The effects of chess on pedagogy and decision theory

Abstract of PhD Thesis

Zoltán Medvegy

Doctoral School of Sport Sciences

Hungarian University of Sports Science

Supervisors: Dr. János Gombocz professor emeritus, CSc

Dr. Tamás Sterbenz professor, PhD

Official reviewers: Dr. László Mérő professor emeritus, CSc

Dr. István Soós research professor, PhD

Head of the Final Examination Committee:

Dr. Csaba Sós professor, PhD

Members of the Final Examination Committee:

Dr. Zita Zoltayné Paprika professor, PhD

Dr. László Révész associate professor, PhD

Budapest

2023

Introduction

Numerous studies have shown that chess has positive effects on cognitive functions (logic, concentration, visualization, memory, perception, planning, creativity) and can delay and slow down the onset of dementia and Alzheimer's disease in advanced age. It has also been suggested that chess promotes healthy psychological development and strengthen psychological immunity, or resilience. There is no doubt that chess has serious personality-developing and character-building effects. The link between chess and musical talent is widely assumed but has not been proven.

Chess is used in many disciplines, and its psychology can help us understand how the human mind works. Chess plays an important role in the study of decision theory, since chess and general decision theory have the same foundations (rationality, intuition) and goals (making the best decision, achieving the optimal outcome).

I use a model of my own to show why chess is a suitable subject for investigating general decision theory issues (Figure 1).

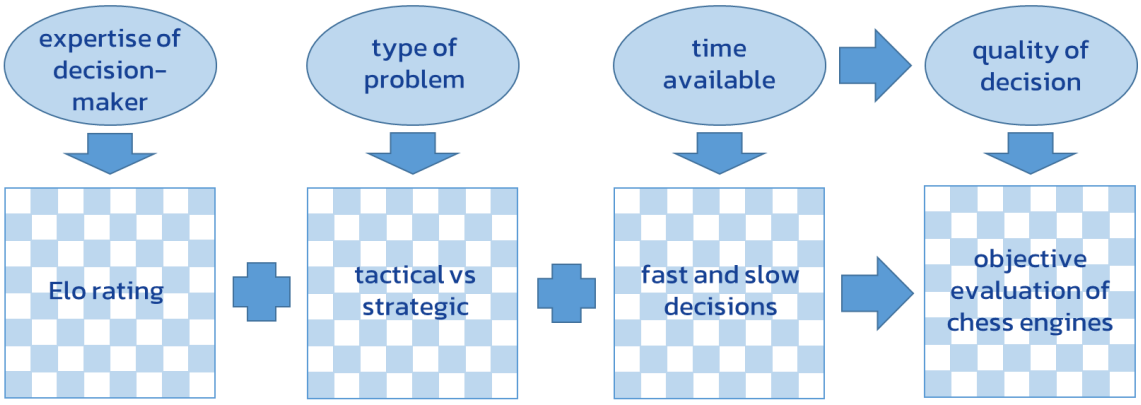

Figure 1: Corresponding factors influencing the decisions in chess

The quality of individual decisions is generally determined by three factors: the expertise of the decision-maker, the nature of the problem and the time available. In chess, the Elo rating system is a very accurate measure of the strength of the players, i.e. their expertise. In case of chess problems, the short-term tactical and long-term strategic (positional) elements can be separated, so that the nature of the problem in chess can be determined relatively well. In chess tasks, the decision time can be varied, so fast decisions based on intuition and slow decisions based on deliberation can be examined

separately. The strength of chess moves can be judged very well by engines that play much better than humans, so the quality of chess decisions can be measured quite objectively. Since all the components of the decision in chess are well defined and quantifiable except the ’nature of the problem’, chess is an excellent tool for investigating general decision theory issues. Using this model, chess offers the opportunity to study several decision-related heuristics (simple methods that facilitate decision-making, such as ’Take The First’), as well as the combined effects of the components of decisions (expertise, type of the task and time available).

The playing style of competitive chess players can be placed on a scale, with tactical and positional styles at either end. The positional chess player usually seeks to improve the position slowly while maintaining security, while the tactical player tries to break the balance by making unexpected, often intuitive moves. The question of which style is more effective is still unanswered.

During a chess game with stakes, measurable physiological changes take place in the competitor's body. Most of these are due to an increase in sympathetic activity (increased heart rate, decreased heart rate variability and skin temperature), but changes in brain hemisphere dominance are also known, and changes in the activity of the alpha brain wave characteristic of calmness and theta brain wave characteristic of concentration can be assumed.

