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Brief article

# The role of intuition and deliberative thinking in experts' superior tactical decision-making

Jerad H. Moxley [a,*], K. Anders Ericsson [a], Neil Charness [a], Ralf T. Krampe [b]

[a] Department of Psychology, Florida State University, Tallahassee, FL 32306, USA
[b] Department of Psychology, University of Leuven, Leuven, Belgium

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ABSTRACT

Current theories argue that human decision making is largely based on quick, automatic, and intuitive processes that are occasionally supplemented by slow controlled deliberation. Researchers, therefore, predominantly studied the heuristics of the automatic system in everyday decision making. Our study examines the role of slow deliberation for experts who exhibit superior decision-making outcomes in tactical chess problems with clear best moves. Our study uses advanced computer software to measure the objective value of actions preferred at the start versus the conclusion of decision making. It finds that both experts and less skilled individuals benefit significantly from extra deliberation regardless of whether the problem is easy or difficult. Our findings have important implications for the role of training for increasing decision making accuracy in many domains of expertise.


## 1. Introduction

In his Nobel prize lecture Daniel Kahneman (Kahneman, 2002), described human decision making using two interacting systems. System 1 (intuition) is fast, automatic, and effortless, while System 2 (deliberative thinking) is slow, controlled, and effortful. In this model System 1 quickly proposes solutions, and System 2 monitors System 1, helps solve problems where the answer is not readily apparent, and attempts to monitor and correct any biases of System 1 (Kahneman & Frederick, 2005). Most recent research has examined biases of System 1 for simple judgments (Gilovich, Griffin, & Kahneman, 2002; Tversky & Kahneman, 1974), but many scientists argue that heuristics and intuitions lead to better and more satisfying decisions in everyday life (Gigerenzer & Brighton, 2009) and characterize even the decision making of experts (Dreyfus & Dreyfus, 1986; Kahneman & Frederick, 2005; Klein, 1998). The present study collected data on how the accuracy of generated decision options changes from the start to the finish of the decision making process as a function of the individual's level of expertise and the difficulty of generating objectively superior decisions.

### 1.1. Skilled decision making

Expertise researchers (Benner & Tanner, 1987; Dreyfus & Dreyfus, 1986) have argued that experts' decisions are primarily the result of accumulation of extended experience, leading to fast intuitive decisions. However, objective accuracy of expert decisions has been found to be generally low and in many domains of expertise longer professional experience has not been associated with better decisions (Choudhry, Fletcher, & Soumerai, 2005; Ericsson, 2007; Swets, Dawes, & Monahan, 2000; Tetlock, 2005). In domains, such as athletics, typing, and music, where we see reproducibly superior performance, expertise is not

* Corresponding author.
*E-mail address:* moxley@psy.fsu.edu (J.H. Moxley).

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associated with length of experience but with the duration of training activities (deliberate practice) that give immediate accurate feedback and opportunities for gradual improvement (Ericsson, Krampe, & Tesch-Römer, 1993).

One of the best examples is chess where deliberate practice such as the reported solitary studying of grandmaster games has been found to be closely related to chess ratings based on tournament success which is related to players' ability to decide the best chess move in the laboratory (de Groot, 1978; Gobet & Charness, 2006). While accurate feedback has been argued as necessary for the development of superior intuition (Hogarth, 2008) the locus of individual differences in chess skill has not yet been clearly linked to either System 1 or System 2 processes. Leading theories of chess expertise (Chase & Simon, 1973; Gobet & Simon, 1996a) hypothesize that intuitive processes based on pattern recognition, allow experts to rapidly retrieve the selected action from memory. In these theories the acquisition of a large body of knowledge linked to familiar patterns allows the expert to recognize patterns which cues the retrieval of the best moves. Extending this hypothesis, major theorists (Dreyfus & Dreyfus, 1986; Kahneman & Frederick, 2005; Klein, 1998) have described chess as an example of a domain where experts rely on superior intuition as stated in Dreyfus and Dreyfus (1986, p. 36) "Serious tournament chess involves deep deliberation, although… quality of move choice depends surprisingly little on anything beyond pure intuitive response. While the reliance on intuition does not preclude a role for deliberation, intuition is thought to be more important".

