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Benefits of Chess Therapy in Mental Health Conditions

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Abstract

Chess is a classic board game with simple rules but requires complex cognitive strategies. Over the years, it has left a huge mark on scientific interest, particularly in cognitive science. This interest led to the conduction of a literature review to summarize the research findings of chess on brain activity, cognition, and clinical applications. Benefiting from the neuroimaging techniques, researchers have identified several more active brain regions known to play an important role in the processing of strategic planning, attention, memory, decision-making, and other cognitive skills that are critical throughout practice of chess. There is solid evidence demonstrating a positive correlation between chess and cognitive abilities. A multitude of studies have been conducted regarding the value of chess intervention as a type of psychotherapy. A chess instructional program improves math skills and overall school performance in children with learning disabilities. Chess therapy is effective in the management of individuals suffering from attention deficit/hyperactivity disorder (ADHD). Chess can also support children with autism by improving certain cognitive and social skills. Playing board games including chess is associated with a lower risk of dementia. Chess intervention can ameliorate the manifestations and quality of life in patients with Alzheimer's disease. Playing chess can restore, at least partially, the executive functions of patients with schizophrenia. As an add-on, chess-based cognitive remediation therapy helps improve cognitive recovery from substance abuse during the initial abstinence period. Altogether, chess has a promising role in the management of neurodevelopmental and mental health disorders.

Keywords: Chess, Brain activity, Cognition, Therapy, Neurodevelopmental disorders, Mental health conditions

1. Introduction

So-called "brain games" are mentally challenging. Over the centuries, mentally challenging games have come a long way in their evolution from simple board games to complex crossword puzzles and modern brain training apps. The key to these games is that they require strategy and problem-solving skills. The board game, which involves moving pieces along a grid, is one of the earliest examples of mentally challenging games that can be traced back to ancient Egypt. Chess, a type of board games, is played by two players on a square board divided into 64 squares of two alternating colors. It is a deceptively simple with simple rules but mentally demanding game. Nowadays, there are numerous chess tournaments at various levels from a small community to the world championship. Chess is enjoyed by people of all ages and has become a common leisure activity all over the world.

Playing chess requires the orchestration of strategic planning, attention, memory, and problem-solving skills. It leaves a huge mark on scientific interest from basic research to clinical applications. Benefiting from the new neuroimaging technology, researchers evaluated the brain activity structurally and functionally in chess players and identified several active brain regions known to play an important role in functions such as complex visual stimuli processing, fluid reasoning, and decision making which are critical to chess playing (Larsson & Wikström, 2017; Franklin et al., 2020). Through various cognitive assessment tests, many studies have demonstrated a positive

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correlation between chess and cognitive abilities in both children and elderly individuals (Sala and Gobet, 2016; Cibeira et al., 2021).

Cognitive deficits are core features of neurodevelopmental disorders and mental illnesses. Common treatments include medications and/or psychotherapy. Psychotherapy explores thoughts, feelings, and behaviors, and aims to improve an individual's well-being and mental health. It generally involves little risk. Some examples include cognitive behavioral therapy, interpersonal psychotherapy, and dialectical behavioral therapy. Since playing chess improves cognitive skills, can this positive effect be transferred to help individuals with mental health issues? A multitude of experiments have been conducted regarding the value of chess intervention as a type of psychotherapy. For example, chess therapy/training has been found to help improve symptoms in children suffering from attention deficit/hyperactivity disorder (ADHD) (Agarwal, 2023). In school, a chess instructional program can significantly improve math skills and overall school performance among children with learning disabilities (Barrett and Fish, 2011). Chess can also support autistic individuals by improving certain cognitive and social skills (Bornstein and Cunningham, 2023). Playing board games including chess can lower the risk of dementia (Lillo-Crespo et al., 2019). In patients with Alzheimer's disease (AD), chess intervention was found to ameliorate AD's manifestations and improve their quality of life (Lin et al., 2015). The chess game has also been reported to enhance cognitive abilities in schizophrenia (Demily et al., 2009). A number of studies have also explored the potential of chess-based cognitive remediation therapy in cognitive recovery from substance abuse (Bates et al., 2013; Karl et al., 2023). In general, as a non-pharmaceutical tool or an add-on therapy, chess-based treatment exhibits benefit in the management of neurodevelopmental disorders and mental health conditions.

The purpose of this review is to summarize the research progress and findings in brain activities related to chess playing and the impacts of chess on cognitive functions from the available literature. The use of chess in the treatment of neurodevelopmental disorders and mental health conditions will be discussed as well. This review will provide solid support for promoting chess therapy in various mental health issues.

