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Does perceived chess skills mediate the relationship between fluid intelligence and academic performance?

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We analysed the association between chess skills and academic performance in primary school students. Additionally, we tested the potential mediating effect of fluid intelligence on this association. The sample consisted of 255 primary school students (48.2% girls), aged between 10 and 12 years, who had received instruction in chess. The students completed fluid intelligence measures and self-reported their chess play abilities. For the academic achievement measure, we accessed the students' school records. Following mediation analysis, results indicated fluid intelligence to mediate the relationship between chess skills and academic performance in that students with high self-reported chess skills also had higher academic grades. We conclude that chess skills might be a reliable proxy measure of student academic achievement and fluid intelligence.

Keywords: academic performance, chess skill, mediating effect, primary school

Introduction

Academic achievement predicts future professional career success (Creed et al., 2007), attainment of social status (Malecki & Demaray, 2006), and individual well-being (Sijtsema et al., 2014). Therefore, any experience that could potentially improve academic achievement deserves careful study. Chess is a great example of a game that is also an intellectual activity (Bilalić et al., 2007a). Several authors have argued that chess is an ideal game for educational purposes (Bart, 2014; Jerrim et al., 2016), and some school systems now provide chess instruction as academic enrichment (Binev et al., 2011). Chess skills likely transfer to academic performance in ways yet to be clarified. It could be that chess skills tap into fluid or general intelligence. Fluid or general intelligence is a well-known predictor of academic achievement (Bart, 2014; Deary et al., 2007). However, the research evidence of the influences of chess skills on academic achievement is mixed. For instance, some studies reported that chess instruction enhances academic performance of primary and middle school students' (Trinchero & Sala, 2016), specifically mathematical skills (Barrett & Fish, 2011; Berkman, 2004; Rosholm et al., 2017; Sala & Gobet, 2016; Trinchero, 2013). However, one study found no evidence of chess instruction influencing mathematics performance in children (Jerrim et al., 2016). We aimed to clarify this relationship in a sample of school children with chess training.

Chess skills and intelligence

Intelligence scores reliably predict academic performance (Colom et al., 2007; Furnham et al., 2003). Previous literature also reported chess skills to be associated with intelligence (Bart, 2014; Charness, 1992; Horgan & Morgan, 1990; Sala et al., 2017; Sala & Gobet, 2017). Chess players outperformed non-chess players on several cognitive skills (Aciego et al., 2012; Grabner et al., 2007; Sala & Gobet, 2017), while young chess players had high fluid intelligence (Burgoyne et al., 2016; de Bruin et al., 2014). For example, Aciego and colleagues (2012) conducted a quasi-experimental study, examining the effects of chess training on IQ. The experimental group (170 students, aged 6 to 16 years) received chess instructions while the control group (40 students in a similar age range) participated in extracurricular sports (e.g., soccer or basketball). After adjusting for pre-test scores, the experimental group showed significantly higher post-test scores on five of nine subtests on a measure of intelligence, as compared to the control group. These findings provide empirical support for the relationship between chess skills and intelligence.

However, the positive relationship between chess skills and intelligence does not necessarily guarantee that participation in chess leads to gaining intelligence. An alternative explanation for the positive association between intelligence and chess skills is that if intelligence is relatively high, individuals will be more likely to engage in and excel at the game of chess, and chess skills would lead to small improvements in fluid intelligence scores (Aciego et al., 2012; Joseph et al., 2018).

Intelligence and academic performance

Children with a higher intelligence quotient (IQ) generally have better academic achievement (Deary et al., 2007; Karbach et al., 2013; Kuncel et al., 2004; Primi et al., 2010). The average correlation between intelligence and academic achievement is estimated to be 0.50 (50%: Strenze, 2007; Ullstadius et al., 2002). In terms of fluid intelligence specifically, a meta-analysis of 419 primary school studies found that the correlation between fluid intelligence and school performance was 0.40 (40%: Postlethwaite, 2011). Furthermore, the observed magnitude of the correlation between academic performance and fluid intelligence varies for different school subjects (Gliga & Flesner, 2014; Kazemi et al., 2012; Lu et al., 2011; Sala & Gobet, 2016). For instance, fluid intelligence better

predicts performance in mathematics than language (Lu et al., 2011). In short, the evidence indicates that general intelligence is an important factor for academic achievement, and the magnitude of the impact would vary somewhat by school subject.