### *1.2. Past research on deliberation in chess*

Since de Groot (1978) amount of search has been quantified by counting the number of different chess moves or move combinations that a chess player verbalizes while selecting the best move for a chess position. Although better chess players consider more alternative chess moves to a deeper level (Bilalić, McLeod, & Gobet, 2008; Charness, 1981), previous analyses have not been able to determine whether additional search increases the quality of move selection by experts or mainly confirms the expert's initially generated intuitions (Dreyfus & Dreyfus, 1986).

Research has provided some empirical support for the idea that experts gain less from deliberation.[1] recognition debate. See for instance Gobet and Simon (1998). For example, studies analyzing expert games (Calderwood, Klein, & Crandall, 1988) as well as tournament outcomes (Burns, 2004) have argued that chess experts are less affected by time reductions for move selection and thus by inference would benefit less by the time-consuming deliberation. On the other hand, other studies have found that rapid chess play is associated with decrease in chess performance, but less than might be expected (Gobet & Simon, 1996b) and is associated with selection of worse chess moves (Chabris & Hearst, 2003).

[1] It should be noted that in chess a discussion very similar to intuition vs. deliberation has occurred in the context of the search vs. pattern recognition

### *1.3. The present study*

This study will approach the question differently by collecting verbal protocols during the decision making process and using controlled laboratory tasks. We used a chess computer program, which selects better moves for tactical chess positions than the best human players, to assess the quality of chess moves on a scale that approximates measurement on the interval level. This allows us to quantify the differences in selected move quality at the start and at the end of the decision making process and to see how much experts and skilled tournament chess players benefit from additional time to search and deliberate. This experimental design reduces potential confounds in studies of complete chess games, where the superiority of expert players can have many different causes. In their pioneering study Klein, Wolf, Militello, and Zsambok (1995) found a nonsignificant experts advantage in initial move strength and final move strength likely due to their small sample. Our current study extends this work by collecting data for a larger sample, and examines a wider range of relations, such as the relation between the initial-move strength and final move strength and their interactions with level of skill that were not tested by Klein et al. (1995).

In this study intuitive selection will be inferred when the first move mentioned agrees with the move chosen in agreement with Kahneman and Frederick's (2005, p. 268) terminology, where judgments "are called intuitive if they retain the hypothesized initial proposal without much modification". This type of decision is also referred to as using "take-the first" heuristic (Raab & Johnson, 2007) and has been proposed to mediate superior expert decision making (Gigerenzer & Brighton, 2009; Raab & Johnson, 2007) in highly time-constrained domains, although some researchers distinguish between heuristics and intuition (Glöckner & Witteman, 2010).

If experts relied primarily on intuition or fast heuristics, such as "take the first" (System 1), the measured strength of the first move mentioned should not differ from that of the move later selected. Within this theoretical framework less skilled tournament players should mention an initial move of lower quality than the experts and with extra deliberation find a better move that reduces their disadvantage (Burns, 2004; Calderwood et al., 1988; Dreyfus & Dreyfus, 1986; Raab & Johnson, 2007). This prediction would not necessarily mean that experts do not gain anything from deliberation, just that there is a significant interaction whereby non-experts gain comparatively more. Based on our view of expert performance, we hypothesize that move selection processes also involve System 2 processes. Rapid access to larger amounts of domain-specific information is hypothesized to give experts an advantage for accessing a superior first move. This expert advantage could be mediated by intuition based on retrieval of accessible memory traces and/or rapid construction of consistent mental representations (Glöckner & Witteman, 2010). Subsequent deliberation (System 2) will benefit the move selection of experts at least as much less skilled players, except possibly on easy problems where they may perform close to ceiling.

## 2. Experiment

### 2.1. Method

#### 2.1.1. Participants

Seventy-one chess players participated in the study at Potsdam Germany under the supervision of the fourth author.[2] Using standard terminology (e.g., Wikipedia, chess ratings) chess players with ratings below 2000 were categorized as tournament players and those rated 2000 or above as experts. The mean Elo for the 34 tournament players was $M = 1836$, $SD = 92.4$, mean age = 43.3, and for the 37 experts it was $M = 2194$, $SD = 130$, mean age = 44.1. The average chess rating of German tournament chess players is about 1500 with standard deviation around 300 points (Bilalić, Smallbone, McLeod, & Gobet, 2009).

