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Short Communication

Effects of Abacus training on the intelligence of Sudanese children

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ABSTRACT

The effects of Abacus training in mental computation on intelligence assessed with the standard progressive matrices (SPM) was investigated in a sample of 3185 children aged between 7 and 11 years in Sudan. The sample was divided into two groups matched for scores on the SPM, sex, age and urbanization. The experimental group was given an intensive Abacus program training for two hours per week for 34 weeks. The control group did not receive any training. Following the end of the training the control and the experimental groups were retested with the SPM. Controlling for practice effects, the experimental group gained a statistically significant 7.11 IQ points attributable to the training. The experimental group also performed significantly faster following training. The results suggest that the introduction of a greater emphasis on problem solving skills in Sudanese schools may be expected to increase general intelligence.

1. Introduction

Intelligence is a determinant of a number of desirable outcomes including educational attainment, earnings, health and longevity (Lynn & Vanhanen, 2002, 2006). For this reason many people from Galton (1869) onwards have considered that it would be desirable if intelligence could be increased. There has been considerable research on the problem of how intelligence can be increased and the evidence indicates that this can be achieved by improvements in nutrition (Benton, 2001; Lynn, 1990) and education (Ceci, 1991). Although education appears to improve intelligence the process by which it does this remains problematical. Presumably, education teaches problem solving skills which are used in intelligence tests.

To examine this question more precisely we report an experiment designed to test whether Abacus training has a beneficial effect on intelligence in Sudanese children. Abacus training consists of training in mental arithmetic including working memory in which information is stored in working memory while other mental operations are performed, and then retrieved. The training procedure has been described by Hatano (1977) and Hatano and Osawa (1983). Mental arithmetic is required in a number of tests of fluid intelligence such as the Progressive Matrices. It has been shown by Carpenter, Just, and Shell (1990) that the Progressive Matrices is largely a mathematical problem solving test in design format, requiring the application of five mathematical rules involving addition and subtraction and arithmetical and geometrical progression. Hence the hypothesis to be examined is that performance on the Progressive Matrices will be improved by Abacus training.

2. Method

The sample in the study consisted of 3185 pupils from rural Khartoum State in Sudan, aged between 7 and 11 years with a mean age of 9.0 years, and of whom 1624 (51%) were males and 1561 (49%) females. The study was carried out in 2007. The sample was drawn from 58 classes from 16 primary schools and was divided into two matched groups, 27 classes for the control group and 31 for the experimental one. The IQ for the sample was first assessed with the standard progressive matrices (SPM) and the time for completion of the test was recorded for the two groups before the training began. The SPM has been applied worldwide and measures fluid intelligence, visual abilities, non-verbal reasoning, and the g factor. It has adequate reliability and validity. Second: after assessing IQ and speed, the sample was divided into two groups matched for sex, age and urbanization. The experimental group was given an intensive Abacus program training by trained teachers consisting of two hours per week for 34 weeks. Following the end of the training the control and the experimental groups were retested with the SPM. Raw scores and the time for completion of the SPM were recorded.

3. Results

Table 1 gives descriptive statistics of the means and standard deviations on SPM scores and speed for experimental and control groups, before and after training on the Abacus program.

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Table 1
Means and standard deviations on SPM scores and speed for experimental and control groups, before and after training

Group	Before	After	*N*
SPM score			
Experimental	17.04 (5.71)[a]	23.42 (5.87)	1348
Control	17.57 (6.17)	21.17 (5.82)	1144
SPM speed			
Experimental	40.76 (13.33)	32.86 (10.75)	1348
Control	38.57 (11.69)	35.80 (12.85)	1144

[a] Standard deviations are in brackets.

Table 2
Means and standard deviations, by age, in SPM scores for experimental and control groups, before and after training

Age	Control		Experimental	
	Before	After	Before	After
7	15.21 (4.81)[a]	19.31 (4.74)	16.31 (5.07)	22.63 (5.29)
8	16.43 (5.26)	20.21 (5.17)	16.50 (5.17)	23.11 (5.33)
9	18.44 (6.37)	21.91 (6.04)	17.74 (6.15)	24.31 (6.31)
10	20.06 (7.27)	23.10 (6.69)	16.76 (5.92)	23.09 (5.96)
11	17.56 (5.49)	21.09 (5.14	18.41 (6.21)	23.12 (6.48)

[a] Standard deviations are in brackets.

Table 2 gives more detailed descriptive statistics for each of the five age groups 7 through 11. These are the ages at the start of the study.

A two way multivariate analysis of covariance was conducted in order to determine the effect of the Abacus program on IQ as measured by the total score and speed of completion on the standard progressive matrices. The covariates of both gender and age were controlled since both showed significant if small multivariate effects on the dependent variables. Overall, significant effects of the Abacus program on the dependent variables were found as indicated by the significance of Wilks' Λ for the interaction between group (experimental vs. control) and time (before and after training) ($\Lambda = .856$, $F(2,209) = 208.78$, p, .001). The multivariate η^2 based on Wilks' Λ was of appreciable magnitude at 0.144. Table 1 shows the means and standard deviations of the total score and speed on the SPM, for the experimental and control groups, before and after training. At time 1 (before training), the difference between the IQ scores of the experimental and control groups, expressed in terms of Cohen's d is $-.089$ and is negligible. At time 2 (after training), the same d-score difference equals .385 in favour of the experimental group, which translates to a net gain of the experimental group over the control of .474d or 7.11 IQ point.

