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Review Article

Rationality and Cognitive Biases in Chess: A Comprehensive Review

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Abstract - *Chess players have long been cited as examples of logical decision-makers in a variety of scientific fields. Does this description, however, reflect reality? Previous studies mostly relied on controlled experiments where participants' responses were gauged under various situations. It is interesting to note that current research has adopted a novel approach using benchmarks drawn from contemporary chess engine algorithms. With this new method, it is simple to monitor in great detail, track movement, and reveal subtle behavioural tendencies. The complexity of the chess players' rationality and their deviations are methodically discussed in this review. It illustrates the subtleties of cognitive biases by observing the prejudices of chess players. This investigation not only deepens the understanding of the synergy between chess playing and rational thinking but also sheds light on the strategic use of cognitive biases as invaluable tools for mastering the game. More significantly, it looks at how these biases might be effectively applied in various contexts to enhance strategic decision-making.*

Keywords - *Behaviour, Bias, Chess, Deviation, Rationality.*

1. Introduction

Rationality has long been a fundamental assumption in economic theory, assuming that individuals are fully rational decision-makers who maximize their utility or objective function based on perfect knowledge and well-defined preferences. [12] However, as we delve deeper into this notion of human decision-making, rationality alone can be said to be quite ideal. Subsequently, this led to the emergence of "bounded rationality", an alternative perspective that recognizes several limits that humans face, disabling them from becoming fully rational. [31] These limits may include information failure, amount of time to make the decision, and difficulty of processing information based on the limit of the human brain. [19]

Understanding the implications of bounded rationality has far-reaching consequences for various fields within economics. From consumer decision-making and market outcomes to the design of public policies and the functioning of organizations, recognizing the bounds of rationality offers a fresh lens through which to examine economic behaviour. [32]

Bounded rationality recognizes that individuals face complexity in the decision-making process and, therefore, rely on simplifying heuristics and cognitive shortcuts to cope with these challenges. This may cause the individual to deviate from a rational decision and make them prone to behavioural and systematic biases. [3]

Chess players, like any other individuals, are susceptible to various behavioural biases that can influence their decision-making and gameplay. These biases include:

1.1. Loss Aversion

Players tend to be more inclined to not lose than maximizing their gains. [26]

1.2. Availability Heuristics

Players deviate from making the most rational decision due to factors such as time pressure and fatigue. [27]

1.3. Confirmation Bias

Players tend to seek information that concurs with their initial hypothesis rather than information that disagrees with their initial hypothesis. [22]

1.4. Overconfidence Bias

Players incorrectly factor in the skills and experience of their opponent to play sub-optimal moves. [21]

These biases shape the decision-making landscape of chess players, influencing their evaluations, strategies, and ultimate success in the game.

The reason to review behavioural biases in chess players is that professional chess players have long been considered rational agents in various behavioural experimental settings. [18]

The aim is to thoroughly scrutinize this notion as rationality extends beyond the realm of a single game or activity. Moreover, the aim is to identify whether heuristics in professional chess players are advantageous or disadvantageous. Understanding whether these heuristics are good or bad can help remove personal biases and influences, leading to (possibly) better decision-making. [34] After exploring the behavioural biases exhibited by chess players, we try to investigate the notion of how rational chess players are by reviewing literature that focuses on the transferability of skills from the game of chess to other real-life domains.

2. Methodology

2.1. Research Aim

This review paper analyses behavioural biases exhibited by chess players by reviewing literature that focuses on move-by-move data on how players deviate from a rational benchmark. Through the literature, we try to identify the causes and consequences of the behavioural biases exhibited by chess players. Chess, being a well-defined and controlled environment, allows researchers to observe and analyze decision-making in a competitive environment vividly. [13] Despite the objective nature of the game's rules, research finds that chess players are prone to various behavioural biases that can affect their decision-making process due to factors such as time pressure, fatigue and complexity. [18]

The following themes were analyzed using a literature review for this review paper:

2.1.1. Behavioral Biases Exhibited by Chess Players

Behavioral biases occur when a person deviates from the rational decision-making process due to certain factors. This section will talk about what these biases are for chess players when they make decisions in a game and what effect these have on their overall performance.

2.1.2. How well do Chess Players perform in different Settings?

In this section, the aim is to thoroughly scrutinize chess players' performances in real-life settings and how well they stem from what they learn while playing the game. This feeds into answering the transferability of skills learned in chess to real-world context.

3. Discussion

3.1. Behavioural Biases Exhibited by Chess Players

Bounded rationality is a decision-making concept that recognizes the limits of human cognitive and information-processing capabilities. [31] This suggests that individuals are influenced by various constraints when making decisions, including time, cognitive resources, and the complexity of the problem at hand.