Objectives

In my research I have investigated the pedagogical and decision-theoretical aspects of chess. My aim was to confirm some previous research results and to make new findings on topics that have not been investigated by others.

Regarding pedagogy, I wanted to analyze the effects of chess on personality development using statistical methods. I tried to confirm the already known links between chess and cognitive functions, and I also looked for a possible connection with music. My aim was to provide scientific evidence to support the hypothesis that playing chess has a positive effect on psychological immunity.

Another goal of my research was to investigate general decision theory issues through chess players' decisions. I used the model shown in Figure 1 to investigate the

combined effects of decision factors such as expertise, task type and time available on decision quality, and to look for the circumstances under which each decision heuristic holds.

I examined the effect of high stakes by analyzing the results of the classical world chess championship matches, and tried to decide whether the positional or tactical style is more effective in the case of world champions.

I also aimed to monitor physiological changes during chess problem solving, such as heart rate, brain waves and skin temperature and eye movements, and to draw the appropriate conclusions.

Methods and subjects

Examining the effects of chess

I compiled a questionnaire, which in most cases asked for answers on a 5-point Likert scale in the areas I wanted to investigate (cognitive abilities, resilience, health). I asked chess players and non-chess players to fill in the questionnaire and distribute it using the 'snowball' method. A total of 396 evaluable responses were received. The respondents included active or retired players ('competitive chess players', 197 persons: 161 men, 36 women), non-competitive chess players ('hobby chess players', 92 persons: 56 men, 36 women) and those who do not play chess or play it only to a minimal extent ('non-chess players', 107 persons: 51 men, 56 women).

Cognitive skills were evaluated based on the responses related to logic, concentration and creativity. The relationship between chess and resilience was examined based on the answers of the topics that are related to the recommendations of APA (American Psychological Association) for strengthening psychological immunity. To investigate healthy lifestyles, BMI (body mass index), smoking and leisure sports were assessed.

During the statistical evaluation it was examined, how the participants in the three chess skill groups were distributed across the integer values of the individual characteristics. A cumulative logit model (Generalized Linear Model) was used that can take three variables into account: group assignment by chess skill, age and gender. The model describes how likely a respondent of a given age and gender chose a given value on the Likert scale. By comparing these probabilities, it determines whether age and

gender have a significant effect on the distribution of responses beyond chess knowledge. For a given question, a significant difference was found in favor of a group when the responses of that group showed a higher relative frequency for higher scoring answers (4, 5) and a lower relative frequency for lower scoring answers.

The role of intuition in chess

At the European Universities Mind Sports Championship in Budapest in 2019, I asked the participants of the chess tournament to take part in the study. 34 chess players agreed to participate (26 men, 8 women; Elo rating average: 2142, SD: 376). The competitors were divided into three groups according to their Elo rating: a) masters: 10 men, international masters and grandmasters (Elo rating mean: 2506, SD: 71); b) candidate masters: 9 men and 5 women (Elo rating mean: 2227, SD: 105); c) hobby chess players: 7 men and 3 women (Elo rating mean: 1659, SD: 284).

The problem solving (2 tactical and 2 strategic chess tasks) was done in three phases: first, players had 15 seconds to make the best move according to their intuition, in the second phase 45 seconds to write down their candidate moves, and finally in the third phase 4 minutes to calculate the variations and make the considered decision. During the slow decision, they could keep or change their fast decision. The quality of the solutions was assessed on a scale of 1 to 5 points using the extremely powerful Stockfish 12 chess program with an estimated Elo rating of 3200.

During the study, the combined effects of the independent variables were analyzed. The independent variables were the personal factor, i.e. the level of expertise (masters, candidate masters, hobby players), the task factor, i.e. the type of task (strategic, tactical) and the situation factor, i.e. the time available (short, long). The dependent variables were the quality of the moves, the number of generated options (candidate moves) and their chronological order. We analyzed when the ’Take The First’ heuristic prevails in chess, according to which levels of expertise can make a good decision even in a short time.

Analysis of the decisions and style of the world chess champions

In a secondary research I studied the results of 45 classical world championship matches and the playing styles of the 16 world champions. Based on the expertise of several grandmasters (co-authors of the study, authors of chess books and myself) I rated

the style of the world champions on a ten-point scale (most tactical -5, most positional +5). I analyzed the effect of particularly high stakes in world championship matches: I compared the results of the reigning world champions and their challengers with Fisher's exact test in cases where the decision was left to the last game of the world championship match.

