

May 19, 2007

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Visuo-spatial abilities of chess players

Andrew J. Waters
Georgetown University

Fernand Gobet & Gerv Leyden
ESRC Centre for Research in Development,
Instruction and Training
School of Psychology
University of Nottingham

Address of correspondence:

Fernand Gobet
ESRC Centre for Research in Development,
Instruction and Training
School of Psychology
University of Nottingham
Nottingham NG7 2RD
United Kingdom

+ 44 (115) 951 5402 (phone)
+ 44 (115) 951 5324 (fax)
frg@psyc.nott.ac.uk

(In Press, British Journal of Psychology)

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Abstract

The extent to which the acquisition of expertise in knowledge-rich domains, such as chess, can be influenced by general individual characteristics, such as intelligence, has remained unclear. Some previous studies with children have documented significant correlations between chess skill and performance on some psychometric tests, such as performance IQ (Frydman & Lynn, 1992). However, we found no evidence for a correlation between chess skill and visual memory ability in a group of adult chess players ($n=36$, age = 28.4). This finding, together with other data in the literature, suggests that there is surprisingly little evidence that chess skill and visuo-spatial ability are associated in adults. Thus, visual memory ability, and perhaps visuo-spatial intelligence, may be relatively unimportant factors in the long-term acquisition of chess skill.

Acknowledgements

This research was supported by a grant from the Economic and Social Research Council of the United Kingdom, awarded to Fernand Gobet. We thank Peter Jansen for tracking down the Elo ratings of Belgian youngsters and Peter Lane for comments.

Visuo-spatial abilities of chess players

The dominant theories of skill acquisition in knowledge-rich domains, such as chess, music or mathematics, assert that large amounts of practice are necessary to acquire the domain-specific knowledge which mediates expert performance (Chase & Simon, 1973; de Groot & Gobet, 1996; Ericsson, Krampe & Tesch-Römer, 1993; Saariluoma, 1995). However, it has remained unclear to what extent general individual characteristics, such as intelligence, may moderate this process. Here we report some new data on this issue by examining whether one component of intelligence – visual memory ability – is related to skill in chess players.

Chess is an ideal task environment to study skill acquisition in knowledge-rich domains, because chess skill is objectively quantifiable (through official rating scales) and because there are much empirical data examining the knowledge structures and problem-solving capacities of expert and novice players (Charness, 1992). It is generally believed that practice leads to the acquisition of chess-specific knowledge which underlies skilled chess play. Chess-specific knowledge is thought to include both memory for a large number of chess-specific structures (e.g. chunks or templates, Chase & Simon, 1973; Gobet & Simon, 1996a) that may index appropriate moves or action plans, and the ability to search through the chess problem-space in an effective manner, which requires knowledge to selectively generate and accurately evaluate chess positions (Chase & Simon, 1973; Gobet & Simon, 1998a).

Intelligence could impact upon skill acquisition in a number of ways. Given the same amount of practice, highly intelligent individuals may be able to acquire the store of chess-specific structures more rapidly than less intelligent individuals. They may also be able to search the problem space more rapidly and accurately. If this were so, we might

expect more intelligent individuals to become better players. However, many expertise researchers have downplayed the potential role of innate intelligence in the acquisition of chess skill (e.g. Ericsson & Charness, 1994), and other intelligence researchers have simply equated “intelligence” with knowledge (Ceci, 1990). At the other extreme, many laypersons and chess players believe that certain innate aptitudes must be important in the acquisition of chess skill, and one intelligence researcher (Howard, 1999) has even argued that the increasing number of young players among the world’s elite provides real world evidence that average human intelligence is rising. The problems with resolving this issue are that there are little data directly assessing the general cognitive abilities of chess players, that the data required to definitively resolve the issue are difficult to obtain, and that intelligence itself is a multi-faceted and controversial psychological construct.

The limited data that exist do suggest that some aspects of intelligence may be associated with chess skill, but it is difficult to draw definitive conclusions about which components are most reliably associated. Three studies have been conducted using child chess players. In their study of the mental abilities of young Belgian chess players ($N=33$, mean age = 11.0), Frydman and Lynn (1992) used the French version of the Wechsler Intelligence Scale for Children and found that (a) the full-scale IQ of their sample (121) was higher than the population mean (100); (b) the performance IQ of their sample (129) was much higher than the population mean (100); (c) better players within their sample had higher performance IQ scores than the weakest players (top third : 131, middle third : 132, bottom third : 124); and (d) the performance IQ of their sample (129) was higher than the verbal IQ (109). Assuming the performance IQ scores provide a measure of visuo-spatial ability,¹ Frydman and Lynn concluded that “high-level chess playing requires good general intelligence and strong visuospatial abilities” (p. 235).