The two measures of IQ were largely uncorrelated at a range from 0.01 to 0.119, so analyses of variance (ANOVA) were conducted to test for the effect of training on the dependent variables. Using a Bonferroni correction, each ANOVA was tested for significance at the .005 level. Both the ANOVAs for SPM scores ($F(1,2400) = 294.91$, $p < .001$) and speed of completion of the SPM ($F(1,8146) = 118.64$, $p < .001$) were significant. The partial η^2 for the effect of training on IQ scores indicated a stronger effect at 10.6%, than was found for speed of completion at 4.6%. Figs. 1 and 2 shows the line plots for the experimental and control group marginal means, before and after training, for both IQ scores and speed of completion, respectively. It is readily apparent from these plots that the effect of Abacus training is to increase IQ scores and to reduce the time for test completion.

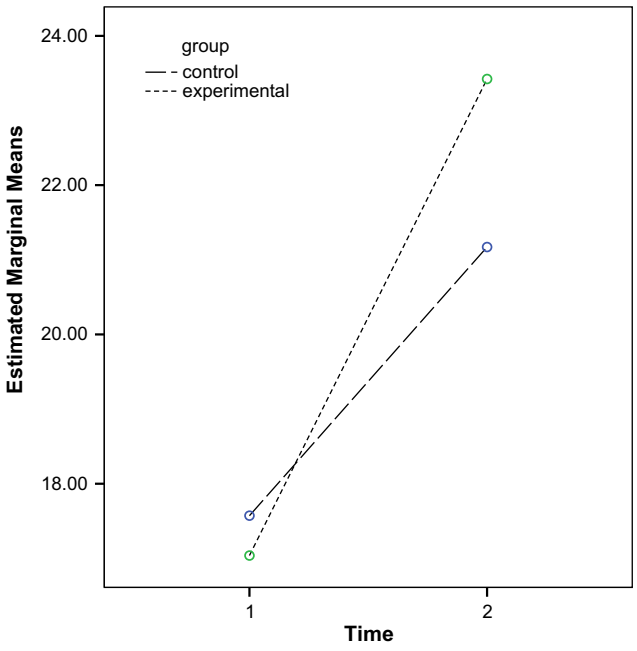

Fig. 1. Scores of the experimental and control groups before and after Abacus training.

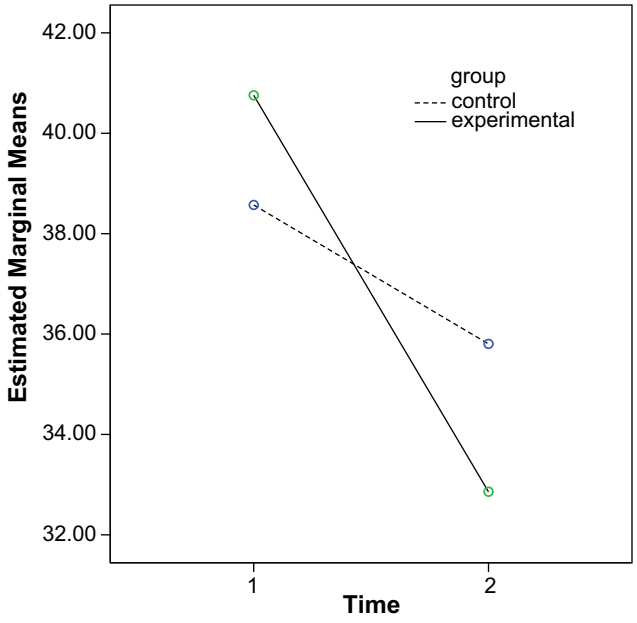

Fig. 2. Time to completion of the SPM for the experimental and control groups, before and after Abacus training.

4. Discussion

The gain of 7.11 IQ points of the Sudanese children on the SPM as a result of Abacus training is a significant and worthwhile achievement. It should be noted that the Abacus program does not provide direct training on the solution of progressive matrices problems. It is well known that training on how to solve the problems of a test produces large gains in the scores (e.g. Bunting & Mooney, 2001; Kulik, Kulik, & Bangert, 1984). The Abacus training is not of this kind but consists of training in the mental processes used for the solution of a wide range of cognitive problems.

The initial scores of the Sudanese children on the SPM were significantly lower than those of British children in the British

standardisation sample given by Raven (1981). The initial average score of the Sudanese children of 17.3 on the SPM is equivalent to the 12th percentile for this age on the British standardisation sample. This is equivalent to a Sudanese–British difference of approximately 17 IQ points. The gain of 7.11 IQ points of the Sudanese children on the SPM as a result of Abacus training is a significant contribution to reducing this difference.

The results suggest that the intelligence of Sudanese children would be significantly increased by introducing a greater emphasis on the acquisition of problem solving skills in Sudanese schools. Education in Sudan and other Arab countries tends to concentrate on rote learning and memorization.

A weakness of the study is that the children were retested shortly after the training and therefore the long term effectiveness of the program is not known. We plan to test the children again after a year to see whether the effectiveness of the training program lasts. It is likely that the effectiveness of the training diminishes over time, but it should be possible to retain its effectiveness with the introduction of a greater emphasis on problem solving skills in Sudanese schools.

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