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# The Role of Deliberate Practice in Chess Expertise

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SUMMARY

Two large, diverse samples of tournament-rated chess players were asked to estimate the frequency and duration of their engagement in a variety of chess-related activities. Variables representing accumulated time spent on serious study alone, tournament play, and formal instruction were all significant bivariate correlates of chess skill as measured by tournament performance ratings. Multivariate regression analyses revealed that among the activities measured, serious study alone was the strongest predictor of chess skill in both samples, and that a combination of various chess-related activities accounted for about 40% of the variance in chess skill ratings. However, the relevance of tournament play and formal instruction to skill varied as a function of skill measurement time (peak vs. current) and age group (above vs. below 40 years). Chess players at the highest skill level (i.e. grandmasters) expended about 5000 hours on serious study alone during their first decade of serious chess play—nearly five times the average amount reported by intermediate-level players. These results provide further evidence to support the argument that deliberate practice plays a critical role in the acquisition of chess expertise, and may be useful in addressing pedagogical issues concerning the optimal allocation of time to different chess learning activities.


How long does it take to become an expert in chess? Based on theoretical arguments about information processing efficiency and computer simulations of pattern recognition in chess, Simon and colleagues (Simon & Chase, 1973; Simon & Gilmartin, 1973) proposed a '10-year rule' for the development of chess expertise. In other words, one needs about a decade of study in order to acquire the necessary knowledge base to perform at very high levels of tournament play (see F. Gobet & N. Charness, submitted; Expertise in chess. In K. A. Ericsson, N. Charness, P. Feltovich, & R. Hoffman (Eds.), *Cambridge handbook of expertise and expert performance*. New York: Cambridge University Press; Gobet, de Voogt, & Retschnitzki, 2004, for review).

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Subsequent studies of populations ranging from elite musicians to marathon runners yielded substantial empirical evidence to support the application of the ten-year rule to other skill domains (see Ericsson, Krampe, & Tesch-Römer, 1993, for review). More importantly, these studies have led to significant insights into the nature or type of activities that are most conducive to the development of expertise.

Based on accumulated evidence from historical records, biographical anecdotes, and experimental investigations, Ericsson and colleagues (Ericsson et al., 1993; Ericsson & Charness, 1994) argue that the key activity in the acquisition of expertise is deliberate practice, which they define as appropriately challenging tasks that are chosen with the goal of improving a particular skill. As such, deliberate practice can be contrasted with activities such as work and competitive performance, where task demands and goals may vary greatly in difficulty and fall beyond one's control, or play, where the task is relatively easy and is performed with minimal regard for accuracy or the improvement of one's ability. The distinction between deliberate practice, performance, and play has been useful in differentiating among learning activities of individuals at various stages of skill acquisition in domains ranging from music (Ericsson et al., 1993; Sloboda, Davidson, Howe, & Moore, 1996) to athletics (Côté, Baker, & Abernathy, 2003; Ward, Hodges, Williams, & Starkes, 2004).

In the present paper, we are primarily concerned with the relative influence of different activities on the development of chess expertise. Comments from prominent chess coaches indicate that there is uncertainty about the relative importance of activities such as serious study alone and tournament play (Pandolfini, 1992). For instance, some would argue that the amount and variety of information available in a given period of time are likely to be greater during self-study, when one can choose from a potentially vast library of materials, than during game play, where one is restricted to solving problems within a single game against a single opponent. At the same time, there may be certain elements of the tournament context that cannot be easily simulated in a solitary study environment. For instance, in high-level chess tournaments, games are played with chess clocks that limit the amount of time that players can spend on choosing their moves, and there may be distractions in a tournament environment that challenge players' abilities to concentrate—a challenge that increases in difficulty as one progresses from one game to the next in a multi-game tournament.

As we have argued elsewhere (Charness, Krampe, & Mayr, 1996), serious study alone fits the definition of deliberate practice presented in Ericsson et al. more precisely than competitive play against others. Our rationale is as follows. First, in self-directed or coached study, materials can be deliberately chosen or adapted such that the problems to be solved are at a level that is appropriately challenging. However, the difficulty of the problems encountered in a tournament environment may vary greatly due to the fact that a given player in a typical chess tournament is usually matched against opponents who are both significantly weaker and significantly stronger than his or her skill level. Skill improvement is likely to be minimized when facing substantially inferior opponents, because such opponents will not challenge one to exert maximal or even near-maximal effort when making tactical decisions, and problems or weaknesses in one's play are unlikely to be exploited. At the same time, the opportunity for learning is also attenuated during matches against much stronger opponents, because no amount of effort or concentration is likely to result in a positive outcome. The player pairing system used in most modern chess tournaments (i.e. the Swiss system) is specifically designed in such a manner that one is unlikely to play an opponent of roughly equal skill until the final rounds (see Elo, 1986). Hence, one may spend an entire weekend in competition, and perhaps only a single game engaged in play against an equally skilled opponent.

