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Checking for the Benefits of Chess for People with Autism Spectrum Disorder (ASD)

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ABSTRACT

This research paper investigates the potential cognitive benefits of learning and playing chess for people with Autism Spectrum Disorder (ASD), specifically for working memory and focused attention. Previous studies have shown the positive effects of chess on cognitive functioning, but they were for neurotypical individuals. Also, studies have shown that people with ASD lack certain cognitive functioning abilities. However, little research has been conducted on the impact of chess on cognitive capabilities in individuals with ASD. The method used in this study involved testing for working memory and focused attention, holding a chess program for participants with special needs, specifically ASD, and testing again for improvement. The results of this study fill the gap in existing knowledge regarding the benefits of chess for individuals with ASD and may provide insights into potential approaches for improving cognitive functions for this population.

Literature Review

History of Chess

Chess is a two-player strategy game played on a board of sixty-four black and white tiles. According to the U.S. Chess Trust, a non-profit chess organization focused on spreading the game of chess to students, chess originated from the Indian game Chaturanga, played during the Gupta Empire in the 6th and 7th centuries. Chaturanga spread across Asia and eventually made its way toward the Middle East and Europe in the 9th and 10th centuries, where it developed into chess. In some countries, religious and political leaders did not like the game due to the gambling and competitive aspects, which were against some religious aspects. However, to others, chess was a symbol of wealth and knowledge, and gained popularity (The U.S. Chess Trust).

With increasing popularity, and as chess spread to other geographies and cultures, different variations of the game formed. Today's most powerful pieces, like the Queen and Bishop, used to be short-ranged and less powerful, meaning a longer time required to capture the King (and win a game). Because of this, some games were said to take hours (The U.S. Chess Trust). According to Andrew E. Soltis, a distinguished chess writer and chess grandmaster, eventually, pieces such as the Queen and Bishop increased in power which sped up and intensified chess matches making it even more popular (Soltis).

Chess grew and changed over the centuries, but one thing stayed constant. The best chess players have been deemed to be very intelligent. The benefits from the game of chess were a topic of study in the late eighteenth century when Benjamin Franklin, U.S. founding father and inventor, wrote "The Morals of Chess" in 1786. The essay explained how chess benefits one's mind. Franklin discussed how chess could apply to real-life situations, such as understanding the values of foresight (looking into the future), caution, and circumspection (viewing surroundings, checking for probabilities, and being wary). He also wrote about how chess can change one's attitude toward staying

positive and not being discouraged in challenging situations (Franklin). While Franklin's essay was not based on experimentation, his beliefs led to many future studies on the benefits of chess.

Studies on Benefits of Chess to Cognitive Functions

In chess, players study the board to gain an advantage. They try to predict their opponent's future moves, think ahead with their own moves, learn their opponent's playing style, memorize strategies and scenarios, problem-solve, and think fast to avoid having their pieces get captured. These aspects of the complex game all relate to different cognitive functions of the brain. In the twentieth and twenty-first centuries, many chess studies have been conducted to test whether the game has cognitive benefits. Many have found these benefits to exist.

In a 2019 Romania study, the effect of chess on intellectual development or cognitive processes was tested. Three groups were formed: a control group (no chess experience) and two experimental groups (1 year and less of experience and two years or more of experience playing chess). The groups took the Sensory Processing Measure (SPM) to determine the effect chess has on perception and thinking skills. Advanced chess players showed significantly higher scores compared to beginners and non-chess players. Beginners, as well, showed an increase compared to non-chess players, but nowhere near as much as the Advanced chess players' difference. (Stegariu et al.). While the study acknowledged an uneven distribution of students between groups, the research gives evidence that chess players have increased cognitive abilities from playing chess.