Examining the physiological background of chess decisions

In cooperation with the University of Physical Education and the Coherence Team, a pilot study was conducted with the participation of ten chess players, who were divided into three groups: a) 4 female top chess players (2200-2400 Elo rating); b) 3 male amateur chess players (1800-2100 Elo rating); c) 3 male grandmasters (over 2500 Elo rating).

Participants were monitored for EEG showing brain activity, pulse indicating sympathetic activity and heart rate variability (HRV) while solving 8 chess tasks (4 tactical and 4 strategic). Facial skin temperature and eye movements were monitored. The measured data were processed and evaluated using complex analysis panels (SPSS, Matlab).

Results

The effects of chess

The difference between competitive and non-competitive chess players was confirmed at the 5% significance level for logic, concentration and creativity, but there was no detectable difference between competitive and hobby chess players. There was no direct correlation with the music indicators, but a correlation was found between the combination of music indicators and creativity.

Regarding the APA's recommendations for strengthening resilience, chess players showed significantly ($p<0.05$) better results than non-chess players in 7 out of 10 (attitude to crisis situations, acceptance of failure, setting realistic goals, adapting to disturbing situations, looking for the cause of failure, foresight, taking care of health).

Regarding the examined aspects of a healthy lifestyle (BMI, smoking, physical activity), there was a significant difference in favor of competitive chess players for women, while no difference was found for men.

Chess and decision making

The biggest effect on the quality of the decision was chess knowledge and the time available. As expected, the masters performed best in both tactical and strategic tasks, followed by the candidate masters and finally the hobby chess players.

I examined the difference between the quality of fast decisions based on intuition and slow decisions based on deliberation at different levels of expertise. While the fast decisions of candidate masters and hobby players were significantly worse than when they had more time, no qualitative difference could be detected between the fast and slow decisions of masters. This result demonstrated that the 'Take The First' heuristic holds in chess when there is a high level of expertise (Figure 2).

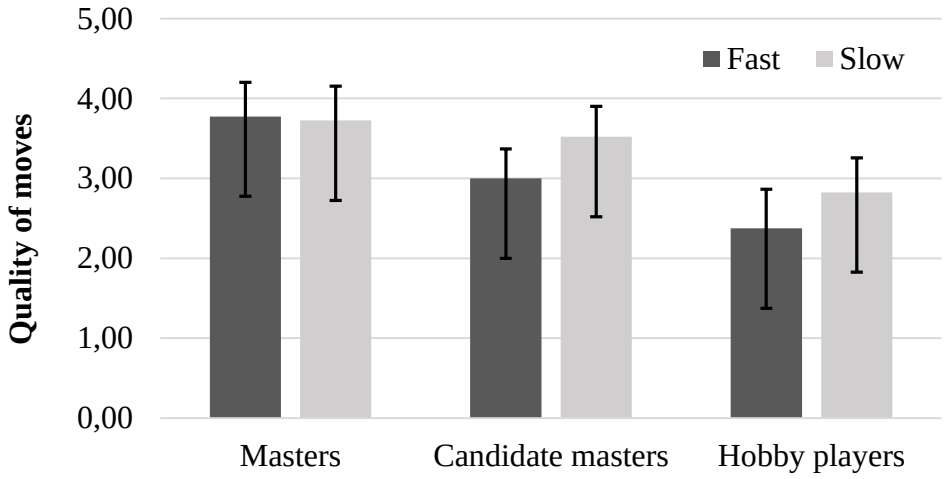

Figure 2: The quality of the decision as a function of expertise and decision time

I examined the combined effect of task type and decision time, finding that candidate masters and hobby players were significantly better at tactical tasks when they had more time, while longer time did not significantly improve their strategic decisions. However, for masters, the decisions were equally good for both types of task regardless of the time available.

There was no significant difference between the groups in the number of generated options, so the 'less-is-more' principle did not apply in my study. I analyzed the quality of the first three candidate moves as a function of chess knowledge. I showed that in the

case of masters the first option was significantly better than the others, while there was no such difference in the other two groups.

Analysis of the playing style of world chess champions (secondary research)

I found that in the 45 classical world championship matches so far, the reigning world champions achieved a significantly better result than their challengers, and in 30 cases they retained their title. In 12 cases the title was decided in the last game. In such cases, the difference in knowledge was no longer the deciding factor, but rather which side was better able to adapt to the increased stakes. In most cases (10 out of 12), the world champion achieved the desired result (meaning a significant difference, $p<0.05$) and retained the title.

The classification of the 16 classical world chess champions resulted in two new findings: among the world champions tactical and positional players were equally represented, meaning that neither chess style was more effective than the other. At the same time, the new world champion was almost always able to defeat the old one with the opposite style (Figure 3).

