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Author: Dr. Fernand Gobet
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Historically, chess has been one of the leading fields in the study of EXPERTISE (see De Groot & Gobet, 1996, and Holding, 1985, for reviews). This popularity as a research domain is explained by the advantages that chess offers for studying cognitive processes: i) well-defined character of the task; ii) presence of a quantitative scale to rank chess players; iii) cross-fertilization with research on game-playing in computer science and artificial intelligence.

Many of the key concepts and mechanisms to be later developed in cognitive psychology were anticipated by Adriaan De Groot's (1946/1978) book Thought and Choice in Chess. De Groot stressed the role of selective search, perception, and knowledge in expert chess playing. He also perfected two techniques that were to be often used in later research: recall of briefly-presented material from the domain of expertise, and use of thinking-aloud protocols to study problem solving behavior. His key empirical findings were that i) world-class chess grandmasters do not search more, in number of positions considered and in depth of search, than weaker (but still expert) players; and ii) grandmasters and masters can recall positions presented for a few seconds almost perfectly, while weaker players are overwhelmed by the task.

De Groot's theoretical ideas, based on Otto Selz's psychology, were not as influential as his empirical techniques and results. It was only about 25 years later that chess research would produce a theory with a strong impact on the study of expertise and of cognitive psychology in general. In their chunking theory, Simon and Chase (1973) stressed the role of perception in skilled behavior, as did De Groot, but added a set of elegant mechanisms. Their key idea was that expertise in chess is made possible by the acquisition of a large collection of relatively small chunks (including at most 6 pieces) denoting typical patterns of pieces on the chess board. These chunks are accessed through a discrimination net and act as the conditions of a PRODUCTION SYSTEM: they evoke possible moves to be made in this situation. In other respects, chess experts do not differ from other players: they have the same limits in memory (a short-term memory of about 7 chunks) and learning rate (about 8 seconds are required to learn a chunk). In chess, as well as in other domains, the chunking theory explains experts' remarkable memory by their ability to find more and larger chunks in a position, and explains their selective search by the fact that chunks evoke potentially good moves. Some aspects of the theory were implemented in a computer program by Simon and Gilmartin (1973). Simulations with this program gave a good fit to the behavior of a good amateur, and led to the estimation that expertise require the presence of a large number of chunks, approximately between 10,000 and 100,000.

A wealth of empirical data were gathered to test the chunking theory, in various domains of expertise. In chess, five directions of research may be singled out as critical: importance of perception and pattern recognition, relative role of short-term and long-term memories, evidence for chunks, role of higher-level knowledge, and size of search.

Converging evidence supports the hypothesis that perceptual, pattern-based cognition is critical in chess expertise. The most compelling data are that eye movements during the first seconds of the presentation of a chess position differ between experts and non-masters (De Groot & Gobet, 1996) and that masters still play at a high level in speed chess games, where they have only five seconds per move on average, or in simultaneous games, where their thinking time is reduced by the presence of several opponents (Gobet & Simon, 1996).

Research on memory has led to apparently contradictory conclusions. On the one hand, starting with Charness (1976), several experiments have shown that the chunking theory's emphasis on the storage of chunks in short-term memory runs into problems, including incorrect predictions on the effect of interfering tasks. This encouraged researchers such as Cooke et al. (1993) to emphasize the role of higher-level knowledge, already anticipated by De Groot (1946/1978). On the other hand, empirical evidence for chunks has also been mounting (e. g., Chi, 1978; Gobet & Simon, 1996; Saariluoma, 1994). Attempts to reconcile low-level and high-level types of encoding have recently been provided by the long-term working memory theory (Ericsson & Kintsch, 1995) and by the template theory (Gobet & Simon, 1996). The former proposes that experts build up both schema-based knowledge and domain-specific retrieval structures that allow them to encode the important elements of a problem rapidly. The latter, based on the chunking theory and implemented as a computer program, proposes that chunks evolve into more complex data structures (templates), which allow some values to be encoded rapidly. Both theories also account for aspects of skilled perception and problem solving in chess.

With respect to search, recent results indicate that stronger players search somewhat more and deeper than weaker players (Charness, 1981; Holding, 1985), although there seems to be an asymptote at high skill levels. In addition, the space searched remains small (thinking-aloud protocols indicate that grandmasters typically search no more than one hundred nodes in 15 minutes). Note that these results are compatible with a theory based on pattern-recognition: chunks, which evoke moves or sequences of moves, both make search selective and allow better players to use chunk-based automatisms to search more and deeper.

While productive on its own, research in computer science and artificial intelligence (SEE GAME-PLAYING) has had relatively little impact on the psychology of chess. The main advances have been made with the development of search techniques, which have culminated in the construction of DEEP BLUE, the first computer to have beaten a world champion in a match. More recently, chess has been a popular domain for testing machine-learning techniques. Finally, some attempts to use a production-system architecture (e.g., Wilkins, 1980) have met with limited success in terms of the strength of the programs.

The key findings in chess research—selective search, pattern recognition, and memory for the domain material—have been shown to generalize to other domains of expertise. This augurs well for current interests in the field: integration of low- and high-level aspects of knowledge and unification of chess perception, memory, and problem solving theories into a single theoretical framework.

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