2. Methods

A literature review was conducted by searching PubMed and Google Scholar. The keywords included chess AND brain, chess AND cognition, chess AND learning, chess AND autism, chess AND ADHD, chess AND dementia, chess AND Alzheimer, chess AND schizophrenia, and chess AND (substance OR addiction). Scientific journal papers, systematic reviews with or without meta-analysis, and bibliographic reviews relating to the target topics published in English were selected. Literature regarding only video or mobile chess games was excluded in this review.

3. Brain activities in chess players

Identifying the topography of brain activation in chess playing has drawn lots of research interests worldwide. In the past, researchers used indirect evidence like handedness or brain lesions to speculate the neural basis in chess expertise (Cranberg and Albert, 1988). The emergence of non-invasive functional neuroimaging techniques such as electroencephalography, positron emission tomography (PET), single photon emission computerized tomography (SPECT), magnetic resonance imaging (MRI), and magnetoencephalography has significantly facilitated the study of brain function (Larsson & Wikström, 2017). Combined with neuropsychological tests, these techniques were widely utilized to identify which brain areas are associated with chess performance (Franklin et al., 2020).

PET is a functional imaging technique that uses radiotracers to visualize and measure changes in metabolic processes or biochemical functions of organs (Heurling et al., 2017). Using PET imaging, Nichelli et al. (1994) found the distinct brain areas related to chess playing. In their study, brain activation was observed at bilateral parieto-occipital lobe junction, left middle temporal gyrus, and left superior premotor cortex of frontal lobe in right-handed male chess experts. Similarly, a study using SPECT found activation of non-dominant prefrontal and temporal lobes during chess deliberation (Onofrj et al., 1995). These brain areas are known to be related to functions including identifying objects, perceiving spatial relations, and organizing movements. Therefore, the activity of a network of

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several interrelated, but functionally distinct, brain regions may contribute to solving a complex problem in a chess game.

MRI applies a powerful magnetic field and radiofrequency pulses to produce detailed pictures of internal body structures. The fMRI uses MRI to measure the tiny changes in blood flow that occur with brain activity. It is widely used to examine which brain regions are handling critical functions. By means of fMRI, studies found that the superior frontal lobe, parietal lobe, and occipital lobe are recruited during chess playing (Atherton et al., 2003). Areas within posterior cingulate, orbitofrontal cortex, and right temporal cortex are active in chess experts (Krawczyk et al., 2011). Further study by Rennig et al. (2013) revealed higher signals at the temporo-parietal junction, a critical area in the processing of complex visual stimulus configurations, in chess experts during presentations of complex chess positions. Researchers also investigated the morphological differences in chess players' brains through fMRI. A reduced gray matter volume in caudate nuclei and thalamus was identified in chess experts (Duan et al., 2012; Wang et al., 2020). Subsequent resting-state functional connectivity analysis showed a significantly enhanced integration in chess experts' brain between caudate and the default mode network. The latter represents an interconnected group of brain structures that is important for goal-directed cognitive performance and theory of mind (Duan et al., 2012). The enhanced integration between thalamus and the fronto-parietal network was also recognized (Wang et al., 2020).

Neuroplasticity, a process of structurally and functionally adaptive changes of neurons, is known to be one of the most intriguing characteristics of the brain. Recently, a new concept "chronnectome" was introduced into fMRI data discovery to capture time-varying properties of connectivity between the brain regions. Unlike structural connectivity looking for physical connections in the brain, functional connectivity refers to similar activating patterns in spatially separated brain regions. One of the approaches to characterize chronnectomic changes is the dynamic functional network connectivity that is observed over a short period of time. It is thought to be a more accurate representation of functional brain networks. Using this approach, Premi et al. (2020) explored the effect of chess game on whole-brain fluidity/dynamism (the chronnectome). Data showed that the professional chess players exhibited an increased dynamic fluidity and dynamic range, indicating that playing chess may induce changes in brain activity through modulation of the chronnectome. Song et al. (2022) used the whole brain functional connectivity pattern homogeneity method in a study and identified a significantly increased similarity of whole brain functional connectivity pattern in anterior cingulate cortex, anterior middle temporal gyrus, and primary visual cortex in chess players. These findings support the hypothesis that continuous practice can boost specific cognitive processes with consequent enhancement of neuroplasticity mechanisms (van der Maas and Wagenmakers, 2005; Aciego et al., 2012).

Taken together, several brain regions have been found to be more active throughout practice of chess, mainly in the prefrontal cortex, posterior cingulate cortex, temporal gyrus, parieto-occipital lobe junction, and basal ganglia. These structures are generally considered part of the default mode network and attention network. Although the findings are not enough to conclude whether the changes are the cause or consequence of the long-term chess practice, the studies help elucidate the neural substrate underlying problem-solving and decision-making skills in chess-related tasks (Franklin et al., 2020).

