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Pièce Touchée![¤]: The Relationship Between Chess-Playing Experience and Inhibition

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Background. Studies have shown that teaching children and youths chess can contribute to their academic achievements and improve their cognitive abilities. Recent studies further indicate the transfer of chess skills to subjects such as mathematics. However, the literature does not address the possible benefits of chess to link between inhibition and ADHD, a disorder in the operational executive functioning system, whenwith chess ias a game that requires various cognitive abilities, and is considered dependent on executive operational functioning abilities and especially inhibition.

Objective. To investigate whether chess experience relates to inhibitory control in teenagers with and without ADHD.

Design. Participants completed a visual-spatial task designed for the purpose of the study, comprising two conditions: In the "free" condition, participants were allowed to test different solutions before choosing the answer, whereas in the "touch-move" condition they were asked to choose the answer without any physical attempts. Participants also completed "Go/No-go" tasks.

Results. The new task was found to be partially effective as only the "touch-move" condition produced group differences, with chess players performing better than non-chess players, regardless of diagnosis. The No-go task performance analysis also showed a significant main effect for chess training, and a significant interaction among chess, ADHD, and medicine use.

Conclusion. Although not establishing causality, these results indicate that chess players were less impulsive than non-chess players, regardless of diagnosis.

***Keywords*:**
ADHD; inhibitory control; executive function; impulsivity; education; chess

[¤] The French term for the touch-move rule in chess that specifies that, if a player deliberately touches a piece on the board when it is his/her turn to move, then s/he must move or capture that piece if it is legal to do so

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Introduction

Attention Deficit: An Educational "Epidemic"

Attention-Deficit/Hyperactivity Disorder (ADHD) is a disorder affecting 3% of school-age children world wide (Fayyad et al., 2017). Due to its prevalence, both its symptoms and its causes have a wide range of descriptions. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5, American Psychiatric Association [APA], 2013) is commonly used for diagnostic purposes. The DSM requires a pattern of symptoms related to attention deficiency and concentration, which includes inattention to details, difficulty in focusing on a goal, and disorganization. Characteristics of hyperactivity include agitation, restlessness, and difficulty in participating in calm activities. In order to establish a diagnosis, persistence of these symptoms for at least six months prior is required (Barkley, 2014).

Attention Deficiency Disorder (ADD) first appeared in the diagnostic manual in 1980 (APA, 1980). Whereas in 1978 the estimate was about 5% of the population in the United States (Lambert, Hartsough, Sassone, & Sandoval, 1987), over the years the disorder's prevalence increased steadily, and today it is estimated at 11%, affecting all areas of life, particularly school (Visser et al., 2014). Although the reasons for the increased frequency of ADHD in particular and child psychopathology in general are not known, some claim that the computer and Internet era is a major contributor (Carr, 2014). A study of Internet users found that a user closes an online video clip if it does not play within two seconds (Krishnan & Sitaraman, 2013). These results provide a glimpse of the future: Internet services are becoming faster, gratification more immediate, and people are becoming less patient and less able to delay gratification and work for long-range returns (Anderson, & Rainie, 2012). The modern lifestyle gives rise to concern that attention-deficit phenomena will increase. It should be asked whether activities that require concentration and patience could help with delaying gratification.

Many scientific papers have focused on the cognitive processes that underlie ADHD, notably deficiencies in executive functions as the main and basic contributor to the development of these symptoms (Doyle, 2006). Despite the many theories that describe executive functions, the literature defines the concept quite broadly as ongoing cognitive processes that contribute to goal-oriented behavior. These processes include many areas such as working memory, future planning, problem solving, attentiveness, and the ability to inhibit. It should be noted that there is no consensus in the literature about the skills included in executive functions (Meltzer, 2007).

Impulsivity and Inhibition

As the name of one of the disorders in DSM-5 – predominantly hyperactive-impulsive presentation – indicates, impulsivity is a key component of ADHD (APA, 2013). Impulsivity is a complex term that involves the inclination to act on a whim, and to behave without (or with little) forethought, reflection, or consideration of the long-term consequences. Reactions such as these are often dangerous, situation-inappropriate, and produce unwanted outcomes. Impulsivity includes a number of independent elements: (a) acting with insufficient discretion; (b) preferring short-term gains over long-term interests; (c) sensation-seeking; and d) difficulty persevering in a task (Whiteside & Lynam, 2001). In fact, one of the key theories claims that disinhibition disorder is the basis for ADHD impulsivity (Nigg, 2001). Whereas some scholars differentiate between impulsivity and inhibition as distinct elements, for the purpose of the current study we conceptualized them jointly; namely, that a high level of impulsivity means a low level of inhibition.