 

Second, serious study activities in chess are usually selected to address specific weaknesses in skill, using tasks that allow for multiple repetitions of similar problems or that provide opportunities to test multiple solutions to the same problem such that one can learn to discriminate between stronger and weaker solutions. Unfortunately, the goals and rules of tournament play do not allow one to engage the same opponent in repeated exposure to a single situation or set of situations in a manner that is conducive to learning. A move, once made, cannot be undone, and there is little motivation for an opponent in a high-stakes chess tournament to help the other player identify the best move in a given position. Consequently, we would argue that opportunities for skill improvement are severely restricted during tournament play.

The kind of exploratory learning activities that are necessary for obtaining accurate and complete feedback about one's solutions can be done more effectively outside of the tournament environment, where a player can construct and reconstruct a given position or series of positions as many times as necessary in order to explore the effectiveness of various move choices. Here, formal instruction from a knowledgeable other may become relevant. Coaches or teachers can provide immediate feedback about move choices, help identify a player's weaknesses and strengths, and direct the player towards appropriate study materials and learning goals. Yet, it is unlikely that such instruction can be effective if the student does not spend time engaging in solitary study to achieve those goals, and does not seek out opportunities to demonstrate skill under actual tournament conditions. In addition, much of the knowledge provided by coaches is available in books and computer programs, and for many beginner players, the financial investment in coaching sessions and the discipline necessary to prepare for regular lessons is neither affordable nor desirable. Indeed, some prominent self-taught players argue that it is possible, and perhaps more practical, to learn the game without the help of a coach.

In a preliminary study of the relative importance of various chess activities, Charness et al. (1996) surveyed tournament-rated chess players from Europe, Russia, and Canada to ascertain their beliefs about the relevance of different chess activities to their overall chess skill, and to collect estimates of the frequency and duration of time spent on these different activities. Although participants in this study rated active participation in tournaments as slightly more relevant to improving one's chess skill than serious analysis of positions alone, subsequent regression analyses revealed that cumulative serious solitary chess study was the single most powerful predictor of chess skill ratings among a broad set of potential predictors, including tournament play and coaching.

Although the results reported in Charness et al. are consistent with the deliberate practice framework, these results were based on a single, moderately sized sample of players, and the regression equations reported in that study were not constrained in such a manner as to allow for direct comparisons of the predictive influence of study, competition, and instruction. Hence, our primary goal in this paper is to assess the relative importance and stability of these three different activities towards the prediction of individual differences in chess skill. To this end, we examined the self-reported frequency and duration of chess-related activities in two international samples of chess players measured several years apart. The first sample represented a completed version of the convenience sample described in Charness et al. (1996). The second, independent sample contained only intermediate and expert-rated players and was recruited in a manner such that age and skill level were orthogonal. Simultaneous regression equations were then constructed in order to assess the relative impact of the quantity of serious study, competitive play, and formal instruction on chess skill in each sample. If self-report

 

estimates of time spent on serious study and other chess-related activities are robust and reliable predictors of ability, their influence ought to remain significant across different age ranges, skill ranges, and time periods. In addition, pooling the two samples together allowed us to conduct the largest analysis to date ($n = 375$) of the role of deliberate practice and other domain-relevant experience in expert performance.

## METHOD

### Sample

Participants in the two samples used for this study were recruited from four different countries: Canada (Toronto), Germany (Berlin and Potsdam), Russia (Moscow), and the United States (Atlanta, Orlando, and Tallahassee). The first sample ($N = 239$; 214 males, 25 females) was recruited between 1993 and 1995,[1] and the second sample ($N = 180$; 153 males, 27 females) was recruited between 1997 and 1999. Participants from both samples were recruited via newspaper ads, personal contacts, and announcements at chess clubs and tournaments. However, the samples differed from each other in terms of eligibility restrictions and selection procedures. In the first study, there were no restrictions on participation in terms of skill level or age, but in the second study, prospective participants needed to have a chess skill rating of 1600 and be at least 18 years of age, and a stratified sample selection procedure was implemented to minimize the relationship between age and skill level.[2] Also, given the estimated 20:1 ratio of men to women participating in high-level chess (Charness & Gerchak, 1996), we attempted to over-sample female players in both samples. All participants were paid a small stipend upon completion of the study.

### Materials

Participants in the first sample completed a paper-and-pencil survey containing the following sections: (1) demographics and chess-related developmental milestones, (2) cumulative chess activities, and (3) current chess activities. The second sample completed a survey containing items identical to those in the above sections, but with additional sections added to measure attitudes toward chess playing (not analysed here). Surveys given to the Berlin and Moscow sites were translated into German and Russian respectively, with back-translation to English to check the accuracy of the translation prior to final distribution. Surveys typically took between 30 min and 1 hour to complete. Selected items from the survey are reproduced in Appendix A.

