done right away; if it was shelved because something was more important. (Session 6)

During each training session, Sophie learned new chess concepts and ways to approach the game in an organized fashion. Sophie used some of the skills she learned through playing chess to organize her work and personal activities, thereby perceiving an improvement in her achievement. She started to use skills learned through chess practice "to compartmentalize, in a very useful way, different things in my life" (Session 6).

Although Sophie received formal chess skills, without any formal lesson, she started to approach other activities of her daily life (professionally, recreationally and personally) using the same methods learned through chess practice. This included separating things, events and tasks in categories, visualizing her options ahead of time, prioritizing her choices and responsibilities as per their importance, organizing her ideas in a linear and logical sequence, planning and being

strategic about her goals and listing and systematically reviewing her options in order to accomplish her objectives.

The following example illustrates the skills she learned while solving chess problems, which shows the similarity between her perception of what is required to solve chess puzzles to her approach to tasks and problem solving situations outside of the chessboard:

> Now that I kind of have this list of things to go through in my head before getting like digging into a problem. So, for example, like analysing all the pieces and where they can go and then thinking ok well the king can flee, attack or interpose. So I kind of have this list of things that I go through before I even begin to move pieces in my head and I think that it has alleviated a lot of the convolution I suppose, that I experienced before." (Session 7)

To summarize how Sophie perceived the transferability of chess skills to other domains of her life, I quote one of her statements during the post chess training sessions interview, "I never had to be engaged in strategizing often in my day to day life but when you play chess it just kind of becomes second nature."

It is well known that playing chess involves tasks such as finding and testing a game plan, prioritizing ideas as per the concrete necessities of each position, and organizing possible move responses (Unterrainer et al., 2006). Therefore, it is not surprising that chess players may try to use a set of executive skills acquired through their practice in other tasks when setting goals, planning or simply organizing ideas are requirements for success (Unterrainer et al., 2006). However, is it possible to successfully transfer skills learned in chess to other activities? Although the body of research exploring whether or not skills gained in a specific area of training are transferable to other domains have found mixed results (for a review on the subject

Gobet & Campitelli, 2006), the results of our study indicated that Sophie perceived the skills she learned through chess practice as transferable.

Sophie's perception of how transferable her chess skills were to other activities does not stand alone. Schoolz, Niesch, Steffen, Ernst Markus, Witruk and Schwarz (2008) conducted a study to investigate whether chess practice could be beneficial in mathematical classes of children with learning disabilities. They compared the concentration and calculation skills of children who received a weekly one hour chess instruction during a year with that of the control group, who received an hour of math instruction. Four randomly assigned German schools participated in that study.

The children who received chess instruction scored higher in tasks designed to measure mathematical calculation and increased their concentration level during tasks. This suggests, as the authors concluded, that skills learned through chess practice were successfully applied to other activities such as math calculation. Additionally, chess practice contributed to an increase in the concentration of children with learning disabilities during written math exercises.

ADHD Symptoms Post-Chess Intervention

Sophie attributed a decrease in her ADHD symptoms to her chess practice and credited the game for changes in the way she began to approach problem-solving situations, using reflexive and analytical skill learned through chess practice. In this section, I present the results of the two self-measures re-administered after the chess intervention (BAARS-IV and BDEFS-LF). After that, I highlight Sophie's perceptions of what, how and why her ADHD symptoms have decreased after the chess intervention.

Self-Measures Post-Chess Intervention

Barkley Adult ADHD Rating Scale–4. Two months after the first administration and immediately after the 10 training sessions were finished, Sophie filled out the BAARS-IV Self-Report Current Symptoms form a second time. Overall, Sophie's total ADHD score placed her within the average range. Likewise, there was a significant reduction of symptoms in every subscale. Sophie's inattention and hyperactivity scores were both within the average range (51-75th percentile) and her SCT score was in the marginally symptomatic range (77th percentile). Impulsivity was her highest score, within the mildly symptomatic range (94th percentile), yet lower than it was before the chess intervention. Although a causal relationship cannot be established based solely on the comparisons between these two assessments, these results suggest that, from Sophie's point of view, chess practice was an effective intervention for reducing her ADHD symptoms.

Barkley Deficits in Executive Functioning Scale- Long Form (BDEFS-LF). Similar to the results found when comparing the two administrations of the BAARS-IV, Sophie's scores on the BDEFS-LF were significantly lower the second time she completed the scale. Sophie's total EF summary score and ADHD Executive Functioning index were both in the average range (51-75th and 26th-50th percentile). She also had average scores on the self-management to time, self-restraint (self-discipline or inhibition), and self-regulation of emotion (self-activation/concentration) subscales.

Additionally, Sophie perceived an improvement in her abilities to deal with situations like those measured in the self-organization/problem solving subscale, in which she placed in the marginal problem range (77th percentile), as opposed to the moderately symptomatic range pre-chess intervention. Finally, there was also an improvement in Sophie's self-motivation score,

which was still within the borderline range but in the 87th percentile instead of the 90th percentile.