#### 2.1.2. Procedure

The players were asked to find the best move for a group of 15 chess positions while thinking aloud (Ericsson & Simon, 1993) and their verbal protocols were transcribed. They were given 5 min for each position. The data had been collected by the third author several years earlier as part of an international study of chess. The chess positions had been selected by a international master to cover a broad range of problems encountered during games. We analyzed all 15 problems with Rybka 3.0 32mb, an extremely strong chess program and found that only six of the problems were tactical positions with a clearly defined best move namely positions where the difference between the best and the second best move was at least equal to the value of half a pawn.[3] Two of the six problems were difficult (19.7% and 25.3% solution rates), and two of them being easy (87.3% and 83.1%), and two of them being average (47.9% and 59.1% solution rates). Rybka was used to analyze both the quality of the first move mentioned during the verbal protocols and the move that each player finally selected for each of the six chess positions. The first mentioned move corresponds to our best evidence for an intuitive choice; however, occasionally players verbalize several alternative moves at the beginning, which can make the selection of the one first mentioned somewhat arbitrary. We therefore will also record the first move analyzed, which is defined as the first move where potential consequences of the move were explicitly verbalized. This first mentioned move and the first analyzed move refer to the same move 76% of the time in our study. The first move analyzed could be influenced by rapid System 2 evaluation (Kahneman & Frederick, 2005) to a greater degree than the first mentioned move and thus is more likely to involve deliberation than the first mentioned move. The verbalized information in the think aloud protocols can only be used to infer thinking but not its absence. Hence, the first move mentioned may have been preceded by thoughts that were not verbalized (Fox, Ericsson, & Best, 2011).

## 3. Results

Fig. 1 shows move strength for first moves mentioned and moves eventually chosen as a function of skill level and problem difficulty (estimated by the Rybka chess program). We conducted a mixed-design ANOVA with expertise level (experts vs. tournament players) as a between- and problem (ordered from easy to difficult) and time of choice (first move mentioned vs. move selected) as within subject factors. Our analysis (degrees of freedom adjusted for violations of sphericity) showed the expected effect of skill $F(1,69) = 13.90$, $p < .001$, $d = .44$ with the better players selecting better moves. With regard to the key research question there was a significant effect of time of consideration on move strength $F(1,69) = 128.78$, $p < .001$, $d = 1.56$ with the move chosen after deliberation being stronger than the move first mentioned. This effect did not interact with expertise $F(1,69) = 1.65$, $p > .05$. The designed significant effect of problem interacted with time of consideration, $F(2.1,131.6) = 18.00$, $p < .001$. Improvement with deliberate search was robust for all three problem types, but most pronounced for the two hard problems ($d = .71, .62, .94$ respectively for easy, medium, and hard problems). This pattern was similar for experts and tournament players. Nor was the triple interaction of expertise by time by problem significant, $F(2.1,145.89) = 2.22$, $p > .05$.

To quantify how much benefit was gained from search we used linear regression to estimate the relation between players' Elo rating on the one hand and the strength of their first mentioned moves and their chosen moves on the other. Both correlations were significant: $r(69) = .28$, $p < .05$, for first move mentioned; $r(69) = .39$, $p = .001$, for move chosen. These slopes did not differ significantly from each other in a repeated measures ANCOVA analysis, $F(1,69) = .03$, $p > .05$. The two regression lines in Fig. 2 provide an estimate of the dramatic improvement resulting from deliberate search.

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[2] One tournament player's data was not available due to a recording failure.