In the second study, Frank and D’Hondt (1979) randomly allocated 90 children (around 14 years old) to a chess playing class or a control class for one year, and

administered four psychometric tests (totalling 18 subtests) both before and after the intervention. Some of the sub-tests were found to predict chess skill at one year ('spatial aptitude' and 'numeric ability' from the Primary Mental Abilities test; 'administrative sense' and 'numeric aptitude' from the General Aptitude Tests Battery; and 'office work' from the Differential Aptitude Test). In the third study, Horgan and Morgan (1990) found that the elite chessplayers (N=15, mean age around 11) in their sample scored higher than the age-relevant norms on the Raven's Progressive Matrices and on the Piagetian plant task (Kuhn & Brannock, 1977). In sum, therefore, strong child chess players do perform better than age-relevant norms on some psychometric tests (Frydman & Lynn, 1992; Horgan & Morgan, 1990), strong child players perform better than weaker players on some tests (Frydman & Lynn, 1992), and performance on certain psychometric measures can prospectively predict chess skill (Frank & D'Hondt, 1979).

A further five studies have examined whether intelligence and chess skill are associated in adult chess players. Doll and Mayr (1987), using the "Berlin Structural Model of Intelligence" test, found that chess masters (N = 27, age = 25.7) did do significantly better than a non-chess-playing control group (N = 88, age = 24.8) on general intelligence, and in tasks related to "information processing capacity for complex information", "working speed", and "numerical thinking", but did not do better in a visuo-spatial task. Djakow, Petrowski, and Rudik (1927) studied a group of eight of the best grandmasters of the time and did not find differences with a control sample on general intelligence or visuo-spatial memory, except in the case where the material to be recalled was related to chess: they found that grandmasters showed some superiority in memory recall when an 8x8 matrix with moving spots was used, and a clear superiority when chess pieces were used. Schneider, Gruber, Gold & Opwis (1993) examined the role of chess expertise in recall in both children and adults. A control task, tapping visual memory, measured memory for the location of wooden blocks of different shapes on a

48-field board (the fields had different geometrical shapes; e.g., triangles, circles). The board was presented for 10 s on each of five successive trials. The results showed that there was no effect of expertise and age in the immediate recall condition, but that across trials, experts improved more than novices. Ellis (1973) found that, in a same-different detection task, chess players ($N = 3$) were better than non-players ($N = 5$) when boards contained chess pieces, but not when they contained dots. Finally, an unpublished study (D. Lane, personal communication with N. Charness, 1980, mentioned in Cranberg & Albert, 1988, p. 161), which used a small sample of players from novices to strong amateurs (but not masters), failed to identify any reliable correlation between chess ability and performance on a visuo-spatial task (the Guilford-Zimmerman Spatial Visualization Subtest, Form B; Guilford & Zimmerman, 1953)².

In sum, the data from adults do not consistently demonstrate a correlation between chess skill and intelligence. In particular, there are no data which support a link between chess skill and visuo-spatial ability assessed using a psychometric test. In addition, no studies have been conducted to determine whether highly skilled adult players – including masters – perform better on psychometric tests than less skilled adult players. Therefore, we aimed to add to this literature by investigating whether one component of intelligence – visual memory ability – was associated with chess skill in a sample of adult chess players. Our sample comprised tournament players ranging in ability from weak club player to strong grandmaster. We could therefore determine whether the visual memory skills of elite players was higher than that of weaker amateur tournament players. In the same study, we also measured memory performance for briefly presented chess-related material which allowed us to examine whether our two principal measures, chess skill and visual memory ability, showed the expected correlations with these measures.

Method

Participants

Thirty six participants (33 males, 3 females) completed the study, which was part of a larger study examining memory for chess positions which has been reported elsewhere (Gobet & Waters, 2000). All participants were active chess players who had ratings of the British Chess Federation [BCF] in the August 1998 ratings list (mean BCF rating = 177, $SD = 45$). Nineteen participants also had international ratings in the FIDE July 1998 ratings list (mean FIDE rating = 2326, $SD = 159$).³ Twelve participants had master level ratings, and seven had attained the title of grandmaster. Participants were recruited by advertisements placed in chess congresses and chess shops in the London area, and by personal referrals. The mean age of the players was 28.4 ($SD = 8.0$). Players rated above BCF 225 were paid £40 for participating. Players rated between BCF 175 and 225 were paid £20. All other players were paid £10. The experiment lasted on average around one and a half hours.

