Does Chess Need Intelligence? – A Study with Young Chess Players

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Abstract

Although it is widely acknowledged that chess is the best example of an intellectual activity among games, evidence showing the association between any kind of intellectual ability and chess skill has been remarkably sparse. One of the reasons is that most of the studies investigated only one factor (e.g., intelligence), neglecting other factors relevant for the acquisition of chess skill (e.g., amount of practice, years of experience). The present study investigated the chess skill of 57 young chess players using measures of intelligence (WISC III), practice, and experience. Although practice had the most influence on chess skill, intelligence explained some variance even after the inclusion of practice. When an elite subsample of 23 children was tested, it turned out that intelligence was not a significant factor in chess skill, and that, if anything, it tended to correlate negatively with chess skill. This unexpected result is explained by a negative correlation between intelligence and practice in the elite subsample. The study demonstrates the dangers of focusing on a single factor in complex real-world situations where a number of closely interconnected factors operate.

Key words: Chess, Intelligence, Practice, Children, Verbal ability, Visuo-spatial ability, Speed of processing, Memory span.

It is widely acknowledged that chess is the king among (board) games. This special status is most likely a result of the intellectual aura which surrounds it (Holding, 1985; Newell, Shaw, & Simon, 1963). While in other competitive activities, especially traditional sporting ones, people can always blame their failure on lack of luck or find a rationalization (e.g., so what if he can run faster than me – I can do many other things better than him), it is more difficult to come up with such excuses in chess. One has the same set of pieces as the opponent, luck does not play any role, and if one loses one can only blame oneself, one's intellect, or lack thereof. Not being smart is more hurtful than not being able to run fast, as many chess players will testify. This notion is not only shared among lay people but also among some researchers - recently there has been a surge of research based, if not entirely then at least partly, on the assumed link between intelligence and chess (Howard, 1999; 2001; 2005a; 2005b; Irwing & Lynn, 2005). Given this common conception about the role of intelligence in chess, it is remarkable how unsuccessful the search for intellectual ingredients of chess skill has been. Despite being an apparently obvious example of a purely intellectual activity, for more than a century researchers have largely failed to connect success at chess with any intellectual ability (e.g., Binet, 1966/1893; Unterrainer, Kaller, Halsband, & Rahm, 2006).

In this study we present new empirical evidence that highlights the difficulty of relating intelligence to success at chess. We will firstly consider the sparse positive evidence for the influence of intelligence on chess skill. We will then describe the studies which failed to uncover the often assumed link between intelligence and chess skill. Next, possible reasons for the lack of evidence for this influence will be considered and important trends that provide clues for solving the chess-intelligence paradox identified. Finally, we will present a study that addresses the problems and shortcomings of previous studies.

1. General intelligence and visuo-spatial abilities in chess – positive evidence

A common theoretical view is that besides general intelligence, chess requires a high level of visuo-spatial ability (e.g., Chase & Simon, 1973a; 1973b; Frydman & Lynn, 1992; Howard, 1999; 2005a; 2005b). Calculating variations/moves, that is imagining potential moves and representing future developments, has been thought to be one of, if not the main factor of chess skill (Aagard, 2004). Given that no external help is allowed, chess players need to do these transformations in their mind's eye (Chase & Simon, 1973b). At first sight, these transformations seem to resemble the popular mental rotation task (Shepard & Metzler, 1971) which taps visuo-spatial ability.

It is thus fitting that Frydman and Lynn (1992), who administered the WISC to 33 young elite Belgian chess players (mean age 11; the average rating was slightly below that of an average adult chess player; see the discussion of the Elite subsample in the Results section for an explanation of the rating system in chess), found that the sample of talented chess players had above-average IQs (about 120) and their 'Performance IQ' (as measured by half of the subtests) was considerably higher than their verbal IQ (as measured by the other half of the subtests). The "stronger" players had higher performance IQ scores than the "weaker" ones, which led Frydman and Lynn to conclude that visuo-spatial abilities are essential for successful chess playing. Similarly, Horgan and Morgan (1990) demonstrated a relationship between intelligence as measured by Raven's Progressive Matrices and improvement in chess skill. The 15 best players from the sample (performing roughly at the level of an average adult player) scored higher on the Raven's Progressive Matrices than the average for children of their age. Stepwise regression analysis showed that 65% of variance on the current chess rating was explained by the rating in the previous year, 77% when the Raven's test score was added to the regression, and 87% when the number of games played was added.

Unfortunately, both studies have some shortcomings that throw a shadow of doubt on the role of intelligence in chess expertise. In the study by Horgan and Morgan (1990), it is somewhat surprising that Raven's matrices explained as much as 12% of variance considering that the children's scores (on Raven's matrices) were not significantly correlated with improvement or with rating once age was controlled for. A plausible explanation is that in the stepwise regression the main confounding variable, age, was not included. Similarly, the conclusion voiced by Frydman and Lynn (1992) about the importance of visuo-spatial abilities in chess is questionable considering that a number of tests in the performance part of WISC do not measure visuo-spatial abilities (and most of them depend heavily on time/speed, Kaufman, 1994). In this respect, it is regrettable that the results on individual subtests were not presented. It is true that the children in both Horgan and Morgan's and Frydman and Lynn's studies performed better than average on the intelligence tests. Still, there was no significant association between intelligence and rating in the former study and it is not clear whether the association among the elite subsample in the latter study was strong, weak, or whether it existed at all.

2. General intelligence and visuo-spatial abilities in chess – negative evidence

The very first empirical investigation of chess by Alfred Binet (1966/1893) set out to examine exactly how expert chess players envision the chess board and anticipate moves when they play blindfold chess (chess without the help of external board). Contrary to his expectation that chess players would have a concrete and detailed image of the board and the transformations that are taking place during a blindfold game, even the very best players reported that their representations were abstract without clear encoding of the board and pieces (but see Fine, 1965).