Working Memory

The Stegariu study addressed cognitive functioning and intelligence in general; however, the relationship between chess and specific cognitive functions has also been studied. Working memory is a critical component of playing chess. According to Ebenezer Joesph, Indian ranked Chess player, researcher, and founder of the Chess Centre-DST Project, "While playing chess, children evaluate positions, visualize new positions in their mind, evaluate the pros and cons of each move, and choose moves based on the information stored in their mind" (Joseph et al.). This type of memory is known as working memory, a cognitive function. Working memory focuses on short-term tasks and stores short parts of crucial information to complete complex tasks (Joseph et al.). This is different from long-term memory, which can be all of the information someone has processed in their life. In a study conducted by Ebenezer Joseph et al. in 2020 in India, the researchers tested the effects of chess on working memory. They formed two groups out of a large sample size of 178 children. One group played chess weekly for two years, while the other participated in other extracurricular activities such as sports. They tested the students before the study, after a year, and after two years. The results evidenced that chess benefits working memory more than other extracurricular activities (Joseph et al.).

Focused Attention

According to CogniFit, a high-end cognitive healthcare company, attention, specifically focused attention, is a cognitive function. Focused attention is "the brain's ability to concentrate its attention on a target stimulus for any period of time" (Cognifit). Outside stimuli can easily affect adolescents, allowing for distraction and worse performance. In chess, focused attention is critical. A player needs to recognize their opponent's moves as defense or attacks as well as focus on the entire board for what pieces are left vulnerable to their opponents. Researchers Teodora Velea and Viorel Cojocaru from the National University of Physical Education and Sport in Romania tested the extent to which chess impacts attention abilities. They had thirty-four elementary students take cognitive tests before chess lessons and post-chess lessons. Almost all subjects increased their scores. Of the three focused attention tests used, the Kraepelin, Bourdon-Anfimov, and the Toulouse-Pieron, respectively, increased by eighteen percent, two percent, and twelve percent, which are very high increases (Velea). The study proved that chess increases focused attention for neurotypical people with no signs of cognitive disability.

While most of the field of knowledge surrounding chess argues for the many benefits of the game, it is important to address that few studies argue chess does not help improve cognitive functions. In a 2019 Australian

study, Graeme Gardiner who graduated from the University of Southern Queensland with a Masters Research Degree in Chess and Education (and other researchers) measured whether chess improves reasoning skills by providing the standardized tests of Raven's Progressive Matrices (RPM) and General Ability Test (GAT) to elementary students before and after learning chess. The data was not significant enough to prove that chess held these benefits. This study concluded that chess may not have cognitive benefits that are typically seen in other research (Gardiner).

The Gap in Existing Knowledge

As mentioned previously, chess has been proven by many studies to improve working memory and focused attention. These functions are essential for everyday activities as part of life. For example, simple tasks such as learning from a teacher in school require working memory and focused attention. Say a student needs to take in instructions from their teacher. Working memory is used to remember the teachings, and focused attention needs to be used to process the information. Chess has already been proven to have benefits for these cognitive functions. However, studies have not been largely tested on neurodivergent people in the United States who may have disorders such as Autistic Spectrum Disorder (ASD). This gap, if filled, could greatly contribute to the bank of knowledge and possibly provide a new method for improving cognitive functions for those who already have challenged abilities.

Why Autism?

While testing has been conducted with neurotypical people and various age groups to determine the effects and benefits of playing the strategy game of chess, people who already have difficulties with their cognitive abilities have largely not been tested. These are people who are neurodivergent. More specifically, the goal is to focus on people with Autism Spectrum Disorder (ASD). According to the Centers for Disease Control and Prevention (CDC), people with ASD can have delayed cognitive functions, potentially including inattentive behaviors (difficulty focusing) and trouble learning new materials (Signs). Along with attention, working memory has been found to be a struggle for people with ASD. In a study conducted in Iran, posted to the Iranian Journal of Medical Sciences and further posted on the United State's National Library of Medicine database, in 2020, Atusa Rabiee et al. used a group of high-functioning adolescents with ASD and a group of typical functioning adolescents to test the relationship between ASD and working memory. The researchers found that working memory is impaired in those with ASD (Rabiee et al.).