### Procedures

Participants received a consent form, a cover letter and the survey either in person or by mail with instructions to complete and return the survey within 1 month.[3] Participants reported estimates of time spent on serious study alone and serious play against others in

[1]Note that the first sample reported here contains 80 additional players that were recruited after the analysis of the sample described in Charness et al. (1996).
[2]A stratified sampling procedure was employed in which roughly equal numbers of participants reporting intermediate (1600–1899), sub-expert (1900–2199), and expert (2200+) chess skill ratings were recruited from within three adult age ranges (18–39, 40–59, 60+).
[3]Given the diverse ways in which players were recruited, we cannot provide reliable estimates of the response rate to initial contacts. At best, we can only say that a majority of the surveys that were distributed were eventually returned.

 

hours per typical week for each year beginning from the first year that they learned to play chess and continuing up to and including the year of the survey (current year). Cumulative yearly estimates of time spent on serious study alone and serious play against others were calculated (by the researchers) by multiplying each participant's typical week time estimates by 52 weeks at each age, and then adding the total hours for each year together. Participants also reported the ages, if any, during which they received either individual or group chess instruction. Estimates of time spent on cumulative chess instruction, both individual and group, were derived by subtracting the age at which each participant began instruction from the age at which each participant ceased instruction.

## RESULTS

Several steps were taken to ensure the quality of the data prior to correlation and regression analyses. First, self-reported current chess ratings were verified wherever possible against published rating lists, and mathematical conversions were made, where necessary, to ensure equivalence of ratings across different tournament organizations.[4] Second, we deleted from analysis any players in the second sample (by examining matches for name and birth date) who appeared to have participated in the first sample in order to ensure independence of the two groups. We also used a conservative list-wise deletion procedure during statistical analyses to eliminate potentially biasing influences of incomplete cases on correlation and regression coefficients. Furthermore, given the relatively large sample sizes and our desire to avoid type-1 errors, we adopted $p < 0.01$ as the criterion for statistical significance. Finally, based on established evidence of non-linear growth in skilled performance with increasing practice (i.e. power law learning functions: Newell & Rosenbloom, 1981; and specifically for chess, Charness, 1989), and to be consistent with prior published studies (Charness et al., 1996), we applied $\log^{10}$ transformations to three variables (cumulative study alone, cumulative tournament play, and chess book library size) prior to correlation and regression analyses.

Descriptive statistics and correlations for a subset of the chess-related variables collected from each sample are shown in Tables 1 and 2. We focus here primarily on the relations between chess-related activities and skill levels. Moderate correlations were found between chess skill and most of the chess activities listed, with log-transformed cumulative study alone being the strongest bivariate correlate of current skill level in both samples ($r = 0.54$ and 0.48 for samples 1 and 2 respectively). However, it should be noted that the distributions of the time estimates for several chess-related activities were strongly positively skewed, with many players (primarily weaker ones) reporting low quantities, and a few players (mainly stronger ones) reporting significantly higher quantities.

Six chess-related activities were submitted to linear regression analyses as predictors of current and peak chess skill. These six variables were chosen to represent two major categories of accumulated serious chess activity (study alone and tournament play), two major categories of accumulated chess instruction (individual and group), and two major

[4]Only the very elite players in the sample had international ratings so for those providing national federation ratings, we converted these ratings to Elo ratings (Elo, 1986) using native rating levels for German (first converting any older INGO ratings that predated the modern rating system using suggested conversions by the German Chess Federation), Canadian, Dutch, and Russian players and by converting US ratings to Elo ratings by subtracting 50 points. The latter correction was suggested by an informal study by the United State Chess Federation (USCF) of how to convert foreign ratings to USCF ones through comparing US players who had both Elo ratings and USCF ratings (Mark Glickman, personal correspondence).

 

Table 1. Correlations and descriptive statistics for chess skill levels, activities, and age variables: Sample 1 (list-wise $n = 200$)

| Variables | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Current skill rating | | **0.54** | **0.41** | **0.38** | **0.21** | **0.37** | **0.22** | **0.53** | **−0.24** | **−0.28** | **−0.41** |
| 2. Total log hours serious study | | | **0.65** | **0.31** | **0.24** | **0.41** | **0.20** | **0.41** | **0.26** | 0.03 | −0.08 |
| 3. Total log hours tournament play | | | | **0.21** | **0.26** | **0.24** | **0.28** | **0.30** | **0.34** | 0.03 | −0.01 |
| 4. Total years private instruction | | | | | **0.52** | **0.24** | 0.04 | **0.18** | −0.08 | −0.17 | −0.17 |
| 5. Total years group instruction | | | | | | 0.15 | 0.12 | 0.17 | 0.04 | −0.15 | **−0.20** |
| 6. Current hours/week serious study | | | | | | | **0.31** | 0.17 | −0.06 | −0.03 | −0.04 |
| 7. Current hours/week tourn. play | | | | | | | | 0.17 | −0.11 | −0.02 | −0.06 |
| 8. Chess books owned (log) | | | | | | | | | −0.05 | **−0.21** | **−0.24** |
| 9. Current age | | | | | | | | | | **0.44** | **0.58** |
| 10. Starting age | | | | | | | | | | | **0.57** |
| 11. Serious age | | | | | | | | | | | |
| Mean | 2032 | 3.4 | 3.5 | 1.2 | 2.4 | 4.1 | 1.4 | 1.7 | 34.7 | 9.4 | 16.1 |
| *SD* | 278 | 0.5 | 0.4 | 3.4 | 4.4 | 5.1 | 2.0 | 0.4 | 14.1 | 4.3 | 9.2 |

*Note*: Coefficients in bold are statistically significant at $p < 0.01$.