Goal of the study

We sought to explore the role of fluid intelligence in the relationship between chess skills and academic achievement in a sample of primary school students. The first goal was to investigate the relationship between chess skills, intelligence, and academic achievement. The second goal was to explore whether fluid intelligence mediated the association between chess skills and academic achievement (chess skill →intelligence → academic performance).

Method

Participants and setting

We sampled 255 primary school students from a school located in the city of Shaoxing, Zhejiang Province, China, where chess is taught as part of the school's curriculum (48% girls; mean age of 11.2 years; SD = 2.2 years). At the school, the students are taught how to play chess, beginning in Grade one, and every student plays chess for approximately 45 minutes each week.

Measures

Fluid intelligence

The students completed the 60-item Chinese version of the Raven's Standard Progressive Matrices Questionnaire (SPM: Raven, 2003; Zhang & Wang, 1989) a non-verbal measure of fluid intelligence. Each item is scored as pass or fail, with a maximum score of 60. In the present study, the internal consistency for scores from the SPM was 0.91.

Self-perceived chess skill

Similar to a previous study (Bilalić et al., 2007b), the students self-reported their chess skills on the question: "How good at chess are you in comparison with your peers?". They self-rated based on a five-point scale ranging from 0 = low, to 4 = high.

Academic performance

In the Chinese school system, teachers evaluate their students using pencil and paper tests. Children's school achievement was based on the average test scores of their mid-term and end-term examinations for Chinese and mathematics. These mid-term and end-term examinations are the two most important tests for school children in China. These two subjects are usually referred by teachers as critical indicators to infer the quality of learning, and a privileged source of information concerning the level of academic achievement of each student.

Procedure

The Research Ethics Committee of the Shaoxing University approved this study (IRB-AF-050-1.0). The school authorities granted permission for the study and the student's parents consented to the study. Moreover, the students assented to the study after we briefed them of the aims and that their participation was voluntary. We assured the students of the confidentiality of their responses.

Statistical analysis

We analysed the data in three stages. First, we calculated a series of partial correlations to confirm the relationships between chess skills, fluid intelligence, and academic performance indicators while controlling for sex and age. Thereafter, we conducted regression analyses to predict academic achievement from fluid intelligence and chess skills. Lastly, we tested whether fluid intelligence mediated the association between chess skills and academic achievement. In the present study, we used 5 000 resamples to estimate 95% confidence intervals. For this method, when zero is not present in the 95% confidence intervals, it can be concluded that the indirect effect is significantly different from zero at $p< 0.05$ (Preacher & Hayes, 2008). The Pm (%), or how much of the total effect was explained by the mediation, was calculated using the following formula: (indirect effect/total effect) × 100.

All analyses were performed using IBM SPSS Statistics for Windows version 22.0, and the SPSS macro-PROCESS (Bolin, 2014). We set the level of significance to $p < 0.05$.

Results

Table 1 shows the partial correlations among the study variables after controlling for age. There was a significant positive correlation between chess skills and fluid intelligence, academic performance, Chinese, and mathematics ($r = 0.17–0.92$, $p < 0.001$).

Table 2 includes the results of three regression analyses for each academic area (i.e., mathematics and Chinese). Models 1 and 2 used intelligence and chess skills as the sole predictors of academic achievement, whereas Model 3 used both intelligence and chess skills. Intelligence alone explained 6% of the variance in school achievement for Chinese and 14.7% for mathematics. Chess alone explained 4.9% of the variance in Chinese and 3.4% in mathematics. The multiple regression analysis (Model 3) indicated that intelligence and chess together explained a significantly greater portion of the variance in school

