Psychological Research (2007) 71:591–597
DOI 10.1007/s00426-006-0076-0

ORIGINAL ARTICLE

The effects of time pressure on chess skill: an investigation into fast and slow processes underlying expert performance

Frenk van Harreveld · Eric-Jan Wagenmakers · Han L. J. van der Maas

Received: 28 November 2005 / Accepted: 3 July 2006 / Published online: 22 December 2006

Abstract The ability to play chess is generally assumed to depend on two types of processes: slow processes such as search, and fast processes such as pattern recognition. It has been argued that an increase in time pressure during a game selectively hinders the ability to engage in slow processes. Here we study the effect of time pressure on expert chess performance in order to test the hypothesis that compared to weak players, strong players depend relatively heavily on fast processes. In the first study we examine the performance of players of various strengths at an online chess server, for games played under different time controls. In a second study we examine the effect of time controls on performance in world championship matches. Both studies consistently show that skill differences between players become less predictive of the game outcome as the time controls are tightened. This result indicates that slow processes are at least as important for strong players as they are for weak players. Our findings pose a challenge for current theorizing in the field of expertise and chess.

F. van Harreveld (✉) · E.-J. Wagenmakers · H. L. J. van der Maas
Department of Psychology,
Universiteit van Amsterdam, Roetersstraat 15,
1018 WB Amsterdam, The Netherlands
e-mail: f.vanharreveld@uva.nl

E.-J. Wagenmakers
e-mail: e.wagenmakers@uva.nl

H. L. J. van der Maas
e-mail: h.j.l.vandermaas@uva.nl

Introduction

One of the important challenges for cognitive science is to shed light on the processes that underlie expert decision making. Across a wide range of fields such as medical decision making and engineering, it has been shown that expertise involves both slow processes such as selective search and fast processes such as the recognition of meaningful patterns (e.g., Ericsson & Staszewski 1989). This distinction between fast and slow processes is very applicable to the game of chess and therefore research on chess is of considerable importance for the understanding of expert performance.

Ever since the groundbreaking work of De Groot (e.g., 1946, 1978), cognitive psychologists have been interested in the skills that distinguish strong from weak chess players. Generally two types of skill are distinguished; the ability to calculate variations (search) and the ability to recognize and remember meaningful patterns on the board (pattern recognition). The early work by De Groot (1946) indicated that strong players are hardly any better when it comes to search. Similarly, Charness (1981), Holding and Reynolds (1982), and Saariluoma (1990) have shown that experts search slightly *deeper* than weaker players but that they do not search *wider*. In other words, they calculate selected variations somewhat deeper, but they do not calculate *more* variations than weaker players. This relatively small effect of skill on search has led Charness (1981) to conclude that at high skill levels the ability to search probably becomes uniform.

In terms of the skills that *do* distinguish strong from weak players, De Groot (1946) found that strong players are much better than weaker players in their ability to memorize and recognize patterns of pieces on the board. This effect has been replicated and extended by Gobet and Simon (Gobet & Simon 1996, 2000; Lassiter 2000). These findings have led psychologists to believe that at a certain level expert skill in chess is predominantly determined by the number of chunks a player has in his “chess vocabulary” which he can access relatively fast and effortlessly (e.g., Simon & Chase 1973). Holding (1985, 1992; see also Gobet & Simon 1998), however, has challenged this view and has emphasized the importance of search.

An important difference between search processes such as calculating variations on the one hand and pattern recognition on the other is that the former takes relatively more time. In other words, search is often labeled a *slow process*, while recognition is seen as a *fast process*. Consequently, restricting the time available to a player will have more of an effect on the (slow) search process and comparatively little on (fast) pattern recognition. Gobet and Simon (1996) have applied this assumption in a study where they compared the performance of Garry Kasparov (generally considered the strongest player of all time) under normal tournament circumstances to his performance when Kasparov was playing a *simul* (i.e., playing several players at the same time) and the time to contemplate his moves was restricted. Gobet and Simon (1996) showed that Kasparov’s chess rating (a numerical measure of skill, cf. Batchelder & Bershad 1979) drops from 2,750 to 2,646 when he has to play faster. Gobet and Simon concluded that imposing a time constraint lowered Kasparov’s quality of play only to a slight extent.[1] Calderwood, Klein, and Crandall (1988) asked grandmasters to rate the quality of moves made in fast (*blitz*) and slow games, played by strong and weak players. Their results showed an interaction between skill and game type, in the sense that stricter time constraints decrease the quality of play particularly for weak players. On the other hand, Chabris and Hearst (2003) have recently shown that even grandmasters make more and bigger mistakes under conditions where they have less time than usual to select their moves.