Table 2. Correlations and descriptive statistics for chess skill levels, activities, and age variables: Sample 2 (list-wise deletion, $n = 164$)

| Variables | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Current skill rating | | **0.48** | **0.26** | **0.21** | **0.25** | **0.27** | **0.22** | **0.52** | 0.02 | −0.13 | **−0.30** |
| 2. Total log hours serious study | | | **0.47** | 0.14 | 0.10 | **0.38** | 0.13 | **0.55** | **0.46** | 0.16 | −0.07 |
| 3. Total log hours tournament play | | | | 0.13 | **0.20** | 0.03 | 0.15 | **0.32** | **0.49** | 0.04 | −0.02 |
| 4. Total years private instruction | | | | | **0.24** | 0.07 | 0.04 | 0.19 | 0.06 | 0.06 | −0.11 |
| 5. Total years group instruction | | | | | | −0.01 | 0.13 | **0.21** | 0.00 | −0.13 | **−0.31** |
| 6. Current hours/week serious study | | | | | | | 0.18 | **0.31** | 0.13 | −0.00 | −0.00 |
| 7. Current hours/week tourn. play | | | | | | | | 0.05 | −0.06 | −0.10 | −0.11 |
| 8. Chess books owned (log) | | | | | | | | | **0.31** | 0.15 | −0.07 |
| 9. Current age | | | | | | | | | | **0.41** | **0.35** |
| 10. Starting age | | | | | | | | | | | **0.36** |
| 11. Serious age | | | | | | | | | | | |
| Mean | 2008 | 3.5 | 3.5 | 1.5 | 2.4 | 4.4 | 1.1 | 1.7 | 44.3 | 9.1 | 16.0 |
| *SD* | 253 | 0.4 | 0.5 | 5.1 | 3.5 | 5.4 | 1.2 | 0.5 | 15.9 | 3.6 | 7.9 |

*Note*: Coefficients in bold are statistically significant at $p < 0.01$.

Table 3. Regression of current chess skill level on chess activities in two independent samples of tournament-rated chess players

| Chess activity predictor variables | Sample 1 ($n = 206$) | | Sample 2 ($n = 169$) | | Combined sample ($n = 375$) | |
|---|---|---|---|---|---|---|
| | B (*SE*) | Beta | B (*SE*) | Beta | B (*SE*) | Beta |
| Constant | 1037 (137.3) | | 1198 (141.5) | | 1145 (98.6) | |
| Total log hours serious study | 185 (44.3) | **0.33** | 198 (42.2) | **0.38** | 195 (30.6) | **0.36** |
| Total log hours tournament play | 83.9 (49.0) | 0.12 | 4.1 (38.6) | 0.00 | 32.7 (30.8) | 0.05 |
| Total years private instruction | 20.8 (5.4) | **0.27** | 5.5 (3.2) | 0.11 | 9.4 (2.8) | **0.15** |
| Total years group instruction | −4.2 (4.2) | −0.06 | 10.4 (4.8) | 0.14 | 4.3 (3.0) | 0.06 |
| Current hours/week serious study | 6.6 (3.4) | 0.12 | 5.2 (3.3) | 0.11 | 6.3 (2.4) | **0.12** |
| Current hours/week tournament play | 16.0 (8.0) | 0.11 | 25.6 (13.5) | 0.12 | 20.3 (6.8) | **0.13** |
| Model summary | $R^2 = 0.41$ (adj. $R^2 = 0.39$) $F(6, 199) = 23.06$ Std. error of estimate = 223 | | $R^2 = 0.31$ (adj. $R^2 = 0.28$) $F(6, 162) = 12.16$ Std. error of estimate = 213 | | $R^2 = 0.34$ (adj. $R^2 = 0.33$) $F(6, 368) = 32.13$ Std. error of estimate = 222 | |

*Note*: Coefficients in bold are statistically significant at $p < 0.01$.

categories of current serious chess activity (study alone and tournament play). As there was no strong theoretical justification for entering the above predictors in any specific order, we entered all six of the above predictor variables simultaneously into the regression equations for each of the two samples.[5]

Coefficients for the prediction of current chess skill are provided in Table 3. Cumulative study alone (log transformed) was the strongest predictor of current skill among the six chess activities in both the first and second samples, with cumulative competitive play and cumulative individual instruction (years of instruction) showing some additional influence. We now discuss the relation of these variables to chess rating in each sample separately (sample 1, sample 2) and then as a combined sample.