4. Cognitive function in chess playing

There is an increasing number of studies investigating the effect of chess practice on cognitive function, although results vary widely. Aciego et al. (2012) performed a study in a group of young students from 6-16 years old who played chess as an extracurricular activity versus those playing soccer or basketball. Children were assessed for intellectual and socio-affective competence at the beginning and the end of the academic year by an IQ test (WISC-R), a self-report test (TAMAI) and a hetero-report questionnaire (teacher-tutor's criterion). After one year of practicing, chess was found to improve attention, cognitive abilities, problem-solving capacity, and even socio-affective development. A meta-analysis by Sala and Gobet (2016) revealed that chess seems to enhance primary and middle school students' achievement in math and overall cognitive ability. Many other studies also showed significantly higher math scores or better overall school performances among students who received chess instruction (Gliga and Flesner, 2014; Sala et al., 2015; Sigirtmac, 2016; Chitiyo et al., 2021).

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In a nonrandomized, controlled pilot study, a group of elderly people (>60 years old) underwent a 12-week chess training protocol, two 60-minute sessions per week. The participants were assessed before and after the intervention program for neuropsychological tests including cognition (Montreal Cognitive Assessment Test), mood (Geriatric Depression Scale Short Form), and quality of life (WHOQOL-OLD Questionnaire). Compared to the control group, results revealed a positive impact of the chess program on general cognitive status and promising evidence of an impact on attention, processing speed, and executive functions. Besides, the participants in the experimental group showed a significant improvement in the scores of quality of life (Cibeira et al., 2021). This positive impact was also observed after a meta-analysis in a large chess database (Pozzi et al., 2023). Amazingly, all the participants expressed their intention and motivation to continue playing chess. The studies provided solid evidence that regular practice of a cognitively stimulating activity such as chess can help maintain a healthy cognitive, social, and psychological state during the aging process (Cibeira et al., 2021).

Recently, a large-scale cluster randomized controlled trial was designed to investigate the effect of leisure activities including chess and cards on the cognitive function in older people over 60 years old. The participants were randomly assigned to an advocacy intervention group which was provided free leisure activities tools (chess and cards) or a control group. A baseline survey was conducted before the intervention, and then a mid-term and a final survey will be taken 12 and 24 months after the intervention, respectively. The hypothesis is that leisure activities could delay cognitive decline, improve neuropsychiatric symptoms of depression, anxiety, and loneliness, and enhance health. The study is currently ongoing, and the final results would be expected to be highly informative (Shi et al., 2023).

5. Chess therapy in the treatment of neurodevelopmental disorders

Neurodevelopmental disorders are a group of childhood-onset conditions associated primarily with brain function leading to developmental impairments such as autism spectrum disorder, ADHD, intellectual disability, learning disorders, communication disorders, and neurodevelopmental motor disorders. The treatments for neurodevelopmental disorders include medications, behavioral therapy, transcranial magnetic stimulation, and complementary and alternative medicine. As discussed above, playing chess improves cognitive skills. This provides a reason to consider chess as a therapeutic option for the management of neurodevelopment disorders.

5.1 Chess and learning disorders

Learning disorders affect a person's ability to learn and communicate. They often have difficulty with reading, writing, or even doing simple math. Learning disabilities can't be cured, but early diagnosis and intervention can lessen their effects. Scholz et al. (2008) performed a study to evaluate the benefit of chess in mathematic lessons among the 3rd and 4th graders with learning disabilities based on lower intelligence (IQ 70-85). The treatment group received one hour of chess lesson instead of one hour of regular math lesson per week. After one school year, the chess group showed a significant improvement in calculation abilities for simple addition tasks and counting. Similarly, a study performed by Barrett and Fish (2011) evaluated a 30-week chess instructional program once per week in middle school students who received special education services. Results displayed a significant improvement in overall math scale scores and end-of-year course grades. These studies suggested that chess could be a valuable learning aid for children with learning disabilities.