[3] Each chess position was analyzed by the Rybka 3.0 32mb chess program to a depth of 20 plies (move by either white or black) to determine the best chess moves and their evaluated outcomes. Each of the best moves is evaluated on a pawn scale, where a value of 1 means that after 20 moves white will have an advantage over black by the equivalent of 1 pawn. Following a long tradition of studies acknowledging that computers have difficulty with positional problems we required that the best move would have to be superior by 0.5 pawns or more compared to the next best moves to qualify as a tactical problem we based this in part on analysis of past best move tasks (e.g., de Groot, 1978). The smallest difference between best move and second best move was 0.86 pawns for the chess positions admitted to analysis. In most of the excluded problems the computer identified multiple moves as equally good or in the case of two positions the difference was less than a twelfth of a pawn. This meant the other nine of the 15 problems could not be analyzed with respect to whether players had identified the correct answer (the best chess move). Although each chess program will produce completely reliable analyses, it is clear that newer and more highly rated chess program will come up with slightly different evaluations as the chess positions are searched to an even deeper level of plies. Hence, small differences likely to be unstable as better programs are developed. Consistent with previous research relying on chess program's evaluations, it was only meaningful to analyze positions with large differences between alternative chess moves with computers (Chabris & Hearst, 2003). Upon the request of one of the reviewers we analyzed the nine rejected problems and found that the associated score had a Cronbach's alpha of −.150 (essentially zero) as would be expected given the problems that are thought to exist for chess computer problems in positional problems. For the tactical problems we selected the alpha = .58 in contrast.

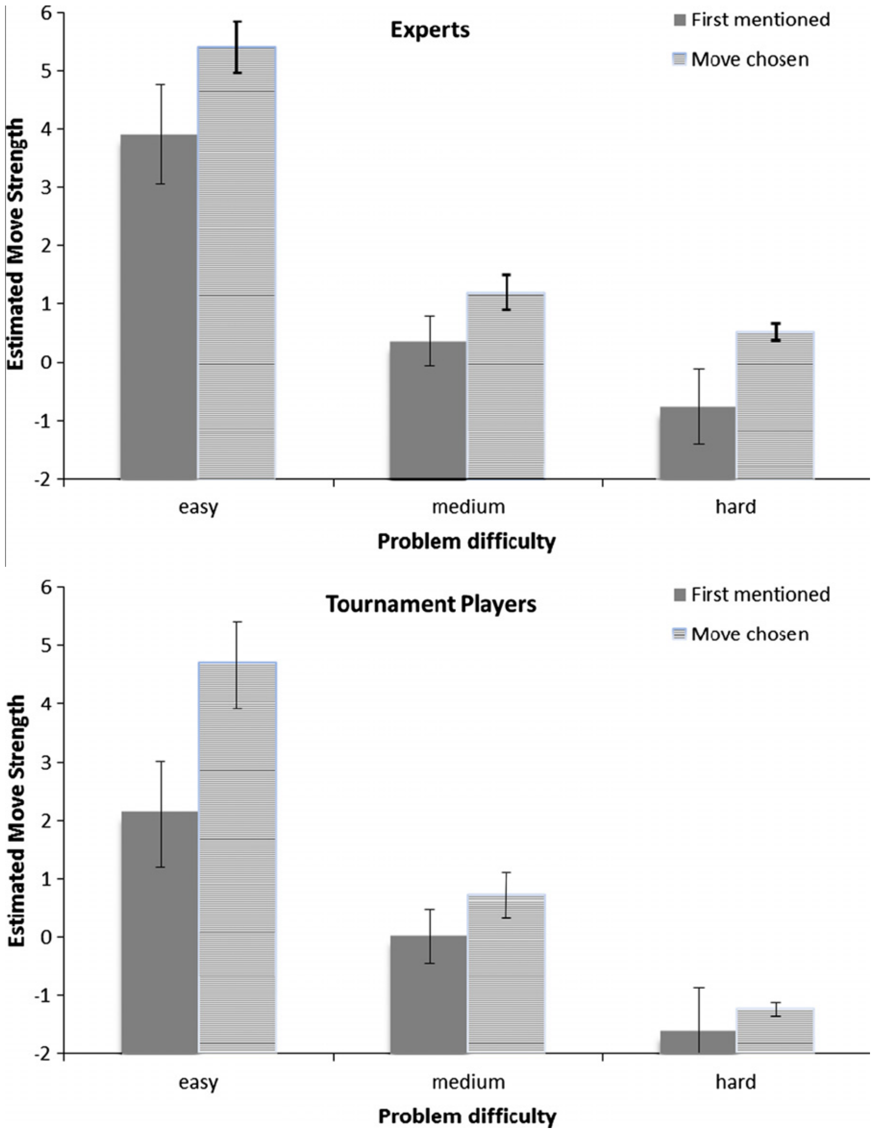


**Fig. 1.** Strength of first mentioned move and move chosen during the move selection task, as a function of problem difficulty and expertise–experts (top panel) and tournament players (bottom panel). Move strength improved in all situations with deliberation. Error bars represents 95% confidence intervals.