Like Gobet and Simon (1996), Burns (2004) hypothesized that increasing time pressure selectively reduces the effectiveness of slow search processes. Analysis of several *blitz* tournaments, in which a player has only 5 min to complete a game, demonstrated that blitz performance and chess skill are very highly correlated. Moreover, time pressure attenuated skill differences among weak players, but not among strong players. Based on the latter finding, Burns concluded that skill differences in chess are predominantly based on differences in the effectiveness of fast processes, and that this holds particularly for strong players. However, this conclusion may be premature, as several alternative explanations exist.

From a theoretical perspective, it is indeed plausible that time pressure reduces the contribution of slow processes in an absolute sense. However, in a game between two players it is the amount of search *relative* to that of the opponent that is crucial. To illustrate, assume that a strong player calculates eight moves ahead under normal time controls, and his weaker opponent calculates four moves ahead. Under time pressure, the strong player and the weak player may only calculate, say, four and two moves ahead, respectively. It is unclear which time controls are more favorable to the stronger player in this example.

When the distinction between absolute effectiveness and relative impact of search processes is taken into account, Burns’ theoretical claim is severely undercut. In a way this resembles the discussion between Gobet and Simon (1996, 2000) and Lassiter (2000) about the increased strength of computers in blitz chess as compared to normal time controls. While Lassiter (2000) argues this is likely due to the fact that the human ability to engage in search is more hampered by the increased time constraints, Gobet and Simon (2000) reply that the human difficulty could just as well be the consequence of having less time for pattern recognition.

Another alternative explanation of Burns’ findings can be found in the specific factors that come into play during a blitz game that may cause strong players to benefit from faster time controls. For example, blitz is associated with more stress and (perhaps consequently) more “blundering” (making very gross mistakes) than normal time controls. Being less experienced, a weaker player is less used to dealing with stress during a game than a seasoned professional—hence, the weaker player may fall victim to blundering even more often than during a normal game. This differential increase in blunders due to stress might also explain the finding that strong players become relatively stronger as a result of increased time pressure. In short, the fact that reducing the time available leads to more variance in results among weak players than among strong players could be due to many factors other than the enhanced reliance of strong players on pattern recognition.

[1] One can question whether Kasparov himself would actually consider a 100-point decrease in rating “slight.” At the time of the simultaneous exhibitions he would have dropped to somewhere around tenth place. In our view, and probably in the view of the strongest player of all time, still a significant decrease. At this moment he would drop from being the strongest player in the world to somewhere around the 60th place in the world ranking.

A second issue is methodological. Burns used *chess ratings* as an objective measure of chess skill, as is indeed accepted practice. However, low ratings are estimated less *reliably* than high ratings. The standard deviation in the rating of amateurs is about twice that of grandmasters (Jonker 1992). This difference in reliability occurs because many amateurs have ratings that are based on very few games. When using chess rating as an index of skill, one should ensure these ratings are sufficiently reliable.

On the whole, the existing research on the importance of fast and slow processes in chess raises a number of interesting ideas, which deserve further investigation. We believe that the most adequate test of his hypotheses would also involve a within-subjects design, where players of various strengths are compared in terms of their performance in fast and slow games. In the present paper we present two studies in which we examine the impact of time pressure on playing strength, taking into account the concerns outlined above. In the first study we examine the ratings (for various time controls) of an online chess club. In the second study we analyze the results of the last world championships, where matches were played with both normal (slow) time controls as well as with faster time controls. We relate these results to the player's skill level and examine whether strong players suffer more or less from increased time pressure.

Study 1

In order to test our hypotheses using highly reliable ratings, we examined ratings of players of various strengths on the *Internet Chess Club* (ICC; http://www.chessclub.com). This is a club with over 30,000 active members, including many of the best players in the world. Thousands of games are played on this server daily and each player has different ratings for different time controls. Only after having played a sufficient number of games, players receive a stable rating. This allows for analysis of reliable ratings based on thousands of games and compare players of different strengths in terms of their vulnerability to an increase in speed.