Table 1. Partial correlations

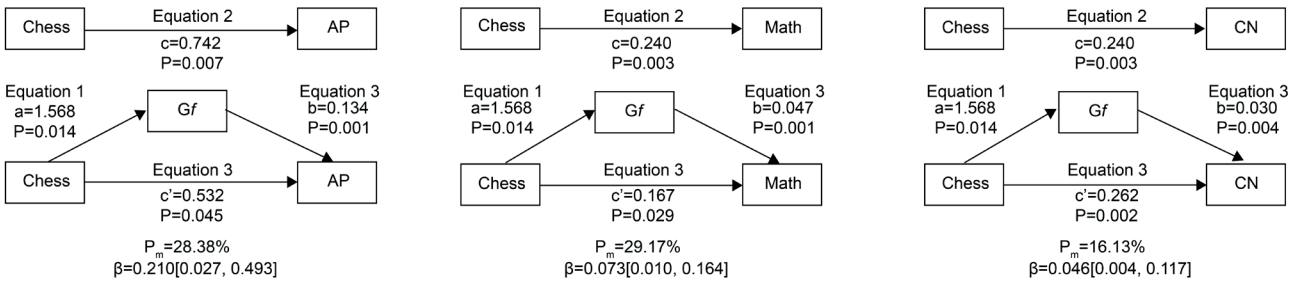
Variables	*M*	SD	1	2	3	4
1. Chess	2.80	0.72	–			
2. Intelligence	45.98	7.31	0.17***	–		
3. Academic performance	0.08	1.76	0.22***	0.34***	–	
4. Chinese	0.02	1.00	0.26***	0.25***	0.92***	1
5. Mathematics	0.05	0.94	0.20***	0.38***	0.91***	0.66***

Note. *M* = mean; SD = standard deviation; ***$p < 0.001$

Table 2. Regression analyses of academic performance on fluid intelligence and chess skill

		β	*T*	*p*	*R*	R^2	Δ*F*(*df*)	Δ*p*
Chinese								
Model 1	SPM	0.034	4.04	< 0.001	0.246	0.060	16.28 (1,253)	< 0.000
Model 2	CHESS	0.308	3.62	< 0.001	0.222	0.049	13.12 (1,253)	< 0.000
Model 3	SPM	0.030	3.58	< 0.001	0.309	0.095	13.26 (2,253)	< 0.000
	CHESS	0.262	3.11	0.002				
Math								
Model 1	SPM	0.049	6.61	< 0.001	0.384	0.147	43.65 (1,253)	< 0.000
Model 2	CHESS	0.240	2.98	0.003	0.184	0.034	8.90 (1,253)	0.003
Model 3	SPM	0.047	6.24	< 0.001	0.440	0.163	13.26 (2,253)	< 0.000
	CHESS	0.167	2.20	0.029				

Note: SPM = Raven's Standard Progressive Matrices test scores; CHESS = self-perceived Chess skill; Chinese = mean standardised scores of two examinations; math = mean standardised scores of two examinations.



Note: AP = average midterm and end-of-term test scores for Chinese and math; Gf = SPM test scores; CN = Chinese; *β* = indirect effect; [LLCI; ULCI] = lower and upper levels for the 95% confidence intervals of the indirect effect between chess skill and academic performance; a, b, c, and c′ = regression coefficients; notation = effect of chess skill on Gf; *b* = the effect of Gf on AP/Math/CN; c = total effect of chess skill on AP/Math/CN; cP = direct effect of chess skill on AP/Math/CN. ***p< 0.001

Figure 1. Chess refers to self-perceived Chess skill

achievement than either predictor alone (R^2 = 0.095 for Chinese and R^2 0.163 for mathematics).

Mediation of chess skills and academic performance by fluid intelligence

Based on previous statistical analyses, we tested fluid intelligence as a potential mediator of the association between chess and academic performance, controlling for sex and grade (Figure 1). Chess skills was associated with academic performance, and the change from low to high chess skills was associated with an increase in academic performance, ranging from 0.24 points to 0.74 points. In addition, chess skills was positively associated with fluid intelligence (Path a; $p < 0.05$). Additionally, fluid intelligence was positively associated with academic performance (Path b; all $p < 0.05$). The mediating effect of fluid intelligence on the relationship between chess skills and academic performance was significant for all indicators (academic performance Pm = 28.38%; Chinese Pm = 16.13%; Math Pm = 29.17%).

