

Chess and Intelligence: Lessons for Scholastic Chess



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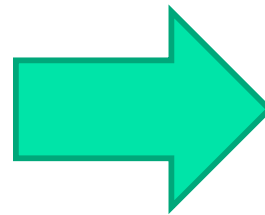


Overview

- Relation between chess and intelligence
 - Are chess players smarter than non-players?
 - Does intelligence correlate with skill level?
 - Does playing chess increase intelligence?
- The broader picture
 - Music, video-game playing and working memory
- Relation between chess and mathematics
 - Does playing chess increase mathematical skills?
 - Two studies with passive and active control groups
- Implications for chess and education

Preliminaries

- Effect size
 - A simple way of quantifying the difference between two groups
- Meta-Analysis
 - A statistical procedure to *quantitatively* compare the effects of a treatment (e.g., drugs, chess instruction) between studies, and to calculate an overall effect size





Intelligence

- Concept difficult to define
- Standard definitions
 - “General mental efficiency” (Burt, 1949)
 - “A general reasoning capacity useful in problem-solving tasks of all kinds” (Kline, 1991)
- Has generated a lot of controversies
- But a valid concept
 - Measures of intelligence correlate with education level, performance in job, etc. etc.
- Chess considered as paragon of intelligence
 - Is this true?



First Question

- Are chess players more intelligent than non-players?
- Yes, medium-size effect
 - Sala et al. (2017)
 - $d = 0.49$



Second Question

- Does skill level correlate with IQ?
- Yes, medium-size effect
 - Burgoyne et al. (2016)
 - $r = 0.24$



Third Question: The Question of Transfer

- *Near transfer*
 - Transfer to a similar domain: algebra to calculus
- *Far transfer*
 - Transfer to a non-similar domain:
 - Latin to mathematics
 - Chess to intelligence
- Use of training experiments
- There might be transfer
 - $g = 0.33$ (medium-size effect)
 - Sala and Gobet (2016)



However...

- No study had an *active control* group (a.k.a. *placebo* group)
- Necessary for controlling placebo effects
 - participation in experiment
 - experimenters' expectations
 - etc...
- Thus, whether chess instructions positively affects intelligence is still unknown



The Broader Picture

- Do we find the same pattern of results with
 - Music
 - Working-memory training
 - Video-game playing



Music

- Correlation between skill and IQ (✓)
 - Moderate correlation
 - Shuter-Dyson and Gabriel (1982)

- Music → IQ (training experiment) ✗
 - $d = 0.16$
 - Sala and Gobet (2017)
 - $d = -0.12$ with randomized samples with active control groups



Working Memory (WM)

- Correlation between WM and IQ ✓
 - $r = .80$
 - Kyllonen and Christal (1990)
- Music → IQ (training experiment) ✗
 - $g = .12$
 - $g = .18$ with passive control groups
 - $g = .05$ with active control groups



Video Game Playing

- Sala, Tatlidil and Gobet (in press)
- Correlation between video-game skill and IQ
 - $r = 0.07$ (✓)
- Video-game players vs. non-players ✓
 - $g = 0.33$
- Video-game playing → CA (training experiment)
 - $g = 0.07$ ✗
 - But $g = -0.01$ with correction for publication bias



Interim Summary

- 1) Skill is related to IQ ✓
 - 2) Training a skill \rightarrow IQ ✗
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- It is possible that IQ \rightarrow Skill
 - But other causal models possible
 - e.g., motivation causes both CA and Skill
 - But clearly, training skill does not improve IQ
 - Far transfer is difficult at best

Maths and Chess

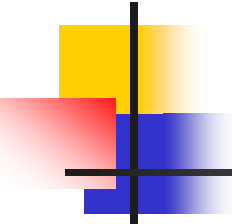
The Question of Transfer

- There might be transfer (✓)
 - $g = 0.38$ (medium-size effect)
 - Sala and Gobet (2016)
- Only two studies with active control group

An Experiment Using Go as Active Control Group



- Sala and Gobet (2017)
- Participants
 - 52 fourth graders in 3 classes of a primary school in Italy
 - Mean age of the participants = 9.3 years
- Mathematics measures (IEA-TIMSS)
 - Measures both procedural knowledge and problem-solving ability
- Measure of metacognitive skills

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- The 3 classes were randomly assigned to:
 - Experimental group: 15 hours of chess lessons during school hours
 - Active control group (placebo group): 15 hours of Go lessons during school hours
 - Passive control group: regular school activities only
 - Chess and Go replaced part of the hours originally dedicated to mathematics and science



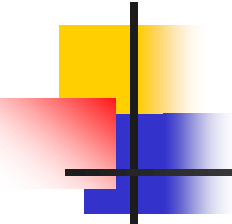
Results: Mathematics

- No significant differences between the three groups in the pretest scores
- An analysis of covariance (ANCOVA) used the pretest scores as a covariate
 - Significant effect of the covariate, $p < .001$
 - Significant effect of group, $p < .04$
 - Control > Go $p < .02$
 - Chess > Go marginally, $p < .09$
 - Control = Chess $p < .487$



Results: Metacognition

- No significant differences between the three groups, $p < .617$
- An analysis of covariance (ANCOVA) used the pretest scores as a covariate
 - Significant effect of the covariate, $p < .001$
 - No significant effect of group, $p < .694$

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- Chess not better than regular school activities
 - But chess better than Go
 - This suggests that some chess-related skills generalized to mathematics
 - Chess effects are not only placebo effects!