Overall, Sophie credited a global improvement in her ability to deal with ADHD symptoms to her chess practice. In her own words, it "seems like everything has improved except impulsivity." Sophie's perceptions of her ADHD symptoms in the post-chess intervention are consistent with the results of the two self-measures collected from the same period, which indicated a global decrease of symptoms after the post chess training was over. To describe how Sophie perceived the changes in her symptomatology, I separated her perceptions of symptoms into six subcategories: impulsivity, inattention, restlessness, time off task, working memory and other executive functions.

Impulsivity. Sophie described impulsivity as the most bothersome ADHD symptom in the post chess training interview. Although she found an improvement in her ability to control her impulsivity, it became more bothersome to her when she failed to do so. Additionally, she became more aware of her impulsive urges, saying, "I do find it easier to collect my thoughts before acting. So I think it is just that impulsivity has kind of come to the forefront as those other symptoms seem to have lessened." In the past, Sophie says, she did not know how to deal with her impulsivity and very often would not be able to control it. As she describes it, "now I will tell myself that you are being impulsive and cool it for a second and then take a moment and step back and try to be less impulsive" (interview post intervention).

Inattention. According to Sophie's self-perception, inattentiveness was the symptom that lessened more than the others did. Her sustained attention and focus on external and internal stimuli improved in a variety of contexts and activities, such as while working, talking to other people and even when trying to organize her own thoughts. Moreover, Sophie felt that it became

easier to pay attention during conversations when she did not find the subject interesting. The following illustrates how Sophie evaluated the effects of chess on her attention to external stimuli:

> I don't think I am nearly as inattentive. I did even notice in conversation with people as well. I used to struggle really, really, really hard to pay attention to someone when they were speaking to me. Especially if that was something I wasn't necessarily interested in absorbing. I have gotten way better with that. (Interview post intervention)

Sophie's attention to internal stimuli also improved. She mentioned that she made a conscious mental effort to "pay more attention into actually getting thoughts in a linear fashion, rather than just kind of blurting and going in circles" (interview post intervention). Consequently, it has helped her maintain attention on her own thoughts and be less distracted by concurrent ideas and other sources of distraction. Therefore, it is likely that Sophie's issues with focused attention still exist. However, she developed a systematic and effective way to cope with her inattentive symptoms.

Restlessness. Sophie was diagnosed with ADHD/inattentive type and did not report major issues with physical hyperactivity. However, she experiences restlessness, anxiety and frustration when her ability to focus, pay attention and stay on-task are disturbed. Although practicing chess has not cured such symptoms, playing the game during breaks at work seemed to help Sophie calm her mind and decrease her agitation when she is restless and anxious:

> It is really funny that when I get restless I open up a chess app and try to play the computer because when I was restless before it just spiraled like I would waste an entire day in this like terrible myriad of restless feelings. And now I generally reach for the

> chess app and play it for a little bit and then it just kind of goes away (Interview post intervention).

Because Sophie is able to go back to work even when experiencing restlessness if she practices chess for a while, the time she stays off-task at work significantly decreased.

Time off task. The time Sophie remains off-task due to her ADHD symptoms have lowered:

> It still happens, but it is lower. I think before it was probably close to 50 to 60% and maybe now it is 25 to 35% like I would not even say like it 40%. Definitely below that even on a bad day now (Interview post intervention).

Chess helped Sophie foresee the consequences of procrastinating. Although on several occasions, she still finds it difficult to engage in activities perceived as boring or difficult, that is requiring prolonged mental effort, it is now easier for her to find motivation to engage in such tasks. What changed is that she now foresees and weighs the consequences involved in delaying the completion of these activities, realizing that "if I don't do it now it's just gonna get worse." Instead of procrastinating or choosing an easier activity, Sophie started often took the time to analyze the pros and cons of her decision.

Additionally, Sophie is more aware of her tendency to "get distracted by something else and do an easier task or check the news or something rather than actually get it done." (interview post intervention) This realization has helped her refrain from procrastinating and increased her productivity at work. For instance, during the last chess training session, Sophie mentioned a task that she was in charge of at work, which involved solving a complex problem in an area that she finds disinteresting and out of her area of expertise. Since she thought she "wasn't capable of handling it" she assumed that the task "was gonna be a really bad headache and was gonna

make" her anxious. Before the chess intervention, she "would get frustrated and would get extremely, extremely distracted in situations like that". Nevertheless, this time she decided avoid procrastinating and added it on her "to do list" for the day and successfully completed the task, which was easier than she expected because she "planned it out and was strategic about it. It was a lot less painful than [she] thought it would be and … that is kind of new" to her.

The overall reduction in Sophie's ADHD symptoms is consistent with what Blasco-Fontecilla et al. (2015) reported in their Spanish chess experiment with schoolchildren. After an 11-week long chess intervention the authors found, through statistical analysis that there was a significant reduction in overall ADHD symptoms as self-reported by participants and by parents and teachers after the chess intervention. The reduction in Sophie's ADHD symptoms was not the only positive effect of the chess intervention in her opinion. She also observed gains in cognitive abilities such as working memory.

