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Chess Training Improves Cognition in Children

Mr. Ebenezer Joseph
First Indian Chess (FIDE) Trainer Senior Auditor - Government of India Part-time Research scholar
Madras University
Chennai, India
emmanuelchess@gmail.com

Dr. Veena Easvaradoss
Associate Professor and Head Department of
Psychology Women's Christian College Chennai, India

Ms. Anita Kennedy
Clinical Psychologist
Emmanuel Chess Centre
Chennai, India

Ms. E. Joanna Kezia
Assistant Professor
Department of Statistics
Madras Christian College
Chennai, India

Abstract — Systematic training of chess has been shown to significantly increase the IQ and cognitive functioning among children. The study assessed the impact of chess intervention on the IQ scores of children and analyzed the cognitive functions that contributed to the IQ gain. Eighty-six school children, boys and girls in the age group (4-15) undergoing chess training were assessed using Binet-Kamat Test of Intelligence. Chess intervention consisted of standardized bi-weekly training sessions of 2 hours' duration over a period of one year. Individual attention was given to every child by assigning one coach for every 4 students. Paired t tests and regression analysis were carried out.

Significant increases were observed inIQ. Regression analysis indicated that non-verbal reasoning, language and memory significantly contributed to the dependent variable IQ. The study has important implications for education.

Keywords - chess training; cognitive development; IQ; non-verbal reasoning; language, memory

I. INTRODUCTION

Chess is widely believed to increase "mental muscle" or intelligence. More and more schools around the world are recognizing the value of chess, with chess instruction now becoming part of standard curriculums. Intelligence has been defined as "the ability to solve problems, or to create products, that are valued within one or more cultural settings" Gardner [8].

Studying chess systematically has been shown to raise students' IQ and exam scores (Dullea [4]; Palm [15]; Ferguson [6]), as well as strengthen mathematical, language, and reading skills (Margulies [2]; Liptrap [12]; Ferguson [6]). Chess has been shown to raise students' overall IQ scores. Using the Wechsler Intelligence Scale for Children, a Venezuelan study of over 4000 second-grade students found a significant increase in most students' IQ scores after only 4.5 months of systematically studying chess. This occurred across all socio-economic groups and for both males and females. The Venezuelan government was so impressed that all Venezuelan schools introduced chess lessons starting in 1988–89 (summarized in Ferguson [5], p. 8).

A recent study [18] examined the effect of chess training on academic performance of middle school children in rural India. The sample consisted of 100 students of sixth grade with an intervention group undergoing chess training and a control group. The results of the paired samples t-test analysis showed significant improvement in academic performances of

students in English, social studies and science, after a year of training in chess skills.

Aciego, Garcia, and Betancourt [1] using a quasi-experimental study examined the cognitive effects of chess training. The experimental group (170 students, 6–16 years of age) received chess instruction. The control group (40 students in a similar age range) received extracurricular sports (soccer or basketball) activities. After adjusting for pre-test scores, the chess group showed significantly higher post-test scores than the sports group for five of nine WISC-R subtests. The authors concluded that chess is a "valuable educational tool".

In another recent study, Kazemi, Yektayar and Abad [11] examined the cognitive effects of chess play. They employed an experimental group composed of 86 randomly selected school-aged students, who received chess instruction for six months, and a control group of 94 randomly selected school-aged students. All participants were male and from fifth, eighth, and ninth grades from schools in Iran. All participants were administered a measure of meta-cognitive ability and a grade-appropriate mathematics exam prior to and after intervention. The chess group participants registered significantly higher post-test meta-cognitive ability scores and higher post-test mathematics test scores than the non-chess group participants. A major conclusion of the study is that chess instruction improves the mathematical abilities and the meta-cognitive capacities of school-aged students significantly.

Masedu, Sabatino, Benzi, Tamorri, and Valenti [14] aimed to find differences in perceptual tasks and the visuo-spatial abstraction cognitive ability of chess players when compared to non-players. A cross-sectional study was conducted by comparing the perceptual and visuo-spatial performance of 50 agonistic chess players, and a referent group of 50 age- and education-matched non-players. The study revealed that after adjusting for age, a significant difference was seen in visuo-spatial abilities between chess players and non-chess players, whereas no difference could be demonstrated with respect to perceptual or abstraction skills. Visuo-spatial abilities did not seem to be influenced by age.

Hong and Bart [10] examined the cognitive effects of chess instruction on students at risk of academic failure in Korea. They reported that chess instruction produces higher chess skill ratings. This may lead to gains in levels of non-verbal intelligence among students at risk of academic failure.

