CHAPTER-II

REVIEW OF RELATED LITERATURE

An essential aspect of a research is the review of the related literature. “The key to the vast store house of published literature may open the doors to sources of significant problems and explanatory hypothesis, and provide helpful orientation for definition of the problem, background for selection of procedure, and comparative data for interpretation of results. In order to be truly creative and original, one must read extensively and critically as stimulus thinking”.

For any specific research project to occupy a place in the development of a discipline, the researcher must be thoroughly familiar with both previous theory and research. The literature related to any problem helps the scholar to discover what is already known, which would enable the investigator to have a deep insight, clear perspective and a better understanding of the chosen problem and various factors connected with the study. So a number of books, journals, and websites were referred. In the following pages, an attempt has been made to present briefly a few of the important researches and studies conducted abroad
and in India, as they have significant bearing on the present study.

The literature in any field forms the foundation upon which all future work will be built. If it is failed to build upon the foundation of knowledge provided by the review of literature, the researcher might miss some work already done on the same topic. The investigator after going through all the available literature presented the following studies conducted on Chess and Psychological variables.

**Howard** (2009) studied on how learners acquire expertise at different rates and reach different peak performance levels. International chess is a good test domain for both issues, because it has objective performance measures, actual practice measures (number of games), longitudinal population data, and minimal gatekeeper influence. Players' expertise development typically follows either a logarithmic or a power-function curve, approaching asymptote by around 750 games. A comparison of eventual top players and other eventually well-practiced players typically reveals a performance difference at domain entry, which widens progressively with practice and then stays large and constant. The data show various correlated signs of apparent
greater natural talent in eventual top players: precocity (indexed by entering the domain and gaining the grandmaster title much younger on average), faster acquisition of expertise (indexed by fewer years and games needed to gain the grandmaster title from domain entry), and a higher peak performance level after extensive actual practice. A factor analysis found evidence for an underlying natural talent factor that constrains ultimate performance level.

Nippold (2009) in this study examined language productivity and syntactic complexity in school-age children in relation to their knowledge of the topic of discussion, the game of chess. Children (mean age=10;11) (n=32) who played chess volunteered to be interviewed by an adult examiner who had little or no experience playing chess. Children's chess knowledge and experience was assessed, and each child was classified as a novice or an expert player. Each child participated in three speaking tasks: a General conversation, Chess conversation and Chess explanation. Interviews were audio-recorded, transcribed into SALT, segmented into T-units, and coded for finite clauses. Each speaking task was analyzed for Total T-units; Mean Length of T-unit; Clausal Density; and Nominal, Relative and Adverbial
Clause Use. Total T-units, Mean Length of T-unit, Clausal Density, and the use of each type of subordinate clause was substantially higher in the Chess explanation task compared to the Chess conversation or the General conversation tasks. Compared to the novices, the experts knew more about chess, had played longer, and were stronger players. Nevertheless, the novices and experts did not differ on any of the language factors for any of the speaking tasks. Language productivity and syntactic complexity in school-age children are strongly influenced by the speaking task. When children are presented with a motivating and challenging topic, they rise to the occasion to explain the finer details of it to a naïve adult.

Troubat et al., (2009) studied the physiological consequences of the tension caused by playing chess in 20 male chess players, by following heart rate, heart rate variability, and respiratory variables. The investigators observed significant increase in the heart rate (75-86 beats/min), in the ratio low frequency (LF)/high frequency (HF) of heart rate variability (1.3-3.0) and also a decrease in mean heart rate variability with no changes in HF throughout the game. These results suggested a stimulation of the sympathetic nervous system with no
changes in the parasympathetic system. The respiratory exchange ratio was rather elevated (over 0.89) at the start and significantly decreased during the game (0.75 at the end), indicating that energy expenditure progressively switched from carbohydrate to lipid oxidation. The changes in substrate oxidation and the sympathetic system seem to be due to high cognitive demands and bring new insight into adaptations to mental strain.

**Brockmole et al.,** (2008) investigated whether any differences in learning can be at least partially explained by the degree of semantic meaning associated with a context independently of the nature of the visual information available (which also varies across stimulus types). In contextual cueing, the position of a search target is learned over repeated exposures to a visual display. The strength of this effect varies across stimulus types. For example, real-world scene contexts give rise to larger search benefits than contexts composed of letters or shapes. Chess boards served as the learning context as their meaningfulness depends on the observer's knowledge of the game. In Experiment 1, boards depicted actual game play, and search benefits for repeated boards were four times greater for
experts than for novices. In Experiment 2, search benefits among experts were halved when less meaningful randomly generated boards were used. Thus, stimulus meaningfulness independently contributes to learning context-target associations.