Method

In order to examine the effect of time pressure on playing skill we randomly selected 300 active players from the ICC lists of players in four categories, decreasing in playing strength: 75 international grandmasters (GMs), 75 international masters (IMs), 75 Fédération Internationale des Echecs (FIDE) masters (FMs) and 75 players with no title. All of these players were very active on the ICC and had highly reliable ratings.

On ICC there are generally two methods of finding an opponent. One can directly challenge another player to a game of *bullet* (1–2 min), *blitz* (3–10 min), or *standard* (10–60 min). A second option is to enter a *pool*, where one is automatically paired to a player of similar strength. There is a pool for 5-min games and one for 1-min games. For each of these options players receive a separate rating. The ratings of the players in the various categories show that playing strength in terms of title is predictive of success on ICC. The ratings for the different title groups in each of the rating categories are presented in Table 1.

It is important to note that ICC has invested a significant amount of effort into the detection of fraud. Two types of fraud may be distinguished; computer fraud and having stronger players use your account. The former form of fraud is now increasingly uncommon because the ICC team of "computer busters" regularly checks games and examines whether or not an unusual number of moves by a player under consideration is predicted by chess playing software. The second type of fraud is detected by examining the extent to which a player performs significantly better if he logs on from a different IP-address. Of course, as during real life tournament play, it is impossible to eradicate fraud altogether but there is no reason to assume it is less common for strong players than for weak players.

Results and discussion

We examined the correlations between 1- and 5-min ratings, blitz and bullet ratings and blitz and standard ratings for each of the various title categories.

The results, shown in Fig. 1, indicate that the correlations between ICC ratings associated with different

Table 1 Mean ratings for grandmasters (GMs), international masters (IMs), FIDE masters (FMs) and untitled players (none)

Title	Standard	Blitz	Bullet	5-minutes	1-minute
GM					
M	2,439.16	2,973.17	2,445.68	2,405.77	2,261.85
SD	166.05	251.16	187.34	142.63	168.77
IM					
M	2,419.28	2,786.66	2,389.01	2,300.05	2,206.45
SD	180.83	262.78	197.30	156.28	182.70
FM					
M	2,321.79	2,581.70	2,234.31	2,178.36	2,068.64
SD	142.83	209.29	196.04	128.53	197.23
None					
M	1,510.30	1,960.27	1,762.19	1,696.68	1,510.30
SD	469.68	467.68	411.58	394.93	469.68

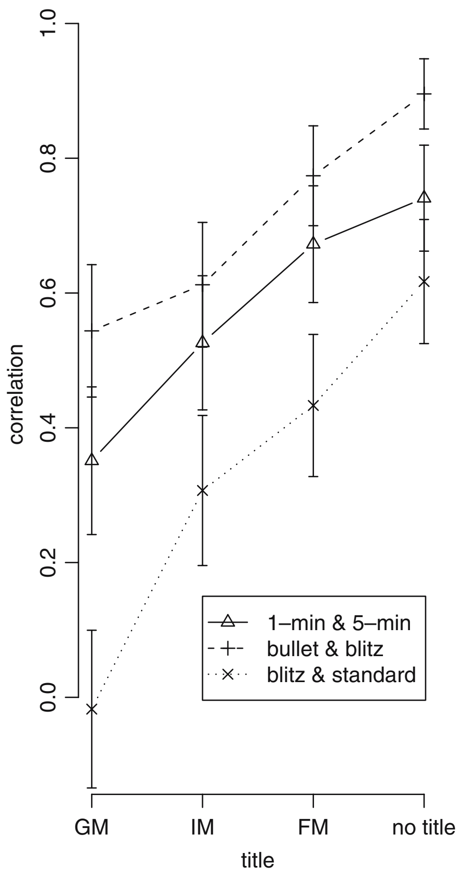

Fig. 1 Correlations and standard errors between chess ratings for strict and lenient time controls, clustered in four categories according to playing strength. In order of decreasing status, the four categories are: *GM* international grandmaster, *IM* international master, *FM* FIDE master, no title

time controls decrease with playing strength: correlations are highest for relatively weak, non-titled players, and correlations are lowest for GMs.