The many studies that focused on specific deficiencies such as in planning, working memory, and inhibition as the main contributors to the disorder, seem to agree that disinhibition is the main precursor of ADHD (Pennington & Ozonoff, 1996). Inhibition is an important feature that allows one to delay or stop a reaction to a stimulus, with its reverse side being impulsivity (Boonstra, Kooij, Oosterlaan, Sergeant & Buitelaar, 2010). On the other hand, Barkley (1997) argued that it is not enough to discuss inhibition in itself, because this feature divides into three separate yet interlinked processes: inhibition of the immediate reaction (the ability to prevent the initial response to the stimulus); control of disturbances (the ability to ignore distractions, whether internal or external); and inhibition of an ongoing reaction.

These three categories of inhibition are usually tested by means of simple cognitive tests. The stop-signal task, which requires examinees to react to a stimulus (for instance by pressing a button) and to avoid a response when a signal is given, examines immediate response inhibition, often called motor inhibition. A common test that examines ongoing inhibition is the "copying a circle" test, in which examinees are required to copy a circle. They are either instructed to copy the circle as slowly as possible (inhibition), or receive no instruction (without inhibition). The Stroop test is the most appropriate to test control of disturbances. Test participants are presented with names of colors written in another color (for example, the word "blue" is written in red), and are instructed to say the color of the ink in which the word is written (in the above example, "red"). All three tests measure response times and the differences between response times for tasks in which inhibition instructions were given or not given (Boonstra et al., 2010).

The issue of inhibition's effect on ADHD has been widely researched, and of the various types of inhibition, some claim that motor inhibition is a key factor in ADHD-related functional problems. A meta-analytic study that reviewed over 20 studies found that there is great variance of response times in motor inhibition tests (such as the stop-signal task) among ADHD patients (Lijffijt, Kenemans, Verbaten, & VanEngeland, 2005). Additionally, research has shown differences between children and adults in average response times (MRT) and stop-signal response times (SSRT). Furthermore, a study that examined the development of inhibition of response showed that these abilities improve with age, and it seems that the cause for lack of motor inhibition in younger examinees is attention deficit, which also stems from a limited capacity of working memory (Tamm, Menon, & Reiss, 2002).

Chess and Attention

The game of chess requires skills such as planning, visual memory, and executive functioning in general (Baddeley, 1992). Consequently, it has been argued that teaching children and youths chess could contribute to academic achievement and improved cognitive abilities (Bart, 2014). The link between chess and attention seems obvious; however, research in this area is almost nonexistent. In a broader context, it can be said that whereas countless fervent believers claim that it has advantages in education (e.g., McDonald, 2005; Vail, 1995), and a number of recent studies indicate the transfer of chess skills to subjects such as mathematics and other abilities (Rosholm, Mikkelsen, & Gumede, 2017; Trinchero & Sala, 2016), other scholars argue that there is no significant empirical evidence of such a link (Gobet & Campitelli, 2006).

Various studies have successfully used chess to strengthen cognitive abilities in schizophrenics (Demily, Cavezian, Desmurget, Berquand-Merle, Chambon & Franck, 2009), and to prevent dementia (Dowd & Davidhizar, 2003). Working memory in general and visual work memory in particular are important parts of the cognitive activities required when playing chess. Baddeley (1992) examined executive functioning, including memory of the pawns' positions on the board and planning the next play, among experienced and novice chess players; as expected, better performance was found for experienced players. It has already been noted that the executive functioning required in chess parallels the deficiencies of ADHD, thus pointing to the option of using chess to treat the disorder (Blasco-Fontecilla et al., 2016).