Research Question

Multiple studies have proven that chess has many benefits that improve cognitive functioning, specifically, working memory and focused attention. Also confirmed is that those with ASD can suffer from impaired cognitive functions of the brain, specifically working memory and focused attention. What has not been proven to a great extent is whether chess can benefit those with ASD, allowing them to improve their cognitive functioning abilities closer to the abilities of neurotypical people. This leads to the research question: to what extent does learning chess improve the cognitive abilities of focused attention and working memory for people (ages 11-23) with Autistic Spectrum Disorder (ASD)?

Method

Design Justification

After reviewing the many studies in the field of research of Chess, a common approach was seen of case studies testing an experimental group for improvement of an intellectual or cognitive ability. These studies provided a test before and after chess lessons. An example is a study conducted by Roberto Trinchero, working for the Department of Philosophy and Education at the University of Turin, where he tested mathematical abilities relating to Chess in Italian public schools. His procedure started by forming separate experimental and control groups. The experimental group would receive additional chess lessons, as well as the chess classes both groups were going to take. He gave the groups a

pretest as well as a post-test. At the end, the scores of those who took additional Chess lessons had significantly improved their scores on the various math tests in comparison to the students who just took the regular chess classes, although both increased (Trinchero).

Another example of a key research paper used to help formulate the method for this paper was a Chess correlation study to different intelligence factors and social-emotional enrichment by Ramón Aciego et al. In this study, the researchers compared Chess's impact on different forms of intelligence to more common extracurricular activities completed after school, such as a sport like basketball. This study was similar to Ebenezer Joseph's study previously mentioned. The Multifactor Self-Assessment Test of Child Adjustment (TAMAI) and the Wechsler Intelligence Scale for Children (WISC-R) were used. The TAMAI tests for social and personal intelligence, while the WISC tests for cognitive functions. The participants took the tests for a year, completed their group's chosen activities, and then retook the test. At the end of this study, those who played chess improved their scores far more than those in the common extracurricular group with activities like sports.

After researching and reviewing many published chess studies, it was clear that testing for change in a group was a good indicator of whether chess benefits participants. In addition to using past studies as examples, Thomas Page, a high school Psychology teacher helped to justify and ensure the validity of the case study. Alex Fishbein, a chess grandmaster also reviewed the study. The prior studies and confirmation of the approach from expert advisors were justification for using the research method of: providing a test that uses working memory and focused attention, teaching a chess program, and then retesting to see potential increases in scores.

Method Overview

1. Find an organization to partner with that can provide a location for the study and assist with finding volunteers and participants
2. Reach out to potential participants and volunteers
3. Provide a form to gain informed consent for the participants and their parents
4. Find out the confidential diagnosis (ASD or other condition) for each participant
5. Review approaches used by others for teaching chess to people with ASD
6. Schedule the sessions
7. Train the volunteers
8. Introduce the participants and volunteers and present overview of the program
9. Provide test on focused attention and working memory
10. Teach chess for seven weeks adjusting lesson plans based on progress
11. Repeat step number five to check for improvement
12. Tabulate, analyze and find the statistical significance of the data

Method Execution

The first step was determining how to gain participants and where to host the testing and chess program. It was necessary to partner with an organization to complete that. After researching local organizations, Ariella's Friendship Circle, a non-profit organization with programs for those with various disabilities in Long Island, New York, was chosen. After speaking with the director, Elizabeth Klein who has a bachelor's degree of Psychology from Hartford University, she agreed to speak with the board of the organization to gain approval to host the study and program from Ariella's Friendship Circle. Following approval from the board of Ariella's Friendship Circle, participants and volunteers from other programs at the Friendship Circle were contacted to offer and assist with the Chess program. Knowing there would be a small conversion rate from those who were informed of the program and the people who actually were interested in the program, it was necessary to expand the recruitment to other individuals including members of other organizations. After sending emails to hundreds of different families of people with disabilities,