Materials

Visual memory test.

All participants performed a test of visual memory (the Shape Memory Test (MV-1) of the ETS Kit of Factor-Referenced Cognitive Tests; Educational Testing Service, 1976). The Shape Memory test was shown to load strongly onto a Visual Memory factor, and to display adequate internal reliability.

The written instructions to the participants for this test ran as follows:

“This is a test of your ability to remember a group of shapes and their relation to each other. You will be given a page of different shapes to study. After you have had some time to

learn the shapes and their orientation, you will be asked to turn to a test page which will show some of the same shapes that you studied. For each picture on the test page you will be asked whether it is the same as the one in the study page or whether it is different from those you studied”.

A “learning” sheet of shapes was presented to participants, which they studied for four minutes. The learning sheet was then removed and sixteen “test” items were presented. These test items contained groups of shapes, some of which had been present on the learning sheet. The instructions to the participants stated:

“For each item, mark the Y (Yes) if the shapes are the same and have the same position in relation to each other as on the study page. Mark the N (No) if they are different”

Thus, for each test item, the participant had to indicate whether or not it had been present in the learning sheet. They had four minutes to make their responses.

Each participant carried out two such tests. The overall score was computed as the sum of performance on the two tests.

Chess stimuli.

Ten types of position were used by Gobet and Waters (2000); we report data from two types here. The first type were positions (with an average of 25 pieces) taken from master games after about 20 moves, which have often been used to examine the memory abilities of chess players in the literature (Chase & Simon, 1973). We refer to these positions as game positions. We used five game positions in the study. We expected recall of game positions to be strongly related to skill, since recall of these positions can be considered a test of knowledge of chess structure. For the second position type, we performed two operations on master-level game positions: (a) the pieces were randomly distributed around the board; (b) the pieces were placed on the intersections between

squares, or, to be precise, the south-east corners of squares (see Saariluoma, 1994, and Gobet & Simon, 1996c, for alternative ways of distorting chess positions). We refer to these positions as intersection random positions, and we used five such positions in the study. We expected recall of intersection random positions to be strongly related to visual memory ability; since these distorted positions contain very little chess structure, presumably recall of these positions is more of a test of general visual memory abilities than a test of knowledge of chess structure.

Insert Figure 1 about here

Procedure

Each participant was tested individually. Participants first completed a questionnaire assessing basic information on chess play in the past year. They then completed the visual memory test. This took 16 minutes to complete. They next completed the chess memory task. For each trial, a position was presented on a computer screen for 5 seconds. The screen then went blank for 2 seconds, and then an empty chess board appeared. The instructions to the participants were to try to recall the positions as completely and as accurately as possible. They had unlimited time to make their response. To make a response, they used a mouse to select pieces, move pieces onto squares (or the intersections between squares), and delete pieces. To go on to the next trial, the participant pressed an OK button in the top left corner of the computer screen (see Gobet & Simon, 1998b, for a detailed description of the software used). In total, participants completed 50 trials covering 10 different conditions. The game positions and the intersection random positions were presented in different blocks. With intersection

positions, the software allowed pieces to be placed only at the intersection points, at not at the centre of squares. (See Gobet & Waters, 2000, for a detailed description of the procedure for all conditions).

Results

Most importantly, there was no correlation between chess skill (measured by BCF ratings) and performance on the visual memory test ($r = 0.03$, $p > .50$). Thus, better players did not do better on the test of visual memory [top third: 17.25 ($SD = 6.5$), middle third: 18.6 ($SD = 7.0$), bottom third: 16.7 ($SD = 7.0$)]. The performance of master-level players ($N = 12$, mean = 16.7, $SD = 7.0$) was not better than that of non-master level players ($N = 24$, mean = 17.9, $SD = 6.7$). In addition, our sample as a whole ($N = 36$, mean age = 28.4), did not do better than a group of about 550 male US Naval recruits (mean = 17.5, $SD = 6.71$, vs. mean = 21.4, $SD = 4.3$, respectively; Educational Testing Service, 1976)⁴.