5.2 ADHD

ADHD is one of the most common neurodevelopmental disorders of childhood charactered by inattention, hyperactivity, and impulsivity that interferes with daily functioning and development. Treatment for ADHD usually encompasses a combination of behavioral therapy and medications. Since chess is a mentally demanding game that needs concentration and other cognitive skills, it is reasonable to consider chess as a therapeutic option for the management of ADHD patients. In a pilot study, 14 youths with ADHD received 4-month chess training twice a week showed an improvement in concentration skills. In the meantime, listening language scores also displayed a slight

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improvement (Nour ElDaou and El-Shamieh, 2015). Another study revealed that children with ADHD improved in both the Swanson, Nolan and Pelham Scale for parents (SNAP-IV) and the Abbreviated Conner's Rating Scale for parents (CPRS-HI), two widely used assessments for core symptoms of ADHD, after a 11-week chess training program (Blasco-Fontecilla et al., 2016). In addition, a recent trial used a chess-based training serious video game to treat patients with ADHD and found that chess game improved the emotional regulation and inattention, but not the executive function symptoms (Rodrigo-Yanguas et al., 2021; 2023). These promising studies have demonstrated a potential beneficial effect of chess training on the treatment of ADHD as an add-on therapy (Agarwal, 2023).

5.3 Autism

Autism is a neurological and developmental disorder. Individuals with autism often have problems with social communication and delayed cognitive functions such as inattentive behaviors (difficulty focusing) and trouble in learning. Previous studies have shown the benefit of chess on cognitive functioning and attention (Aciego et al., 2012; Pozzi et al., 2023). Some researchers have investigated if this benefit can be transferable to help individuals with autism. Through the game, chess forces interaction with other people. It doesn't involve too much touching or noise that autistic individuals typically would not be comfortable with. Chess provides a safe space for interaction and an opportunity to make friends (Bernstein and Cantor-Cooke, 2017). One of the earliest cases of using chess therapy was back in 1939 when an isolated schizoid 16-year-old boy struggled with social anxiety despite his high marks in school. His doctor used chess to gain rapport in therapy and his symptoms were getting better after he became interested in chess (Fleming and Strong, 1943). Recently, a small study with only six participants was conducted to evaluate the effects of chess training on working memory and attention in participants with autism. Of the six participants, five of them were functioning effectively at a high enough level to learn chess and one of them was the most severe and low functioning. While there was no statistically significant difference for the whole group of all six participants, the five participants did show significant improvements in working memory and focused attention after chess training (Bornstein and Cunningham, 2023). Despite the limited literature in this topic, psychologists have used chess to help assess a child's thinking and behavior patterns, as well as manage these issues.

6. Chess therapy in the treatment of mental health conditions

Mental health disorders are conditions that affect a person's thinking, feelings, mood, and behavior. There are many different treatment options available. Besides medications, cognitive behavioral therapy is one of the effective ways to promote recovery from mental illnesses. Because playing chess is mentally demanding and requires significant cognitive skills, it may potentially represent effective cognitive therapy in mental disorders. Dozens of studies have been performed to address this mystery. The published data showed that chess can help with the symptoms or severity of several health conditions including dementia, AD, schizophrenia, and substance use disorders.

6.1 Dementia and Alzheimer's disease

People with dementia often experience loss of memory and declined cognitive functions that are severe enough to interfere with their daily life and activities. AD is the most common cause of dementia, representing approximately 70% of all dementia cases. It is thought that cognitively stimulating activity is a protective factor against dementia. Since chess practice can improve cognitive function, it is of interest to explore whether chess playing could help mitigate symptoms of individuals with dementia (Lillo-Crespo et al., 2019). Coyle (2003) performed a study involving almost 500 participants and lasting 5 years. The results demonstrated that individuals older than 75 years old engaged in leisure activities including chess were less likely to develop signs of dementia. Chess was thus advocated as a nonpharmacological treatment for dementia. A similar study by Wu et al. (2023) also reported an association between lifestyle enrichment including chess in later life and lower risk of dementia.

Lin et al. (2015) conducted a clinical trial based on the GO game, a sort of chess game popular in China, Japan, and Korea, to study the effect of chess games on AD's outcomes. The enrolled patients with AD were randomly

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assigned into either control or GO game intervention groups. After a six-month follow-up, the GO game intervention showed reduced mean scores of Montgomery-Asberg Depression Rating Scale (MADRS) and Hospital Anxiety and Depression Scale (HADS). It also increased the mean score of Global Assessment of Functioning (GAF) and quality of life as assessed by RAND-36. In addition, they also tested the serum levels of brain derived neurotrophic factor (BDNF), a key molecule involved in neuronal growth and neuroplastic changes related to learning and memory. Results demonstrated a strong negative relationship between the severity of AD and the levels of BDNF. Alzheimer patients with GO game intervention had higher BDNF levels. The BDNF level was negatively related to MADRS and positively related to RAND-36. Therefore, GO game intervention ameliorates AD manifestations at least partly through up-regulating BDNF levels.