The pattern of results from Fig. 1 is interesting because it points to the opposite pattern than the one obtained by Burns (2004) and Gobet and Simon (1996). According to these researchers, skill differences between strong players are based to a larger extent on differences in fast processes than are skill differences between weak players. Burns (2004) argues that slow processes suffer more under time pressure than fast processes, because the latter are more automatic and effortless and thus do not rely on time as much as the more intensive search processes. Consequently, Burns' hypothesis predicts that correlations between ratings of various time controls should increase with playing strength. The data from Fig. 1, however, shows the opposite result. A simple explanation for the current findings is that increasing time pressure enhances the probability of errors on both sides. When the absolute number of errors increases in the same amount for weak and for strong players, this constitutes a larger relative increase for the stronger player. This explanation suggests that faster time controls benefit the *weaker* player in the sense that the game almost becomes a game of chance once time pressure increases severely.

A drawback of the current dataset is that a random selection of untitled players will have a much larger variance in rating as compared to the groups of title holders. These differences in variance can of course have an impact on the correlational data, although the standard deviations presented above show that this alternative explanation does not account for the differences found between the three groups of title holders. The next study examines the effect of time pressure within a more homogeneous group: contenders for the world championship.

Study 2

In 1999 the FIDE introduced a new format for the world championship. Whereas previously the title was disputed in a series of very long knockout matches of often 24 games in the traditional time controls (i.e., 2 or 2.5 h for the first 40 moves, followed by 1 h for the subsequent 20 moves), FIDE now had players engage in 2-game knockout matches, which would in case of a tie be decided by a 2-game tiebreak with a faster time control. If this tiebreak was tied as well two more games were played and if it was still tied after that, players had to play blitz games until a winner did arise. This format allows us to study whether an increase in playing tempo benefits the weaker player, as was the case in Study 1.

Method and results

Since the new format was installed world championships were held in 1999, 2000, 2002 and 2004. We examined all 441 matches played in these world championships. Three hundred and seventy-four matches were decided during the games with normal time controls. During the so-called rapid playoffs (25 min per game + 10 s per move) 37 matches were decided. The remaining 30 matches were decided with blitz games. Ratings of the players ranged from 2,257 to 2,797 ($M = 2{,}617.47$, $SD = 57.18$).

For each match we examined a difference score based on the ratings of the two players. This difference score ranged from 0 to 923 with a mean of 97.65 ($SD = 85.68$) and we correlated this difference score with the result of the matches in each of the various time controls. A score of 1 was given to the result of a game where the higher rated player won and a score of 0 when the higher rated player lost. A score of 0.5 was given to a game that ended in a draw. These scores were added up over the different games that were played in the match. Thus, over a 2-game match, the score ranged from 0 to 2. The correlation between the rating difference score and the result during the regular games is 0.44 ($P < 0.001$) and for the rapid games this correlation slightly decreased to 0.38 ($P = 0.002$). Interestingly, for the blitz games the correlation with rating difference dropped to −0.02.

Of course it is quite likely that pairings that are closely matched in terms of rating are more likely to go "all the way" and reach the blitz stage. Thus it could be that the range of the rating difference score is simply not sufficient to allow for significant correlations with the result of the blitz match. Examining the ranges for the matches decided in each of the three (normal, rapid, blitz) stages does indeed show that the range is highest for the normal matches, where the rating difference ranges from 0 to 923 points ($M = 103.36$, $SD = 90.58$). The rapid matches show a much smaller range; from 0 to 151 points ($M = 67.95$, $SD = 32.67$). For the blitz games the rating difference ranges from 5 to 166 points ($M = 63.10$, $SD = 41.76$). The fact that there is no significant difference in range and distribution between blitz and rapid games ($t < 1$) indicates that the low correlation with match result for the blitz games is not attributable merely to a restriction of range. It appears that (even) among grandmasters in contention for the world championship, performance in blitz games seems to rely on skills very different from the ones used during regular tournament play.

General discussion

The two studies reported here both show that while previous research has suggested that increasing the playing tempo during a game of chess will benefit the stronger player due to his decreased reliance on slow skills such as calculation of variations, data of online play and world championship matches indicates otherwise. Our data suggests that once players are forced to play faster, their ability during regular play under normal time controls becomes less predictive of their performance.