including mostly those with ASD, interested participants were reached and confirmed for the study. Many parents were skeptical of having their children participate in a chess program due to the expectation of chess being a difficult "intellectual" game, so gathering participants was a very difficult process. Also, while most participants had ASD, others were included without ASD because they were contacted and expressed interest prior to their diagnosis being shared. It would not be ethical to exclude those with other disabilities besides ASD from the study, given that the prior research indicated they might benefit. Finally, all confirmed parents and participants signed informed consent to be in the study before participating. This was collected electronically through Google Forms, and participant's information such as age, chess experience and diagnosis was also collected. Volunteers were gathered until there was at least a one-to-one volunteer to participant ratio so that all participants had the support needed to learn chess.

Participant #	1	2	3	4	5	6	7	8
Diagnosis	ASD	ASD	Williams Syndrome	ASD	ASD (Low functioning)	ASD	ODD (Oppositional defiant disorder)	ASD
Chess Experience	Yes, minimal (basic)	No	No	No	No	No	Yes	No
Age	20	17	16	20	23	20	11	20

Figure 1- Participants (Age, Diagnosis and Chess Experience)

Originally, the study had twelve confirmed participants- seven with Autism Spectrum Disorder and five with other disorders. Some participants chose to drop out of the program before it started. This left six participants with ASD and two without. Participant 5 had the most severe and low-functioning ASD. Background information from the participants' parents was necessary for data grouping and planning. The age range, which is shown in Figure 1, was 11-23 years old. While the goal was to obtain adolescents, since it was so difficult to obtain participants, this age range was not strict. Knowing each participant's chess experience before the class was essential for planning the curriculum of the chess program. People who already knew certain aspects of chess would be ahead of those without any chess experience and would need to learn new information for the study to test the benefits of learning aspects of chess. Finally, the diagnosis of each participant was needed to group the data between those with ASD and those without. This is kept confidential, which is why the participants are labeled with a number, as shown in Figure 1, and their names are never to be revealed.

Instruments

The next step in the study was finding a test that would measure working memory and focused attention, which would also be suitable for participants with autism spectrum disorder and other disabilities. Most tests that chess studies have used featuring neurotypical participants are challenging, such as the previously mentioned Wechsler's Intelligence test. For the purposes of this study, it was necessary to find a test that could be completed for all levels of the Autistic Spectrum without too much assistance or frustration by the participants. After research, a game known as Concentration, or the Memory Match Game, was chosen.

Figure 2- Assessment (Memory Match Game)

The Memory Match Game in figure 2 is a simple children's game where the goal is to find tiles that match. The tiles are flipped over and mixed up, and a player must turn over two tiles. If a match is found, then they leave them face up, as completed. If a match is not found, the player must flip them back over and try to remember where a pair of matching tiles are as they make their next selections. If a player gets a tile they have seen before, they will attempt to flip over the match for that tile, which they try to remember from their previous turn. This test is an assessment for both working memory and focused attention. Working memory is tested because the player needs to memorize where the tile they are trying to match is located. Focused attention is tested because, in order to perform well, the player must focus on the task at hand without getting distracted. For this research study, seven pairs of tiles were included. The decision to use seven times was based on consideration of psychologist George Miller's famous study in 1956 which demonstrated that the working memory can hold seven items (plus or minus two) at a time (Cowan).

Testing Procedure

The test was conducted as follows. Every participant was paired with a volunteer trained on how to run the test. After learning the game, they completed three timed trials of The Memory Match Game, which were then averaged to get an initial score before being taught chess. The three trials would account for different variables in each trial, such as potentially being distracted or a card being placed differently. The tiles were faced down and then shuffled to ensure the participant did not know the tiles ahead of time. The tiles chosen for each participant did not matter since they were all just simple pictures of different simple sea animals. However, what needed to be different was the color of each tile so the participants would not get confused between them and would see a clear difference. For example, two green tiles would not get chosen in a group of seven pairs. This is seen in figure 2.