To determine if problem difficulty was related to how likely players were to select the first mentioned move as their final move we compared the likelihood of taking the first mentioned move on easy and difficult problems. Experts were significantly less likely to take the first mentioned move on difficult problems (22% compared to 73% for easy problems) $\chi^2 = 20.63$, $p < .001$. The tournament players also were less likely to choose the first move on the hard problems compared with easy problems (25% compared to 50%) $\chi^2 = 8.03$, $p < .005$. The experts were significantly more likely to take the first move on easy problems than the tournament players $\chi^2 = 6.99$, $p < .01$, but there was no significant difference for the hard problems $\chi^2 = .08$, $p > .05$. Overall participants choose the first move mentioned as their final move 45% of the time. Experts did not select the first mentioned move significantly more often then tournament players (49% compared to 40%) $\chi^2 = 2.37$, $p > .05$.

Finally we conducted an ANOVA using the first move analyzed as the dependent variable. This analysis also found that more skilled players selected better moves $F(1,69) = 17.92$, $p < .001$, $d = .50$. Furthermore, time for move generation (move quality at the start and end) was again strongly significant $F(1,69) = 81.57$, $p < .001$, $d = 1.27$, and this effect did not interact with expertise $F(1,69) = 3.61$, $p > .05$. Finally, the significant effect of problem difficulty interacted with time, $F(2.55, 176.26) = 10.74$, $p < .001$, however, in all cases the move chosen was significantly $p < .001$ better than the move first analyzed. The only substantial difference between the analyses of first mentioned and first analyzed is that in the latter case the 3-way interaction of expertise by time by problem is

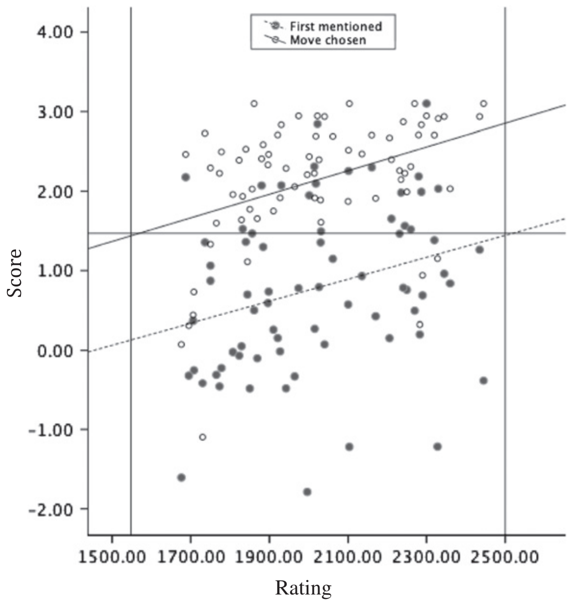


**Fig. 2.** Strength of first moves mentioned (filled symbols) and moves chosen (open symbols) for individual players as a function of the players ELO rating and linear regression lines. The dotted line illustrates the relation between players ELO ratings and strength of their first moves mentioned. The straight line shows the relation between ELO rating and strength of the move chosen. Based on the regression equations we can predict the quality of the first move mentioned by a chess grandmaster (ELO rating = 2500 for these particular positions, indicated as right vertical line) to correspond to the strength of the final move chosen by a tournament player with a rating of 1548 (left vertical line).