The link between inhibition and chess is intuitive. The saying "When you see a good move, see if you can find a better one", attributed to Domenico Lorenzo Ponziani (1719-1796), is well-known in chess history. Siegbert Tarrasch, the second-best chess player of his time, added: "When you see a good move, sit on your hands and see if you can find a better one" – a typical expression of the need for inhibition in chess. Nevertheless, since there is no research on chess and inhibition, one of the goals of this study is to empirically establish this intuitive link.

Giftedness

Chess is often connected with giftedness, at least in the popular culture, although the empirical evidence is inconclusive (Frydman & Lynn, 1992; Gobet & Campitelli, 2002). The definition of giftedness is not uniform, and the literature presents different definitions according to various outlooks. The variance of definitions affects the policies of locating gifted children and the rationale of teaching and treating these children (Landau, 2001). Dai and Chen (2013) described three paradigms to define giftedness: The "gifted child" paradigm sees giftedness as potential, a quantitative, congenital, and fixed feature represented by intelligence; the "developmental" or "talent development" paradigm views giftedness as a dynamic feature, unique to a preferred field of knowledge that leads to outstanding achievements and leadership in that field, and composed of a variety of cognitive, emotional-social, and environmental features; and the "differential" paradigm, which aspires to individually match learning to each student's personal needs. This approach casts doubt on the effectiveness of "pull-out" programs to supplement regular education, and seeks to create a learning environment suitable for each day, according to the changing educational needs of gifted students.

In Israel, the Department for Gifted and Excellent Students in the Ministry of Education defined "giftedness" according to the decisions of the Steering Committee for the education of gifted students in Israel (Nevo, 2004). The committee decided to use the term "gifted" for both gifted students, who excel in scholastic areas, and for talented students, who excel in arts and sports. The committee defined gifted students as the top percentile of the population in each year in each of the examined areas of "giftedness", so that the definition is in fact quantitative and relies on IQ and achievements. However, the committee added aspects of motivation, perseverance, and creativity as additional assessment parameters (Renzulli, 1986). These aspects are not tested today in gifted identification processes, but they are observed and reported during the child's participation in dedicated programs, and they add qualitative evidence to the definition. Additionally, the department continues to examine the optimal ways to include measures of creativity in the identification battery, and operates to promote identification of talent-oriented giftedness.

One can argue that every serious chess player is gifted, at least in chess. However, the connection between playing chess and the more rigid criteria for giftedness has not been established (e.g., Frydman & Lynn, 1992; Gobet & Campitelli, 2002). Nonetheless, in the present study we examined whether the identification of giftedness is related to inhibition, whether high intelligence is related to higher inhibition, or the same social forces that drive the identification of giftedness also drive children to play chess.

Chess as an Educational Intervention

Chess is a mandatory subject in many countries, and is part of the school curriculum in certain schools in Israel and other countries (Binev, Attard-Montalto, Deva, Mauro & Takkula, 2011; Garner 2012; Shefer, 2011). Recently, a meta-analysis attempted to quantitatively assess whether skills acquired through learning chess at school were transferred to math, reading, and general cognitive skills. This review of 24 studies with 2,788 participants who had learned chess, and a control group of 2,433 who had not, found a moderate general connection between chess skills and skills in these areas – especially math achievements, more than reading skills (Sala & Gobet, 2016).

A number of attempts have been made over the years to use chess as an intervention in ADHD, including to improve math skills in special education schools (Barret & Fish, 2011). For example, an exploratory study examined the possible effect of routine learning of chess for students diagnosed with ADHD. It tested the effect on ADHD symptoms of routine chess-playing with a professional teacher in addition to practicing at home. After 11 weeks of steady practice of chess, the researchers found improvement in the symptoms, which was even greater among students who had also received medication (Blasco-Fontecilla et al., 2016).

As mentioned, the literature indicates that ADHD is a disorder in the executive functioning system, and specifically in inhibition. Chess is a game that requires various cognitive abilities, and is considered dependent on executive functioning. Therefore, the current study examines whether chess training has an effect on improving ADHD symptoms.

Aim of Research

Following previous studies on the relationship between chess and learning in general, and math in particular, the present study aimed to examine the possible relationship between learning chess and the difficulties that characterize ADHD (Sala & Gobet, 2016; Scholz et al., 2008). This examination could contribute to the discussion about including chess in school curricula, as well as to possible educational-therapeutic interventions in ADHD.