Subsequent research confirmed that intelligence and visuo-spatial abilities are rarely, if ever, correlated with chess skill among *adult* chess experts. Djakow, Petrowski and Rudik (1927) tested eight grandmasters—including several world champions and some of the best players at their time—with a number of measures of general intelligence and visuo-spatial memory. They found no differences between this highly talented group and a control group of adult non-chess players. Lane (an unpublished study, D. Lane, mentioned in Cranberg & Albert, 1988, p. 161) found no association between chess ability and performance on a visuo-spatial task (the Guilford-Zimmerman Spatial Visualization Subtest, Form B; Guilford & Zimmerman, 1953). Doll and Mayr (1987) also failed to identify any reliable correlation between chess skill and various intellectual abilities as measured by the Berlin Structural Model of Intelligence Test in 27 expert chess players. Waters, Gobet and Leyden (2003) found virtually no association between chess skill and the Shape Memory Test (MV-1), a measure of visual memory ability, among 36 adult chess players despite a positive correlation between the scores on the Shape Memory Test and the recall of random positions. Similarly, a recent study by Grabner, Neubauer and Stern (2006) could not establish significant association between chess rating and intelligence (as measured by the Intelligenz-Struktur-Test 2000 R) among 47 adult players (including solid tournament players as well as master players). Finally, Unterrainer, Kaller, Halsband and Rahm (2006) found no association between chess skill and the scores on the Raven's Progressive Matrices, Digit Span, and Corsi block-tapping test among a group of 25 experienced chess players. In addition, the same group of players did not have better fluid intelligence (Raven matrices), memory capacity (Digit Span), or visuo-spatial working memory (Corsi block-tapping test) than a group of non-players matched for age and education.

Even more surprising was the finding of Gruber and colleagues (Gruber, Renkl, & Schneider, 1994; see also Opwis, Gold, Gruber, & Schneider, 1990) who measured the general memory capacity (with the Digit Span subtest from the Wechsler Intelligence Scale for Children (WISC)) of expert and novice *child* chess players and their recall of briefly presented chess positions. While novice child players showed a small but positive correlation (between .20 and .50) between digit span and the recall task, expert child players had a high negative correlation (larger than -.70). Expert child players with better memory capacities were reproducing briefly presented chess stimuli worse than their peers with worse memory capacity.

The reviewed studies indicate that intelligence, visuo-spatial abilities, and basic memory capacities do not play a significant, if any, role at later stages of chess skill acquisition. There seems to be a link between intelligence and performance on stimuli unrelated to standard chess material (e.g., Waters et al., 2003), but the association disappears (e.g., Waters et al., 2003), or it even becomes negative (Gruber et al., 1994), as soon as chess related stimuli are used. Closely related is the result that has been found many times that experts' huge advantage over weaker players (or non-players) in recalling chess positions disappears when the positions are scrambled, that is, they no longer make chess 'sense' (see Chase & Simon, 1973a, Vicente & de Groot, 1990; but see also Gobet & Simon, 1996b, for the explanation of minor differences). In addition, Ellis (1973) found that chess players were better at a same-different detection task only when (chess) boards contained chess pieces. The differences disappeared when dots were used instead of pieces.

3. Reasons for the lack of association between intelligence and chess skill

Given that intelligence plays a significant role in many activities (e.g., academic success – Neisser et al., 1996; school achievement – Gagne & St.Pere, 2002; vocational success – Schmidt & Hunter, 1998; 2004; various motor-perceptual tasks; Ackerman, 1988), some of which could be seen as less intellectual than chess, it is surprising that the studies with established players could not establish its role in chess, seen as an intellectual activity *par* *excellence*. There are several possible explanations for the absence of the link between intelligence and chess among established players. For example, most of the current theories of expertise (Chunking Theory – Chase & Simon, 1973a; 1973b; Template Theory – Gobet & Simon, 1996a; Apperception-Restructuring Theory – Saariluoma, 1995; Long Term-Working Memory – Ericsson & Kintsch, 1995) assume that chess skill depends more on knowledge (e.g., stored patterns of chess configurations, chunks and templates) than on analytical abilities such as search or calculation of variations (but see Holding, 1985; 1992). It has been estimated that chess experts have between 10,000 and 100,000 chunks stored in their memories (Simon & Gilmartin, 1973), a number that recent computer simulations place as high as 300,000 (Gobet & Simon, 2000). These constellations are connected with common moves and plans which are responsible for successful chess playing. In order to acquire such a large number of chess position patterns, prolonged training is a necessity for every chess expert.

There are disagreements about exactly how much time is necessary to become a good chess player (see Howard, 1999 and Gobet, Campitelli, & Waters, 2002), but it is certain that nobody will become a successful player overnight. Several studies point out how important training is in skill acquisition. In a survey of over 230 expert chess players, Charness and colleagues (Charness, Krampe, & Mayr, 1996) found that "practice alone" was moderately associated with chess skill even when a number of other factors, such as practice with others, competitive games played, and number of chess books owned were entered in a regression analysis. Furthermore, the addition of time spent on playing games did not explain any additional variance once solitary practice had been entered in the equation. Similar results were obtained in recent large scale studies with chess players (Charness, Tuffiash, Krampe, Reingold, & Vasyukova, 2005; Gobet and Campitelli, in press), as well as in the number of different sports (see Ward, Hodges, Williams, & Starkes, 2004 for a review).

These findings underline the importance of focused practice, also called deliberate practice (Ericsson, 2003; Ericsson, Krampe, Tesch-Roemer, 1993), where practice is intentionally targeted at those aspects of performance one wants to improve. Focused practice is a part of experience (e.g., number of games played, number of years playing) but it is also different in that focused practice has a clearly beneficial influence on performance while the same cannot be claimed for experience. Although the studies mentioned above illustrate the pivotal role of focused practice, none of them took account of intelligence measures and all were of a retrospective character using already established performers. This makes it difficult to say anything about the influence of practice and intelligence on chess skill and their interplay in the chess skill acquisition process.