Although chess originated in India, research assessing its impact on the cognitive development of the child is not available. The primary objective of this study was to evaluate and measure the enhancement of cognitive functioning with chess training. This is an essential step towards proving the benefits of chess for an Indian population. Such research can also help to seriously consider the use of chess within educational curriculums and schools in India.

Keeping this in mind, the following research questions were posed: Does chess intervention increase cognitive functioning (as measured through IQ, verbal comprehension, numerical reasoning, verbal reasoning, non-verbal reasoning, social intelligence, language, conceptual thinking, memory, and visual-motor ability) in Indian children? Which of the subcomponents of IQ contribute to the gains in IQ after chess training? Is age of the child a significant predictor?

II. Research Design

The study used a single group pre-test–post-test design without a control group. The independent variable was chess training and the dependent variables were IQ, verbal comprehension, numerical reasoning, verbal reasoning, non-verbal reasoning, social intelligence, language, conceptual thinking, memory, and visual-motor ability in children. Age and gender were the socio-demographic variables.

III. Sample

For this study 86 students who were undergoing chess training at a chess center between 2012 and 2014 were recruited. The age range considered for the study was 4–15 years. The mean age of the sample was 7 years, 7 months (SD = 27.51). Chess training was given twice a week for a duration of one year. The average IQ score of the child at the start of the intervention was 128.7 (SD = 17.390).

IV. Measures

The children were assessed using the Binet-Kamat Test of Intelligence. The Stanford revision of the test was adapted as the Binet-Kamat Test of Intelligence to suit the Indian children. The present version consists of various verbal and performance tests that can be administered to children and adults from ages 3 to 22 years. Validity of the test shows that when a fourfold table was drawn up and the correlation of the pluses and minuses of each test with mental age as obtained by the whole scale was found, the correlation coefficients of the tests were generally higher than 0.70. Correlations between IQ (as determined by the scale) and teacher's estimates were found to be nearly 0.50, which is fairly high considering the variability of teacher's estimates.

V. Procedure

Baseline IQ assessment was done after obtaining informed consent. Reassessment was carried out by the same examiner after an average duration of one year. The assessment environment was quiet without any disturbance and kept standardized. Psychologists were trained to administer the test in a uniform standardized methods to minimize the testing error. Prior consent of the parents was obtained. The children were tested on a specified time in the evening for both pre and post tests. Chess intervention consisted of standardized bi-weekly training sessions of 2 hours' duration over a period of one year. Clustering technique was used to form the

training groups. There were 8 groups for training and 4 children were assigned to each coach according to their playing strength which kept changing dynamically through the year. The children were given a standardized curriculum and were sent to tournaments from time to time. The coaches were also assigned carefully to each group in accordance to their strength of training and their ability to communicate and interact with children of various age groups and differing strength of chess playing. Chess training was done using the following methodology.

- DVD learning (Winning Moves, Episodes 1–22)
- Demonstration board
- On-the-board training
- Chess exercise through workbooks (Chess school 1A, Chess school 2, and tactics)
- Chess playing on computer (Kasparov's Chess mate, Fritz)
- Tactical chess training using software (Maurice Ashley Teaches Chess, Advance Chess School, CT ART 3.0)
- Mapping the prodigies' games using chess base software and understating brain patterns of the child
- Cognitive correction using Maurice Ashley Teaches Chess software for problems such as perception for normal as well as special children
- End game training using theory and practice of End Games, ABC of Endgames, and Winning Moves DVD)
- Ideas behind chess openings
- Exposure to classical games
- Chess playing sessions
- Mock training tournaments
- Participation in regular chess tournaments
- Analysis of score sheets and thought patterns

VI. Results

The results were analyzed using SPSS 15. The impact of chess training on the IQ, memory, language, social intelligence, non-verbal reasoning, numerical reasoning, visual-motor functioning, conceptual thinking, and verbal reasoning was assessed by comparing the means scores obtained on the Binet-Kamat test pre- and post-intervention using paired t tests.