Working Memory. During the intake interview, Sophie described her ability to retain small pieces of information in immediate awareness and then later retrieve it as very poor. Her appraisal of the same abilities changed after 10 weeks of chess training; after the last chess training session, she affirmed, "I don't think it is anything worse than anyone else now, which is nice" (interview post intervention). Both her confidence in her ability to take in information as well as the abilities itself seem to have improved.

Sophie had concrete evidence observed during her work routine to support this improvement. For instance, she mentioned on several occasions that the amount of notes she is taking to remember things has progressively decreased and that her "forest of sticky notes is a lot smaller now. So it is nice. That is really nice." Moreover, she has not felt the need to be

"tracking things as fastidiously as before in order to make sure that things were actually going to get done or being kind of shelved and forgotten" (interview post intervention).

Sophie's confidence in her ability to remember appointments and deadlines allowed her to spend less time using apps and other remembering systems and devices, and gave her more free time at work and at home. Additionally, her "recollection of something sitting and waiting is a lot better now." Furthermore, she "can actually retain a decent amount of tasks in [her] head without getting really anxious or forget them. Like I can actually count on myself and trust on myself to remember them, which is completely new" (interview post intervention**).**

Due to this enhancement in her perceived ability to remember, Sophie now has found it easier "to prioritize and strategize and be comfortable with shelving projects" because she is confident that she will remember shelved projects. Furthermore, Sophie has remembered more often than before where her personal objects such as keys, glasses, personal and work-related objects are stored and because her "memory has gotten quite better" she has not "lost anything for a while" (interview post intervention).

Although Sophie already had general strategies in place to deal with her perceived deficits in working memory and other executive functions at work and while in school, she used to spend a lot of time keeping track of her agenda. Lately, she does not need to spend as much time making sure she is not forgetting anything, as she trusts more in her ability to remember things. This indicates that if Sophie's memory has not improved, at least her confidence in her ability to remember has increased. Nevertheless, as I have already discussed in this paper, a large body of research has recently shown that training can improve working memory capacity. The results of my study and a recent amount of research evidence have suggested that chess may be a viable intervention in working memory-training programs (Urra, 2015).

Other executive functions. Sophie's 10 weeks of chess practice helped us explore whether solving chess puzzles would be an effective intervention to improve executive function skills of adults diagnosed with ADHD. The results were similar to those of Demily et al. (2009). Similar to their study, my participant reported executive functioning improvements after 10 hours of consistent weekly chess practices. Although at the outset of her chess practice Sophie did not present a severe level of executive dysfunction, in our study as in Demily et al.'s study, chess seemed to be a contributing factor in the overall level of improvement of abilities such as planning, prioritizing, organizing and sequencing activities.

Sophie affirmed during the last chess session that her thoughts are more organized than before and because of that she does not need to "write things in multiple places and set as many alarms as she used to. Besides the ability to organize herself, Sophie perceived an improvement in her ability to finish projects, set priorities according to the necessity of the situation and create self-regulation strategies to accomplish her goals. Sophie recently prepared a breakfast for 10 of her friends. Her friends noticed she was calmer and less stressed than normal. Additionally, Sophie felt less anxious while planning and delivering breakfast to her friends. She evaluated as a positive experience and not a source of stress and anxiety, which was often the case when she was surrounded people.

Many comments made by Sophie throughout the chess training sessions could be cited to illustrate how some of her executive functioning skills have qualitatively improved after she started playing chess. I chose four statements that seem to encompass Sophie's perceptions of her current executive functioning abilities. Because the statements chosen were part of Sophie's final appraisal the chess training sessions and how she was affected by it I decided to reproduce those statements verbatim:

1. *Solving problems: In chess as in life:*

I have gotten better at finishing things and prioritizing things and I think pretty much all of that is just due to taking a step back from a situation and taking a moment to strategize that situation like you do in chess. You don't just automatically go like ahh I will move it out there. You have to think of what is actually going to happen and what is the best course of action.

2. *Believing you can, first step to getting it done*. Playing chess has helped Sophie with "strategizing and prioritizing, and taking a moment to evaluate something before moving and it's given [her] some confidence in [her] ability to strategize, prioritize and maybe not act in a way that [she] would've formerly done."

3. How to proceed: "If someone gives me a task I don't immediately start working on it. I might write it down because I have thought how important it is and it is less important than what I am doing right now."

4. Putting it all together: "It is just really thinking about the situation before you make any decisions."

According to Urra's literature review (2015), consistent chess practice can improve executive function skills and cognitive abilities in children and adults. He highlighted the positive effects that chess had when used as an intervention to improve children's cognitive functioning and fostered higher levels of achievement. Urra mentioned that chess has been useful with adults in preventing memory loss in the general population and in recovering intellectual skills with patients who experienced a psychotic episode.

Among the executive skills that are relevant in a game of chess, Urra (2015) listed "activation, impulse inhibition, attention management, goals, plannification, emotion

management, memory management, effort maintenance, flexibility, and metacognition" (p. 4). Those skills, Urra (2015) defended, would positively respond to "constant and repeated practice, through works of raising difficulty" (p.4). Sophie's chess practice has confirmed Urra's claims. This supports our claim that Sophie's perceptions of her chess experience are not an isolated case, but rather it exemplifies how consistent and systematic chess practice can benefit executive functioning and improve cognitive abilities.