Discussion and conclusion

Similar to previous studies (Berkman, 2004; Rosholm et al., 2017), we found a positive association between fluid intelligence and academic performance in young chess players. As with previous research (Lu et al., 2011), this relationship varies by subject. Specifically, our study showed a large difference between mathematics and Chinese. Specifically, almost one-and-a-half times more variance was explained by fluid intelligence in mathematics (36.4%), as compared to Chinese (18.7%). The data are also consistent with previous studies that showed a positive relationship between chess skills and intelligence in young chess players (de Bruin et al., 2014). The current results suggest that intelligence might play a role early in acquiring chess skills (Vaci & Bilalić, 2017).

We found fluid intelligence to mediate the association between chess skills and academic performance. This finding may be explained by the fact that individuals with a higher fluid intelligence are efficient in learning a new skill, increasing their potential for achieving success in chess activities (Ren et al., 2015) and academic achievement (Strenze, 2007; Ullstadius, et al., 2002).

Limitations and future recommendations

This study has some limitations that should be considered. First, the proposed causal relationship between chess skills, fluid intelligence, and academic performance cannot be proven by the cross-sectional nature of this study. The correlation design of this study does not provide evidence for causal connections between the students' self-perceived chess skills, intelligence, and performance in school. Longitudinal studies with more detailed observations should be conducted to understand the dynamic interplay between chess skills and academic achievement. Second, this study examined chess skills using a single self-report question. Therefore, it did not objectively measure the chess performance of young chess players. Future research is needed using a variety of assessments. Finally, other factors, not examined in the current study, may have affected the relationship. For example, chess skill was positively correlated with cognitive abilities, such as fluid

intelligence, processing speed, short-term and working memory (Burgoyne et al., 2016). Future research is needed to determine the relative importance of these cognitive variables, in addition to intelligence, to the relationships between chess instruction and academic performance.

Conclusion

In sum, the current study is the first to reveal a mediating effect of fluid intelligence on the association between chess skills and academic performance. Our results suggest that chess skills and academic achievement share common underlying cognitive skills, which might explain the relationship found in the current study (see Sala & Gobet, 2016). These findings suggest that self-rated chess skills assessment by students could be a reliable indicator of both their fluid intelligence and academic potential in mathematics and Chinese. Educational policy should encourage the use of chess in schools as an educational enrichment tool.

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Declaration of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Aciego, R., García, L., & Betancort, M. (2012). The benefits of chess for the intellectual and social-emotional enrichment in schoolchildren. *The Spanish Journal of Psychology, 15*, 551–559. https://doi.org/10.5209/rev_SJOP.2012.v15.n2.38866

Barrett, D. C., & Fish, W. W. (2011). Our move: Using chess to improve math achievement for students who receive special education services. *International Journal of Special Education, 26*(3), 181–193.

Bart, W. M. (2014). On the effect of chess training on scholastic achievement. *Frontiers in Psychology, 5*: 762. https://doi.org/10.3389/fpsyg.2014.00762

Berkman, R. M. (2004). The chess and mathematics connection: More than just a game. *Mathematics Teaching in the Middle School, 9*(5), 246–250. https://doi.org/10.5951/MTMS.9.5.0246

Bilalić, M., McLeod, P., & Gobet, F. (2007a). Does chess need intelligence? A study with young chess players. *Intelligence, 35*, 457–470. https://doi.org/10.1016/j.intell.2006.09.005

Bilalić, M., McLeod, P., & Gobet, F. (2007b). Personality profiles of young chess players. *Personality and Individual Differences, 42*, 901–910. https://doi.org/10.1016/j.paid.2006.08.025

Bolin, J. H. (2014). Hayes, Andrew F. (2013). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. New York, NY: The Guilford Press. *Journal of Educational Measurement, 51*(3), 335–337. https://doi.org/10.1111/jedm.12050