The assessment previously explained was first conducted at the beginning of week one. The assessment was supervised by Carrie Grochow, a licensed mental health counselor who holds a bachelor's degree in psychology from Emory University and a Master's degree from New York University (NYU) in Counselor Education/School Counseling and Guidance Services.

After this, the chess program began. To keep track of what was learned and organize each week's lesson effectively, lesson plans were created before each week. After each week, volunteers provided feedback to help improve the next week's lesson plan as well as any advice for the participant. The lesson plans can be found in the

appendix. Volunteers arrived early each week to receive training on how to teach the lesson. At first, the lesson plans were generalized for all participants; however, as participants' learning abilities and progress were observed, individualized lesson plans for participants became essential. Each week also included exercises to reinforce the understanding from the preceding week.

For week one, the aim was to teach the six pieces and introduce the setup of the board. Teaching the pieces included how they move and how they capture. Week twos lesson emphasized recognizing and memorizing each piece's appearance, recapped the pieces' abilities, and included a math worksheet designed to teach the value of the pieces (Shown in the Week Two lesson plan in the Appendix). Week three introduced a drill designed to practice capturing other pieces. Other drills were practiced in chess workbooks to teach how to "check" (attack the king) and learn endgame (how to achieve checkmate where the opponent's king cannot escape) skills.

In week four, the dynamic of the chess program shifted. Up to that point, everyone had been taught the fundamentals of chess through lessons and drills. However, it was clear by week four that some people were at further points than others and thus needed different individualized lesson plans. For example: some participants learned better through one-on-one instruction with explanations while others learned better through games. Weeks four through seven consisted of playing mini-games and drills with most participants eventually playing full games. An example of a mini-game is one featuring only some of the pieces, like "Pawntastic," only having the pawns and king on the board (Shown in the Week Four-Seven lesson plan in the Appendix). This continued in week five, six and week seven. At the end of week seven, the memory match game was once again conducted three times for a final average to compare to from the first week, the assessment was also supervised by Carrie Grochow.

Results, Findings, and Conclusions

The scores of each participant's three trials from the first week were averaged together as were those of the last week to get an average working memory and focused attention score before and after the chess program.

Participant #	1	2	4*	5**	6	8	Average for all six participants	Average without #5
Average of 3 trials (Week 1)	1:40	1:27	1:47	1:29	1:22	0:41	**1:24**	**1:23**
Average of 3 trials (Week 7)	1:07	0:46	0:41	1:46	0:52	0:31	**0:57**	**0:47**
Time improvement (Seconds)							**0:27**	**0:36**

Figure 3- Assessment Results (ASD Participants)
*2 trials
**Lower functioning

Participant #	3	7	Average
Average of 3 trials (Week 1)	0:37	0:31	**0:34**
Average of 3 trials (Week 7)	0:20	0:54	**0:37**
Time increase (Seconds)			**0:03**

Figure 4- Assessment Results (Non- ASD Participants)