Conclusions

I conducted a qualitative case study to explore how an adult diagnosed with attention-deficit/hyperactivity disorder/inattentive type perceived the influence of chess practice on her working memory and other executive functions. I aimed to understand whether chess practice can be used to improve executive functions such as working memory as well as organizing, prioritizing and planning skills.

The results from this chess experiment, as perceived by the participant, suggested that chess practice can successfully be used as an intervention for ADHD and to improve executive functioning. After the chess training intervention, there was a significant reduction in ADHD symptoms in every subscale of the self-measures BAARS-IV and BDEFS.

The participant's inattentiveness score in the BAARS-IV was the ADHD symptom most positively affected by the participant's chess practice, dropping from the moderately symptomatic range (98 percentile) to the average range after 10 weeks of chess training (51-75th percentile). Impulsivity was the symptom affected the least by chess practice. However, the participant's score in the impulsivity subscale was lower after the chess intervention when compared to its pre-chess intervention administration. Similarly, what can be seen when the two

measures of the BDEFS are compared is that the participant's scores were significantly lower at the second administration of the scale.

Additionally, the qualitative data gathered through interviews indicates that the participant experienced lower levels of ADHD symptoms such as impulsivity, inattention, restlessness, time off-task, working memory and other executive functions deficits. Furthermore, there was a perceived improvement in the participant's planning, organizing and prioritizing skills. Finally, I collected qualitative evidence showing that the participant was able to apply a set of skills learned through chess practice to personal, recreational and professional activities with similar cognitive requirements.

Chapter 5: Self-Assessment of the Study and Recommendations

In the first section of this chapter, I discuss the strengths and limitations of this study. After that, I suggest topics for future research to further the knowledge on the significance of chess for the improvement of cognitive abilities and executive functions. I also discuss the study's implications for applied psychology.

Strengths

Exploring Sophie's self-perceptions during a chess intervention was a creative way to understand how chess can affect ADHD symptoms and cognitive abilities. The method I used in this study gave me detailed information on one particular individual. However, the knowledge produced can be used to help others with similar issues. Although Sophie's experience is unique, several of the issues she described are similar to that reported by individuals diagnosed with ADHD. Thus, the benefits produced through chess practice as evidenced in Sophie's experience might be extended to others diagnosed with ADHD.

The single case study design made it possible to empower Sophie to focus on what she experienced as important, rather than focusing on the researcher's pre-established conceptions and personal biases regarding the game. Sophie was not only involved, but rather implicated in every aspect of the chess program, having ownership to highlight what should be taken into consideration and what should be analyzed during the entire chess intervention. It was her discourse and her personal experiences that drove the course of analysis, and not pre-existing theory on the subject matter studied.

Using multiple data instruments allowed me to compare and contrast Sophie's discourses in different moments of the chess practice. I recorded her chess performance and used self-measures of ADHD and executive functioning to ascertain that Sophie's self-perceptions were

internally consistent. This procedure increased the trustworthiness of the study. Additionally, I tailored other procedures to assure quality during this study and capture singular characteristics of chess practice.

The results of this study suggested that abilities learned through chess practice can be transferred to activities in which similar underlying cognitive processes are required. However, more studies focusing on this specific topic are still required before any conclusions can be made.

Limitations

This study explored the perceptions of one participant on the effects of a chess practice program on her executive functions and ADHD symptoms. However, I did not use psychometric tools to assess working memory. Future studies using an experimental or quasi-experimental design could focus on using psychometric tools to expand the knowledge on the effects of chess on working memory of adults diagnosed with ADHD. For instance, measures of working memory could be collected prior and post chess intervention and then compared after a year or two of chess practice to ascertain chess can improve working memory capacity.

Another limitation of this study is in that the chess program was only 10 weeks long. Even though 10 hours of chess practice was sufficient time to generate data and explore my participant's perceptions on her chess experience in depth, showing her executive function improvements, the results could be more conclusive if the program was longer. Sophie's discourse might have reinforced the positive impacts of chess on her life. However, if she played the game for longer than a year she might have lost interest in it or even devaluate its gains on her other activities.

Furthermore, my literature review was limited due to the scarcity of studies exploring the relationship between chess practice and ADHD with university students in Canada. Research studies from different countries were used to theoretically guide my interpretation of the data gathered. Thus, the comparisons between the results of this case study with those reported in the foreign research literature are cross-cultural. As a consequence, any rigorous interpretation of the results should take into consideration how cultural variables (e.g., different social roles of research participants in their country of origin, cultural acceptance and understandings of psychiatric disorder and threshold for diagnosis) are understood in the countries where the studies were conducted. Among these countries are Spain, England, Australia, Brazil and Cuba.

Moreover, most of the studies I used were done with child and adolescent participants. While the lack of research in the topic provided a rationale for this research study, it restricted the theoretical knowledge at hand to "make sense" of and interpret the data. Because I often referred to studies done with children and adolescents to support the findings of this study, its results should be interpreted carefully and take into consideration how ADHD affects people differently depending on their developmental stage.