## Sample 1

A slightly different pattern of predictors was significant in this enlarged sample, compared to Charness et al. (1996), though age, which correlated negatively with skill in the original sample, was not included as a predictor here. Log cumulative hours of serious study alone and years of private instruction were significant independent predictors of current skill level. The combined set of predictors together accounted for about 40% of the variance in current rating.

[5]Our goal here is to use multiple regression analysis as a descriptive technique for assessing the extent to which naturally correlated predictor variables account for unique variance in chess rating. Such analysis does not permit us to make statements about causal relations, but does allow us to test some aspects of the framework outlined in Charness et al. (1996), namely, whether some significant bivariate relations between predictors and rating are mediated by others. In both samples, it appears that cumulative study strongly mediates the influence of cumulative tournament play. For sample 1, $R^2 = 0.29$ with study first, and does not change ($R^2 = 0.29$) when tournament play is added. With tournament play entered first, $R^2 = 0.18$, but increases to 0.29 when study is added. For sample 2, $R^2 = 0.21$ with study first, and does not change ($R^2 = 0.21$) when tournament play is added. With tournament play entered first, $R^2 = 0.05$, but increases to 0.21 when study is added.

 

### Sample 2

As seen in Table 3, the only significant predictor of current chess rating from this variable set was log cumulative hours of serious study alone.

### Cross-validation

To assess the stability of the predictors in sample 1 we used the regression equation from this sample (constant and regression weights shown in column 2 of Table 3) to predict the current rating of chess players in the second sample. The correlation between predicted rating and actual rating in the second sample ($n = 169$) was $r = 0.46$, $p < 0.001$. Considering the differences in sample selection, wherein the second sample was selected to make age and skill unrelated, this is a reasonably strong validity coefficient.[6]

### Combined samples

When the two samples are combined, log cumulative serious study alone, years of private chess lessons and both current hour/week serious study alone and current hour/week of tournament play were all statistically significant predictors of current chess rating.

### Peak chess rating

One constraint on the ability to predict ratings is age of the player. Older players may have reached their peak before entering the study and have shown the type of slow decline past peak that Elo (1965) first identified. Thus, we examined the extent to which cumulative practice variables predict peak rating rather than current rating. Practice variables were created up to the age that the player recorded as their peak age. Table 4 shows the results.

Table 4. Regression of peak chess skill level on chess activities in two independent samples of tournament-rated chess players

| | Sample 1 ($n = 180$) | | Sample 2 ($n = 149$) | | Combined sample ($n = 329$) | |
|---|---|---|---|---|---|---|
| Chess activity predictor variables | B (*SE*) | Beta | B (*SE*) | Beta | B (*SE*) | Beta |
| Constant | 837.8 (154.5) | | 1229.2 (139.0) | | 1030.5 (102.9) | |
| Total log hours serious study | 203.9 (49.1) | **0.37** | 202.3 (44.4) | **0.44** | 199.5 (33.0) | **0.39** |
| Total log hours tournament play | 159.4 (56.3) | **0.24** | 30.4 (50.3) | 0.06 | 96.9 (37.5) | 0.17 |
| Total years private instruction | 14.3 (5.4) | 0.18 | 3.6 (3.3) | 0.07 | 6.6 (2.9) | 0.11 |
| Total years group instruction | 1.6 (4.1) | 0.02 | 9.5 (5.3) | 0.13 | 6.6 (3.1) | 0.10 |
| Peak hours/week serious study | 4.2 (3.0) | 0.11 | −1.4 (3.6) | −0.03 | 3.3 (2.2) | 0.08 |
| Peak hours/week tournament play | −5.1 (3.7) | −0.10 | 4.4 (3.9) | 0.10 | −0.7 (2.7) | −0.01 |
| Model summary | $R^2 = 0.45$ (adj. $R^2 = 0.44$) $F(6, 173) = 24.41$ Std. error of estimate = 212 | | $R^2 = 0.32$ (adj. $R^2 = 0.29$) $F(6, 142) = 11.45$ Std. error of estimate = 203 | | $R^2 = 0.38$ (adj. $R^2 = 0.37$) $F(6, 322) = 33.945$ Std. error of estimate = 210 | |

*Note*: Coefficients in bold are statistically significant at $p < 0.01$.

[6]Cohen (1988) considers $r = 0.5$ to be a large effect size in social science research.

 

This time, both serious study alone and tournament play uniquely predict peak rating in sample 1, though only serious study alone predicts peak rating in sample 2 or in the combined sample.

### Age subsets

It is also necessary to consider how the chess activities investigated here may vary in their predictive strength across different age periods. Based on a longitudinal study of grandmasters (Elo, 1965) and an evaluation of cross-sectional trends in a complete cohort from the US (Charness et al., 1996), there is significant evidence to argue that the peak age of competitive chess performance occurs in the mid-to-late thirties. Thus, we partitioned players in the combined sample into those below versus above age 40, and re-computed the simultaneous regression equations with the six predictor variables. Results for the regressions of current skill ratings on the six chess activity predictor variables in each age sub-sample are shown in Table 5.