A related problem in the studies of exceptional performance, and another possible reason for the absence of an intelligence-chess skill link among established players, is selective drop-out (Detterman, 1993; Sternberg, 1996). By the time some people become proficient players, many others of them have long given up chess. This drop-out is usually selective because many of the people who give up chess were usually not very good in the first place. The main consequence of this selective drop-out is a restriction in the range - established players are likely to be highly selected individuals with similar characteristics (e.g., intelligence, motivation) which artificially reduces the association between these characteristics and chess skill. The restriction in the range of important individual characteristics as a consequence of selective drop-out may also be a reason why the link between intelligence and chess skill was established only among young players (children) while the link seems to be absent among established players (adults).

4. Present study

In short, the data and theoretical assumptions on the role of intelligence in chess skill are inconsistent. On the one hand, we have a general theoretical assumption that intelligence plays a part in intellectual activities (e.g., Howard, 1999; 2005). On the other, many researchers on expertise believe that practice is the main ingredient in the development of most skills (e.g., Ericsson & Lehmann, 1996; Howe, Davidson, & Sloboda, 1998). Both theoretical standpoints have been repeatedly supported (e.g., Ericsson et al., 1993; Gagne & St.Pere, 2002; Neisser et al., 1996; Schmidt & Hunter, 1998; 2004; Ward et al., 2004) and one can also say that they have received some support in chess. Practice explains a significant part of variance in chess skill (Charness et al., 1996; 2005) while there is still some evidence that intelligence is correlated with chess skill at least among children (Frydman & Lynn, 1992; Horgan & Morgan, 1990). The studies showing the association between intelligence and chess skill are, however, far from conclusive. In addition, there is also counter-evidence that even suggests a negative relation between intelligence and chess expertise among expert child players (Gruber et al., 1994).

We believe that one of the reasons we do not know how intelligence influences chess skill is that none of the studies described so far took other relevant factors into account. The studies on intelligence generally neglected to control for practice (an exception to this rule being Horgan and Morgan's study, 1990, which included the number of played games) while the studies on practice did not take intelligence and the consequences of restricted range into account. In this study, we used not only measures of intelligence but also measures of practice and experience. We tested children who had recently started to play chess because we felt that it is necessary to see how intelligence and practice interact at the beginning of the chess skill acquisition process. Our study also included a subsample of star players who participated in national and international competitions, thus enabling us to see how intelligence and practice influence the very best young players, possibly highly selected children who are likely to become very good players.

We used three measures of chess expertise (Chess Test, Recall, Knight's Row Task), four WISC subtests (Vocabulary, Block Design, Symbol Search, Digit Span) and measures of experience and practice. We tested how verbal and spatial ability, as well as speed of processing and memory, correlate with various measures of chess expertise among children. The Vocabulary subtest was included because Holding (1985) speculated, on the grounds of the observation that many remarkable chess players were journalists and that there was no evidence that visuo-spatial ability is connected with successful chess playing, that verbal ability is more important for chess than visuo-spatial ability.

5. Method

5.1. Participants

Fifty-seven primary and secondary school children from four schools in Oxfordshire, UK, participated in the study. Age and gender can be found in the first two columns of Table 1. All children could play chess and were attending a chess club in their schools (at least once a week). They had been playing chess for about four years at the time of the study was conducted (see Table 1).

5.2. Measures

Chess skill. In order to measure the skill level of children, we employed three different measures of chess skill. The main measure was a **Chess Test** that contained two parts. The first part dealt with the rules of the game (e.g., moves, castling, en passant), while the second part contained chess problems (puzzles) that featured different chess motifs (e.g., double attack, pin). The time for trying to solve one item was limited to two minutes. There were 55 items in the Chess Test with one point for each correct answer. The second measure was De Groot's (1978/1946) **Recall Task** where participants recall/reconstruct a position previously seen for a brief period. We adapted this task for the use with children in such a manner that the positions were presented for 10 seconds on a computer screen instead of the usual 5 seconds. In addition, the chosen positions were highly structured (coming from openings) so that the task was easier than usual. There were three target positions which were preceded by two practice positions. The average percentage of correctly recalled pieces across all three target positions was used in subsequent analysis. Almost identical results were found when individual positions were analyzed. The last measure was the **Knight's Row Task** (KRT; adaptation of Milojevic, 1967, Knight's Row Tour; reported in Holding, 1985) in which the task was to transfer, as fast as possible, the knight from one corner of the board to the other on the same horizontal (a1 to h1), visiting each square between the two corners (in order a1, b1, c1 and so on until they reach h1). Two obstacles were on squares c3 and f3 which made the task more demanding. The time for the task was limited to 10 minutes. We first calculated the average time needed per square to finish the task. We then applied a $\log_{10}$ transformation on the average time per square in order to ensure a normal distribution. The descriptive statistics for the three chess skill measures can be found in Table 1. The Chess Test and Recall tasks included highly internally consistent items - Cronbach's alphas for Chess Test and Recall were .92 and .96, respectively. To check whether the three chess skill measures indeed measured chess skill (criterion validity), we used the scores of the tournaments organized in the schools, as well as coaches' estimates of children's chess ability. Pearson correlation between the number of points in the tournaments and the number of points in the Chess Test was .80 while the correlation was slightly weaker for Recall and KRT – r = .60 and -.50, respectively. Spearman's correlation between the ranks of coach's estimates and the results in the Chess Test were also high (.90), while the correspondence with Recall and KRT were slightly weaker (.80 and -.65, respectively). All correlations are the average of the correlations in the four schools and all were significant at the .05 level. All three chess skill measures correlated highly with each other (see Table 1) and a factor analysis using the three chess skill measures produced one factor. This reinforces the belief that all tasks captured the same construct, most likely chess skill, which is evidence for concurrent validity (sharing the variance with measures that are believed to measure the construct).