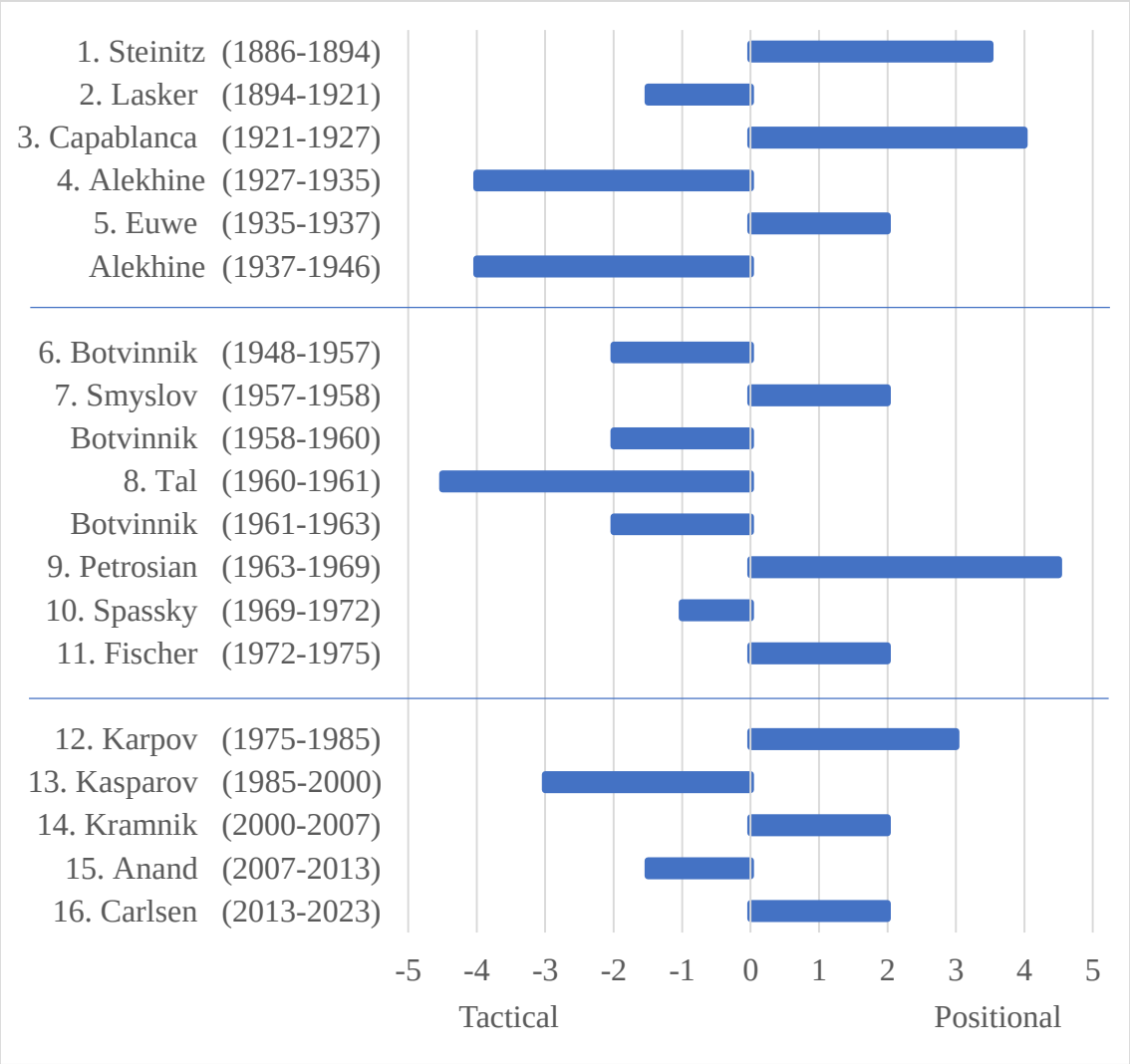

Figure 3: Style of successive classical world champions

The physiological background of chess players' decisions (pilot study)

It was found that the physiological changes that take place while solving chess problems can be well monitored. As the study was small (10 participants), the results cannot be evaluated statistically, but attention-grabbing observations and assumptions can be drawn.

The initial high heart rate changed continuously according to the outcome of the task solution. In the case of a good solution, it decreased from the moment of finding the key move, while in the case of an incorrect solution, it increased even further. A significant drop in skin temperature during the task solution was characteristic, indicating fatigue.