Nobel Prize-winning economist Herbert Simon introduced the concept of bounded rationality in the 1950s. According to Simon, humans are rational beings, but cognitive limits limit their rationality. Individuals make "satisfying" decisions rather than optimizing them based on perfect information and perfect rationality. [28][16] That is, they seek solutions that are sufficient to achieve their goals, given the limitations they face. Bounded rationality plays an important role in the context of chess decision-making.

Chess is a finite, sequential game of perfect information with alternating moves, where players have complete information about the opponent player's past moves and current position. However, since humans are boundedly rational with limited working memory and attention span, there are limitations to the human mind in evaluating various permutations of moves possible at a given board state in chess. [6] Thus, chess players are prone to using various cognitive strategies and heuristics to simplify the decision-making process. [7, 10]

A key strategy used by expert and novice chess players alike is pattern recognition. [7, 10] In the sense that both novice and expert chess players rely on clusters of pieces observed from past gameplay to find the optimal play given a board state. [7, 10] Consequently, given that pattern recognition is a common technique used by chess players, chess players are susceptible to a common behavioural bias known as confirmation bias. Confirmation bias refers to the behavioural phenomena of seeking or interpreting information that aligns with one's priors or beliefs rather than seeking information that invalidates one's priors. [20] A study finds that novice chess players showcase a higher degree of confirmation bias (54%) relative to expert players (44%). [6] Cowley, G., & Underwood suggest that the results are likely because experts have more task-specific information than novices. Particularly, the authors suggest that since novices possess limited task-specific information, their cognitive workload is higher relative to experts. Hence, they display higher rates of confirmation bias relative to experts.

However, since chess is a complex game with factors including time pressure, cognitive loads and fatigue affecting play, it is natural for both expert and novice chess players to rely on heuristics based on experience.[6] Thus, given the prevalent use of heuristics in chess, it becomes critical to investigate the extent to which heuristics are useful in gameplay. [6] It investigates this by analyzing the quality of moves in two scenarios: 1) the case where both novice and expert players are exposed to relatively common game states, and 2) the case where both novice and expert players are exposed to a random game state that does not commonly occur in chess gameplay. The results find that the quality of moves by both novice and expert chess players is substantially better in the known game state scenario than random game states, suggesting that heuristics are useful to a certain extent and experience leads to better overall gameplay.

This finding somewhat aligns with Zegners et al., which investigates the causes and consequences of deviations from rationality by comparing move-by-move data to a rational benchmark for professional chess players developed using chess engines. The authors find that while factors such as time pressure, fatigue and complexity induce deviations from the rational benchmark, the deviations are not necessarily worse. [36] Zegners et al. find that in the case of faster decisions, even though there are more deviations from the benchmark, the performance is overall better. The authors suggest this to be strong evidence supporting theoretical literature that intuition and experience of players result in overall better play since players rely on experience and understanding to respond better than the rational benchmark. This finding of Zegners et al. is noteworthy since quicker moves made by chess players are likely to be based on heuristics and thus support the notion that heuristics do not necessarily lead to worse play. However, since the games analyzed by the authors involve two human players, it is possible that the deviation from the benchmark could lead to better play because a player is capitalizing on a known weakness of their opponent based on the observed gameplay. [36] Thus, while the mechanism as to why deviations lead to better play is not clear, it can be noted from [6] that experience does reduce rates of confirmation bias and that strategies stemming from experience potentially serve as a useful heuristic, resulting in better overall play in certain scenarios in chess. [36]

In addition to suffering from confirmation bias and being prone to using availability heuristics, chess players exhibit biases commonly observed among investors and in settings such as lotteries. Behavioural biases such as the house-money effect and break-even effects have been shown to commonly occur in settings where the risk is dependent on randomness in the world. [16, 30] However, even in a setting such as chess, which is an adversarial game (meaning that the quality of a move by a player is likely dependent on the observed play of the opponent), it is probable that chess players are perhaps susceptible to such behavioural biases. In their paper, Holdaway, Cameron, and Edward investigate this by analyzing risk-taking in chess players using data from several thousands of games by players with a wide range of ELO ratings. [14] The authors find that in settings where players are in the lead or trailing, there is a higher propensity to take risks. These results, the authors say, are consistent with the house-money effect (which predicts that when players are in the gain, they are likely to take more risk) and the break-even effect (which predicts that when players have experienced a loss, they are more prone to take higher risks for the chance to break-even). Moreover, the authors find that when the games are close, the players are more risk-averse and behave more rationally, somewhat consistent with what has been observed in settings such as lotteries where risk is random. [14]

Moreover, they also investigate the extent to which chess players exhibit risk depending on the rating of their player. The authors find that experts are more risk-averse relative to novice players and that both experts and novices are more risk-averse when facing a stronger opponent.[14] Finally, they find that the highest-rated players are more consistent in their play irrespective of the opponent and more risk-averse and thus less rational. This finding is noteworthy since, to some extent, it supports the notion that quicker decisions are more likely to result from experience than from players tricking their opponents. Therefore, the argument in Zegners et al. that heuristics used by chess players are useful is somewhat bolstered.