The lack of strong correlation could not be due to restricted ranges of the variables, since our players ranged in skill from weak club player to strong grandmaster (BCF ratings from 98 to 244, spanning almost six standard deviations),⁵ and there was also a large range in performance on the visual memory test (from 2 to 32, maximum score = 32). Since age was associated with skill in our sample ($r = 0.38$, $p < .05$), with better players being older, we controlled for this possible confound and still found a non-significant correlation between skill and visual memory when age was partialled out ($r = 0.11$, $p > .50$). There were no other obvious potential confounders.

Furthermore, both BCF rating and the visual memory score are reliable and valid measures. For the skill measure, BCF rating in 1998 (time of data collection) correlated very highly with BCF rating in 1997 ($r = 0.99$, $p < .001$), and for those 19 participants with ratings of the International Chess Federation, BCF rating correlated very highly with

international ratings ($r = 0.98$, $p < .001$). In addition, chess skill correlated highly with memory for recall of briefly-presented game positions ($r = 0.68$, $p < .001$), a standard finding in the literature.

For the visual memory measure, there was a fair correlation between performance on the two parts of the visual memory test ($r = 0.61$, $p < .001$), which yields a split-half correlation of 0.76 when the Spearman-Brown correction is used. In addition, participants who had higher visual memory scores performed better in the recall of the briefly-presented intersection random positions ($r = 0.47$, $p < .005$), demonstrating external validity for the visual memory measure. Thus, in general, the skill and visual memory measures show the expected pattern of correlations with external variables, yet they do not correlate with each other.

Discussion

To the best of our knowledge, this is the first study to compare the performance of highly skilled and less skilled adult chess players on a psychometric test. In this study, visual memory ability did not correlate with chess skill. The performance of master-level players, the elite of the UK chess world, on the visual memory test was not better than that of the other players. This finding suggests that visual memory abilities, and perhaps visuo-spatial abilities more generally, are relatively unimportant factors in the long-term acquisition of chess skill. At the very least, the data indicate that individuals can become exceptional chess players without having exceptional visual memory abilities.

At first sight, our finding appears to go against some previous data that have suggested a correlation between visuo-spatial ability and chess skill in a sample of chess players (e.g. Frydman & Lynn, 1992). How, then, do we reconcile our findings with the previous data? We suggest two possibilities. First, our task tapped visual memory, whereas the performance IQ measure of Frydman and Lynn would have tapped a wider

range of abilities. Thus, some component of performance IQ, unrelated to visual memory, or even visuo-spatial abilities in general, may be associated with chess skill in adults. For example, chess players' thinking time is limited by a clock, which is likely to foster the development of time-management skills allowing good performance under time pressure. These skills, in turn, are useful for several performance subtests of the Wechsler test, such the digit symbol or the block design tasks, which either are timed or award bonus points for fast answers (Mackintosh, 1998). Clearly, this is an important area for further research.

Second, our data were from adult players whereas Frydman and Lynn's data (and Frank & D'Hondt's data) were from children. Visual memory skill and visual-spatial ability may be associated with chess skill in children but less strongly in adults. Thus visuo-spatial skills may be important in the early development of chess skill (i.e. when domain knowledge is low), but ultimately other characteristics may become more important (e.g. motivation to engage in large amounts of deliberate practice, Ericsson, Krampe & Tesch-Römer, 1993) such that associations between these visuo-spatial abilities and chess skill erode over time.

The strengths of the present study were that we recruited and tested some of the leading players in UK on the visual memory test, and that we assessed performance on additional chess-related memory tasks which allowed us to validate our measures. Nonetheless, the study had a number of limitations. First, we only measured performance on visual memory; we cannot be certain that chess skill in adults is unrelated to other components of visuo-spatial ability. Future studies should collect richer data on spatial (and verbal) IQ of chess players to investigate this issue further. Second, we only had a modest sample size (though a comparable size to the studies that have detected an effect in children); our study may have lacked the power to detect a correlation. For example, if the correlation between chess skill and visual memory ability in the adult chess-playing