significant, $F(2.55, 176.26) = 5.71$, $p < .01$. Post-hoc tests using a Bonferroni protected p value showed that experts selected significantly better first-analyzed moves for the easy problems $t(69) = 4.08$, $p < .001$ $d = .98$, compared to the tournament players, but not for the medium difficulty problems $t(69) = 1.21$, $p > .05$, $d = .27$, or for the difficult problems $t(69) = .489$, $p > .05$, $d = .12$. In contrast, for the chosen moves the experts did not have a significant advantage over the less skilled players for the easy problems $t(69) = 1.74$, $p > .05$, $d = .42$ nor even for the medium problems based on the adjusted significance level, $t(69) = 2.04$, $p = .045 > p_{\text{bonf}} = .017$, $d = .49$. The experts did, however, select better final moves for the difficult problems, $t(69) = 2.80$, $p = .007$, $d = .67$. The means and confidence intervals for each condition are displayed in Fig. 3.

## 4. Discussion

Our findings demonstrate that in controlled environments experts benefit as much from deliberation as less skilled tournament players. The general application of the "take the first" heuristic and intuitive decision-making is inconsistent with the observed large improvements through deliberate thinking in all conditions. While experts clearly showed an early advantage they consistently relied on deliberate search to attain dramatic improvements in the quality of their move selection. The alternate measure of the first analyzed move shows a distinctive pattern. For easy problems a reduced benefit for continued deliberation is seen for experts, who establish a strong advantage early with the first move analyzed but the non-experts reduce this advantage with deliberation and the difference for the selected move is no longer significant. For the difficult problems, however, precisely the opposite pattern was observed with no difference for the first move, but a clear superiority for the experts' selected move attained through deliberation. Our study analyzed a wide but restricted range of skill: the least skilled players were at the 50th percentile and the best in the top 0.1%. It studied a wide range of difficulty levels of problems without including floor and ceiling effects, from problems that could be solved by most but not all players to problems could only be solved by experts occasionally. Only future research will be able to assess whether our results are generalizable to less skilled chess players and to non-tactical or simpler problems.

In line with the notion of expertise as maximum adaptation to task constraints (Ericsson & Kintsch, 1995) we found that experts more frequently changed their initial move selections (presumably based on System 1) for difficult than for easy chess positions. Our controlled study with process data shows chess expertise cannot be described as either intuitive or deliberative and more complex theories based on process data are needed for intuition (Campitelli & Gobet, 2010) possibly extending ideas based on pattern recognition (Gobet & Simon, 1996a), for a recent proposal see Betsch and Glöckner (2010).

Rather than accessing a superior immediate intuitive response (Kahneman & Frederick, 2005; Klein, 1998; Raab & Johnson, 2007) chess players often changed their move during search and this process was associated with large improvement in accuracy of the selected move. This finding can be accommodated by these theories by other parts of their decision-making models. For example, in Klein's (1998) decision model mental simulation might generate functionally equivalent outcomes to those produced by search in our proposal.

Our findings of large benefits of search might appear inconsistent with the much smaller effects of reduced time for move selection on chess performance at the highest levels of chess skill (Burns, 2004; Gobet & Simon, 1996b). This difference is likely due to the difference between studying the outcome of entire chess games compared to our study of move selection for individual chess positions. As we mentioned earlier, the studies of outcome of complete chess games will be influenced by opening knowledge and many other aspects not necessarily related to intuition or deliberation. For instance a recent analysis of a large database of rapid games showed both that better players varied time of play more and that their time was disproportionately spent in the middle game suggesting they rely on opening and end game knowledge bases and try to maximize search in the middle game (Sigman, Etchemendy, Slezak, & Cecchi, 2010).

Our study showed that when having to select a move for an unfamiliar position experts can more rapidly perceive important aspects of the position as demonstrated by their early advantage for the first analyzed move for