Waters and Gobet (2008) investigated experts' imagery in chess, players were required to recall briefly presented positions in which pieces were placed on the intersections between squares (intersection positions). Position types ranged from game positions to positions in which both the piece distribution and the location were randomized. Simulations were run with the CHREST model (Gobet & Simon, 2000). The simulations assumed that pieces had to be centered back, one by one, to the middle of the squares in the mind's eye before chunks could be recognized. Consistent with CHREST's predictions, chess players (N=36), ranging from weak amateurs to grandmasters, exhibited much poorer recall for intersection positions than for standard positions (pieces placed on the centers of the squares). For the intersection positions, the skill difference in recall was larger for game positions than for the randomized positions. The participants recalled bishops better than they recalled knights, suggesting that Stroop-like
interference impairs recall of the latter. The data supported both the time parameter in CHREST for shifting pieces in the mind’s eye (125 m/sec per piece) and the seriality assumption. In general, the study reinforced the plausibility of CHREST as a model of cognition.

Hasegawa et al., (2008) Using a representative table game popular in Japan known as shogi, or Japanese chess, investigated the effects of winning and losing on saliva composition. The subjects were 90 healthy male university students who were members of a shogi club. Saliva samples were collected immediately before and after playing shogi, and again 30 min later. Salivary cortisol and testosterone levels in the samples were determined by ELISA and EIA, respectively. After finishing each game, the competitiveness of the game was evaluated using questionnaires. In the samples taken after playing shogi, there was an increase in the levels of salivary testosterone and cortisol, regardless of whether the subject won or lost, and the tendency was more pronounced in competitive games. There were no such changes in the control group, who did not play a game prior to providing the samples. The results suggested that stress response is intimately linked with
competition and could be used to determine which players are more capable of handing stress in a competitive environment.

**Bilalic et al.,** (2008) studied the Einstellung (set) effect that occurs when the first idea that comes to mind, triggered by familiar features of a problem, prevents a better solution being found. It has been shown to affect both people facing novel problems and experts within their field of expertise. The investigators showed that it works by influencing mechanisms that determine what information is attended to. Having found one solution, expert chess players reported that they were looking for a better one. But their eye movements showed that they continued to look at features of the problem related to the solution they had already thought of. The mechanism which allows the first schema activated by familiar aspects of a problem to control the subsequent direction of attention may contribute to a wide range of biases both in everyday and expert thought – from confirmation bias in hypothesis testing to the tendency of scientists to ignore results that do not fit their favoured theories.

**Gobet** and **Campitelli** (2007) investigated markers of talent, environment, and critical period for the acquisition of expert performance in chess. Argentinian chess players (N= 104),
ranging from weak amateurs to grandmasters, completed a questionnaire measuring variables including individual and group practice, starting age, and handedness. The study reaffirmed the importance of practice for reaching high levels of performance, but it also indicated a large variability: The slower player needed 8 times as much practice to reach master level than the faster player. Additional results showed a correlation between skill and starting age and indicated that players are more likely to be mixed-handed than individuals in the general population; however, there was no correlation between handedness and skill within the sample of chess players. Together, these results suggested that practice is a necessary but not sufficient condition for the acquisition of expertise, that some additional factors may differentiate chess players and non-chess players, and that starting age of practice is important.

Harreveld et al., (2007) studied 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 the investigators examined the performance of players of various strengths at an online chess server, for games played under
different time controls. In a second study they examined the effect of time controls on performance in world championship matches. Both studies consistently showed that skill differences between players become less predictive of the game outcome as the time controls were tightened. This result indicated that slow processes were at least as important for strong players as they are for weak players. The findings posed a challenge for current theorizing in the field of expertise and chess.

**McLeod** (2007) tested the two possibilities in a series of experiments using the Einstellung (set) effect paradigm. Chess players tried to solve problems that had both a familiar but non-optimal solution and a better but less familiar one. The more familiar solution induced the Einstellung (set) effect even in experts, preventing them from finding the optimal solution. The presence of the non-optimal solution reduced experts’ problem solving ability was reduced to about that of players three standard deviations lower in skill level by the presence of the non-optimal solution. Inflexibility of thought induced by prior knowledge (i.e., the blocking effect of the familiar solution) was shown by experts but the more expert they were, the less prone they were to the effect. Inflexibility of experts is both reality and
myth. But the greater the level of expertise, the more of a myth it becomes.

Hernandez (2006) in his research revealed the impact of cognitive-affective strategies (Molds of the Mind) on subjective well-being, interpersonal relationships, or school achievement. However, it seems odd that such strategies could influence the success of chess players, because this game is usually considered to be influenced mainly by technical and cognitive skills. To examine the influence of cognitive-affective molds, 53 chess players, ages from 9 to 16 years old, enrolled in sport competitions, were assigned to two groups, high and low success. They responded to the MOLDES, designed to evaluate individuals' molds. The results showed that the "Mental Molds" of the most successful players are more realistic, positive and regulators of the emotions, while the molds of the less successful players are more evasive, magical, defensive and inoperative.