An Experiment Using Checkers as Active Control Group

- Sala and Gobet (2017)
- Participants
 - 233 third and fourth graders from eight Italian schools
 - Mean age of the participants = 8.5 years
- Same design as the Go study
- No group differences with
 - Mathematics measures (IEA-TIMSS)
 - Metacognitive skills





Maths and Chess

- Unclear whether chess exerts positive effects on mathematical skills
- Far transfer is difficult
- But this is consistent with what we know about the development of expertise (Gobet, 2016)
- Chess is not a magic bullet



The Way Forward



Better Theoretical Understanding of Potential Effects

- Sala, Foley and Gobet (2017)
- Use of rigorous experimental designs
 - To understand the mechanisms involved
 - Active control group necessary
- Necessary to measure
 - A wide set of cognitive skills
 - Academic achievement in some domain
- Development of a testable model linking
 - Chess
 - Cognitive abilities
 - Academic skills



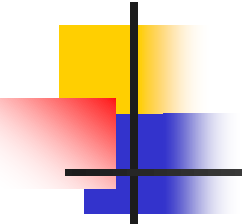
Mechanisms Behind (Potential) Transfer

- Non-specific to chess
 - Chess teachers are highly motivated and passionate
 - Topic is novel and different to standard schools activities
 - Chess is a game, and thus fun
 - Chess is a competitive activity
 - Chess shows that school can be fun and interesting



Mechanisms Behind (Potential) Transfer

- Factors specific to chess
 - Diversity of pieces help maintain attention
 - Chess offers an optimal trade-off between complexity and simplicity
 - Balance between tactics and strategy is ideal
 - Chess combines numerical, spatial, temporal and combinatorial aspects
- These factors foster
 - Attention
 - Learning
 - Problem solving and decision making

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- Important point: Placebo effects are not only a nuisance, but can be used to make teaching efficient



Optimisation of Chess Teaching

- Many parameters have not been systematically studied
- Optimal duration of a chess lesson?
- What are the most efficient teaching methods?
- Order of covering the material
- Make sure that all children (at least most) profit from chess
 - Non only the smart ones
 - Non only the competitive ones



What Should be Done

- Identify goals, and use chess as tool to reach these goals
- Important question: What are the key goals?
 - Teach mathematics
 - Improve general abilities such as problem solving, concentration, etc.
 - Improve social skills
 - Etc.



The Ideal Approach for the Link between Chess and Mathematics

- Start from mathematics curricula in primary schools
 - Mathematics teachers
 - In several countries
- Extract the key concepts
 - Which ones can be taught with chess?
- Build chess lessons teaching these concepts
 - Make them exciting but technically correct
 - Make link with mathematics explicit
 - Coordinate with mathematics lessons



Ideas for Primary Mathematics

- Basic arithmetic – counting, addition, subtraction
 - Value of pieces
 - Control of squares
- Cartesian geometry
 - Coordinate system $(a, b, \dots, h) \times (1, 2, \dots, 8)$
- Basics of matrix algebra
 - Rows and columns
 - Concept of a matrix

■ Fractions



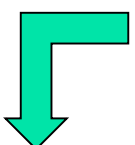
$\frac{1}{2}$



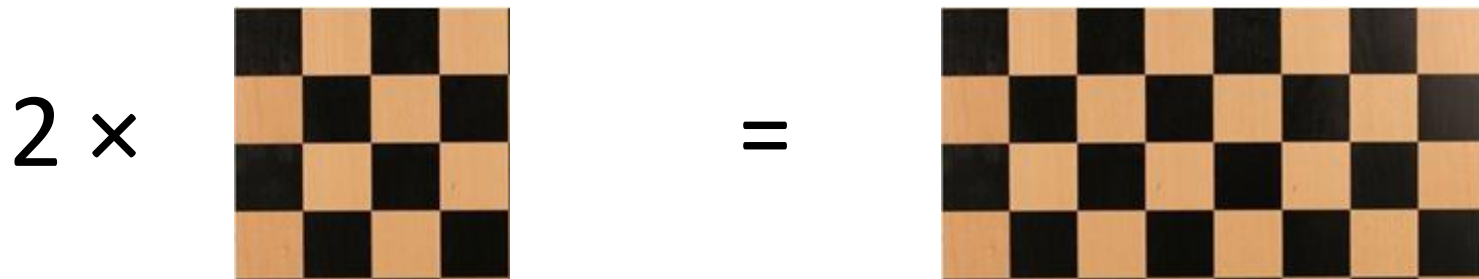
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$\frac{1}{8}$



$\frac{1}{4}$

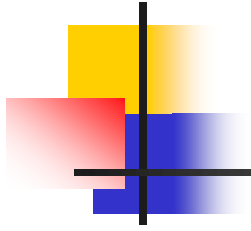


$2 \times \frac{1}{4} = \frac{1}{2}$



Conclusions

- Chess players' intelligence is higher than that of the general population
- There is a correlation between chess skill and intelligence
- Whether there is transfer from chess instruction to other fields is an open question
- Chess instruction should be informed by school curricula
- The bridge between chess and the concepts to teach should be made explicit



Questions?





The Ideal Experiment

| Random Allocation | | |
|-------------------|------------------|---------------|
| Pre-test | Pre-test | Pre-test |
| Treatment Group | Do-Nothing Group | Placebo Group |
| Post-test | Post-test | Post-test |

- Standard design in medicine
- Rarely used in education
- Never used with chess instruction!