By tracking the eye movements, it was possible to follow which square of the chess board the players were focusing on at any given time. Eye-tracking was therefore a way of testing the effectiveness of intuition. In the case of successful solutions, the participants looked at the correct key squares continuously or repeatedly before making the move. However, even in the case of incorrect solutions, it was common (especially for women) that the eye focus returned to the squares of the correct move for the last 10 seconds.

In the case of correct solutions, simultaneous assessment of physiological processes could be used to determine when the chess players first realized the solution. This was indicated by a prolonged eye focus on the correct squares of the key move, an increase in alpha brain activity corresponding to the resting state, a near-absence of theta activity indicating concentration, a decrease in high heart rate indicating state of excitement, and a halt in the decrease in skin temperature. Grandmasters had a higher rate of correct recognition of the key move in the first 10 seconds than the other two groups. The combined assessment of the physiological functions gave an accuracy of 94% in inferring the level of knowledge.

Conclusions

Below is a summary of the most important findings of my research and the conclusions that can be drawn from them.

My research has confirmed the already known positive correlations between chess and cognitive functions (logic, concentration, creativity). The association with resilience has been previously demonstrated in physical sports but not in chess. My studies confirm that playing chess also strengthens resilience.

In terms of healthy lifestyles, I found no difference between the chess players' and non-chess players' groups for men, indicating that the sedentary lifestyle associated with chess was not a disadvantage for them. At the same time, for women the examined competitive chess players were found to be healthier than the non-chess players in terms of smoking, physical activity and body composition.

Although many examples indicate a connection between playing chess and musicality, I could not prove a direct link. At the same time, I found that creativity is the common basis of both activities, and this finding could be the basis for further research.

Using a model of my own (Figure 1), I have shown that chess offers an excellent opportunity to investigate certain issues in decision theory. The components of decisions (expertise, nature of the problem, time available) and the quality of decisions in chess can be clearly defined, and the interaction of these components can be studied. Research has shown that the ’Take The First’ heuristic holds for experts (but only for them), i.e. they can trust their intuition. The advantage of greater expertise was mainly demonstrated for short time available and tactical tasks. This suggests that in other areas of life it may be worthwhile to entrust tasks requiring fast, intuitive decisions to the experts.

I found that positional or tactical chess style was not an advantage itself, but (presumably due to its psychological effect) the new world champion could usually beat the previous one with the opposite style. At increasingly high stakes, the world champions outperformed their challengers. Lessons from the world championship matches can also provide hints for everyday competitive situations (e.g. business, market competition, applying for a leadership position etc.). A ’newcomer’ may want to take the opposite tactics in a negotiation, and in case of high stakes, it is not advisable to leave the decision to the last moment.

Studying the physiological changes that take place during chess decision-making offers many new research opportunities. For example, changes in brain activity (alpha and theta waves) and eye movements can be used to predict high expertise, fast pattern recognition and a tendency to intuition. It seems very interesting and far-reaching to study the subconscious ’warning signal’, according to which the correct but not applied solution can be detected about 10 seconds before the effective decision is made. This finding could also imply that the choice ’offer’ of the pre-decision period should be preferred, perhaps its conscious application could improve the quality of the decision or even serve as an alarm signal. As this suggestion may be of great importance, further, larger studies are needed to confirm it.

List of own publications

Medvegy Z, Mihalovits M, Medvegy N, Gombocz J, Major Zs, Bretz K, Sterbenz T. (2018) Van-e összefüggés a sakkozás, a matematika és a muzikalitás között? Magyar Sporttudományi Szemle, 19: 20-24.

Medvegy Z, Varga K, Durucz Sz, Lovass L, Dávid R, Sterbenz T. (2018) Sakkozók stratégiai és taktikai döntései közötti élettani különbségek nagymesterek és amatőrök esetében. Magyar Sporttudományi Szemle, 19(5): 23-27

Medvegy, Z, Raab, M, Toth, K, Csurilla, G, Sterbenz, T. (2022) When do expert decision makers trust their intuition? Applied Cognitive Psychology, 36(4), 748-757.

Medvegy Z, Mihalovits M, Medvegy M, Zabos I, Sterbenz T. (2022) Does playing chess strengthen resilience? Studia Universitatis Babes-Bolyai Educatio Artis Gymnasticae, 67(3): 5-18.

Major Zs, Medvegy Z, Tulit TT, Simonyi G, Pavlik G, Medvegy M (2023) Versenysportolók hirtelen szívhalálának elemzése, az esetszámok csökkentésének lehetőségei. Orvosi Hetilap, 164 (29): 1155-1163.