Burgoyne, A. P., Sala, G., Gobet, F., Macnamara, B. N., Campitelli, G., & Hambrick, D. Z. (2016). The relationship between cognitive ability and chess skill: A comprehensive meta-analysis. *Intelligence, 59*, 72–83. https://doi.org/10.1016/j.intell.2016.08.002

Charness, N. (1992). The impact of chess research on cognitive science. *Psychological Research, 54*, 4–9. https://doi.org/10.1007/BF01359217

Colom, R., Escorial, S., Shih, P. C., & Privado, J. (2007). Fluid intelligence, memory span, and temperament difficulties predict academic performance of young adolescents. *Personality and Individual Differences, 42*, 1503–1514. https://doi.org/10.1016/j.paid.2006.10.023

Creed, P. A., Patton, W., & Prideaux, L. A. (2007). Predicting change over time in career planning and career exploration for high school students. *Journal of Adolescence, 30*, 377–392. https://doi.org/10.1016/j.adolescence.2006.04.003

de Bruin, A. B., Kok, E. M., Leppink, J., & Camp, G. (2014). Practice, intelligence, and enjoyment in novice chess players: A prospective study at the earliest stage of a chess career. *Intelligence, 45*, 18–25. https://doi.org/10.1016/j.intell.2013.07.004

Deary, I. J., Strand, S., Smith, P., & Fernandes, C. (2007). Intelligence and educational achievement. *Intelligence, 35*, 13–21. https://doi.org/10.1016/j.intell.2006.02.001

Furnham, A., Chamorro-Premuzic, T., & McDougall, F. (2003). Personality, cognitive ability, and beliefs about intelligence as predictors of academic performance. *Learning and Individual Differences, 14*, 47–64. https://doi.org/10.1016/j.lindif.2003.08.002

Gliga, F., & Flesner, P. I. (2014). Cognitive benefits of chess training in novice children. P*rocedia-Social and Behavioral Sciences, 116*, 962–967. https://doi.org/10.1016/j.sbspro.2014.01.328

Grabner, R. H., Stern, E., & Neubauer, A. C. (2007). Individual differences in chess expertise: A psychometric investigation. *Acta Psychologica, 124*, 398–420. https://doi.org/10.1016/j.actpsy.2006.07.008

Horgan, D. D., & Morgan, D. (1990). Chess expertise in children. *Applied Cognitive Psychology, 4*, 109–128. https://doi.org/10.1002/acp.2350040204

Jerrim, J., Macmillan, L., Micklewright, J., Sawtell, M., & Wiggins, M. (2016). Chess in schools: Evaluation report and executive summary. Education Endowment Foundation.

Joseph, E., Easvaradoss, V., Kennedy, A., & Kezia, E. J. (2018). Chess training improves cognition in children. *GSTF Journal of Psychology, 2*(2), 1–6. Retrieved from https://www.researchgate.net/profile/Joanna_Kezia/publication/327337702_Chess_training_improves_cognition_in_children/links/5b88ebcb92851c1e123d405d/Chess-training-improves-cognition-in-children.pdf

Karbach, J., Gottschling, J., Spengler, M., Hegewald, K., & Spinath, F. M. (2013). Parental involvement and general cognitive ability as predictors of domain-specific academic achievement in early adolescence. *Learning and Instruction, 23*, 43–51. https://doi.org/10.1016/j.learninstruc.2012.09.004

Kazemi, F., Yektayar, M., & Abad, A. M. B. (2012). Investigation the impact of chess play on developing meta-cognitive ability and math problem-solving power of students at different levels of education. *Procedia-Social and Behavioral Sciences, 32*, 372–379. https://doi.org/10.1016/j.sbspro.2012.01.056

Kuncel, N. R., Hezlett, S. A., & Ones, D. S. (2004). Academic performance, career potential, creativity, and job performance: Can one construct predict them all? *Journal of Personality and Social Psychology, 86*, 148–161. https://doi.org/10.1037/0022-3514.86.1.148

Lu, L., Weber, H. S., Spinath, F. M., & Shi, J. (2011). Predicting school achievement from cognitive and non-cognitive variables in a Chinese sample of elementary school children. *Intelligence, 39*, 130–140. https://doi.org/10.1016/j.intell.2011.02.002