This effect is particularly apparent when the players engage in a game of *blitz* or even faster playing tempos. The data of the world championship matches showed that speeding up to a *rapid* game (approximately 30 min per game) does not have such a strong effect. Only when the games become even faster does the rating advantage of the stronger player become insignificant. Exactly why the difference between normal play and rapid is less important than that between rapid and blitz is an open question.

What causes the attenuation of differences in playing strength when people are playing blitz? Several possibilities should be considered. As we have mentioned before it could very well be that increasing the playing tempo also increases the possibility of making very serious mistakes during a game. In fact such blunders often end a game immediately because the consequences are beyond repair, even by a stronger player. If it is the case that increased time pressure increases the likelihood of blunders *regardless* of playing strength this increase constitutes a larger *relative* increase for the stronger player because weak players make blunders anyway.

Another possible explanation lies in the fact that when playing blitz different skills come into play. A blitz player needs to be able to cope with the increased stress that is associated with blitz. With respect to the world championship data it could even be the case that the higher rated player experiences relatively more stress because he has not been able to capitalize on his rating advantage. Moreover, because of the importance of moving quickly, even refined motor skills can be a significant advantage in blitz. Many chess players specialize in blitz, but many others do not want to have anything to do with it, which suggests we are almost (but of course not entirely) dealing with a different game.

If it is indeed the case that playing with faster time controls induces a lot of "noise" into a game, then maybe examining quality of play with fast or slow time controls is not the best way to study if expert skill in chess is based on fast processes like pattern recognition or slow processes such as search. In fact we believe that an experimental test of this question with a "choose-a-move" paradigm (Campitelli & Gobet 2004; van der Maas & Wagenmakers 2005) would be more appropriate, where one can present players with both typical search items and pattern recognition items and manipulate the time players have to select the best move. Nonetheless, we believe that the current data is useful because it helps to put the findings of Burns (2004) and Gobet and Simon (1996) into perspective.

One of the origins of the fact that the recent literature on chess continues to emphasize the relative importance of fast processes such as pattern recognition might be the fact that it still very much relies on relatively old work on the psychology of chess (e.g., De Groot 1978) and the limited attention paid to chess literature. The view on the thinking process of the (strong) chess player relying on pattern recognition and rules of thumb that is generally found in scientific literature on the issue, if anything, seems related to the old (and somewhat outdated) views of Nimzowitsch (1930). Nimzowitsch stressed the importance of certain rules and principles, to which chess players should abide such as not putting knights on the edge of the board, do not move pawns in front of your king etcetera. Modern chess on a high level, however, no longer relies on rule-oriented and principle-oriented thinking (fast processes) but focuses on concrete analysis of the position at hand (slow processes). Watson (1998) argues that this emphasis on concrete analysis is what constitutes the core of the modern Soviet School of Chess. One exponent of this school is Alexander Kotov, who in his influential *Think Like a Grandmaster* (1987) argues: "Having examined the games of other players, particularly masters, I became even more convinced that the ability to analyze clearly a sufficient number of variations so as to clarify the position was the basic condition for success." Kotov describes a process of self-examination subsequent to his participation in the Moscow championship, when he already was a very strong player. In other words, reliance on slow processes such as calculating variations also differentiates among strong players.

A rapidly growing body of research indicates that thousands of hours of training are necessary to attain expert level in any domain. Charness, Tuffiash, Krampe, Reingold, and Vasyukova (2005) for example show that extensive deliberate practice is the fundamental factor in the development of expert chess performance. Such deliberate practice often takes place in a form where a chess player goes through a large number games by grandmasters and for each move tries to find the one that was played by the grandmaster (e.g., Ericsson 2004, 2005; Ericsson, Krampe, & Tesch-Römer 1993). Such intensive methods of training may very well be aimed at making slow processes more efficient and thus faster and not at learning and memorizing entirely new patterns. *This quality to direct slow processes toward the most appropriate target* may over time turn into a fast process and as such the two processes become intertwined.