Finally, chess players are also susceptible to another common behavioural bias seen among investors called the overconfidence bias. Overconfidence bias refers to the tendency to inaccurately estimate their abilities or talents. [22] Research in the area has found that, in general, humans tend to overestimate their abilities in skill-based settings relative to settings where luck plays a major role. [4] Park, Young Joon, and Luís Santos-Pinto build on this research by studying the extent to which chess players' priors about their abilities are accurate relative to those of poker players. [22] The authors find that chess players exhibit overconfidence bias to a lesser extent than poker players, whose forecasts the authors find are random guesses. Particularly, they find that chess players' guesses are informed guesses, with the forecasts of more skilled chess players being better than those of novice chess players. Given that chess is a game of perfect information with complete information where players' skill plays a key role in game outcomes, this finding seems intuitive.

Findings of a related study by Gerdes and Gransmark are suggestive of chess players exhibiting overconfidence bias. [9] Gerdes and Gransmark analyze expert chess player behaviour across male and female players and find that while females are more risk-averse than males, males are susceptible to aggressive strategies when facing a female opponent, reducing their winning probabilities. [9] This again suggests that chess players deviate from rationality, and male players are susceptible to overconfidence bias when facing female players. It remains unclear, however, whether this contradicts the findings of Holdaway, Cameron, and Edward since it does not examine whether the extent of the bias reduces with the player's skill.

The papers discussed above highlight the behavioural biases exhibited by chess players, such as confirmation bias, overconfidence bias, house-money effect and break-even effect. What is noteworthy from the findings, however, is that the rates of biases exhibited by players are inversely related to the player's skill and are more risk-averse and, thus, probably more rational. [6, 22] Since the exact mechanism for these findings is not clear in the papers above, what remains to be explored is whether there is a causal relationship between the skill of chess players and their propensity to exhibit behavioural biases. [14] More importantly, we must investigate the extent to which chess players are rational agents, as hypothesized. [19]

3.2. How well do Chess Players Perform in Different Settings?

This question is delved into the following sections by looking at chess players' performance in related settings.

To understand decision-making and departures from conventional economic rationality, behavioural economists investigate a variety of contexts. Investment and gambling are two important situations. Researchers in the field of investing delve into how people decide on risk management and financial investments. They examine elements such as loss aversion, risk tolerance, and the influence of emotions on financial decision-making. [25] They aim to identify irrational behaviour patterns among investors, such as overreacting to market volatility or following the herd, using experiments and analysis of real-world data. [12]

The study of decision-making by behavioural economists extends beyond investing and gambling. They research online behaviour, consumer behaviour, healthcare decisions, charitable giving, labor markets, and public policy. [2, 24] Understanding how chess players handle decision-making under uncertainty and risk in competitive scenarios is based on insights from these environments. A lot may be learnt about the rationality of chess players and how psychological factors affect their decisions in all spheres of their professional lives by bridging the gap between behavioural economics and the game of chess.

Researchers look into people's choices in the context of gambling, including lotteries, games of chance, and other betting scenarios. They investigate risk preferences, loss aversion, and the impact of framing on gamblers' decisions. [31] Participants learn a lot about the psychological biases that influence decision-making in gambling environments by examining how individuals react to uncertain outcomes and variable probabilities. [5] A study looking into the possible advantages of using chess instruction as a teaching technique in classrooms was designed to determine whether teaching chess to students may enhance their scholastic ability (math and reading).[26] To determine the variables that can affect how well chess is taught in schools, researchers looked at how transferable chess skills are to other fields. The important findings show that teaching youngsters to play chess moderately impacts their mathematics, reading, and cognitive abilities. [26] The authors point out that the overall impact size is insufficient to demonstrate that chess training is more successful than other educational interventions. They also talk about how placebo effects, which might skew the results in some studies, could have an impact. The findings also imply that lengthier chess training sessions (about 25–30 hours) can produce more notable transfer effects. While there is evidence that chess training has some good effects on academic and cognitive skills, the research finds that there are questions about the usefulness of chess practice in general. The authors underline the need for rigorous experimental designs, including active control groups, to prove causality and better comprehend the mechanisms underlying any reported transfer effects. They also advise more study to determine the precise cognitive processes involved in playing chess and their possible impact on academic performance. [26]

Another study evaluated the advantages of ongoing chess practice on a sample of teenagers, concentrating on cognitive and socio-affective components for which there was scant empirical support in the literature.[1] The findings demonstrated that consistent chess practice enhanced cognitive abilities such as linguistic abstraction, concentration, visuomotor coordination, and problem-solving abilities. According to teacher evaluations, the chess-playing group also displayed better personal adjustment, more happiness with school and teachers, and enhanced coping skills. Regarding socio-affective advancements, there was a difference between teachers' observations and students' self-evaluations. One important conclusion was that chess players generally had better school performance than those who selected basketball or sports. According to the study, students who chose chess as an activity had different profiles, with chess players demonstrating greater school adjustment. The authors suggested more investigation into chess training techniques and examining the socio-affective impacts on pupils with difficulties adjusting to school. Overall, the study offered proof that chess can be a useful instructional instrument, influencing students' socio-personal development and problem-solving skills in addition to their cognitive ability. The motivation of less acclimated kids to participate in the game, however, continues to present difficulties.