The present study only used self-measures to explore how chess can affect ADHD symptoms and executive functioning. Despite of how useful this strategy was to understand the participant's perception in-depth it did not account for misperceptions or misjudgments in the participant's self-appraisal. As discussed by Knouse et al. (2008), a few studies have highlighted how "children with ADHD overestimate their competence in a variety of domains" (p. 653). Although I couldn't find articles done with adult participants discussing this issue, it is possible that my participant has overestimated the effects of chess on her performance during other professional and personal activities.

Suggestions for Future Research

Although chess has been instrumental in a variety of research inquiriesin cognitive psychology and education, our current knowledge of how the game can affect executive function skills of university students diagnosed with ADHD remains limited. Future research could focus on what elements of the game contribute to the enhancement of specific executive functions such as working memory, metacognition and processing speed, usually impaired in people with ADHD.

For example, a mixed-method study with university students diagnosed with ADHD could explore if and how chess can enhance working memory. Participants would be divided in three different groups. Group A would solve chess problems weekly for an entire year, systematically observing and recording differences in their working memory capacity. Group B would also solve chess puzzles for the same period. However, people within this group would not have to observe or record differences in their working memory. Finally, group C would not practice chess and simply perform their regular school activities.

Participants from all these three different groups would undergo interviews and cognitive assessments of their working memory skills prior and post chess intervention. A comparison from standardized scores and semi-structured interviews from these two different periods would indicate whether the participants' perceived and measured working memory skills changed with chess practice. Additionally, such study would allow comparing and contrasting groups A and B perceptions of what aspects of chess practice positively affected the participants' working memory skills. This comparison between different groups would also yield more information on if, why, how and what in chess contributes to memory improvements.

Similarly, it would be interesting to develop studies exploring whether chess can improve metacognition and planning skills of university students diagnosed with ADHD. For example, if we assume that developing a research project is an activity that exemplifies the use of metacognition and heavily demands planning abilities, a study could compare the ability to create a research project in a methodology class of students practicing chess versus a control group. Besides their grades, the strategies students used to build their own project could be investigated through interviews. This type of study might indicate whether chess practice can improve planning skills and project development abilities.

Likewise, it would be beneficial for cognitive science to learn more about the positive socio-affective qualities of chess players and investigate whether chess can foster personal and social adjustment skills beyond cognitive improvements. If that is the case, as suggested by a few existing studies (e.g., see Ramon et. al, 2012), then children, adolescents and adults who struggle with self-regulation and present with lower emotional control than expected due to the disorder could benefit from the positive effects of chess practice.

If I were to conduct another chess training intervention, I would make a few changes to refine the study's method. Firstly, I would include more participants so that I could compare their experiences. Secondly, I would run a longer chess-training program to increase the trust or confidence of my findings. Although ten hours of chess practice already showed significant results, running a longer chess program would show the stability of the gains acquired through chess practice. Thirdly, I would use specific checklists for the participants to track their perceptions of how chess is affecting their executive functioning and ADHD symptoms in different contexts. As an example, I would ask them to track at the end of their workday how intense their ADHD symptoms were. Fourthly, I would use collateral measures, such as the

parenting version of the BAARS-IV, to account for possible misperceptions or overestimation of abilities, thus improving the trustworthiness of the research.

Implications for Practice

The chess intervention showed the potential of the game as a non-stigmatizing intervention for ADHD in educational contexts. For instance, as I discussed in the results session, Sophie switched her own self-perception from a general negative self-appraisal to a positive one, and became more confident in her own cognitive abilities. Initially, when talking about herself Sophie placed her focus on her disorder and on the distress caused by the symptoms she used to experience. However, at the end of the program her potential to overcome the barriers created by the disorder became central in her discourse, rather than her personal limitations. This suggests that, in Sophie's case, chess practice produced self-confidence and positive self-appraisal.

Furthermore, Sophie highlighted how much she enjoyed playing chess in several occasions throughout the chess training sessions. This is of particular importance because it is widely-mentioned in the ADHD literature that, generally speaking, people with the disorder might experience a reduction of symptoms during activities they perceive as enjoyable. Thus, if skills acquired through chess practice can be used to decrease ADHD symptoms, then people diagnosed with the disorder can potentially benefit from the game so long they enjoy and find motivation to study it.

Additionally, Sophie became more aware of her already existing cognitive strengths. Besides alleviating ADHD symptoms and making daily life easier, the game improved Sophie's self-confidence and self-image. Clinicians working in the mental health field, educators and student services could recommend chess to their clients as a complementary, cost-effective way

to improve self-confidence, executive functioning and decrease ADHD symptoms. The game offers no harm or side effects, it is available for people of all ages and gender and rather than bringing a stigma, it is commonly associated with intelligence.

Having the opportunity to teach Sophie how to play chess while researching the perceived effects of the game on her ADHD symptoms and cognitive abilities was a rewarding experience for me, both as a researcher and as a chess enthusiastic. Although the book used and procedures followed to teach her the game were contributing factors in the development of her chess skills, the relationship created during the chess practice was just as important. Sophie kept coming back to the next chess training session and reporting the positive aspects of the game in her life.