The study aimed to find whether there would be a difference between youths with and without ADHD in tasks that require inhibition abilities similar to those learned in chess, which we called "Pièce Touchée" tasks. Therefore, the initial aim was to examine the effectiveness of the new tasks in measuring inhibition ability, and the central research question was whether there would be a difference between youths with ADHD who had not learned chess and those without ADHD who had not learned chess, in inhibition measures in the "Pièce Touchée" tasks and the "Go/No-go" tasks. The hypotheses were that youths with ADHD who had not learned chess would make more mistakes in "Go/No-go" tasks, and would be less successful in "Pièce Touchée" tasks, and that those who had learned chess would be more successful in "Pièce Touchée" tasks, and make fewer mistakes in "Go/No-go" tasks.

Method

Participants

107 examinees (all boys, since chess is a male-dominated game [Polgar, 2019]) filled out an online questionnaire. The boys' average age was 11 years and 11.76 months ($SD = 3.7$ months). *Table 1* presents the relevant demographic and background data of the sample, divided into "play chess"/ "do not play chess" categories. *Table 1* indicates that over half of the participants (55%) were diagnosed with ADHD, of whom fewer than half (25) were on medication. Also, about 25% of the participants are in some form of gifted program. No significant differences were found between the children as a function of playing chess ($t(105) = -.64$; $p = .53$).

Table 1

Sample characteristics (N = 107)

Variable		Entire sample	Played chess	Did not play chess	
Categorical variables *n*, (%)					
					$\chi^2_{(1)} = 0.18$; p = 0.67
ADHD	Yes	59 (55%)	38 (57%)	21 (52%)	
	No	48 (45%)	29 (43%)	19 (48%)	
					$\chi^2_{(1)} = 0.71$; p = 0.48
Medication	Yes	25 (23%)	10 (25%)	15 (23%)	
	No	81 (76%)	30 (75%)	51 (77%)	
					$\chi^2_{(1)} = 3.23$; p = 0.60
Gifted	Yes	27 (25%)	14 (35%)	13 (19%)	
	No	80 (75%)	26 (65%)	54 (81%)	
Continuous variables *M* ± *SD*					
Age (years)		11.8 ± 3.3	12.2 ± 3.0	12.0 ± 3.2	

Tools

"Go/No-go" tasks. This is a well-known task that has been used in different variations in hundreds of studies. In the present study, the paradigm used by Loman and colleagues was chosen. This is a computerized task, in which the participant must press a button as quickly and accurately as possible when a certain sign (green circle: Go) is presented, and avoid pressing the button when another stimulus (red circle: No-go) is presented. The stimuli were displayed for 600 milliseconds, with a possible response time of 1,600 milliseconds. The gaps between the end of one item and the start of the next item were random (200–400 milliseconds). Following a short practice session (8 Go items and 6 No-go items), 100 stimuli were presented (75 Go items and 25 No-go items).

(a) This is a fish made out of matches. Move only three matches to reverse the fish's direction.

(b) This is a triangle made out of circles. You must reverse the triangle by moving only three circles.

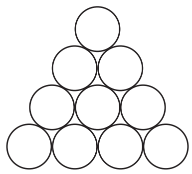


Figure 1. "Pièce Touchée" tasks.

"Pièce Touchée" tasks. Participants were tested individually in this task, which includes two items under different conditions. The items (see *Figure 1*) are equivalent. Two tasks were presented through the website, each under one of two conditions: "touch-move" or "free". Under the free condition, participants could move the stimuli (circles or matches) as much as they wished until a solution was found. Under the "touch-move" condition, the participants were told that they could move the stimuli three times only, and "touch-move" ("As soon as you have moved the circle/match, you cannot put it back and try again").

Validation of new tasks. The success rates in the "Pièce Touchée" tasks showed that 83% of the participants succeeded in the free condition. *Table 2* shows that this task is unable to differentiate among participants (those with or without ADHD, those who had studied or had not studied chess), because most participants usually succeeded in the task; that is to say, the task was too easy – known as the "ceiling effect". On the other hand, the "touch-move" condition excellently differentiated between the various groups – the success rate was significantly higher among participants without ADHD, participants who did not take medication, gifted participants, and participants who played chess ($p = .01$ for all comparisons).