Jastrzembski et al., (2006) studied on Novice, intermediate, and expert chess players of various ages, playing with two chess pieces on a quarter-section of a chessboard, who performed a simple task to detect that the king is in check or is threatened with being in check. Age slowed response for both
tasks. An interaction of task and skill revealed differences in diminishing response time between check and threat tasks as skill increased; experts were equally fast on both tasks. Measures of speed and working memory were negatively related to age but unrelated to skill. Skill did not mitigate age-related effects on speed of detection. These results suggested that knowledge-activation processes necessary to assess basic chess relationships slow with age, even in experts.

Bilalic et al., (2006) in this study presented the personality profiles as measured with the Big Five model (BFQ-C; Barbaranelli, Caprara, Rabasca, & Pastorelli, 2003) of 219 young children who play chess and 50 of their peers who do not. Children who score higher on Intellect/openness and Energy/extraversion are more likely to play chess while children who score higher on Agreeableness are less likely to be attracted to chess. Boys with higher scores on Agreeableness are less likely to take up chess than boys with lower scores. Considering that girls score higher on Agreeableness, this factor may provide one of the possible reasons why more boys are interested in chess. Although none of the Big Five factors were associated with self-reported skill level, a sub-sample of 25 elite players had
significantly higher scores on Intellect/openness than their weaker chess playing peers.

Campitelli et al., (2005) in this study compared a grandmaster and an international chess master with a group of novices in a memory task with chess and non-chess stimuli, varying the structure and familiarity of the stimuli, while functional magnetic resonance images were acquired. The pattern of brain activity in the masters was different from that of the novices. Masters showed no differences in brain activity when different degrees of structure and familiarity where compared; however, novices did show differences in brain activity in such contrasts. The most important differences were found in the contrast of stimulus familiarity with chess positions. In this contrast, there was an extended brain activity in bilateral frontal areas such as the anterior cingulate and the superior, middle, and inferior frontal gyri; furthermore, posterior areas, such as posterior cingulate and cerebellum, showed great bilateral activation. These results strengthened the hypothesis that when performing a domain-specific task, experts activate different brain systems from that of novices. The use of the experts-versus-novices paradigm in brain imaging contributes
towards the search for brain systems involved in cognitive processes.

Gobet and Clarkson (2004) in this study aimed at testing the divergent predictions of the chunking theory (Chase & Simon, 1973) and template theory (Gobet & Simon, 1996a, 2000) with respect to the number of chunks held in visual short-term memory and the size of chunks used by experts. The investigators presented game and random chessboards in both a copy and a recall task. In a within-subject design, the stimuli were displayed using two presentation media: (a) physical board and pieces, as in Chase and Simon's (1973) study; and (b) a computer display, as in Gobet and Simon's (1998) study. Results showed that in most cases, no more than three chunks were replaced in the recall task, as predicted by template theory. In addition, with game positions in the computer condition, chess Masters replaced very large chunks (up to 15 pieces), again in line with template theory. Overall, the results suggested that the original chunking theory overestimated short-term memory capacity and underestimated the size of chunks used, in particular with Masters. They also suggest that Cowan's (2001) proposal that STM holds four chunks may be an overestimate.
Burns (2004) studied two types of mechanisms that may underlie chess skill: fast mechanisms, such as recognition, and slow mechanisms, such as search through the space of possible moves and responses. Speed distinguishes these mechanisms, so the investigator examined archival data on blitz chess (5 min for the whole game), in which the opportunities for search are greatly reduced. If variation in fast processes accounts for substantial variation in chess skill, performance in blitz chess should correlate highly with a player's overall skill. In addition, restricting search processes should tend to equalize skill difference between players, but this effect should decrease as overall skill level increases. Analyses of three samples of blitz chess tournaments supported both hypotheses. Search is undoubtedly important, but up to 81% of variance in chess skill (measured by rating) was accounted for by how players performed with less than 5% of the normal time available.

Eisele (2004) in the present study examined how experts differ from non-experts in estimation and evaluation during a judgment-and-decision task. In the experiment, the performance of 125 chess players (21 women and 104 men) whose mean age was 32.5 yr. (SD=13.3) was examined to assess
decision processes with an emphasis on post decision differentiation and consolidation. Chess players of differing skill made evaluations of a complex middle-game chess position. The experimental condition was made by the means of chess articles with enclosed information, either about the current chess position or about other similar positions. Both novices and experts upgraded their chosen alternative in a post decision phase more than intermediate level chess players did. Various explanations of these results are discussed.