population were small, for example 0.3, the power of the study to detect a significant positive correlation between visual memory and chess skill with $n=36$ was about 0.55 ($\alpha=0.05$, 1-tailed). On the other hand, Frydman and Lynn's data imply that the difference in performance on performance IQ between their top third and their bottom third was large, and significantly different at $p < .01$, 2-tailed. If these data - which are from a children's sample - are used to estimate our population scores on visual memory, then our study had a power of around 0.95 ($\alpha=0.05$, 1-tailed) to detect a difference between our top third (elite players) and our bottom third with n 's of 12 in each group. This is likely to be a conservative estimate, as our sample spanned six standard deviations, while Frydman and Lynn's spanned only three standard deviations. In actual fact, the performance of the top third and bottom third was almost identical. Thus - despite the modest sample size and constraints on power - the present data certainly indicate that there is unlikely to be a strong relationship between visual memory ability and chess skill, if there is any relationship at all. Third, our study was cross-sectional; it will clearly be necessary to take multiple measures of intelligence and chess skill in a longitudinal study extended over many years to fully investigate the relationship between intelligence and skill acquisition in chess. Last, individuals with higher levels of visual memory ability may be able to attain the same level of chess skill as other individuals with less deliberate practice; we did not get measures of amount of practice which would have allowed us to investigate this.

In sum, given the conflicting evidence, we believe it is too early to say whether good visuo-spatial abilities are necessary for strong chess play. Clearly, these results are of significance to the broader debate about whether domain-general abilities - whether innate or acquired - are necessary to the acquisition of a high level of expertise in knowledge-rich domains, such as chess. This issue has seen a resurgence of interest in recent years (e.g. Ceci, 1990; Ericsson & Charness, 1994; Howard, 1999). However, it is

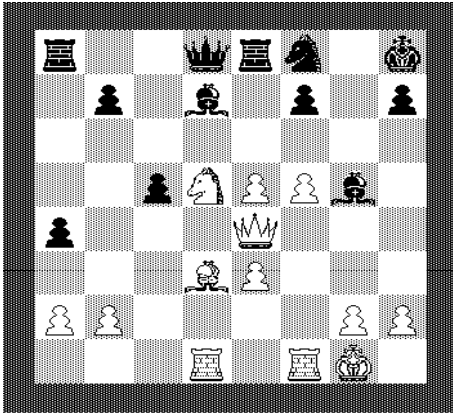
likely that only detailed longitudinal studies, which are yet to be conducted, will be able to settle the question.

Reference list

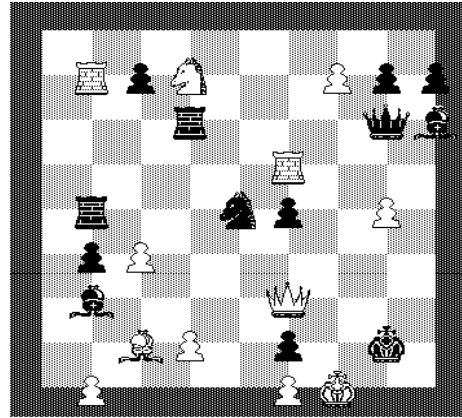
- Anastasi, A. (1988). *Psychological testing* (6th ed.). New York: Macmillan.
- Ceci, S. J. (1990). *On intelligence.... More or less: A bio-ecological theory of intellectual development*. Englewood Cliffs, NJ: Prentice Hall.
- Charness, N. (1992). The impact of chess research on cognitive science. *Psychological Research*, 54, 4-9.
- Chase, W. G., Simon, H. A. (1973). The mind's eye in chess. In W. G. Chase (Ed.), *Visual information processing*. New York: Academic Press.
- Cranberg, L., & Albert, M. L. (1988). The chess mind. In L. K. Obler & D. Fein (Eds.), *The exceptional brain. Neuropsychology of talent and special abilities*, pp. 156-190. New York: Guilford press.
- de Groot, A. D., & Gobet, F. (1996). *Perception and memory in chess. Heuristics of the professional eye*. Assen: Van Gorcum.
- Djakow, I. N., Petrowski, N. W., & Rudik, P. A. (1927). *Psychologie des Schachspiels* [Psychology of the game of chess]. Berlin: de Gruyter.
- Doll, J., & Mayr, U. (1987). Intelligenz und Schachleistung—eine Untersuchung an Schachexperten [Intelligence and performance in chess—A study of chess experts]. *Psychologische Beiträge*, 29, 270-289.
- Educational Testing Service (1976). *ETS[®] Kit of Factor-Referenced Cognitive Tests*. Princeton, NJ.