6.2 Schizophrenia

Schizophrenia is a chronic brain disorder that causes delusions, hallucinations, disorganized speech, trouble with thinking and lack of motivation. Cognitive remediation could improve cognitive performance and psychosocial functioning in patients with schizophrenia (McGurk et al., 2007; Bowie et al., 2020). Chess, which needs complex cognitive strategies, has also been tried for the management of schizophrenia. In a study, 26 clinically stable schizophrenic patients were randomly assigned into chess or control groups. The chess group practiced chess 10 times (twice per week, one hour per session) within 5 weeks. The control group didn't receive any specific activities. All patients were assessed twice with a battery of cognitive tests at the time of before and after the treatment. Results showed that chess training has improved the planning abilities and executive functions in patients with schizophrenia. Surprisingly, most of the patients kept playing chess on their own after completion of the study (Demily et al., 2008).

6.3 Substance use disorder

Substance use disorder is a disease that is manifested by compulsive substance use despite harmful consequences. Drug addiction is the most severe form of substance use disorder. Besides the well-known substances such as opioid, cocaine, amphetamine, and hallucinogens, other substances like alcohol, nicotine, and marijuana are also considered drugs. Individuals with substance use disorder usually demonstrate reduced cognitive functioning in the domains of problem-solving, mental flexibility, judgment forming, and memory. Cognitive impairments are also known to facilitate instances of relapse. Cognitive remediation therapy (CRT) is a psychotherapeutic approach to improve cognitive deficits. As an add-on therapy, CRT shows evidence in the treatment of substance use disorders (Bates et al., 2013). In a study, cocaine-dependent subjects were recruited in a four-week standard inpatient program for the treatment of cocaine dependence. The experimental group was provided a newly developed intervention named "motivational chess" which consists of a combination of motivational interviewing with the game of chess. Motivational interviewing is a psychologically based treatment designed for addicted patients that helps them change their maladaptive behaviors by focusing on the various stages of motivation. After one month of treatment, this interventional combination exhibited greater improvements in executive functions including attention, mental flexibility, inhibitory control, abstraction abilities, decision-making, and working memory (Bates et al., 2013). Thus, tailored interventions focusing on complex executive functions accelerate the process of cognitive recovery during the initial period of abstinence (Gonçalves et al., 2014).

Most recently, a study protocol focused on investigating the effects of chess-based CRT as an add-on therapy in alcohol and tobacco use disorders has been published. Ninety-six individuals with either alcohol or tobacco use disorders between 18 and 65 years of age have been recruited in a randomized, controlled clinical trial. The add-on therapy groups will receive an additional six-week chess-based cognitive remediation in addition to standard treatment. Neurocognitive tests and fMRI tasks will be performed before and afterwards. All individuals will be followed up monthly for 3 months. The hypothesis includes that chess-based CRT improves cognitive functioning and neuronal aberrant. If chess-based CRT is more effective than standard treatment alone, this intervention might help improve health outcomes in affected individuals. The results will be disseminated by open-access publications and conference presentations (Gerhardt et al., 2022; Karl et al., 2023).

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7. Conclusion

Chess is a mentally demanding game that involves an intense intellectual challenge. It is more than a game for scientists focused on mental health. Playing chess can activate several key brain regions that are critical for cognitive functions. Chess has been found to improve cognitive skills in a number of studies. Although the underlying mechanisms have not been fully elucidated, several factors should be considered. Because chess games require players to proactively think several steps ahead, it may enhance players' logical thinking skills. On the other hand, chess players are more likely to gather and participate in a joyful game with each other. This could strengthen their social networks and protect against cognitive decline. In school, playing chess helps children learn to follow the rules, increase concentration, and stimulate their interests and motivation (Nakao, 2019). These features may contribute to the students' improvement of school performance after introducing chess lessons. In terms of application, chess, as a non-pharmaceutical therapy tool or an add-on therapy, shows a therapeutic potential in treating various mental health issues. Chess instructional lessons enhance math skills and overall school performance in students with learning disabilities. Playing chess can reduce the severity of symptoms in individuals with ADHD. Chess can also help autistic children develop social skills and relieve anxiety. Elderly people practicing leisure activities including chess are less likely to develop dementia. This, at least to some degree, contributes to the improvement of quality of life in AD patients. Playing chess can restore overall executive functions of patients with schizophrenia. As a therapy add-on, chess-based CRT promotes cognitive recovery from substance abuse during the initial period of abstinence. Although the evidence is weak to moderate that needs more studies to address the limitations such as sample size, age gap, grouping by disease severity, levels of the game difficulty, intensity of the practicing, follow-up period, and standardization of measurement methods, chess plays a favorable role in the treatment of neurodevelopmental disorders and mental health conditions.

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