TABLE I. SHOWING THE PAIRED T TEST COMPARING THE MEAN SCORES PRE AND POST INTERVENTION

Variable	Mean and Standard Deviation		Standard Error of Mean		t
	Pre-test	*Post-test*	*Pre-test*	*Post-test*	
Intelligence	128.71 (17.390)	136.10 (18.378)	1.875	1.982	–4.605**
Memory	28.09 (12.903)	34.56 (13.899)	1.391	1.479	–7.921**
Language	13.65 (6.517)	16.30 (5.953)	.703	.642	–5.373**
Social intelligence	22.72 (5.260)	25.72 (3.759)	.567	.405	–5.881**
Non-verbal reasoning	11.26 (5.666)	13.98 (6.504)	.611	.701	–6.000**
Numerical reasoning	12.00 (4.831)	14.70 (5.408)	.521	.583	–6.277**
Visual-motor	4.19 (1.613)	4.35 (1.686)	.174	.182	–0.910
Conceptual thinking	4.14 (4.507)	7.21 (5.959)	.486	.643	–7.275**
Verbal reasoning	1.47 (2.556)	2.86 (3.875)	.276	.418	–3.526**

** $p < .001$

The results indicated significant increases in IQ ($p < .001$), memory ($p < .001$), language ($p < .001$), social intelligence ($p < .001$), non-verbal reasoning ($p < .001$), numerical reasoning ($p < .001$), conceptual thinking ($p < .001$), and verbal reasoning ($p < .001$) following the intervention. No significant difference was observed on visual-motor functioning.

TABLE II. SHOWING THE REGRESSION ANALYSIS OF THE FOUR PREDICTOR VARIABLES ON IQ

Model Summary				
Model	***R***	***R*²**	***Adjusted R*²**	***Standard error of the estimate***
1	.381(a)	.145	.135	17.091
2	.621(b)	.386	.371	14.577
3	.698(c)	.487	.468	13.406
4	.717(d)	.514	.490	13.129
a. Predictors: (Constant), Non-verbal Reasoning2				
b. Predictors: (Constant), Non-verbal Reasoning2, Age on IQ2 in months				
c. Predictors: (Constant), Non-verbal Reasoning2, Age on IQ2 in months, Language2				
d. Predictors: (Constant), Non-verbal Reasoning2, Age on IQ2 in months, Language2, Memory2				

In Table II, we observe that R value in the final iteration is 0.717, and it indicates that the correlation between the dependent variable IQ and significant predictors, non-verbal reasoning, age, language, and memory is 0.717. The R^2 value of 0.514 indicates that 51.4% of the variability in the dependent variable is explained by these predictors.

TABLE III. SHOWS ANALYSIS OF VARIANCE

ANOVA(e)						
Model		*Sum of squares*	*Df*	*Mean square*	*F*	*Sig.*
1	Regression	4170.084	1	4170.084	14.276	.000(a)
	Residual	24,537.605	84	292.114		
	Total	28,707.689	85			
2	Regression	11,070.474	2	5535.237	26.049	.000(b)
	Residual	17,637.215	83	212.497		
	Total	28,707.689	85			
3	Regression	13,970.833	3	4656.944	25.913	.000(c)
	Residual	14,736.856	82	179.718		
	Total	28,707.689	85			
4	Regression	14,745.080	4	3686.270	21.385	.000(d)
	Residual	13,962.609	81	172.378		
	Total	28,707.689	85			
a. Predictors: (Constant), Non-verbal Reasoning2						
b. Predictors: (Constant), Non-verbal Reasoning2, Age on IQ2 in months						
c. Predictors: (Constant), Non-verbal Reasoning2, Age on IQ2 in months, Language2						
d. Predictors: (Constant), Non-verbal Reasoning2, Age on IQ2 in months, Language2, Memory2						
e. Dependent Variable: Intelligence Quotient2						

The ANOVA table shows that the there is no significant difference between the observed and predicted values obtained by using the linear regression model, hence confirming that the model is a good fit.

VII. DISCUSSION

It is interesting to note that almost all the parameters of cognitive functioning (excluding visual-motor functions) showed an increase following chess training in this study. This is not totally unexpected as we observe that chess playing focuses on developing cognitive skills like focusing, visualizing, thinking ahead, weighing options, analyzing concretely, thinking abstractly, planning, and juggling multiple considerations simultaneously. Over time, chess helps develop patience and thoughtfulness. However, what is heartening and surprising is that these cognitive changes that have occurred have translated to quantifiable scores on a test of intelligence. While much has been said about the impact of chess training on specific skills or abilities, there are only a few studies that have unequivocally demonstrated an increase on an IQ test. This study is one of the first Indian studies to clearly show a significant increase in IQ scores

The question that arises as a corollary to this finding (and similar findings by other researchers) is with reference to the fixed nature of IQ. The intelligence quotient was thought to be a stable parameter with very little scope for manipulation. However, since IQ gains have been demonstrated, researchers need to develop a model of intelligence that can explain these findings.