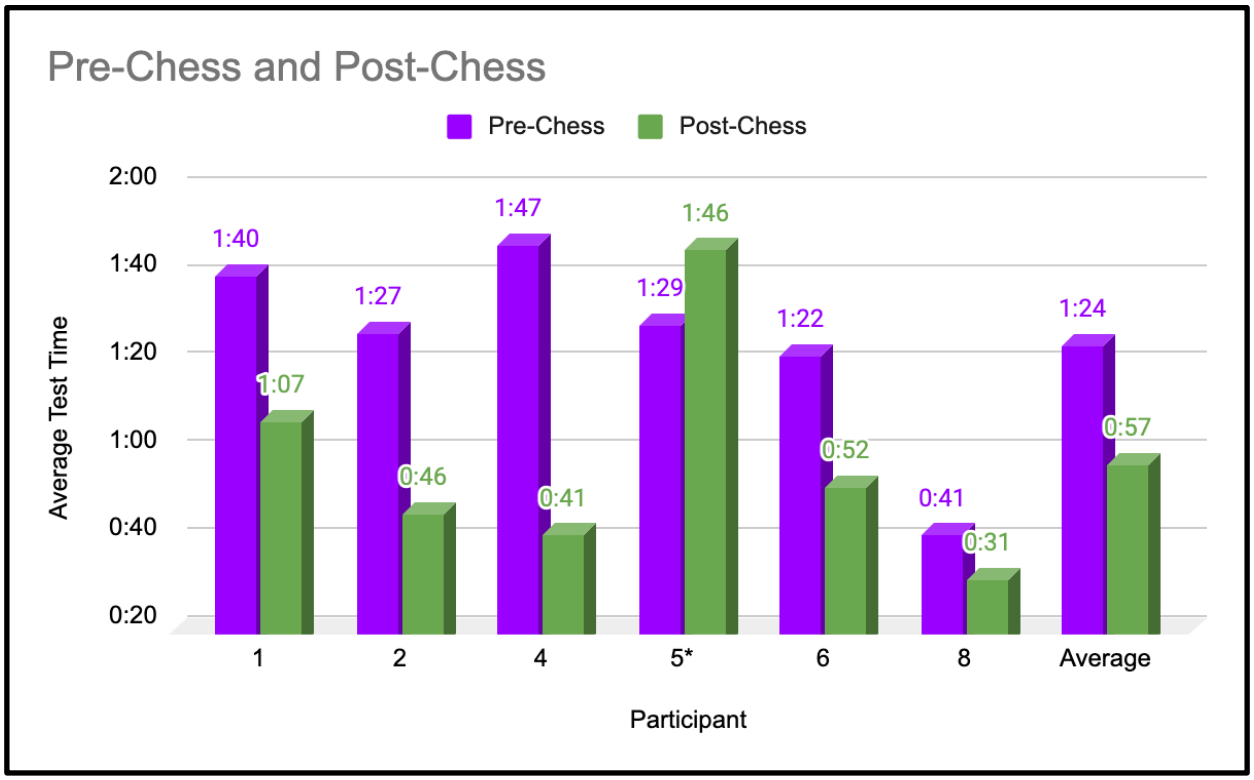

Figure 5- Assessment Results (Bar Graph- ASD Participants)

Prior to learning chess, the average time trial for the participants with ASD was one minute and twenty-four seconds. After learning chess, they had an average of fifty-seven seconds. This is an improvement of twenty-seven seconds. For all ASD participants excluding participant five, who had lower functioning ASD and could not understand chess as well or could not focus during the Memory Match game, a decrease of thirty-six seconds occurred. Participant 1 decreased 33% in average time for the Memory Match Game. Participant 2 had a decrease of 47%. Participant 4 had a decrease of 62% (only recorded two trials the first time, so it was held constant, and two trials were completed the second time for the average of timed trials). Participant 5 had the only increase with ASD of 19%. Participant 6 had a decrease of 37%. Participant 8 had a decrease of 24%.

The data appeared to show that an improvement for working memory and focused attention occurred. In order to be sure, it was important to conduct a statistical test to determine if the findings were significant. T-Tests were used, which are tests for statistical significance. The T-Tests conducted were paired, due to the case study comparing results of the same subjects before and after a change (learning chess) and one tailed because results were expected to stay the same or decrease in Memory Match scores (time). The T-Test was conducted once for all six participants with ASD and once for five participants (not including the lower functioning Participant 5). The test was not performed for those without ASD because: that was not the focus of the study, there were only two participants, and it was clearly shown that the data was not significant due to only a slight change in times.