Table 3 presents the correlations between "Go/No-go" and "Pièce Touchée" tasks, and shows the ineffectiveness of the free condition for differentiating among the various students. In contrast, the "touch-move" condition reflected moderate yet significant correlations with the "Go/No-go" tasks, which indicate a link with these tasks. However, the fact that the correlations are not high indicates that these are two different types of tasks, and that these tasks require higher thinking skills than "Go/No-go" tasks. A moderate correlation such as this can be found in previous studies (for example, Sonuga-Barke, Dalen, Daley & Remington, 2002), between simple inhibition tasks and planning tasks.

Table 2

Success in "Pièce Touchée" tasks (N = 107)

Variable		Success – free condition	Statistical significance	Success – "touch-move" condition	Statistical significance
ADHD			$\chi^2(1) = 2.11; p = 0.43$		$\chi^2_{(1)} = 11.64; p = 0.01$
	Yes	80%		36%	
	No	88%		69%	
Medication			$\chi^2(1) = 2.11; p = 0.43$		$\chi^2(1) = 6.33; p = 0.01$
	Yes	80%		28%	
	No	88%		57%	
Gifted			$\chi^2(1) = 2.29; p = 0.11$		$\chi^2(1) = 5.72; p = 0.01$
	Yes	93%		70%	
	No	80%		44%	
Chess			$\chi^2(1) = 2.13; p = 0.12$		$\chi^2(1) = 7.41; p = 0.01$
	Yes	90%		68%	
	No	79%		40%	

Table 3

Correlation coefficients between the various tasks

	1	2	3	4
1. Precision in "Go" task (%)	–	.75**	–.15	.15
2. Precision in "No-go" task (%)	–	–	–.15	–.21*
3. Free condition (yes/no)	–	–	–	.45**
4. "Touch-move" condition (yes/no)	–	–	–	–

**p* < 0.05, ***p* < 0.01

*Parents' questionnaire***.** The parents were asked about their child's birth date, whether he had been diagnosed with ADHD (yes/no), whether he had been diagnosed as gifted (yes/no), whether he ever took medication for ADHD (Ritalin, Adderall, Concerta, etc.), whether their child had learned to play chess (yes/no), and if yes – in which setting and for how long.

Variables

Dependent variables. Two dependent variables were examined in this study. First, the inhibition measure in the "Go/No-go" task: The number of mistakes in 75 "Go" items (omission errors) and in 25 "No-go" items (commission errors) is a common measure of inhibition. Weafer, Baggott, and deWit (2013) found moderate to high test-retest reliability ($r = .65$, $p < .001$) for the inhibition measure (commission errors) in this task. Second, the measure of success in the "Pièce Touchée" tasks: Under both conditions, success in the task was scored 1 and failure was scored 0.

Independent variables. The main independent variable was whether the participant had learned or not learned chess. The analysis also controlled for possible intervening variables: age, ADHD (yes/no), ADHD medication (yes/no), gifted (yes/no), learned chess (yes/no), and years of learning chess.

Procedure

Following approval by the Chief Scientists of the Ministry of Education, school principals throughout the country were approached, with emphasis on special education schools with ADHD students, and schools in which chess was taught, as well as chess clubs and social media. Participants were directed to a website that included demographic details, the parents' questionnaire, and the computerized tasks.

Statistical Processing

Performance of the "Go/No-go" task was subjected to multiple analyses of variance that included four main effects: learned chess (yes/no), ADHD (yes/no), on medication (yes/no), and gifted (yes/no), together with triple interactions among having learned chess, ADHD status, and medication. In addition, simple effects were analyzed to examine the interaction's direction and significance. Performance of the "Pièce Touchée" tasks was analyzed by logistic regression, because the dependent variable was dichotomous. The regression model also included the four main effects and the triple interaction described above. All analyses were performed with SPSS software version 21, and results at a $p \leq .05$ significance level were considered statistically significant.

Results

Figures 2a and 2b describe the performance differences of the "Go" task as a function of four independent variables: learned chess (yes/no), ADHD (yes/no), medication (yes/no), and gifted (yes/no). Analysis of the results showed a main effect for having learned chess ($F(1,99) = 40.06$, $p < .001$), so that boys who played chess made on average fewer mistakes than those who did not play chess, regardless of diagnosis and medication. No main effects were found for ADHD status, medication, and giftedness (p = 0.41, 0.13, 0.31, respectively).