Atherton et al., (2003) analysed that the Chess is a game that involves many aspects of high level cognition and requires sophisticated problem solving skills. However, there is little understanding of the neural basis of chess cognition. This study employed functional magnetic resonance imaging (fMRI) to identify cortical areas that are active during the analysis of chess positions compared with a spatial task with matched visual stimuli. Bilateral activation was revealed in the superior frontal lobes, the parietal lobes, and occipital lobes. Some small areas of activation were observed unilaterally in the left hemisphere. The left hemisphere showed more activation than the right. Results are discussed in relation to a similar brain imaging study on the game Go.
McGregor and Howes (2002) attempted to verify that chess skill is based on chunks in memory that represent parts of positions from previously encountered games. However, the content of these chunks is a matter for debate. According to one view, (1) the closer two pieces are to each other on a board (proximity), the more likely they are to be in the same chunk, and (2) skilled players encode the precise locations of pieces. An alternative view is that what information is encoded in a chess chunk is determined more by processing of the attack/defense relations during evaluation. In three experiments, participants evaluated positions and completed recognition tests. Experiment 1 supported the view that expert players make more use of attack/defense relations than of locations of pieces in a recognition test. Experiments 2 and 3 demonstrated that, for both long and short presentation times, expert players’ recognition for a piece within a position was primed more by a piece related by attack or defense than by a piece merely proximal. These findings challenged theories of expertise for chess that assume a primary role for proximity and location in determining which pieces are grouped together in memory.
Reingold et al., (2001) employed a check detection task in a 5x5 section of the chessboard, containing a King and one or two potential checking pieces. The checking status (i.e., the presence or absence of a check) and the number of attackers (one or two) were manipulated. It was found that the reaction time cost for adding a distracter was differentially greater in no trials than yes trials for novice, but not for expert, chess players. In addition, the investigators contrasted standard check detection trials with trials in which one of two attackers was cued (colored red) and the task was to determine the checking status of the cued attacker while ignoring the other attacker. The investigators documented a Stroop-like interference effect on trials in which a cued non-checking attacker appeared together with an attacker that was checking (i.e., incongruent). These findings suggested automatic and parallel encoding procedures for chess relations in experts.

Schultetus and Charness (1999) tested 17 chess players on both quasi-random and structured chess positions. Consistent with the earlier study, initial recall of quasi-random chess positions is unrelated to chess skill level, and quality of the move selected in subsequent problem solving is related to
skill level. However, recall following problem solving is related to chess skill level. These results supported the view that pattern recognition processes underlie superior performance by skilled chess players, contrary to the conclusions of Holding and Reynolds (1982). Mechanisms such as long-term working memory retrieval structures (Ericsson & Kintsch, 1995) or templates (Gobet & Simon, 1996a) could explain the effective encoding of quasi-random positions during problem solving.

Saariluoma and Hohlfeld (1994) attempted to evaluate that the Chess players’ long-range planning or chess-strategic thinking is based on more or less poorly definable and intuitive notions such as weak-square, initiative, space advantage, etc. Since these concepts are fuzzy and thus close to everyday concepts, chess players’ long-range planning provides a good environment to study apperception with poorly definable notions. The three experiments provided data indicating that problem subspace abstraction has both benefits and costs. Active representation blockades alternative representations unless subjects restructure. As a result, chess players often make serious cognitive errors by abstracting the wrong problem subspaces. Even in strategic positions, the problem subspaces
generated are self-consistent and bound by unconscious content-specific principles.

Nicolas (1994) in this article reviewed in a diachronic perspective Binet’s major contributions on memory: mnemonic virtuosity, visual and auditory memories, and influences of suggestibility on memory. If Alfred Binet (1857-1911) is famous as the author of the IQ test that bears his name, he is almost unknown, however, as the psychological investigator who generated original experiments and fascinating results in the field of memory. As Hermann Ebbinghaus, Binet was a pioneer in this domain of research. The first contribution to the understanding of memory came from Binet’s study of the role of this faculty in expert mental calculators (Inaudi and Diamandi) and in expert blindfold chess players. The second original contribution was his examination of children’s visual memory for lines and auditory memory for words and prose (memory for ideas). The third original contribution was the pioneering work of Alfred Binet on eyewitness testimony. Although all these contributions are not often cited today in the psychological literature, the researchers showed that Binet’s conclusions made
nearly 100 years ago are mirrored in modern conceptualizations of memory and are still informative today.

**Saariluoma** (1994) attempted to study the chunks and role in memorizing the positions in chess game. Whether the chunks used in memorizing chess positions are general and relatively encoded schemata or very precisely coded instances is a problem that has raised some controversy within the psychology of chess skill. As chess research has had a strong impact on expertise research, this problem is important in many areas of skills research other than chess. To resolve it, four experiments were set up. In the experiments it was shown that subjects were better at recalling correctly located non-transposed chunks than transposed chunks, which were similar in structure but incorrectly located on the chessboard. The results implied that the representation of chess-specific patterns in the memory of a chess player contains not only information about the forms of chess-specific patterns, but also about their absolute locations on the chessboard. This provided an explanation for the well-known interaction between skill and type of position and its disappearance in recent experiments by Lories and Saariluoma. It can be argued that the difficulty of
recalling random positions is not chiefly caused by the total absence of chunks but by their dislocation.