The study of how time pressure influences thought processes in chess is of considerable theoretical interest. The question whether or not strong players rely less on search processes than do weak players is something that has an impact on our understanding of expert behavior in a wider range of domains. Our results suggest that experts do not use completely different tools when creating their work or play their game, but they use these tools more effectively than those who are less skilled.

Acknowledgment The authors would like to thank Joop van der Pligt, Rene Zeelenberg, Vittorio Busato, and Bruce Burns for insightful discussions and useful comments.

References

Batchelder, W., & Bershad, N. (1979). The statistical analysis of a Thurstonian model for rating chess players. *Journal of Mathematical Psychology*, *19*, 39–60.

Burns, B. D. (2004). The effects of speed on skilled chess performance. *Psychological Science*, *15*, 442–447.

Calderwood, R., Klein, G. A., & Crandall, B. W. (1988). Time pressure, skill, and move quality in chess. *American Journal of Psychology*, *101*, 481–493.

Campitelli, G., & Gobet, F. (2004). Adaptive expert decision making: skilled chess players search more and deeper. *International Computer Games Association Journal*, *27*, 209–216.

Chabris, C. F., & Hearst, E. S. (2003). Visualization, pattern recognition, and forward search: effects of playing speed and sight of the position on grandmaster chess errors. *Cognitive Science*, *27*, 637–648.

Charness, N. (1981). Search in chess: age and skill differences. *Journal of Experimental Psychology: Human Perception and Performance*, 2, 467–476.

Charness, N., Tuffiash, M., Krampe, R., Reingold, E., & Vasyukova, E. (2005). The role of deliberate practice in chess expertise. *Applied Cognitive Psychology*, *19*, 151–165.

De Groot, A. D. (1946). *Het denken van den schaker*. Amsterdam: Noord Hollandsche.

De Groot, A. D. (1978). *Thought and choice in chess.* 2nd ed. The Hague: Mouton.

Ericsson, K. A. (2004). Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Academic Medicine*, *10*, S1–S12.

Ericsson, K. A. (2005). Recent advances in expertise research: a commentary on the contributions to the special issue. *Applied Cognitive Psychology*, *19*, 233–241.

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*, 363–406.

Ericsson, K. A., & Staszewski, J. J. (1989). Skilled memory and expertise: mechanisms of exceptional performance. In D. Klahr, & K. Kotovsky (Eds.), *Complex information processing: The impact of Herbert A. Simon*. Hillsdale: Erlbaum.

Gobet, F., & Simon, H. A. (1996). The roles of recognition processes and look-ahead search in time-constrained expert problem solving: evidence from grand-master-level chess. *Psychological Science*, *7*, 52–55.

Gobet, F., & Simon, H. A. (1998). Pattern recognition makes search possible: comments on Holding (1992). *Psychological Research*, *61*, 204–208.

Gobet, F., & Simon, H. A. (2000). Reply to Lassiter. *Psychological Science*, *11*, 174.

Holding, D. H. (1985). *The psychology of chess skill*. Hillsdale: Erlbaum.

Holding, D. H. (1992). Theories of chess skill. *Psychological Research*, *54*, 10–16.

Holding, D. H., & Reynolds, R. I. (1982). Recall or evaluation of chess positions as determinants of chess skill. *Memory and Cognition*, *10*, 237–242.

Jonker H. (1992). *Het Nederlandse Elo-rating boek*. Venlo: Van Spijk.

Kotov A. (1987). *Think like a grandmaster*. London: Batsford.

Lassiter, G. D. (2000). The relative contributions of recognition and search–evaluation processes to high-level chess performance: comment on Gobet and Simon. *Psychological Science*, *11*, 172–173.
van der Maas, H. L. J., & Wagenmakers, E-J. (2005). The Amsterdam Chess Test: a psychometric analysis of chess expertise. *The American Journal of Psychology*, *118*, 29–60.
Nimzowitsch, A. (1930). *My system*. UK: Hayes.
Saariluoma, P. (1990). Apperception and restructuring in chess player's problem solving. In K. J. Gilhooly, M. T. G. Keane, R. H. Logie, & G. Erdos (Eds.), *Lines of thinking* (Vol. 2). London: Wiley.
Simon, H. A., & Chase, W. G. (1973). Skill at chess. *American Scientist*, *61*, 394–403.
Watson, J. (1998). *Secrets of modern chess strategy*. London: Gambit.