For both statistical tests a null hypothesis was formed stating that the results would not decrease enough to be significant. Before the study, a critical value was found for what T- Value would cause the data to be significant for an Alpha level of .05, meaning past the 95th percent confidence interval, and which would reject the null hypothesis. To be considered a significant decrease in test scores for all six participants averaged data, the T-Value would need to be greater than 2.015. To be significant for the five participants without low-functioning ASD (without Participant 5's data), the T-Value would need to be greater than 2.130. For both of these, the respected P-value would determine what percentile of significance the data would fall into or not be significant at all. If the P-value were less than .05, the data would be significant.

Group	Critical Value	T-Value	P-Value α=.05	Percentile	Significance
All ASD	2.015	1.410	.108	89th+	Not enough
ASD, not including Participant #5	2.130	3.957	.0083	**99th+**	**Very much**

Figure 6- Statistical Test (T-Test Results)

It was found that for the grouping of all six participants with ASD, the data was not statistically significant as it was past the 89th percentile with a P-value of .108 but not the 95th alpha value. The T-value was 1.410, which was not past the critical value of 2.015 and needed to be significant. The null hypothesis could not be rejected. However, the data was extremely significant for the five participants (not including Participant 5). The T-value was 3.957, higher than the critical value of 2.13, meaning the data was past the 95th percentile. The P-value was .0083, meaning that the data would not only be significant with an alpha value of .05 but also with an alpha value of .01 and past the 99th percentile.

Limitations

This research is subject to limitations. A major limitation is the small sample size. There were six participants with ASD, but five participants who were functioning effectively at a high enough level to learn chess. A second limitation was incomplete attendance on an already short study of seven weeks. While most of the participants attended all the weeks of the program, not everyone could attend every week due to circumstances outside of the study's control. However, everyone attended five or more weeks and the first and last weeks.

Another limitation was the differences between the volunteers. While there was an intended lesson plan reviewed with every volunteer before each week's session, each volunteer had slightly different ways of teaching the lesson with their own teaching style. Therefore, the outputs of how the participants learned chess would have differed slightly.

The largest limitation was the difference between the participants. The study had an age gap of 12 years and different genders. Since there is an Autistic spectrum, every participant has different abilities and disabilities. Certain participants were more easygoing, while others were frustrated at times. Certain participants learned faster and advanced further than others in Chess, while others needed more guidance. Because of this, the lesson plans were changed to fit individual needs from week four and on, as previously stated in the paper; however, this could also be seen as a limitation because personalized lesson plans meant all participants were learning at different speeds and in different ways. Finally, the same memory match game with the same procedure was performed at the beginning of week one and the end of week seven.

A limitation of using the same memory match could have been due to repeated testing or the carryover practice effect, which according to the renowned peer-reviewed textbook "Research Methods in Psychology" is "where participants perform a task better in later conditions because they have had a chance to practice it" (Jhangiani, Rajiv S.). However, much thought was put into the test to avoid this from being a limitation. The memory match game, as explained previously, has the pieces in different positions, no information to memorize previous to the game, and each participant performed practice trials before the official trials so that they already knew how to play the game and would use the same strategy used each time played. However, it is possible that as the participants played the game, they got better at it as they were familiarized with how to play.

Future Studies

This study aimed to find whether learning Chess improves the cognitive skills of focused attention and working memory for those with Autistic Spectrum Disorder. While it was found that it is likely those with mild to high functioning ASD improved the cognitive functions of working memory and focused attention, further studies should be conducted regarding the limitations addressed in this research paper, for example: using a larger sample size, a closer age gap, grouping by gender, grouping by functioning levels of the Autistic Spectrum, and a longer study to find more accurate results and potentially corroborate these findings.

Implications

Ultimately, with this study and future studies further proving the benefits of chess for those with mild to high-functioning ASD, these findings could have major implications for the ASD community. Chess can be taught as a fun and helpful way to improve cognitive skills. This could help people with ASD in their everyday lives perform typical activities that require working memory and focused attention such as memorizing a grocery list, phone number, following multi-step instructions, or listening to a presentation. Overall, learning and playing chess can improve the daily functioning of those with ASD.

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