**Ericsson** and **Charness** (1994) analysed the expert performance - its structure and acquisition in expert performers. Counter to the common belief that expert performance reflects innate abilities and capacities, recent research in different domains of expertise has shown that expert performance is predominantly mediated by acquired complex skills and physiological adaptations. For elite performers, supervised practice starts at very young ages and is maintained at high daily levels for more than a decade. The effects of extended deliberate practice are more far-reaching than is commonly believed. Performers can acquire skills that circumvent basic limits on working memory capacity and sequential processing. Deliberate practice can also lead to anatomical changes resulting from adaptations to intense physical activity. The study of expert performance has important implications for our understanding of the structure and limits of human adaptation and optimal learning.

**Abernethy et al.**, (1994) evaluated the visual perceptual and cognitive differences between expert, intermediate, and
novice snooker players. The performance of seven expert, seven intermediate, and 15 novice snooker players were compared on a range of general visual tests and sport-specific perceptual and cognitive tests in an attempt to determine the locus of the expert advantage. No significant expert-novice differences were apparent on standard optometric tests of acuity, ocular muscle balance, colour vision, and depth perception, nor on the relative frequency of unilateral and cross-lateral eye-hand dominances. Experts, however, were found to be superior in their ability to both recall and recognize rapidly-presented slides depicting normal game situations, but were no better than novices in recalling information from slides in which the balls were arranged randomly on the table. The expert group’s superiority on the perceptual recall and recognition tasks was consistent with a deeper level of encoding for structured (meaningful) material. Experts were also shown, through the use of thinking-aloud and evaluation paradigms, to use a greater depth of forward planning in choosing appropriate shot options and to evaluate existing situations with greater accuracy, discriminability and prospective planning than did novices. The cognitive advantage is shown to be a potential contributor but not a total explanation of the superior performance of the experts
on the perceptual tasks. The findings of this study are consistent with existing works on expertise in board games and ‘open’ skill sports in indicating that the expert’s advantage is not a general but a specific one, arising not from physical capacities but from acquired processing strategies.

**Gruber et al.,** (1994) addressed two main research questions: (1) what are the differences between experts within the domain of chess and dropouts of expert careers? (2) How do chess-specific and general memory skills change within several years? At two measurements times, 27 experts and novices were studied. The subjects’ average age was 12 and 16 years, respectively. The dropouts proved to have worse memory performance on chess-specific tasks than experts, even at the time of first measurement. Thus, the assumption of selective dropouts was confirmed which questions the validity of cross-sectional expert-novice comparisons. Both experts and novices improved their chess-specific memory performance between the first and second measurement times. For experts domain-specific factors seem to account for this result, for novices this effect is due to general developmental factors.
Cooke et al., (1993) investigated the role of high-level information in skilled chess memory in three experiments. In the first two experiments, experienced chess players were presented with a high-level verbal description of the position either before or after its presentation. If this type of knowledge facilitates the perception and subsequent recall of chess positions, then recall performance should be better in the description-before condition in which the information is available at the time of perception. In these two experiments, subjects performed better when given the description prior to viewing the position, supporting the proposal that a level of knowledge, beyond that of a set of chunks, is used to perceive a chess position. In the third experiment, subjects reconstructed multiple positions (between 1 and 9) immediately after seeing the entire set. Results indicated that experienced players could reconstruct multiple positions at a level beyond chance or guessing. Again, these results can be better explained in terms of high-level conceptual knowledge associated with each position than in terms of perceptual chunks.

Walczak and Dankel (1993) evaluated the generalized method for chunking of game pieces to acquire the tactical and strategic knowledge. The physical configuration of playing pieces
on a game board contains a plethora of information which can be used by the game player. Current computer game programs deal well with some positional and tactical information that is built into the program, but are incapable of acquiring and using strategic information. They presented a technique for capturing strategic and tactical chunks or patterns of pieces in game domains. The chunking technique mode is the cognitive method employed by expert level human game players and acquires knowledge that is mostly domain independent. Induction is performed on the collection of chunks captured for a particular adversary to identify the playing style of that adversary.