- Ellis, S. H. (1973). *Structure and experience in the matching and reproduction of chess patterns*. Unpublished doctoral dissertation, Carnegie Mellon University, Pittsburgh.
- Ericsson, K. A., & Charness, N. (1994). Expert performance: Its structure and acquisition. *American Psychologist, 49*, 725-747.
- 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.
- Frank, A., & D'Hondt, W. (1979). Aptitudes et apprentissage du jeu d'échecs au Zaïre [Aptitudes and learning of the game of chess in Zaïre]. *Psychopathologie Africaine, 15*, 81-98.
- Frydman, M. & Lynn, R. (1992). The general intelligence and spatial abilities of gifted young Belgian chess players. *British Journal of Psychology, 83*, 233-235.
- Gobet, F., & Simon, H. A. (1996a). Templates in chess memory: A mechanism for recalling several boards. *Cognitive Psychology, 31*, 1-40.
- Gobet, F., & Simon, H. A. (1996b). Recall of rapidly presented random chess positions is a function of skill. *Psychonomic Bulletin & Review, 3*, 159-163.
- Gobet, F., & Simon, H. A. (1996c). Recall of random and distorted positions. Implications for the theory of expertise. *Memory & Cognition, 24*, 493-503.
- Gobet, F., & Simon, H. A. (1998a). Pattern recognition makes search possible: Comments on Holding (1992). *Psychological Research, 61*, 204-208.
- Gobet, F. & Simon, H. A. (1998b). Expert chess memory: Revisiting the chunking hypothesis. *Memory, 6*, 225-255.

- Gobet, F. & Simon, H. A. (2000). Five seconds or sixty? Presentation time in expert memory. *Cognitive Science*, 24, 651-682.
- Gobet, F. & Waters, A. J. (2000). *The role of constraints in expert memory*. Submitted for publication.
- Horgan, D. D., & Morgan, D. (1990). Chess expertise in children. *Applied Cognitive Psychology*, 4, 109-128.
- Howard, R. W. (1999). Preliminary real-world evidence that average human intelligence really is rising. *Intelligence*, 27, 235-250.
- Kuhn, D. & Brannock, J. (1977). Development of the isolation of variables scheme in experimental and 'natural experiments' contexts. *Developmental Psychology*, 13, 9-14.
- Mackintosh, N. J. (1998). *IQ and human intelligence*. Oxford: Oxford University Press.
- Saariluoma, P. (1994). Location coding in chess. *The Quarterly Journal of Experimental Psychology*, 47A, 607-630.
- Saariluoma, P. (1995). *Chess players' thinking: A cognitive psychological approach*. London: Routledge.
- Schneider, W., Gruber, H., Gold, A., & Opwis, K. (1993). Chess expertise and memory for chess positions in children and adults. *Journal of Experimental Child Psychology*, 56, 328-349.
- Guilford, J. P., & Zimmerman, W. S. (1953). *Guilford-Zimmerman Aptitude Survey*. Orange, CA: Sheriden Psychological Services.



Standard normal



Intersection random

Figure 1. Examples of standard normal and intersection random positions.

Footnotes

¹ It ought to be noted, however, that there is increasing skepticism about the treatment of WISC Performance Quotients as straightforward measures of visuo-spatial skills—whatever that might mean in this context—without recognition of visual perception as a dynamic, organisational process which may draw on a number of factors, including verbal components and freedom from distractibility (e.g., Anastasi, 1988; Mackintosh, 1998). From the data presented by Frydman and Lynn (1992), it is not possible to determine which specific Performance sub-test, or patterns of sub-tests, contributed most to their findings.

² In addition, the recall of briefly-presented random positions, which could be considered a test of visual memory (Chase & Simon, 1973), is a poor measure of visual memory for chess players, for at least three reasons. First, later experiments have shown that masters do enjoy a small advantage in recall of random positions (Gobet & Simon, 1996b), which could be explained by their more extensive knowledge base (Gobet & Simon, 2000); second, the task may be insensitive since players rarely recall more than five pieces and the range of performance tends to be limited; and third, strong players tend to show a low motivation when memorising random positions.

³ The World Chess Federation (FIDE, *Fédération Internationale des Echecs*) semestrally publishes rating lists of its members and awards titles such as grandmaster.

⁴ Surprisingly, our sample appears to do worse than the male naval recruits. Although we don't have precise information on the average age of the recruits, our sample was probably much older, and this factor might partially explain the difference. The nine

participants aged 21 or less in our sample (mean = 19.2, SD = 7.74, SE = 2.58) did not do significantly worse than the recruits.

⁵By comparison, Lynn and Frydman's (1992) sample spanned about three standard deviations.