(a) "Go" task for ADHD participants (b) "Go" task for non-ADHD participants

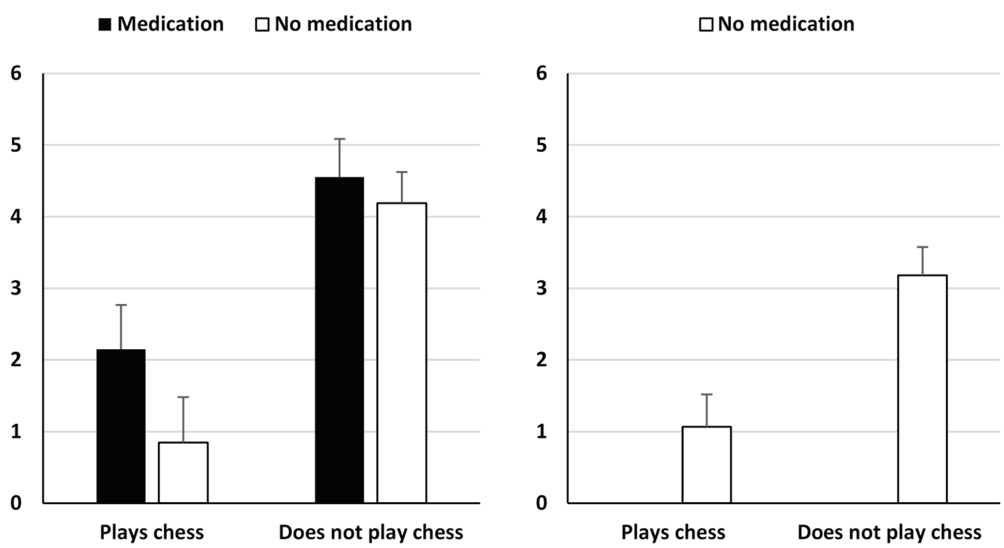
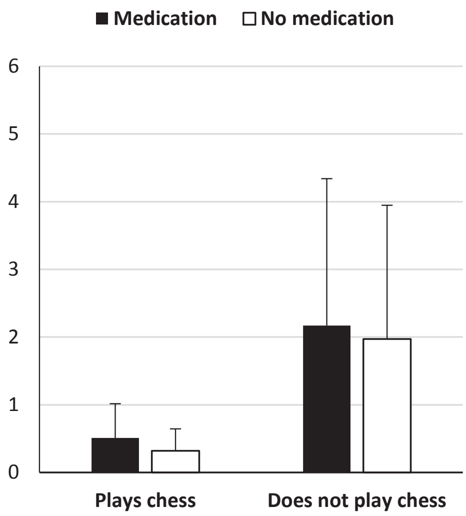


Figure 2. Relationship between playing chess, taking medication and number of mistakes in "Go" tasks

Figures 3a and 3b describe the performance differences of the "No-go" task as a function of the same four independent variables. Analysis of the results showed a main effect for having learned chess ($F(1,99) = 40.06$, $p < .001$), so that boys who played chess made on average fewer mistakes than those who did not play chess, regardless of diagnosis and medication. Also, a triple interaction was found among chess, ADHD, and medication. Among participants who do not play chess and are not on medication, those who are not diagnosed with ADHD made fewer mistakes. On the other hand, among participants who play chess and are not on medication, no significant difference was found between ADHD and non-ADHD participants ($F(2,99) = 3.5$, $p = 0.03$). No main effects were found for ADHD status, medication, and giftedness ($p = 0.65, 0.58, 0.78$, respectively).