Vicente and Brewer (1993) investigated the role of reconstructive memory in citation errors that occur in the scientific literature. The researchers focused on the case of de Groot’s (1946) studies of the memory for chess positions by chess experts. Previous work has shown that this research is very often cited incorrectly. In Experiment 1 they showed that free recall of this work by research psychologists replicates most of the errors found in the published literature. Experiment 2 shows that undergraduates reading a correct account of the de Groot study also make the same set of errors in recall. They
interpreted these findings as showing that consistent errors in secondary accounts of experimental findings are frequently reconstructive memory errors due to source confusion and schema-based processes. Analyses of a number of other examples of scientific literature that have been frequently cited incorrectly add additional support to the reconstructive account. They concluded that scientists should be aware of the tendency of reconstructive memory errors to cause violations of the scientific norm of accurate reporting of the scientific literature.

**Reynolds** (1992) attempted to recognize the expertise in chess players in this study. Fifteen chess players with U.S. Chess Federation (USCF) ratings from 1300 to 2210 judged six unfamiliar chess positions taken from games between players with USCF ratings from 1400 to 2600. The moves immediately preceding the starting position were successively revealed, with rating and confidence estimations made at each move. Estimation error decreased as a function of number of moves revealed (p<.001). Higher rated players consistently made lower estimation errors (p<.01). Judges at all personal levels were more accurate about positions arising between players close in rating to themselves. A self-reference heuristic is proposed in which
estimation of expertise is made relative to the judge’s own projected performance.

**Frydman** and **Lynn** (1992) evaluated the general intelligence and spatial abilities of gifted young Belgian chess players. Thirty-three tournament-level young Belgian chess players aged 8 to 13 were tested with the French WISC (Wechsler Intelligence Scale for Children). The mean full scale IQ=121, verbal IQ=109 and performance IQ=129. The results suggested that a high level of general intelligence and of spatial ability are necessary to achieve a high standard of play in chess. The high spatial ability of these young chess players suggested by the high performance IQs may go some way towards explaining why males tend to be more numerous than females among high-standard chess players.

**Horgan** (1992) attempted to measure the chess expertise among the children for which three studies of calibration are reported. Calibration refers to the accuracy with which one can predict one’s own performance. In the first study child chess players, non-chess playing parents, and statistics students were asked to predict chances of winning chess games against hypothetical opponents. These subjective probabilities
were compared to the actual probabilities, based on the Elo rating system. Better players’ predictions were better calibrated. Confidence and ratings are negatively correlated, indicating that with lower ratings, players are overconfident. Skilled child players’ predictions were better calibrated than any of the adults’. In the second study subjects were asked to estimate chances of winning in conjunctive situations, e.g., winning all the rounds in a tournament. Again, better child players were more accurate in their predictions and more accurate than adults. In the third study, child players were asked to predict their chances of winning in a non-chess domain after hearing a hypothetical win/loss history. Higher-rated players’ predictions were again better calibrated, even though the domain was outside their expertise. The motivational and cognitive implications of calibration are discussed.

Gobet (1992) learned helplessness in chess players - the importance of task similarity and the role of skill. The effects of non-contingency between subjects’ responses and outcomes were examined with respect to treatment-and-posttest similarity and skill in the task. The experimental design consisted of three groups. The first group had to solve chess problems with
objective solutions and received veridical feedback; each member of the second group faced problems with no objective solutions, and received the same feedback as the member of the first group he was yoked with, but without any control on it; the control group received a waiting task. It was round at the end of the experiment that the group with unsolvable problems was more depressed than the two other groups. The mid-strength players were the most sensitive to the manipulation, and the weakest players showed little effect of learned helplessness. It was also found that the effects were proportional to the degree of similarity between the treatment and the posttest. The results limit the domain of applicability of the learned-helplessness model.

Freyhof et al., (1992) examined the expertise and hierarchical knowledge representation in chess. In two experiments the structure of knowledge representation in chess experts and average players was examined. Pattern-recognition theory explains expertise through the existence of many small, unrelated knowledge units. Recent research stresses the structure of knowledge representations. However, the standard paradigm does not allow for the detection of relations between
chunks; the theoretical shift has to be accompanied by a methodological shift. In Experiment 1, by means of a partitioning task, evidence was provided for a hierarchical representation of chess positions. Chess masters formed larger and more complex knowledge units than average players. In Experiment 2, the typicality of the positions was varied. The more typical the positions were the larger and more coherent the constructed knowledge units were. The greatest differences between both groups occurred in more typical positions. This reflects the experts’ ability to relate several knowledge units with one another.

Saariluoma (1992) evaluated error in chess - the apperception-restructuring view with the five protocol-analysis experiments with tactical, endgame, and strategic positions. The experiments were conducted to study cognitive errors in chess players’ thinking. It will be argued that chess players’ errors can be only partially explained in terms of unspecified working-memory overload, because the working-memory loads caused by the solution paths are usually small. It is therefore necessary to consider apperceptive mechanisms also, as these control information intake. Subjects fail either because they are not able
to see the right prototypical problem space at all, or because they fail to close them as a result of missing some crucial task-relevant cue. This makes chess players lose their “belief in the idea” and restructure, after which the apperceptive information-selection mechanisms make the finding of the solution still more unlikely.