Intelligence. Four subtests from the WISC III were applied. They represent four major abilities that could influence chess skill acquisition. The **Vocabulary** subtest (children orally define a series of orally presented words) was used to test verbal abilities; **Block Design** (replicating geometric patterns with red and white colored cubes from both two and three dimensional models) for visuo-spatial abilities; **Symbol Search** (indicating, by marking a box, whether a target symbol appears in series of symbols) for speed of processing; and **Digit Span** (repeating a list of orally presented numbers forward and backward – we used a combined score of both forward and backward span, but similar results were obtained when forward and backward scores with age control were used separately) for memory capacity. Vocabulary and Block Design are the most reliable tests for measuring *g* in the whole WISC III (Kaufman, 1994) and are frequently used together as a short form (Sattler, 1992; the correlation between the IQ obtained with Vocabulary and Block Design and the full scale IQ is above .80). Adding Symbol Search and Digit Span provides additional reliability to the estimated IQ and makes it possible to use a composite intelligence score (IQ) in the study. On the other hand, all four subtests tap different abilities and are not particularly highly related. Therefore, it is possible to examine diverse intellectual abilities and their influence on the acquisition of chess skill. The estimated overall IQ is obtained using the formula provided by Sattler (2001; pp. 744-748) which converts the standardized scores (where M is 10 and SD is 3) of subtests into the IQ scale (where the mean is 100 and the standard deviation 15). The standardized scores were used in all analyses.

Practice. A face to face interview was conducted in order to collect the background data (e.g., date of birth) and to obtain children's estimates of the time when they started to play chess (start year) and the amount of time they spent playing chess up to the point of the interview (practice). The obtained estimates were cross-checked with parents who were sent a questionnaire with the same questions. Over 70% of parents returned the filled questionnaire. The Pearson correlation between parents' and children's estimates of the time spent on chess before the interview was .71. As a rule, we kept parents' estimates in the analyses except in the cases where children had learnt to play chess in their schools. We felt that those parents would be an unreliable source of the time spent on chess because they only rarely played chess with their children (some of them could not play chess at all). In addition to the interview, diaries for logging daily amounts of practice were used in the first two terms (about half a year) before the actual testing took place. Children were asked to fill in the diaries every week and the first author visited the chess clubs every week to ensure that the children remembered to do this. In addition, parents were informed about the diary routine and most of them agreed to help logging the time spent doing chess. At the end of the diary period, children were asked to estimate the time they spent on chess during the diary period. The Pearson correlation between their estimates and the data from diary was very high (.99 and .98 for each of the two school terms) which indicates that children can reliably estimate their practice times at least within a couple of months. In all analyses we used a $\log_{10}$ transform of the practice data time.

Experience. Experience was measured as the number of years of playing chess, that is, the time in years between the point where the child learned to play chess and the actual testing. As previously mentioned, the questionnaire was sent to the parents to estimate the time when their children started to play chess. The Pearson correlation between parents' and children's answers for questions about the start year was .91. As with practice, we took parents' estimates in the cases where they introduced their children to chess and children's estimates if they learned it in school.

5.3. Procedure

As a part of a larger project (Bilalić, 2006), we firstly obtained agreement from the schools which were regularly organizing a chess club within their programme. The children in the chess clubs were then familiarized with the project and asked if they were willing to participate. All children who were regularly attending the chess clubs agreed to participate. A letter briefly describing the study was sent to the parents of the children. About 75% of parents contacted agreed to participate in the study. The initial face to face interview was conducted first. The parents' questionnaire was sent out next while the intelligence testing was conducted during the diary period. The session with chess skill measures was conducted last and just after the second face to face interview in which we collected children's estimates of the practice times for the diary period. All four WISC-III subtests were administered in one session in the following sequence: Block Design, Vocabulary, Symbol Search, and Digit Span. The testing with chess measures was done in two sessions in order to minimize the pressure on young children. In the first session, the Knight's Row Task and the Recall task were conducted. The knight's row task was conducted on a chess board taken from the chess club so that the children were familiar with it. A Macintosh laptop (11" screen) was used for the recall task (for information about the software used, see Gobet & Simon, 1998). The second session featured only the chess test which was administered on a PC laptop (15'' screen). Both testing sessions, as well as the intelligence testing and face to face interview, were conducted in the same quiet room (e.g., head teacher's office, library or computer room during classes when they were quiet).

5.4. Statistical analysis

We used hierarchical regression analysis to test how gender, age, intelligence, practice, and experience predict the results on the chess skill measures. All variables were checked for normal distribution and necessary transformations were made where needed (e.g., practice and KRT). The relations of the predictors with the chess skill measures were linear but some of the predictors were moderately related (see Table 1). Although none of the correlations between predictors exceeded .65, the inter-predictor correlations may result in multicollinearity which would make the estimation of the error terms inexact and produce distorted significance levels. To test out this possibility, we calculated the variance inflation factor (VIF) for each predictor. VIF shows the increased amount of variance for the regression coefficient in question relative to a situation where all predictors were unrelated. Almost all predictors had the VIF value of less than 2.00 (the exception being experience which had a VIF value of less than 3.00) indicating that multicollinearity was not a problem (the cut-off value being 4.00; Fox, 1991). Finally, we made sure that other relevant indicators (e.g., homoscedasticity, error distribution, outliers) confirmed that the regression analyses were reliable (Cohen, Cohen, West, & Aiken, 2003).

6. Results

6.1. General intelligence of young chess players – descriptive statistics

The means and standard deviations of the variables used in the study, as well as the intercorrelations among the variables, are presented in Table 1. Our sample was above average intelligence, confirming the previous findings of high intelligence in young chess players (e.g., Horgan & Morgan, 1990; Frydman & Lynn, 1992). Chess skill measures were positively and moderately correlated with age, gender, experience, and the composite IQ score. The highest correlation with chess skill measures was practice, that is the $\log_{10}$ of hours children spent on playing chess (over .75 for all three chess skill measures). The Vocabulary and Block Design subtests were rather moderately associated with chess skill measures, while Digit Span and Symbol Search correlated higher. Both experience, that is the number of years playing, and the composite IQ score were positively correlated, with a similar magnitude, with all three measures of chess skill. It should be noted that experience was not significantly related to IQ nor any other intelligence subtest except Digit Span. Practice, on the other hand, was moderately but significantly correlated with the IQ as well as with all intelligence subtests, especially Digit Span and Symbol Search. Finally, there were no stark discrepancies between different measures of chess skill and their associations with intelligence, practice, and the other variables of interest.