I truly believe that Sophie's experience shed light on how powerful chess can be as an intervention for reducing ADHD symptoms and, as such, should be recommended by psychologist and other mental health professionals working with people diagnosed with ADHD and executive functioning difficulties.

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Appendices

Appendix A. Interview prior to the chess intervention

Section A Exploring ADHD history and symptoms

1. How long ago were you diagnosed with ADHD? Why did you seek for professional help?
2. Do you have any other medical/psychiatric diagnosis?
3. How did you deal with the diagnosis at the time? I mean it has been only one month since the formal diagnosis but what have you done since then?
4. Who did diagnose you? Psychologist/Doctor?
5. What type of ADHD were you diagnosed with?
6. On a scale of one to ten where one is very low and ten is very high how bothersome are the ADHD symptoms you currently experience? Explain.
7. What are the types and frequency and intensity of symptoms you current experience related to ADHD? (e.g. Inattention, hyperactivity, once a day, pretty strong, mild, etc.)
8. How many hours do you sleep on average per night?
9. Interviewer: Is it it that it is harder for you to fall asleep or it is both it is hard to fall asleep and stay asleep?
10. Do you exercise? If yes, what kind of exercise and frequency?
11. Do you take any medication? and for ADHD?
12. Interviewer: Oh so you need to take hormones?
13. What have you done/tried to cope with the ADHD symptoms you experience?
14. Has ADHD affected you the most in which environment/activity?
15. Has it affected your social life at all?

16. Is there anything else you would like to ADHD regarding your personal experience with ADHD?

17. How would you describe your ability to retain small pieces of information in immediate awareness for a short period of time? (For instance, a cell phone number, or an address someone gives you over the phone).

18. On a scale of one to ten where one is very low and ten is very high how would you rate your ability to retain and mentally manipulate information?

19. Do you find it easier to retain numbers, words, both or none, in immediate awareness for a short period of time? Does it matter whether the information is given orally or visually?

20. How do you perceive your planning skills? Please explain (Base your answer on school projects, professional, personal goals, free time and your general ability to plan). Does it make a difference in your level of performance whether the activity you are planning is professional or recreational?

21. On a scale of one to ten where one is very low and ten very high how would you rate your overall planning skills?

22. How would you describe your ability to organize activities (Professionally, educationally, recreationally, family activities, etc).

23. On a scale of one to ten where one is very low and ten is very high how would you rate your overall organizational skills? (At home, school, work and in general).

24. How would you describe your ability to prioritize events as per their importance? (Professionally, educationally, recreationally, family activities, etc).

25. On a scale of one to ten where one is very low and ten is very high how would you rate your prioritizing skills? (At home, school and in general).

26. Is there any other information you would like to share regarding your organizing, planning and prioritizing skills?

27. How do you perceive your interpersonal relationship skills?

Appendix B. Interview after the chess intervention

1.What are the types, frequency and intensity of symptoms you currently experience related to ADHD?

2.On a scale of one to ten where one is very low and ten is very high how would you rate how bothersome are the ADHD symptoms that you still experience?

3.How many hours do you sleep on average per night?

4.Do you still exercise like you did before?

5.Are you taking any medication for ADHD?

6.Is there anything else you would like to ADHD regarding your current personal

7.How would you describe your ability to retain small pieces of information in immediate awareness for a short period of time? (so say instance, a cell phone number, or an address someone gives you over the phone or something like that, somebody gives you a verbal or visual information and you gotta retain for a little bit that information in your immediate awareness).

8.On a scale of one to ten again where one is very low and ten is very high how would you rate your ability to retain and mentally manipulate information in immediate awareness?

9.Do you think your chess practice experience over the last two months roughly affected your ability to retain information in immediate awareness?

10. How do you perceive, you were talking about planning, how do you perceive your planning skills?

11.On a scale of one to ten again where one is very low and ten very high how would you rate your overall planning abilities?

12. How would you describe your ability to organize activities (Professionally, educationally, recreationally, family activities).

13.On a scale of one to ten where one is very low and ten is very high how would you rate your overall organizational skills?

14. How would you describe your ability to prioritize events as per their importance?

15.Do you think your chess practice experience over the last two months affected your ability to organize, prioritize and plan? and if yes, what ability and how? I guess you talked about what the abilities that improved are but if you could say a little bit of how?

16.Is there any other information you would like to share regarding your organizing, planning and prioritizing skills? Any other information?

17.Can you tell me how was for you to participate in this chess practice program?

18.Did you experience any difficulties while solving chess problems? If so, what kind of difficulties?

19.In your perception, what was helpful for you while solving chess problems?

20.Is there anything that could have made your chess experience to be more effective in your opinion?