Holding (1992) reviewed the evidence for and against the recognition-association theory and a forward-search (SEEK) theory of chess skill. The recognition-association theory appears to be founded on indirect evidence concerning visual short-term memory, together with supplementary assumptions that may be questioned, and provides no role for verbal processes. There is no direct support for the theory, which omits forward search for reasons that are reexamined. In contrast, the SEEK theory maintains that move choice is based on search and evaluation processes supplemented (or else supplanted) by a knowledge base. These processes are directly evidenced by experimental findings. The objection that search theories cannot account for speed chess is met by a review of the available evidence. It is concluded that chess skill relies on thinking ahead rather than on pattern recognition.
Bachmann and Oit (1992) attempted to study the stroop-like interference in chess players’ imagery—an unexplored possibility to be revealed by the adapted moving-spot task. A group of highly skilled chess players and two control groups of subjects (non-skilled players and non players) participated in a moving-spot task (cf. Attneave & Curlee, 1983). They had to move either a spot or one of several chess pieces within an imaginary grid according to instructions given by the experimenter (the imaginary motion of the imaginary object consisted of a quasi-random sequence of steps in the direction-up, right, left, or down). The general findings were as follows: (1) chess players’ error rates were lower than those in the non player group; (2) in a moving-spot condition there were no significant differences in the efficiency of skilled vs. non skilled player groups; (3) in a moving chess-piece condition, ranges of spatial errors differed for chess-player and non player groups, depending on the symbolic meaning of the chess pieces in the former group; (4) in a moving chess-piece condition we also found tendencies for Stroop-like interference in the group of skilled players (e.g., bishop moving illegally up, fight, etc.); (5) all groups benefitted from the use of a checkerboard instead of an 8 x 8 grid as the imaginary spatial framework within which to
move a piece; (6) the post hoc analysis showed that the two small selected subgroups of subjects comprising those who used either pure visual strategy or pure chess-annotation strategy were susceptible to some Stroop-like interference and that the set of pieces with the highest incongruity of moves (bishop, knight) yielded higher error rates than the set of pieces that had congruity of moves (king, rook). Taken together, these results seem to indicate that visuospatial tasks like Attneave and Curlee’s (1983) moving-spot task are performed neither on the basis of a static “picture-in-the-head” type of visual image, for which it is just the same whether one or another type of piece is imaginarily moved, nor on the basis of purely symbolic or propositional operations that bear no relation to the visual-configurational and spatial-localizational representations. Imagery seems to constitute a dynamic process of interplay between visuospatial and verbal-propositional codes.

**Charness** (1992) studied the impact of chess research on cognitive science. Although chess research has not been a mainstream activity in cognitive science, it has had a significant impact on this field because of the experimental and theoretical tools it has provided. The two most-cited references in chess
research, de Groot (1965) and Chase and Simon (1973 a), have accumulated over 250 citations each (SSCI and SCI sources summed), with the majority of citations coming a decade or more from their publication dates. Both works are frequently cited in contemporary cognitive-psychology textbooks. Chess playing provides a model task environment for the study of basic cognitive processes, such as perception, memory, and problem solving. It also offers a unique opportunity for the study of individual differences (chess expertise) because of Elo’s (1965, 1978) development of a chess-skill rating scale. Chess has also enjoyed a privileged position in Artificial-Intelligence research as a model domain for exploring search and evaluation processes.

Mazur et al., (1992) studied the impact of Testosterone and chess competition. The hormone testosterone (T) has a central role in recent theories about allocation of status ranks during face-to-face competition. It has been methodologically convenient to test the hypothesized T mechanism in physically taxing athletic contests, where results have been supportive, although their generalizability to normal social competition is questionable. Competition among chess players is a step closer to normal social competition because it does not require physical
struggle, and it is the arena for tests of the T mechanism which are reported here. The investigators found that winners of chess tournaments show higher T levels than do losers. Also, in certain circumstances, competitors show rises in T before their games, as if in preparation for the contests. These results generally supported recent theories about the role of T in the allocation of status ranks.

**Garland** and **Barry** (1992) examined the effects of interpolated processing on experts recall of schematic information. The present study, using schematic sport diagrams, examined the perceptual chunking hypothesis (Chase & Simon, 1973a; 1973b) that visual patterns are represented by labels in a limited-capacity, short-term memory. This study, which employed three subject-skill levels and an interpolated processing paradigm, indicated that for experts, information extracted during an 8-second study period has great longevity and durability. Interpolated processing demands, along with an additional encoding activity of a second diagram presentation, had minimal effects on recall performance. This evidence supported the position that meaningful and familiar information abstracted during a brief exposure period is immediately
processed in long-term memory, thus facilitating subsequent retrieval.