Another paper examines the benefits of chess training on elementary school pupils' cognitive capacities. [10] A group of inexperienced students participated in the study and received blended learning chess instruction; the control group took part in engaging math courses. The goal of the study was to evaluate how chess instruction affected academic performance, memory, sustained attention, and creativity. The results demonstrate that both groups improved in various cognitive domains, but the Chess Group (ChG) significantly outperformed the control group in math and Romanian language test scores. Additionally, the ChG showed improved resilience to monotony, which is probably a result of training-related repetition and application of the chess rules. [10] The study investigated the relationship between chess performance and intelligence quotient (IQ). While IQ and academic performance (as determined by a School Performance Test) showed a favourable link, IQ and performance in the chess competition did not. This shows that persistent attention rather than a high IQ is the key to performing well at chess. After a brief training period, the researchers found that chess training using blended learning improved beginner pupils' cognitive abilities. They recognize that longer training sessions (at least 20 hours) are necessary to obtain bigger results. The study also notes significant limitations, including the few pupils participating and the lack of a comparison group receiving conventional chess training. The paper's overall thesis is that teaching chess to primary school pupils using blended learning can have a good effect on their cognitive capacities. The results may have consequences for chess inclusion in school curricula and research into the advantages it offers to both developing and kids with learning difficulties. It is necessary to conduct more studies to see how well-blended learning and conventional chess instruction perform with various student populations.

The consistency in results over various research papers not demonstrating more than a little discernible positive effect of chess and its learnings shows how the overall impact of chess on cognition remains modest and may not lead to substantial improvements. This suggests that while there might be some cognitive benefits, they are generally limited in magnitude and may not have a significant influence on broader cognitive abilities.

4. Conclusion

Empirical evidence indicates that some behavioural biases are present in the decision-making of chess players. The availability heuristic, often seen in both novice and experienced players, refers to reliance on past patterns and recognizable groups of pieces to make decisions. A tendency to avoid losses and accumulate risks can be observed in the reactions of chess players to game situations. Novices tend to show greater confirmation because they seek information that is consistent with their existing beliefs, perhaps due to limited task-specific knowledge. [6] On the other hand, skilled players have reduced confirmation bias, which means that expertise reduces this bias. Although overconfidence exists, it is conscious among chess players, especially among the more skilled players, whose judgments of ability are more in line with actual performance. [22]

Further research may improve our understanding of these biases in chess decision-making. Examining biases under time pressure and cognitive load can reveal their effects in high-stress situations. Comparing the biases of skill domains would give an idea of their particularity to chess. Investigating possible gender differences in bias manifestations and evaluating the effectiveness of cognitive training interventions to reduce bias can contribute to a more rational decision-making process in chess players. Overall, the empirical findings suggest that biases exist in chess decision-making but tend to decrease with expertise, providing opportunities to increase rationality through targeted interventions.

Research into the potential benefits of playing chess in different contexts has revealed fascinating insights into its effects on cognitive skills and socio-affective development. Research has shown how learning chess can improve academic performance, strengthen cognitive skills, and promote better personal adjustment in students. In addition, research on the effects of ongoing chess has highlighted its positive effects on concentration, language abstraction and problem-solving.

To advance this research, future research could delve into more nuanced aspects of chess playing. Examining how chess training interacts with individual differences, including learning abilities and demographic factors, can provide deeper insights into its benefits. Comparative analysis of different teaching methods, such as blended learning and traditional methods, could provide insight into the most effective strategies for developing cognitive skills. In addition, long-term studies that observe the lasting effects of chess training on problem-solving skills and socio-affective development would provide a comprehensive view of the educational value of chess training.

Combining the research results on chess advantages with research on behavioural biases is crucial to a comprehensive understanding of decision dynamics. Although the cognitive benefits of chess are significant, they have context-dependent and moderating effects. Identifying similarities between chess decision-making and real-world scenarios, such as positioning and online behaviour highlights the importance of studying the behavioural biases of chess players. Bridging the gap between behavioural economics and chess not only enriches our understanding of the rationality of chess players but also contributes to the broader discussion of decision-making processes, cognitive psychology and educational practices.

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