In the young adult partition of the combined sample, cumulative solitary practice, cumulative tournament play, years of private chess lessons, and current serious study alone were significant predictors. In the older sample, only serious study alone was a significant predictor.

### Rating gain during the first decade of serious play

Elo (1986) argued that the trajectories of rating gain for those who eventually became top players (e.g. grandmasters) seemed to be steeper over time than that for international masters or that for national masters. One potential explanation for that rating gain difference is a difference in the rate of accumulated knowledge about chess. The latter variable may be a direct function of deliberate practice differences. To assess this possibility, we plotted the cumulative hours of deliberate practice for our combined sample after dividing them into five rating ranges corresponding to 200-point intervals in the Elo system. Figure 1 shows that there is little difference in hours of study in the first year that players reported becoming serious about chess, though the players who later

Table 5. Regression of current chess skill level on chess activities in younger (age $< 40$) and older (age $> = 40$) chess players

| | Younger ($n = 216$) | | Older ($n = 159$) | |
|---|---|---|---|---|
| Chess activity predictor variables | B (*SE*) | Beta | B (*SE*) | Beta |
| Constant | 796 (131.9) | | 796 (158.6) | |
| Total log hours serious study | 219 (36.8) | ***0.37*** | 248 (46.1) | ***0.45*** |
| Total log hours tournament play | 133 (38.9) | ***0.20*** | 53.8 (44.8) | 0.09 |
| Total years private instruction | 16.4 (5.2) | ***0.19*** | 4.9 (3.0) | 0.10 |
| Total years group instruction | 1.9 (4.7) | 0.02 | 2.1 (3.5) | 0.04 |
| Current hours/week serious study | 9.5 (3.2) | ***0.16*** | 2.5 (3.1) | 0.05 |
| Current hours/week tournament play | 2.0 (7.2) | 0.01 | 32.3 (13.6) | 0.15 |
| Model summary | $R^2 = 0.47$ (adj. $R^2 = 0.46$) $F(6, 209) = 31.84$ Std. error of estimate $= 200$ | | $R^2 = 0.41$ (adj. $R^2 = 0.39$) $F(6, 152) = 18.18$ Std. error of estimate $= 206$ | |

*Note*: Coefficients in bold are statistically significant at $p < 0.01$.

 

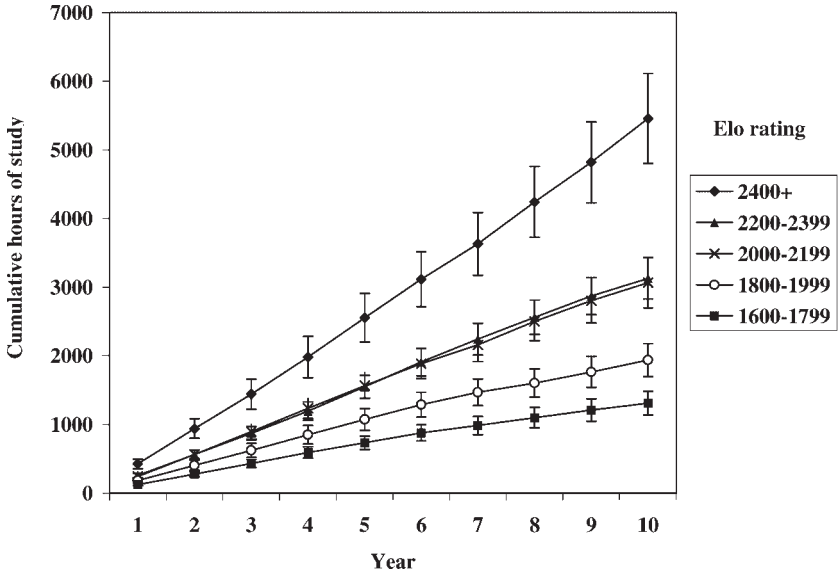


Figure 1. Accumulated solitary chess study by Elo rating during the first decade of serious chess play (bars represent $\pm 1$ standard error from the mean)

occupy the top skill group have put in somewhat more time. However, the groups begin to differentiate strongly by about the fourth year. By the tenth year, the top-performing group has accumulated in excess of 5000 hours of serious study alone, a figure quite comparable to that estimated for symphony-level classical musicians (Ericsson et al., 1993).

## DISCUSSION

Cumulative hours of serious study alone, arguably the best index of cumulative deliberate practice in chess, was the single most important predictor of a player's current chess rating among a set of activities considered by experts to be relevant to chess skill (Charness et al., 1996). This variable consistently carried the most weight of all chess activity variables in the series of analyses that we presented, and it strongly differentiated between elite (i.e. grandmaster) and average (i.e. intermediate) tournament-rated chess players by the tenth year of play.

In some analyses, particularly for younger players, cumulative hours of play in tournaments also served as an independent predictor of current skill level. Years of individual chess lessons also played a significant role in current skill level under certain circumstances, but in terms of the standardized regression weights, played a relatively minor role.