**Chabris** and **Lton** (1992) evaluated the impact of hemispheric-specialization for skilled perceptual organization by chess masters. The right cerebral hemisphere may be relatively specialized for parsing simple visual stimuli according to default rules, such as the Gestalt laws of perceptual organization, whereas the left cerebral hemisphere may be relatively specialized for overriding such default rules. The researchers extended this model to ‘semantically rich domains’ by performing a divided-visual-field experiment on 16 chess masters. Such subjects are able to recall and recognize complex chess positions by chunking the basic elements of the stimuli—the chess pieces—into meaningful groupings according to certain rules that are specific to the semantic structure of the chess domain. They showed that the right hemisphere is superior to the left at parsing according to the default rules of chess chunking, but that the left hemisphere is superior to the right at grouping pieces together in violation of those rules. These results suggested that the right hemisphere is better able to acquire and apply new sets of default parsing rules for specific contexts. It is
concluded, consistent with other neuropsychological evidence, that the right hemisphere is critical for chess skill.

Frydman and Lynn (1992) tested thirty-three tournament-level young Belgian chess players aged 8 to 13 with the French WISC (Wechsler Intelligence Scale for Children). The mean full scale IQ=121, verbal IQ=109 and performance IQ=129. The results suggested that a high level of general intelligence and of spatial ability are necessary to achieve a high standard of play in chess. The high spatial ability of these young chess players suggested by the high performance IQs may go some way towards explaining why males tend to be more numerous than females among high-standard chess players.

Horgan (1992) conducted three studies of calibration which refers to the accuracy with which one can predict one’s own performance. In the first study child chess players, non-chess playing parents, and statistics students were asked to predict chances of winning chess games against hypothetical opponents. These subjective probabilities were compared to the actual probabilities, based on the Elo rating system. Better players’ predictions were better calibrated. Confidence and ratings are negatively correlated, indicating that with lower
ratings, players are overconfident. Skilled child players' predictions were better calibrated than any of the adults'. In the second study subjects were asked to estimate chances of winning in conjunctive situations, e.g., winning all the rounds in a tournament. Again, better child players were more accurate in their predictions and more accurate than adults. In the third study, child players were asked to predict their chances of winning in a non-chess domain after hearing a hypothetical win/loss history. Higher-rated players' predictions were again better calibrated, even though the domain was outside their expertise. The motivational and cognitive implications of calibration are discussed.

Saariluoma (1992) conducted five protocol-analysis experiments with tactical, endgame, and strategic positions to study cognitive errors in chess players' thinking. It will be argued that chess players' errors can be only partially explained in terms of unspecified working-memory overload, because the working-memory loads caused by the solution paths are usually small. It is therefore necessary to consider apperceptive mechanisms also, as these control information intake. Subjects fail either because they are not able to see the right prototypical
problem space at all, or because they fail to close them as a result of missing some crucial task-relevant cue. This makes chess players lose their "belief in the idea" and restructure, after which the apperceptive information-selection mechanisms make the finding of the solution still more unlikely.

Reynolds (1982) distinguished Information-processing models of chess-playing ability between players of different calibers solely in terms of perceptual encoding and recognition of chess configurations. A reanalysis of deGroot's verbal protocols of 1965 indicates that players of different calibers direct their attention toward different areas of the board. Grandmasters and masters consider squares that are affected by many pieces, while lesser players direct their attention toward squares on which the pieces are located. In a recall experiment, chess positions were presented that had been randomly generated so as to differ only in the degree to which the pieces converge on the same squares. Masters showed superior recall for briefly presented positions only when the material affects a highly centralized area of the board.

Charness (1981) studied whether there is any difference between the Young (M=20 years) and older (M=54 years) equally
skilled chess players who reconstructed slides of chess diagrams shown for 1, 2, and 4 sec either immediately or following 15 sec of interpolated processing. Recall was more accurate for younger players, with the gap widening as viewing time increased. Interpolated processing decreased accuracy and increased retrieval time equally in the two groups. Measures of chunking indicated no age-related differences. These results implied that there is an age-related deficit in encoding but not retrieval for visual short-term memory. Since young and old were affected equivalently by interpolated processing, it appears likely that they have similar memory consolidation functions. Since the players were equally skilled, the results contradicted the view that skill in chess derives primarily from encoding ability.

Simon (1974) evaluated from a game-theoretic standpoint, in any two-person game of perfect information, each position is won, lost, or drawn, and a move is to be considered an error only when it transfers the game from a more favorable to a less favorable state. A psychological concept of error is quite different, in that it must take into account the fallibility of the players as information processing systems. This paper introduces a psychological concept of error in such games based
on the distinction between "obvious" and "problematic" moves, and proposes a formalism for this concept that appears to capture, at least to a first approximation, the notion of "losing move" as that phrase is actually used by players in games like chess.