(a) "No-go" task for ADHD participants (b) "No-go" task for non-ADHD participants



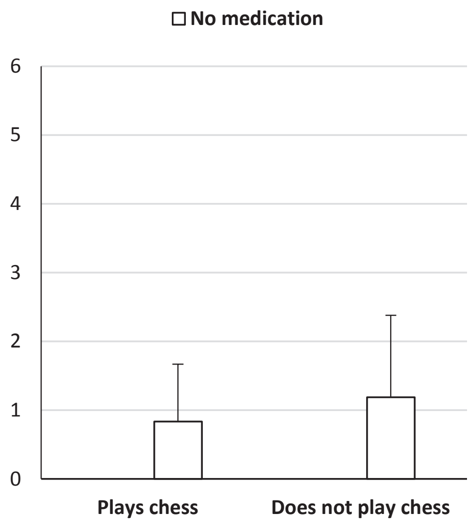


Figure 3. Relationship between playing chess, taking medication and number of mistakes in "No-go" tasks

Analysis of the results for the "touch-move" condition was performed by logistic regression, and the entire model was found to be significant ($\chi^2_{(5)} = 24.62$, $p < 0.001$, Nagelkereke $R^2 = 0.28$). *Table 4* shows that learning to play chess and ADHD status significantly predict success in the task ($p = 0.03, 0.05$, respectively). The odds ratio indicates that learning chess increases the chance to succeed in the task by 3.08, and ADHD decreases the chance to succeed by 2.70 (1/0.37).

Table 4

Logistic regression to predict success in "touch-move" condition

Variable	B	SE	Wald	p-value	OR	95% CI
Plays chess	1.12	0.53	4.55	*0.03	3.08	1.10–8.63
ADHD	0.99	0.49	4.02	*0.05	0.37	0.14–0.98
Medication	–1.19	0.49	1.87	0.17	0.30	0.05–1.67
Giftedness	1.00	0.87	1.87	0.08	2.71	0.90–8.16

*$p < 0.05$, **$p < 0.01$

Discussion

This research had a number of goals. The first was to look at new tasks to examine inhibition. The "Pièce Touchée" tasks examine inhibition at a higher thinking level than tasks such as "Go/No-go", and is given under two conditions: "touch-move" and "free". Validity testing of the task revealed that the "free" condition was not challenging enough, and did not differentiate among the various groups of children, whereas the "touch-move" condition differentiated among the groups, and produced moderate correlations with the "Go/No-go" tasks. This finding supports the possibility to use the "touch-move" condition as a test of inhibition at high cognitive levels in future research.

The central aim of the study was to examine the link between learning/playing chess and inhibition abilities as measured in a simple, established task ("Go/No-go") and a new task ("touch-move" condition). In all three tasks – "Go", "No-go", and "touch-move" – a main effect was found for learning chess.

In the "Go" task, the participants made omission errors; namely, they were supposed to press a button when the signal appeared, and for some reason they did not do so. The number of mistakes made by chess players was significantly lower than those made by others who had not learned to play chess. No such effect was found for any of the other variables that were tested – ADHD (yes/no), medication (yes/no), or giftedness (yes/no).

In the "No-go" task, the participants made commission errors; i.e., they were supposed not to press a button when the signal appeared, and for some reason they did so. For mistakes such as these, in addition to the main effect of having learned to play chess (chess players made significantly fewer mistakes than non-chess players did), a triple interaction was found among chess, ADHD, and medication. Among participants who did not play chess and were not on medication – those who were *not* diagnosed with ADHD made fewer mistakes. On the other hand, among participants who played chess and are not on medication, no significant difference was found between those who were diagnosed with ADHD and those who were not. These findings can be interpreted in a number of ways, but it seems that for participants who did not have ADHD, the chess-playing experience was less beneficial. It should be noted that, in this study, the medication-taking population was part of the ADHD population (there were no undiagnosed participants who were on medication). Therefore, in this study, this could be an extreme population regarding their difficulty with inhibition.

Limitations

Since this is a correlational study, causality cannot be inferred, but the findings indicated a difference among chess players, whether due to having learned to play chess or to an existing difference that led them to learn chess in the first place. It is also possible that children whose inhibition skills are better would be more drawn to play chess compared with children who are more impulsive. Future research would benefit from a longitudinal study with pre- and post- comparison of children who are assigned to a chess intervention compared with children who do not attend chess classes.

Conclusion

This initial study adds to the research literature that indicates the possible contributions of teaching chess to children and youths in general (Rosholm, Mikkelsen, & Gumede, 2017; Trinchero & Sala, 2016) and to those diagnosed with ADHD in particular (Blasco-Fontecilla et al., 2016). In this era of computer games, it is possible that concentration on chess pieces could help students overcome attention-deficiency disorders without resorting to medication.

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee.

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