The relationships between rating and the various forms of practice replicated reasonably well across samples, and our validity coefficient was reasonably strong. Indeed, questionnaire estimates of time devoted to these practice variables accounted for about 40% of the variance in skill in two large, independent, diverse populations of chess players.

We can now attempt to answer the question posed by chess coaches about how a player should allocate time to study versus over-the-board play. Based on the regression equations presented in this paper, we could argue that players ought to devote more

 

time to the former than the latter if they want to see large increases in their tournament ratings. For instance, for the combined sample in Table 3, each log unit of serious study alone yields about 200 rating points compared to 33 rating points for log tournament play. Hence, players ought to devote the majority of their time to that activity. However, for a younger player, tournament play does make an independent contribution to current skill level.

One reason for the difference in the influence of tournament experience among younger versus older players may be that there is a fair amount of knowledge required to self-regulate during tournament play. For instance, unlike study alone (except perhaps when playing practice games with a computer opponent), under tournament conditions a player must play with a chess clock and learn to manage time effectively when choosing a move, all while ignoring potentially distracting events taking place in the tournament hall. In short, there are skills to be acquired that are probably best developed during tournament play. Probably by age 40 those skills are honed and make little contribution beyond serious study alone. Another possibility, supported by work on the relation between emotion and age (e.g. Carstensen & Charles, 1999, showing that older adults manage negative emotions better than younger adults), is that managing anxiety and emotional lability during play becomes easier with increased age.

It is also worth noting that the stability of chess ratings is directly related to the number of tournament-rated games played. Hence, a certain amount of tournament experience is absolutely necessary before beginning players (who are likely to be younger) may obtain a reliable rating. However, it is unlikely that the reliability of the skill measure played a major role in the results of this study. In the samples studied here, we can assume that most players have played enough tournament-rated games to reduce the margin of error in their ratings to adequate levels ($\pm 50$ points, or one quarter of a rating class interval), and even if the ratings were less reliable, the probability of an intermediate-level player being misclassified as a grandmaster (or vice versa) is extremely low. At the same time, the number and variety of chess tournaments have increased dramatically in recent decades (Gobet, Campitelli, & Waters, 2002). Hence, the relatively larger predictive influence of tournament experience among younger players may simply reflect greater opportunities for competitive experience in newer cohorts.

If Chase and Simon's (1973) ten-year rule is correct, the amount of deliberate practice time needed to become a top-level (i.e. grandmaster) player is on the order of 5000 hours. It is worth noting, though, that retrospective estimates of practice usually over-estimate actual practice as measured by self-report diaries (Ericsson et al., 1993; Starkes, Deakin, Allard, Hodges, & Hayes, 1996) or by independent observers (Deakin & Cobley, 2003). Thus, the cumulative practice trajectories presented here are probably somewhat inflated estimates. Unfortunately, we cannot ascertain the degree to which different skill groups or age groups in our study may have over-estimated the frequency or duration of time spent on various chess-related activities—a topic that clearly warrants further investigation. Also, although our samples include those in the top ranks of chess players, grandmasters, we did not sample world champion players and cannot extrapolate easily to that part of the skill range.

At least as judged by the cumulative practice functions shown in Figure 1, skill differences are not very noticeable at the beginning of a player's career of being serious about chess playing. Rather, like the longitudinal findings from studies of young musicians (Sloboda et al., 1996), those who practice more intensively appear to gain more skill in the long run. Ideally, we would like to have prospective year-by-year data on both study

 

activities and tournament performance in order to link practice variables to skill acquisition more tightly. It would also be useful to know the relationship between the amount of time spent on study or tournament play and the probability of continued participation in chess, such that firmer conclusions can be drawn regarding the generalization of results from our highly experienced survey participants to the larger chess community. With the current data set, we were only able to look back in time from the current rating to practice during the first decade of becoming a serious chess player. Thus, we cannot make claims about the causal relationships between study and performance.

Despite the limitations inherent in observational data, we believe that the results of the present study address some long-standing pedagogical debates concerning the importance of study versus play and the potential role of coaching in the development of chess skill. There is no doubt that participation in tournaments and coaching sessions provide certain learning opportunities that are difficult to replicate in a solitary study environment. However, our data suggest that anyone with serious thoughts about becoming a title-level player will need to engage in several thousand hours of concentrated analysis and memorization of chess tactics and positions in order to build the knowledge base necessary to achieve regular success in highly competitive chess tournaments.

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## REFERENCES

Carstensen, L. L., & Charles, S. T. (1999). Emotion in the second half of life. *Current Directions in Psychological Science, 7*, 144–149.

Charness, N. (1989). Expertise in chess and bridge. In D. Klahr, & K. Kotovsky (Eds.), *Complex information processing: The impact of Herbert A. Simon* (pp. 183–208). Hillsdale, NJ: Lawrence Erlbaum Associates.

Charness, N., & Gerchak, Y. (1996). Participation rates and maximal performance: a Log-linear explanation for group differences, such as Russian and male dominance in chess. *Psychological Science, 7*, 46–51.