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Insert Table 1 about here

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6.2. The association of intelligence, practice, and experience with chess skill - predictive analysis

In order to see how intelligence (and different abilities), practice, experience, age, and gender are correlated with chess skill when they are all taken into account, we performed a hierarchical regression analysis for each of the three chess skill measures. We made sure that the following variable in the hierarchical regression analysis was unlikely to cause the preceding one (Cohen et al., 2003). In all three regression analyses we first entered gender (Model 1) followed by age (Model 2), then added the composite IQ (Model 3) after which practice was included (Model 4), and finally experience was added as the last predictor (Model 5). While one can imagine that intelligence can cause practice because more intelligent children may be more interested in an intellectual endeavour such as chess, one can be relatively sure that chess practice should not influence intelligence. Similarly, experience and practice are related but while experience per se does not necessarily equal practice, practice always equals experience. The results for the Chess Test, Recall, and KRT are presented in Table 2.

In all three regression analyses, age and gender explained around 40% of the variance in the chess skill measures pointing to an unsurprising pattern of results where boys and older children play better chess than young children and girls (see Model 1 and 2 in Table 2). The inclusion of IQ, nevertheless, increased the explained variance to around 55% in all three chess skill measures (see Model 3 in Table 2). When practice was entered (Model 4) in the analyses it raised the explained variance to around 70% for Recall and KRT, while the Chess Test variance was particularly well explained (86%). After the inclusion of practice all other variables became weaker predictors of chess skill. Intelligence still remained a significant predictor, although its influence was weaker, while age became an insignificant predictor. The exception to this pattern of results was KRT where age remained significant even after the inclusion of practice, while intelligence became insignificant when practice was accounted for. In all three chess skill measures, practice was the best predictor. Experience (Model 5) did not contribute significantly to the explanation of the Chess Test and Recall results. Experience was also not a significant predictor of the KRT scores but it did significantly explain some variance in the results. This is most likely due to the association of experience with age and practice – the coefficients for age and practice became higher in absolute value with the inclusion of experience. This was also reflected by the VIF value for experience as well as by the increase in the VIF values for age and practice.

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Insert Table 2 about here

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When the intelligence subtests were entered separately and individually to Model 3 instead of IQ, the best predictors were not spatial (Block Design) and verbal (Vocabulary) abilities as some researchers speculated (e.g., Chase & Simon, 1973a; 1973b; Frydman & Lynn, 1992; Holding, 1985; Howard, 1999; 2005a; 2005b) but memory capacity (Digit Span) and processing speed (Symbol Search). Block Design did not predict significantly any of the three chess skill measures while Vocabulary significantly predicted Chess Test and Recall (standardized beta coefficients, β, of .27 and .33 respectively). The best predictors of the Chess Test and Recall scores were Digit Span and Symbol Search (βs of .38 and .37 for Chess Test; .28 and .39 for Recall, respectively) while the KRT scores were only significantly predicted by Digit Span (β = -.38).

We also checked how individual intelligence subtests predicted the three chess skill measures when practice had been included in the regression analyses (Model 4). Chess Test was significantly predicted only by Digit Span (β = .14) while Symbol Search and Vocabulary just failed to reach the 0.05 significance level (β = .12 and .11, respectively). Recall was significantly predicted by Symbol Search and Vocabulary (both β = .20) while Digit Span proved to be the only significant predictor of KRT (β = -.22). Bock Design was not a significant predictor of any of the chess skill measures, although it just failed to reach the significance in Recall (β = .16).

6.3. Elite subsample

It thus seems that intelligence has a role in chess playing of children even when gender, age, experience, and practice are controlled for. It is possible, however, that the influence of intelligence is present only with samples of children of wide chess skill range who had just recently started to play chess. As previously mentioned, other studies using a sample of elite child chess players did not find a significant link (e.g., Horgan & Morgan, 1990) while some even found a significant negative association (e.g., Gruber et al., 1994). In order to examine this possibility, we performed a similar analysis on a subsample of elite young chess players. Among the children participating in the study there were 23 children (all boys, mean age 11.4, *SD* = 1.2) who were regularly participating in local, national and some even in international chess competitions. In comparison with the players in the rest of the sample, the players had higher IQ scores (133 vs. 114; $t(55) = 4.9$, $p < .001$), were more experienced (5.5 vs. 3.5; $t(55) = 5$, $p < .001$) and spent more time playing chess (2.8 vs. 1.9; $t(55) = 10.4$, $p < .001$).

All of players in the elite subsample had a chess rating which we will use as the measure of chess skill. Chess rating is based exclusively on the results against other rated players. It is thus an objective measure of chess skill (given enough rated games). The average rated player, all adults and children included, has a rating of 1500 with a standard deviation of 200. One can be fairly sure that children as good as 1100 (2 SD below the average) will beat adults who occasionally play chess and regard themselves as competent players. Expert chess players start from 2100 (3 SD above the mean) while the very best players in the world, grandmasters, have a rating 2500 or more (5 SD above the mean). Taking these considerations into account, and given their age, our elite subsample was truly exceptional. The average rating was 1603 (*SD* = 109). The highest rating was 1835, more than 1.5 SD above the mean, while the lowest was 1390, half a SD below of the average player. (All children had British Chess Federation ratings which we converted into the international ELO rating using the current formula provided by the British Chess Federation: ELO = (BCF*5) + 1250.)

The results of the hierarchical regression analysis using age, experience, practice and IQ or intelligence subtests as predictors of the rating are presented in Table 3. The most surprising result was that IQ negatively correlated with chess rating, indicating that the children with lower IQ scores were better players in the elite subsample (see Model 2). Age, on the other hand, did not play a significant role in the chess rating prediction (Model 1 and 2). But practice had a large positive impact on the rating (Model 3). Intelligence had moderately negative and significant influence when practice was not included (Model 2). After the inclusion of practice, intelligence lost some of its negative impact on chess rating. Experience, on the other hand, became a moderately and significantly negative predictor when it was added (Model 4). Again, this probably reflects the association of experience with age ($r(23) = .64$, $p = .001$) and practice ($r(23) = .46$, $p = .028$) which can also be seen in the relatively high VIF value for experience. Model 3, which included practice, explained altogether 60% of the variance in the chess rating, 30% more than the previous model (Model 2) did with age and IQ. The full model with experience as the final predictor explained 70% of the variance.