Grabner, Stern, and Neubauer [9] reported a similar increase in general intelligence in 90 adult tournament players, the strongest predictor of the attained expertise level, was the participants' chess experience, which highlights the relevance of long-term engagement for the development of expertise.

Aciego, Garcia, and Betancourt [1] used a quasi-experimental study to examine the cognitive effects of chess training. The experimental group consisted of 170 students, 6–16 years of age, who received extracurricular chess instruction. The comparison group consisted of 40 students in a similar age range. After adjusting for pre-test scores, the chess group registered significantly higher post-test scores than the sports group for five of nine WISC-R subtests—i.e., the Similarities, Digit Span, Block Design, Object Assembly, and Mazes subtests.

In addition to increases in overall intelligence, the subcomponents such as memory language, non-verbal reasoning, numerical reasoning, conceptual thinking and verbal reasoning showed significant gains. The children trained in the present study worked on tactical studies, end game techniques, and chess playing with analysis. Such focused chess intervention developed the meta-cognitive skills sharpening cognitive patterns and improving precision in calculation. This possibly quickened their decision making and improved their scores on the psychometric test.

Trinchero [17] reported similar findings in 556 primary school children who were undergoing chess training. One prominent result was that the experimental group that received chess training registered a modest but statistically significant increase in scores on mathematics test items that required problem-solving skills on complex tasks. This effect was greater among students who had more hours of chess instruction.

Scholz et al. [15] investigated the effects of chess training on mathematics learning among students with learning disabilities, based on intelligence scores in the 70–85 IQ range. Classes from four elementary schools in Germany were randomly assigned to two groups: (a) an experimental group that received chess instruction of one hour per week for one entire school year; and (b) a comparison group that received supplementary mathematics instruction for one hour per week. The two

groups did differ significantly, in their calculation abilities for simple addition tasks and counting.

The study also pointed to three predictors of IQ gains, namely non-verbal reasoning, language, and memory. The chess training curriculum used in the present study includes workbook, score sheet writing, the Winning Moves Chess DVD, and various softwares for solving case studies and playing chess. Utilization of this curriculum could be a factor that improved the children's critical thinking skills, strategy, and long-range planning, resulting in the emergence of non-verbal reasoning, language and memory as predictors of IQ gains.

This finding is corroborated by the work of Ferreira and Palhares [7]. They studied the relationship between chess and problem solving involving geometric and numeric patterns, with 437 children from the third to sixth grades. The main result of the study was the existence of a relation between strength of play and patterns involving problem solving.

The factors identified are clearly targeted in chess training and practice. These skills are strengthened in the child in an implicit manner without effortful learning. Studies with special children for this reason have used chess to enhance cognitive functioning in children (Barrett and Fish [3]; Aydin [2]).

An interesting finding in this study was that as age increased, the IQ scores decreased. This effect could be an artefact of the procedures inherent in calculating IQ using the Binet-Kamat Test. IQ has been calculated by dividing the mental age by the chronological age. Hence, as age increases, the child has to perform at a higher level to show comparable increases in IQ.

VIII. Implications

It is clearly established in the present study that chess is a powerful intervention resulting in significant increases in the child's cognitive abilities. The average 7-point increase in IQ evident in the present study is remarkable. Chess intervention is also time effective as bi-weekly sessions were sufficient to lead to this increase.

The simplicity of the game makes it a versatile tool that can be used in schools, homes, and intervention centres. Recognizing the impact of chess as an educational Tool, the Tamil Nadu government has taken the initiate to make chess mandatory in government schools. While this is a praiseworthy effort, earlier age-group intervention and systematized chess curriculum such as *Winning Moves* (An Educational Chess learning DVD programme produced by the Emmanuel Chess Centre, Chennai India) and professional training for all children will lead to gains in educational performance and societal transformation.

As children learn to play together and win and lose, they learn valuable lessons that will generalize to academic functioning.

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[2] This research was conducted at Emmanuel Chess Centre, Chennai, India.

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AUTHORS' PROFILE

Mr. Ebenezer Joseph is India's first FIDE trainer and Candidate Master of the World Chess Federation. He is the founder of Emmanuel Chess Centre and has trained more than 5000 children and 125 chess trainers in the past 20 years. He is senior auditor in the Indian government and part-time research scholar in Madras University.

Dr. Veena Easvaradoss is Associate Professor and head of the psychology department in Women's Christian College, Chennai, India.

Mrs. Anita Kennedy is a Clinical Psychologist.

Mrs. Joanna Kezia is Associate Professor in the statistics department of Madras Christian College, Chennai, India.