Malecki, C. K., & Demaray, M. K. (2006). Social support as a buffer in the relationship between socioeconomic status and academic performance. *School Psychology Quarterly, 21*(4), 375–395. https://doi.org/10.1037/h0084129

Postlethwaite, B. E. (2011). *Fluid ability, crystallized ability, and performance across multiple domains: A meta-analysis* [Unpublished Doctoral dissertation). University of Iowa. https://doi.org/10.17077/etd.zopi8wvs

Preacher, K. J., & Hayes, A. F. (2008). Assessing mediation in communication research. In A. F. Hayes, M. D. Slater, & L. B. Synder (Eds.), The Sage sourcebook of advanced data analysis methods for communication research (pp. 13–54). Sage Publications. https://doi.org/10.4135/9781452272054.n2

Primi, R., Ferrão, M. E., & Almeida, L. S. (2010). Fluid intelligence as a predictor of learning: A longitudinal multilevel approach applied to math. *Learning and Individual Differences, 20*, 446–451. https://doi.org/10.1016/j.lindif.2010.05.001

Raven, J. (2003). Raven progressive matrices. In Handbook of nonverbal assessment (pp. 223–237). Springer.

Ren, X., Schweizer, K., Wang, T., & Xu, F. (2015). The prediction of students' academic performance with fluid intelligence in giving special consideration to the contribution of learning. *Advances in Cognitive Psychology, 11*(3), 97–105. https://doi.org/10.5709/acp-0175-z

Rosholm, M., Mikkelsen, M. B., & Gumede, K. (2017). Your move: The effect of chess on mathematics test scores. *PLoS One, 12*(5), e0177257. https://doi.org/10.1371/journal.pone.0177257

Sala, G., Foley, J. P., & Gobet, F. (2017). The effects of chess instruction on pupils' cognitive and academic skill: State of the art and theoretical challenges. *Frontiers in Psychology, 8*: 238. https://doi.org/10.3389/fpsyg.2017.00238

Sala, G., & Gobet, F. (2016). Do the benefits of chess instruction transfer to academic and cognitive skill? A meta-analysis. *Educational Research Review, 18*, 46–57. https://doi.org/10.1016/j.edurev.2016.02.002

Sala, G., & Gobet, F. (2017). Experts' memory superiority for domain-specific random material generalizes across fields of expertise: A meta-analysis. *Memory & Cognition, 45*, 183–193. https://doi.org/10.3758/s13421-016-0663-2

Sijtsema, J. J., Verboom, C. E., Penninx, B. W. J. H., Verhulst, F. C., & Ormel, J. (2014). Psychopathology and academic performance, social well-being, and social preference at school: The TRAILS study. *Child Psychiatry and Human Development, 45*, 273–284. https://doi.org/10.1007/s10578-013-0399-1

Strenze, T. (2007). Intelligence and socioeconomic success: A meta-analytic review of longitudinal research. *Intelligence, 35*, 401–426. https://doi.org/10.1016/j.intell.2006.09.004

Trinchero, R. (2013). Can chess training improve Pisa scores in mathematics? An experiment in Italian primary schools. Kasparov Chess Foundation Europe.

Trinchero, R., & Sala, G. (2016). Chess training and mathematical problem-solving: The role of teaching heuristics in transfer of learning. *Eurasia Journal of Mathematics, Science and Technology Education, 12*, 655–668.

Ullstadius, E., Gustafsson, J. E., & Carlstedt, B. (2002). Influence of general and crystallized intelligence on vocabulary test performance. *European Journal of Psychological Assessment, 18*, 78–84. https://doi.org/10.1027//1015-5759.18.1.78

Vaci, N., & Bilalić, M. (2017). Chess databases as a research vehicle in psychology: Modeling large data. *Behavior Research Methods, 49*, 1227–1240. https://doi.org/10.3758/s13428-016-0782-5

Zhang, H. C., & Wang, X. P. (1989). Standardization research on Raven's standard progressive matrices in China. *Acta Psychologica Sinica, 21*(02), 3–11.