The situation was not much different when IQ was replaced with individual intelligence subtests in Model 2. Virtually all intelligence subtests were negatively related to chess skill. Symbol Search and Block Design had the highest significant correlations ($\beta = -.44$ and $\beta = -.42$, respectively) while Vocabulary and Digit Span were not significant predictors of chess rating (βs of -.26 and -.07, respectively). All subtests had a negative association with rating in Model 3, but none of them reach the significance level.

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Insert Table 3 about here

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At first sight the surprising result of a *negative* influence of intelligence on chess rating does not seem to be a result of using different measures for the two groups, chess skill measures for the whole sample and chess rating for the elite sub-sample. Chess rating was highly correlated with Chess Test even after controlling for age ($pr(23) = .82$, $p < .001$; Pearson correlation, r, = .77) showing that both measures capture the same construct. The other two chess skill measures, Recall and KRT, were somewhat less related to chess rating (.45 and -.24, respectively). However, when a hierarchical regression analysis was carried out on the same elite subsample using Chess Test scores instead of chess rating, intelligence had virtually no influence on Chess Test after practice was included (the association was negative, $\beta = -.22$, before the inclusion of practice). The effect of intelligence on Recall and KRT was not significant but at least it did not have negative influence. The bivariate correlations between intelligence and chess skill measures within the elite subsample indicated that chess rating was particularly negatively associated with intelligence ($r(23) = -.51$; $p = .014$), while the other three chess skill measures did not have significant associations (-.21, .05, -.10, for Chess Test, Recall, and KRT, respectively).

This indicates that the negative association between intelligence and chess rating was partly the consequence of different chess skill measures. Given that the chess skill measures were relatively well associated with external predictors (see Method section), it could be argued that chess rating was not a stable measure. This does not seem to be the case because, just in the last year, the average number of competition games the elite subsample played was around 30 ($SD = 7.6$). The number of games on which the rating is based is a useful indicator of the rating validity and stability and in this case it indicates that chess rating was reliable. The number of games is probably even bigger given that most of the children had a chess rating for a couple of years. (We were not able to obtain the exact numbers because BCF does not have this information in their database.)

Furthermore, the same external criteria used to validate the three chess skill measures also indicated that chess rating is a valid measure - correlations with coaches' ratings were over .90. If anything, chess ratings seem to be a better measure of chess skill than Chess Test, Recall, and KRT. It is possible that the three chess skill measures applied here were less sensitive when it comes to the elite subsample, which may, in part, explain the discrepancy in the results obtained with the elite subsample when different measures of chess skill were employed.

One could also argue that our results may be artefacts of the decision to use standardized intelligence scores and to include age as one of the predictors in the regression analyses. However, we performed the same analyses with raw intelligence scores and age as well as with standardized scores and without age. All analyses produced comparable results as presented here – intelligence had a positive albeit weaker effect on chess skill than practice when the whole sample was taken into account, while the link was moderately negative (just failing to reach significance) in the elite subsample.

Finally, it is possible that the elite subsample was not only highly intelligent but also restricted in the range of intelligence, which may have distorted the association with chess rating. The intelligence scores in the elite subsample varied slightly less than the intelligence scores of the other child players (standard deviation for the elite subsample was 12, while it was 15.3 for the rest of children) and were slightly more restricted in comparison with the other players (range for IQ in the elite sample was 108 – 157, while the range for the other players was 83 - 146). The elite sample did not, however, encompass only highly intelligent children but also children with average IQ scores (e.g., some of the best players had IQs lower than 116). It is possible that these children with average intelligence had to spend more time in order to compensate for their less advanced intelligence, while highly intelligent children could achieve similar proficiency with less practice (see Detterman & Ruthsatz, 1999). This indeed seems to be the case as indicated by the negative relationship between intelligence and practice in the elite subsample ($r(23) = -.44$, $p = .036$). If the less intelligent children in the elite subsample needed more time than their intellectually better endowed peers to achieve a similar skill level, the association between practice and skill should become weaker when intelligence is controlled for. The effect of intelligence on the practice - chess skill link, however, was not strong enough to render the link among the elite subsample insignificant (the correlation after controlling for intelligence was still respectable - $pr(23) = .60$, $p = .003$; the correlation without controlling for intelligence was higher – $r(23) = .69$, $p < .001$).

7. Discussion

Our results highlight how difficult it is to find an unambiguous association between intelligence and chess skill. When we tested the whole sample of children, some of whom had just recently started to play chess, we found a moderately positive correlation between intelligence and chess skill thus confirming some previous studies (e.g., Horgan & Morgan, 1990; Frydman & Lynn, 1992). But when we examined the role of intelligence among highly skilled young chess players we found not only the same absence of the association between intelligence and chess skill that is usually reported among adult chess players (e.g., Cranberg & Albert, 1988; Djakow et al, 1927; Doll & Mayr, 1988; Ellis, 1973; Grabner et al., 2006; Unterrainer et al., 2006; Waters et al., 2003), but also that smarter children had actually achieved a lower level of chess skill. This unexpected negative association between intelligence and chess skill is partly the consequence of the different chess skill measures used for the whole sample and the elite subsample. When the chess skill measures were used instead of chess rating in the elite subsample, the association between chess skill measures and intelligence was not negative. But, nevertheless, the association was nonexistent which implies that intelligence does not have a major impact on the chess skill of very good young chess players.

The unexpected results in the elite subsample can be explained by considering practice. While more intelligent children seemed to spend more time on chess than their less intelligent peers (see Table 1), this was not the case in the elite subsample - more intelligent children in the elite subsample invested less time in chess. Since practice is by far the best predictor of chess rating, it can be understood why intelligence had a negative association with chess rating.

On the other hand, it was also clear that the elite subsample had a restricted range of IQ scores in comparison with the other players. The range restriction in this particular study was not, however, particularly high and although more intelligent elite players spent less time on chess than their less intelligent peers, practice was still highly associated with rating after intelligence was controlled for.