Charness, N., Krampe, R., & Mayr, U. (1996). The role of practice and coaching in entrepreneurial skill domains: an international comparison of life-span chess skill acquisition. In K. A. Ericsson (Ed.), *The road to excellence: The acquisition of expert performance in the Arts and Sciences, Sports and Games* (pp. 51–80). Mahwah, NJ: Erlbaum.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Côté, J., Baker, J., & Abernathy, B. (2003). From play to practice: a developmental framework for the acquisition of expertise in team sports. In J. Starkes, & K. A. Ericsson (Eds.), *Expert performance in sports: Advances in research on sport expertise* (pp. 90–113). Champaign, IL: Human Kinetics.

 

Deakin, J. M., & Cobley, S. (2003). An examination of the practice environments in figure skating and volleyball: a search for deliberate practice. In J. Starkes, & K. A. Ericsson (Eds.), *Expert performance in sports: Advances in research on sport expertise* (pp. 90–113). Champaign, IL: Human Kinetics.

Elo, A. E. (1965). Age changes in master chess performances. *Journal of Gerontology, 20*, 289–299.

Elo, A. E. (1986). *The rating of chessplayers, past and present* (2nd ed.). New York: Arco.

Ericsson, K. A., & Charness, N. (1994). Expert performance: its structure and acquisition. *American Psychologist, 49*, 725–747.

Ericsson, K. A., Krampe, R. Th., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*, 363–406.

Gobet, F., Campitelli, G., & Waters, A. J. (2002). Rise of human intelligence: comments on Howard (1999). *Intelligence, 30*, 303–311.

Gobet, F., de Voogt, A., & Retschnitzki, J. (2004). *Moves in mind: The psychology of board games*. New York: Psychology Press.

Newell, A., & Rosenbloom, P. S. (1981). Mechanisms of skill acquisition and the power law of practice. In J. R. Anderson (Ed.), *Cognitive skills and their acquisition* (pp. 1–55). Hillsdale, NJ: Lawrence Erlbaum Associates.

Pandolfini, B. (1992). *Pandolfini's chess complete*. New York: Simon & Schuster.

Simon, H. A., & Chase, W. G. (1973). Skill in chess. *American Scientist, 61*, 394–403.

Simon, H. A., & Gilmartin, K. (1973). A simulation of memory for chess positions. *Cognitive Psychology, 5*, 29–46.

Sloboda, J. A., Davidson, J. W., Howe, M. J. A., & Moore, D. G. (1996). The role of practice in the development of performing musicians. *British Journal of Psychology, 87*, 287–309.

Starkes, J. L., Deakin, J. M., Allard, F., Hodges, N. J., & Hayes, A. (1996). Deliberate practice in sports: what is it anyway? In K. A. Ericsson (Ed.), *The road to excellence: The acquisition of expert performance in the arts and sciences, sports and games* (pp. 81–106). Mahwah, NJ: Erlbaum.

Ward, P., Hodges, N. J., Williams, A. M., & Starkes, J. L. (2004). Deliberate practice and expert performance: defining the path to excellence. In A. M. Williams, & N. J. Hodges (Eds.), *Skill acquisition in sport: Research, theory and practice* (pp. 231–258). London: Routledge.

## APPENDIX A. WORDING OF RELEVANT ITEMS FROM CHESS BACKGROUND QUESTIONNAIRE

Question 1. provides starting age; 2. provides serious age; 3. provides club joining age; 4. provides group and individual coaching; 5. provides chess books owned; 6. provides cumulative serious study alone, cumulative serious play with others, current serious study alone and current serious play with others.

1. At what age did you learn the chess moves?_____ (Age)
2. At what age did you start playing chess seriously?_____ (Age)
3. Did you ever join a chess club or a group where chess was played on a regular basis (club, school, workshop, etc.) ? If YES, at what age for the first time? _____(Age)
4. Did you ever receive any formal chess instruction from a teacher or trainer?
   ___Yes ___No

   INDIVIDUALLY: from (Age) _____ to (Age)_____
   GROUP: from (Age) _____ to (Age)_____

5. How many chess books do you own (excluding magazines)?_____
6. The table below has two columns where we would like you to give estimates of your time investment into (1) *serious analysis of positions* you did *alone* (using chess books,

 

magazines, data bases, playing postal chess, or the like) and (2) the amount of time you spent *seriously playing opponents*. This includes standard chess, blitz, or rapid chess, however, we want you to restrict your estimates to serious competition, like in tournaments. Note that postal chess is part of the solitary activities (first column) and should not be included here.

On the left you will find age as a reference point. You may add years (e.g. 1980) for your own reference. It is not necessary to provide entries for each single year! Please estimate the *number of hours* you spent during *a most typical week* on solitary study and playing *serious* games. Start out with the age when your chess activities began and fill in an estimate for each activity. Draw a vertical line until the next age, when this amount changed according to your memory, and continue until your current age. An example is provided on the next page.
(Table omitted)

 