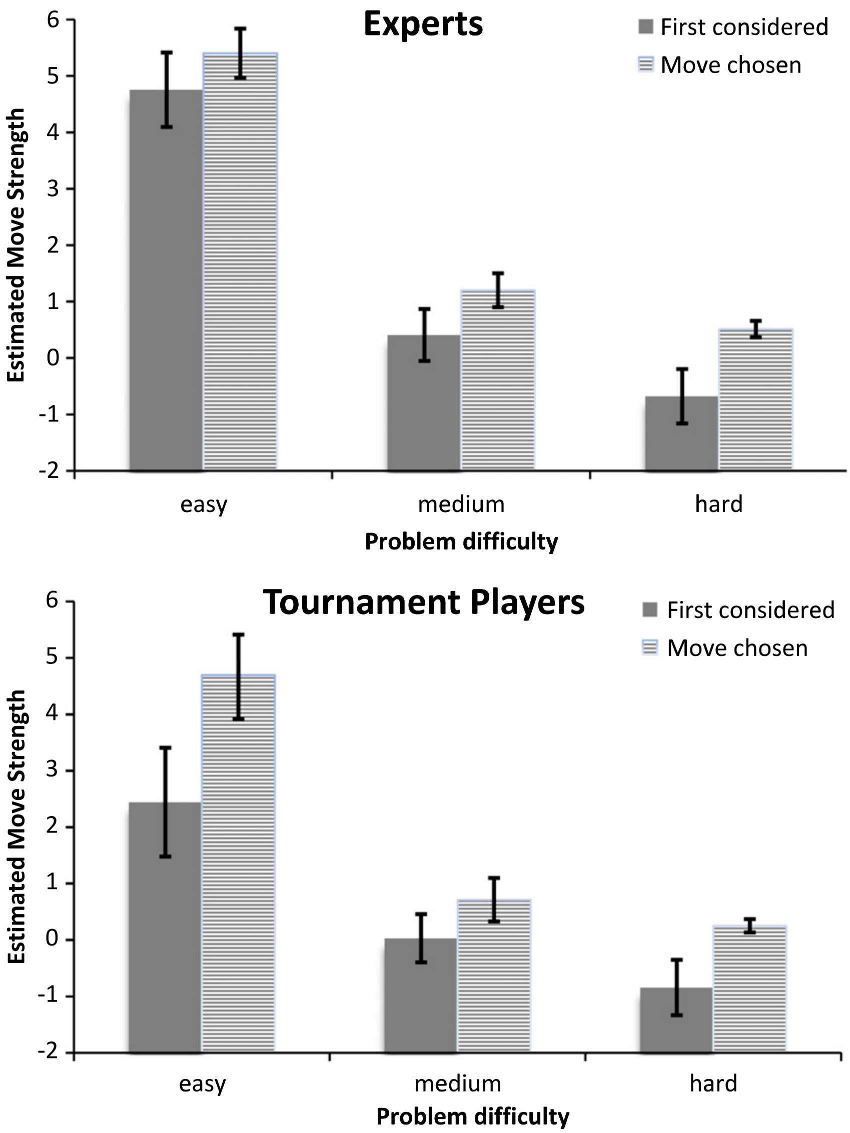


**Fig. 3.** Strength of first move analyzed and move chosen during the move selection task, as a function of problem difficulty and expertise–experts (top panel) and tournament players (bottom panel). Move strength improved in all situations with deliberation. Error bars represents 95% confidence intervals.

the easy positions and then build on that representation through a deliberative process and generate their chosen move (see de Groot's (1978) protocols for similar processes). This is similar to how an educated adult generates a deep understanding of an unfamiliar text or a medical doctor interprets information about a patient by sequentially considering a list of symptoms by integrating new information with prior knowledge to form an appropriate mental representation of the situation (Ericsson & Kintsch, 1995). The dual processes in chess may be mutually beneficial. For instance it has been suggested that fast processes continually operate throughout forward search, where patterns discovered during the search guides the continued direction of the search (Gobet & Simon, 1998). This view is also consistent with the hypothesis that intuition is based on knowledge accumulated through training and honed by deliberation (Betsch & Glöckner, 2010).

This study has shown that experts use System 2 as well as System 1 to make better decisions for tasks that reflect their superior level of achievement. These findings are consistent with the poor accuracy of experts in domains without immediate objective feedback cited in the introduction as well as recent findings of less biased decision making by experienced professionals in environments with readily available objective feedback (List, 2003). Our methods applied to the study of chess can be generalized to improve understanding of clinical, medical, and other important decisions (Ericsson, 2007). We think the time has come to study systematically superior decision making in domains with objective criteria so that we can help professionals to develop their decision making performance in designed learning environments to reach their full potential for making decisions that will benefit their job, organization, and society.

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