These results suggest that the differences in the amount of time spent on chess between less and more intelligent players in the elite subsample may not be as large as one would expect if intelligence was particularly strongly correlated with chess skill. It is possible that some specific chess activity children engaged with made an additional impact on chess skill. Practice in our study can hardly be called deliberate practice where players intentionally focus on parts of their performance they want to improve, because it consisted mostly of playing chess games during the chess club time. However, some players in the elite subsample were particularly active playing tournaments and receiving individual and group chess coaching.

Individual intelligence subtests were weaker predictors than the composite IQ score. Some of them, especially Symbol Search and Digit Span, nevertheless predicted chess skill measures well. It is somewhat surprising that visuo-spatial ability, as measured by Block Design, was arguably the worst predictor of chess skill among all other abilities we used in this study. This finding is in stark contrast with speculation of lay people and some researchers (e.g., Frydman & Lynn, 1992; Howard, 2005a; 2005b) as well as with some empirical findings (e.g., Frydman & Lynn, 1992; Horgan & Morgan, 1990). The studies on visuo-spatial abilities and chess are not without their problems, as we argued in the introduction. It is also possible that mental rotation tasks (Shepard & Metzler, 1971), which were not used in the previous studies or in this one, would be more suited to capture the layman's notion of calculation and manipulation of chess positions. Given that Binet's study on blindfold chess (1966/1893) demonstrated that even the best players do not visualise the transformations on their imagined chess board with concrete images, and given the abundance of findings which suggest that search abilities do not matter as much as knowledge acquired through practice (e.g., Chase & Simon, 1973a; Campitelli & Gobet, 2004; de Groot, 1978/1946; Gobet, 1998; Saariluoma, 1995), we believe that the common view of the great importance of visuo-spatial ability is a myth.

One of the reasons why visuo-spatial abilities did not correlate with chess skill in this study with young players is practice. Practice had the biggest effect on chess skill measures in all analyses. When it was included in the analyses, not only was the influence of intelligence lowered, but also age and experience, previously significant predictors of chess skill, became irrelevant factors. Older and more experienced children will have had more time to log in more practice hours which in return should be reflected in high intercorrelations between the three constructs (see Table 1). However, age and experience were rather moderate predictors of chess skill even when practice was not included. Age also did not play a significant role in the elite subsample even before practice was introduced in the analysis. These findings indicate that the distinction between experience per se and practice by some researchers (e.g., Ericsson et al., 1993) is justified even among children where the connection between experience and practice is arguably stronger than in adults.

Practice is a better predictor of chess skill than intelligence, even among children with limited experience. This seems to be particularly true for highly skilled young chess players as in our study the association of chess skill with intelligence in this group was at best nonexistent and at worst negative. There are, however, several reasons why it would be premature to write off intelligence as a factor in the process of chess skill acquisition. Firstly, our sample was undoubtedly exceptional (average IQ of above 120) which may have distorted the results. We do not know how well other children in the same schools would score on the intelligence tests we administered. It should be noted, however, that our study was conducted more than ten years after the UK norms for WISC III were published (the norms were made in 1992 and our study in 2005). Is it well established that next generations score around 10 points higher on the same standardized scale (Kaufman, 1994).

Secondly, the scores of our elite subsample were impressive (average IQ above 130, some scoring as high as 157) and by themselves present evidence that intelligence plays a role in the process of chess skill acquisition. Intelligence did not have significant influence among these highly intelligent children but it is a fact that they did play better chess than their peers who scored less on WISC III. One could hypothesise that for successful chess playing a certain level of general intelligence is necessary after which other factors contribute more. This may be the case but the rest of the sample also had been playing chess for a much shorter period of time, which makes it difficult to disentangle the influence of practice and intelligence.

Similarly, the elite players were of a more uniform intelligence than the other players. Although the restricted range of intelligence in the elite players in this study did not seem to be particularly pronounced, it is difficult to deny that established performers are usually highly selected which makes it difficult to uncover unambiguous associations with skill. The case of intelligence in our study, which was a significant predictor when we used a full range of players and negligible when we considered only the best players, nicely illustrates the danger of drawing conclusion based on association among a restricted pool of established performers.

Our study demonstrates that the role of intelligence in the acquisition of chess skill should not be assessed separately from other relevant factors. Many factors beside intelligence played significant roles in the process (e.g., practice, experience, age, gender). They are all relevant and, when analysed separately, explain quite well on their own why some children are better at chess than others. Some of them are related to each other which makes it even more difficult to assess their relative contribution to the chess skill acquisition process. These problems are not only related to chess skill but to most real-life situations. The complexity of the real-world situations with a number of factors and their numerous interactions makes it difficult to disentangle the influences of intelligence and practice. Avoiding focusing on only one aspect of performance will at least spare us unpleasant surprises. Our study, for example, showed that more intelligent children tend to spend more time on chess activities. In the elite subsample, however, the situation was reverse - less intelligent children spent more time on chess activities which resulted in negative correlation of intelligence with chess skill. Without the additional inclusion of practice in the study, we would be left wondering about the paradoxical situation of positive association between intelligence and chess skill in the whole sample and negative in the elite subsample.

Given that intelligence seems to correlate with chess skill at the beginning (our sub-sample of non-elite players; Frydman & Lynn, 1992; Horgan & Morgan, 1990), it makes sense to assume that intelligent children will have more success at the beginning. The positive association between intelligence and practice could hence be the consequence of this initial success – more successful children will be more motivated and interested which will turn result in more time spending on chess activities. The children who lag behind their peers in chess development are more likely to be less motivated and to eventually stop with the activity altogether. This plausibly explains why practice and intelligence are related and why we may end up with highly selective individuals as a consequence of selective drop-out. The possible scenario described above is, however, just a first step on the long road to excellence. How many of the children in the elite subsample will become very good chess players remains to be seen. It is, however, almost certain that it will happen not because of just one factor but because of a complex interplay between many factors. Our study presents the first step in shedding some light on those complex processes.