Appendix C. Self-measure results collected prior to the chess intervention

BAARS-IV

Ranges for clinical interpretation of all of the percentile scores are as follows:

Percentile	Qualitative Descriptor
≥ 99th	Severely Symptomatic
96 – 98th	Moderately Symptomatic
93 – 95th	Mildly Symptomatic
84th – 92nd	Borderline or Somewhat Symptomatic
76 – 84th	Marginal Symptomatic
≤ 75	Average

Scores collected prior to the chess intervention

Self-Report: Current Symptoms			**Self-Report: Childhood Symptoms**		
Subscales	**Percentile**	**Qualitative Descriptor**	**Subscales**	**Percentile**	**Qualitative Descriptor**
Inattention	**98th**	**Moderately Symptomatic**	Inattention	**97th**	**Moderately Symptomatic**
Hyperactivity	85th	Borderline	Hyperactivity-Impulsivity	**51-75th**	**Average**
Impulsivity	**94th**	**Mildly Symptomatic**			

Total ADHD Score	**97th**	**Moderately Symptomatic**	Total ADHD Score	**93rd**	**Mildly Symptomatic**
Symptom Count	**97th**	**Moderately Symptomatic**	Symptom Count	87th	Borderline
Sluggish Cognitive Tempo (SCT)	**96th**	**Moderately Symptomatic**			
Impaired functioning setting: School, home, work, social relationships			Impaired functioning setting: School, home, social relationships		

BDEFS-LF

Scoring Guide:

Percentile Score	Qualitative Descriptor
≥99	Markedly deficient, severe problem
96 - 98	Moderately deficient, significant problem
93 - 95	Mildly atypical, probably significant problem
85 - 92	Borderline/somewhat deficient, possibly significant problem
76 - 84	Marginal problem
≤75	Average

Scores collected prior to the chess intervention

Domain and Description	Percentile	Qualitative Descriptor
Self-Management to Time This factor pertains to the individual's ability to manage his/her time. The items dealt with sense of time, time management, planning, preparing for deadlines, and other goal-directed behaviour	**99th**	**Markedly deficient**
Self-Organization/Problem Solving This factor pertains to the individual's ability to organizing one's thought, actions, and writing as well as problem solving. Items included the individual's ability to think quickly when encountering unexpected events and their ability to invent solutions to problems or obstacles encountered while pursuing goals.	**96th**	**Moderately deficient**
Self-Restraint (Self-Discipline or Inhibition) This factor pertains to the individual's self-restraint, self-discipline or inhibition. Items included making impulsive comments, poor inhibition of reactions to events, impulsive decision-making, doing things without regard to their consequences, and not thinking about the relevant past or future before acting. A few items also dealt with poor self-awareness and the inability to take other people's perspectives about one's	87th	Borderline/ somewhat deficient

own behavior or a situation.		
Self-Motivation This factor pertains to the individual's ability to maintain motivation independently. Items mainly deal with taking shortcuts in one's work, not doing all assigned work, being described as lazy by others, not putting in much effort on work, needing more supervision than others while working, getting bored easily, and so forth	90th	Borderline
Self-Regulation of Emotion (Self-Activation/Concentration) This factor pertains to the individual's ability to regulate his/her concentration and emotion. Items concerning being easily distracted by one's thoughts when doing boring work; staying awake and alert while working; being able to persist in boring activities; sustained concentration to reading, paperwork, meetings, or other activities that were not interesting; being prone to daydreaming when one should be concentrating; and having to re-read uninteresting written material in order to comprehend it.	**98th**	**Moderately Deficient**
Total EF Summary Score	**98th**	**Moderately Deficient**
ADHD-EF Index This index indicates the level of risk an individual has for meeting the diagnostic criteria for ADHD. Ten items from the five factors were used, such as has trouble planning ahead or preparing	86th	Borderline

upcoming events, can't seem to get to the point of his/her explanations, and acts without thinking things over		

Adapted from: Barkley, R. (2011). *Barkley Deficits in Executive Functioning Scale (BDEFS).* New York, New York: The Guilford Press.

Appendix D Self-measure results collected post chess intervention

BAARS-IV

Administration post chess intervention

Self-Report: Current Symptoms		
Subscales	**Percentile**	**Qualitative Descriptor**
Inattention	51-75	Average
Hyperactivity	51-75	Average
Impulsivity	**94th**	**Mildly Symptomatic**
Total ADHD Score	51-75	Average
ADHD Symptom Count	1-75	Average
Sluggish Cognitive Tempo (SCT)	**77th**	**Marginally Symptomatic**
Impaired functioning setting: work, social relationships		

BDEFS-LF

Administration post chess intervention

Domain and Description	**Percentile**	**Qualitative Descriptor**
Self-Management to Time	51-75	Average

This factor pertains to the individual's ability to manage his/her time. The items dealt with sense of time, time management, planning, preparing for deadlines, and other goal-directed behaviour		
Self-Organization/Problem Solving This factor pertains to the individual's ability to organizing one's thought, actions, and writing as well as problem solving. Items included the individual's ability to think quickly when encountering unexpected events and their ability to invent solutions to problems or obstacles encountered while pursuing goals.	77%	Marginal Problem
Self-Restraint (Self-Discipline or Inhibition) This factor pertains to the individual's self-restraint, self-discipline or inhibition. Items included making impulsive comments, poor inhibition of reactions to events, impulsive decision-making, doing things without regard to their consequences, and not thinking about the relevant past or future before acting. A few items also dealt with poor self-awareness and the inability to take other people's perspectives about one's own behavior or a situation.	51-75	Average
Self-Motivation This factor pertains to the individual's ability to maintain motivation independently. Items mainly deal with taking shortcuts in one's work, not doing all assigned work, being described as lazy by others, not putting in much effort on work, needing more supervision than others while working, getting bored easily, and so forth	87	Borderline

Self-Regulation of Emotion (Self-Activation/Concentration) This factor pertains to the individual's ability to regulate his/her concentration and emotion. Items concerning being easily distracted by one's thoughts when doing boring work; staying awake and alert while working; being able to persist in boring activities; sustained concentration to reading, paperwork, meetings, or other activities that were not interesting; being prone to daydreaming when one should be concentrating; and having to re-read uninteresting written material in order to comprehend it.	51-75th	Average
Total EF Summary Score	51-75th	Average
ADHD-EF Index This index indicates the level of risk an individual has for meeting the diagnostic criteria for ADHD. Ten items from the five factors were used, such as has trouble planning ahead or preparing upcoming events, can't seem to get to the point of his/her explanations, and acts without thinking things over	26-50th	Average

Adapted from: Barkley, R. (2011). *Barkley Deficits in Executive Functioning Scale (BDEFS).* New York, New York: The Guilford Press.

Appendix E: Observation log

The chess sessions were all audio/video recorded. During the chess sessions the research student was attentive to the following:

- **Learning strategies that the participant uses to solve the chess puzzles**
  1. Does the participant recognize similar patterns he/she was previously exposed by other chess puzzles?
  2. Does the participant look at the whole chess board before choosing the answer or does the participant get his eyes and perception fixed in certain areas of the board? (e.g. edges, center, king's side, queen's side).
  3. Is the participant progressively understanding the coordination of chess pieces (how pieces work together) to solve the chess puzzles?
  4. How does the participant prioritize candidate/potential chess moves?
  5. How does the participant organize his/her thinking process to choose a move?
  6. What are the planning skills used by the participant during the chess training?

- **Verbal expression during the chess training**
  1. Does the participant use loud self-talk while solving chess puzzles?
  2. Does the participant ask questions when solving chess puzzles?
  3. Is the participant talkative during the chess sessions? (Talk about what? Goes off-topic?).
  4. Does the participant talk about the level of difficulty of the task?
  5. Does the participant express the desire to quit the chess practice? (Definitely quit or quit one particular chess session?)

- **Nonverbal expressions during the chess training**
  1. What kinds of nonverbal behavior do the participant displays during the chess training? (Mannerisms? calm or agitated body movements? When during the chess session? Anxiety and stress symptoms? (Restlessness, nervousness, biting nails/lips? Scratching head? Body shaking? Agitated/restless arms/legs?

- **Motivation during the chess training**
  1. Does the participant keep his/her level of motivation during the chess session? (Get tired/bored easily?)
  2. Does the participant give up easily? (When the puzzles become harder or at any given point?)

Appendix F: Responses to the chess puzzles as per level of difficulty

1 Session
The game was taught to the participant during this first session. This took more than half the time of the session
Number of problems presented 9
Correct answers 9
Wrong Answer 0
Level of complexity: Very easy

2 Session
Number of problems presented: 19
Correct answers: 17
Wrong Answer: 2
Level of complexity: Very Easy

3. Session
Number of problems presented: 16
Correct answers: 13
Wrong Answer: 3
Level of complexity: Easy

4. Session
Number of problems presented: 16
Correct answers: 12
Wrong Answer: 4
Level of complexity: Easy

5. Session
Number of problems presented: 13
Correct answers: 8
Wrong Answer: 5
Level of complexity: Intermediate

6. Session
The chess board wasn't used. Instead, the chess problem solving exercises were shown directly to the participant.
Number of problems presented: 16
Correct answers: 13
Wrong Answer: 3
Level of complexity: Intermediate

7. Session
Number of problems presented: 12
Correct answers: 10

Wrong Answer: 2
Level of complexity: Hard

8. Session

Number of problems presented: 17
Correct answers: 11
Wrong Answer: 6
Level of complexity: Hard

9 Session

Number of problems presented: 16
Correct answers: 14
Wrong Answer: 2
Level of complexity: Very Hard

10 Session

Number of problems presented: 14
Correct answers: 11
Wrong Answer: 3
Level of complexity: Very Hard

Appendix G: Sample of questions asked after each chess training session

1.What are your overall impressions of this chess training session?

2. Did you get anxious at all while you're trying to solve the problems?

3. Did you notice any change in your attention, concentration and memory skills during the session? What about when you compare this session with last weeks?

4. What were the strategies you used to solve the chess problems? Any new strategies? Different ones?

5. Have you perceived any difference in the way you approach problem solving situations outside of here, like in your life?

6. When you compare the ADHD symptoms you described to me in our first interview with what you experience today, do you notice any difference in their frequency, duration and intensity?