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Table 1. Descriptive statistics and intercorrelations of variables used in the study ($N = 57$).

	M	*SD*	Gend	Exp	Pract	CT	Rec	KRT	IQ	Voc	BD	SS	DS
Age (years)	10.7	1.2	.17	.64**	.51**	.48**	.49**	-.53**	.08	-.20	.04	.17	.26*
Gender (0 = girls)	23% girls		--	.27*	.36**	.51**	.48**	-.48**	.37**	.23	.36*	.18	.32*
Experience (years)	4.3	1.8		--	.65**	.54**	.56**	-.44**	.15	-.03	.01	.14	.26*
Practice ($\log_{10}$ hours)	2.1	0.6			--	.90**	.79**	-.76**	.44**	.28*	.31*	.48**	.51**
Chess Test (points)	34.2	9.7				--	.87**	-.82**	.55**	.26*	.28*	.50**	.58**
Recall (%)	39	24					--	-.71**	.54**	.30*	.33*	.51**	.48**
KRT ($\log_{10}$ av. time)[1]	1.1	0.5						--	-.49**	-.18	-.29*	-.42**	-.57**
IQ	121.6	16.7							--	.73**	.77**	.77**	.77**
Vocabulary	15.1	3.0								--	.46**	.41**	.32**
Block Design	13.0	3.0									--	.47**	.50**
Symbol Search	12.4	3.0										--	.51**
Digit Span	11.2	3.4											--

Note. *$p < .05$, ** $p < .01$; *Gend = gender, Exp = experience, Pract = practice, CT = Chess test, Rec = Recall, KRT = Knight's Row Taks, IQ = Intelligence, Voc = Vocabulary, BD = Block Design, SS = Symbol Search, DS= Digit Span. (See text for the details of the tests used.)*

[1] This is the $\log_{10}$ of the average time per square, in seconds.

Table 2. Hierarchical regression analysis on Chess Test, Recall, and KRT using age, gender, experience (years playing), practice, IQ, and individual intelligence subtests as predictors.

Chess Test (*N* = 57)		*β*	*p*	VIF	R^2	ΔR^2	$\Delta F(df)$	Δp
Model 1	Gender	0.51	0.00	1.00	0.26	0.26	19.71 (1,55)	0.00
Model 2	Gender	0.45	0.00	1.03	0.43	0.16	15.33 (1,54)	0.00
	Age	0.41	0.00	1.03				
Model 3	Gender	0.30	0.00	1.18	0.57	0.14	17.5 (1,53)	0.00
	Age	0.40	0.00	1.03				
	IQ	0.41	0.00	1.16				
Model 4	Gender	0.17	0.01	1.24	0.86	0.29	104.74 (1,52)	0.00
	Age	0.08	ns	1.39				
	IQ	0.16	0.01	1.37				
	Practice	0.72	0.00	1.80				
Model 5	Gender	0.18	0.00	1.25	0.86	0.01	2.14 (1,51)	0.15
	Age	0.12	ns	1.76				
	IQ	0.15	0.02	1.40				
	Practice	0.78	0.00	2.33				
	Experience	-0.12	ns	2.32				
Recall (*N* = 57)								
Model 1	Gender	0.48	0.00	1.00	0.23	0.23	16.19 (1,55)	0.00
Model 2	Age	0.41	0.00	1.03	0.40	0.17	15.75 (1,54)	0.00
	Gender	0.42	0.00	1.03				
Model 3	Age	0.26	0.01	1.18	0.54	0.14	16.44 (1,53)	0.00
	Gender	0.41	0.00	1.03				
	IQ	0.40	0.00	1.16				
Model 4	Gender	0.16	0.06	1.24	0.71	0.16	29.06 (1,52)	0.00
	Age	0.17	0.06	1.39				
	IQ	0.22	0.02	1.37				

	Practice	0.54	0.00	1.80				
Model 5	Gender	0.16	0.07	1.25	0.71	0.00	0.18 (1,51)	0.67
	Age	0.15	ns	1.76				
	IQ	0.22	0.02	1.40				
	Practice	0.52	0.00	2.33				
	Experience	0.05	ns	2.32				
KRT (*N* = 57)								
Model 1	Gender	-0.47	0.00	1.00	0.23	0.23	16.01 (1,55)	0.00
Model 2	Gender	-0.40	0.00	1.03	0.43	0.21	19.54 (1,54)	0.00
	Age	-0.46	0.00	1.03				
Model 3	Gender	-0.27	0.01	1.18	0.54	0.11	12.25 (1,53)	0.00
	Age	-0.45	0.00	1.03				
	IQ	-0.35	0.00	1.16				
Model 4	Gender	-0.18	0.04	1.24	0.67	0.13	20.16 (1,52)	0.00
	Age	-0.24	0.02	1.39				
	IQ	-0.19	0.05	1.37				
	Practice	-0.48	0.00	1.80				
Model 5	Gender	-0.20	0.02	1.25	0.69	0.03	4.47 (1,52)	0.04
	Age	-0.34	0.00	1.76				
	IQ	-0.16	0.09	1.40				
	Practice	-0.60	0.00	2.33				
	Experience	0.25	0.04	2.32				

Table 3. Hierarchical regression analysis on ELO of the elite subsample using age, experience (years of playing), practice, IQ, and individual intelligence subtests as predictors.

Chess Rating (*n* = 23)		β	*p*	VIF	R^2	ΔR^2	$\Delta F(df)$	Δp
Model 1	Age	0.32	ns	1.00	0.10	0.10	2.33 (1,21)	0.14
Model 2	Age	0.22	0.26	1.05	0.30	0.20	5.76 (1,20)	0.03
	IQ	-0.46	0.03	1.05				
Model 3	Age	0.26	ns	1.05	0.59	0.29	13.11 (1,19)	0.00
	IQ	-0.18	ns	1.31				
	Practice	0.60	0.00	1.25				
Model 4	Age	0.58	0.01	1.98	0.70	0.11	6.42 (1, 18)	0.02
	IQ	-0.29	0.07	1.42				
	Practice	0.79	0.00	1.59				
	Experience	-0.54	0.02	2.72				