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Original article

Effect of board games to enhance visuospatial working memory in preschool children in Foundation for Children

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Background: Working memory impairment is a risk factor predicting learning difficulties in children, particularly, visuospatial working memory was found to be associated with mathematical skills and concentration.
Objective: This study aimed to develop board games to train visuospatial working memory in preschool children to prepare them for school.
Methods: Thirty children aged 4 - 6 years in the Foundation for Children were divided into experimental and control groups (n = 15 per group). A simple random sampling was conducted to assign the children into each group. Corsi block-tapping test was administered to assess visuospatial working memory. The scores were retrieved from block span test (the number of block longest correct sequence); children with scores between 2.63 to 4.63 were in normal range. Within two months, the children in the experimental group obtained 10 – 30 minutes board games training twice a week.
Results: The mean of visuospatial working memory scores after having received board game training to improve visuospatial working memory among the children in the experimental group was significantly higher than that of the pre-training scores ($P < 0.01$) and also higher than in the control group ($P < 0.01$).
Conclusions: Board games effectively improved visuospatial working memory in preschool children, which would positively influence their learning performance in school.

Keywords: Board games, visuospatial working memory, Corsi block-tapping test, preschool.

Working memory is a capacity to temporarily store information available for an operation of complex cognitive activities afterwards. The theory of working memory which has been widely adopted is Baddeley's multi-component model. [1 - 3] It proposes that there are four components included in the model: 1) phonological loop, 2) visuo-spatial sketchpad, 3) episodic buffer, and 4) central executive. Moreover, working memory is needed to be promoted in children. Alloway TC, *et al.*'s study[4] discovered that 80% of children with poor working memory had difficulties in executing reading and arithmetic calculation tasks. Specifically, mathematical skills and concentration were found to be related to visuospatial working memory. It was found that there were increases in mathematical skills and concentration among children who had received visuospatial working memory training. Besides, visuospatial working memory training in preschool children was found to be more effective than the training in adolescents or adults. [5 - 7] Accordingly, considerable effort has been devoted in the enhancement of working memory program for children.

Board games and computer software programs are generally used in visuospatial working memory training in foreign countries. The most popular software training program is Cogmed.[8] However, some limitations in applying Cogmed program were found. It is a computer-based program that requires

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internet access to apply and practice online via Cogmed website; however, Thai translation is not available. Thus, the present study aimed to develop visuospatial working memory training through board games to remove such limitations and increase an opportunity for children in accessing visuospatial working memory training.

Methods

Study population

This study has received ethical approval from Ramkhaemhaeng University with the Ethical Approval Code RU-REC/xd-031-61. Thirty subjects were children aged 4 - 6 years old in the Foundation for Children, Nakhon Pathom, selected by a purposive sampling method. The study participants had no physical disability such as impaired hearing or impaired vision and had never acquired brain injury. Simple random sampling was applied to assign these participants into the experimental and control groups (n = 15 per group). For two months, the control group received 10 - 30 minutes board games training to enhance visuospatial working memory twice a week.

Measurements

Subject's general information included age, gender, grade, congenital diseases, reasons for getting adopted, and duration of stay at the foundation for children. Corsi block-tapping test, a computer-based program, was used to assess visuospatial working memory. There were nine blue square blocks displayed in a random position on a computer screen. When the test started, a blue block change its color to be yellow for 500 milliseconds long, and then switched to another block in different position with the Inter – Onset Interval 1,000 milliseconds to remain the proximity of each appearance to appearance. The subjects then repeated the presented sequence. The test was terminated after two trials were failed in each level; the sequence length started from 2 to 9 (the longest sequence). Mean scores of block span was 3.63 (SD = 0.97), scores between 2.63 to 4.63[9] were in normal range. The quality of the research tool was tested using test-retest method, the reliability was 0.812.

Board games to enhance visuospatial working memory designed on the basis of Baddeley's working memory model[1] , Cogmed games[8] and studies related to visuospatial working memory were comprised of five games, namely: 1) Fruit placement game consisted of a 3×3 board and five fruit cards. The players were required to take a look at an instruction card and place the cards on the board accordingly. 2) Color sequence memory consisted of a 4×4 board with six colors randomly place on it. The examiner pointed the colors in a sequence as shown in an instruction card; then, the children repeated the color sequence. 3) Fruit matching game consisted of 5 pairs of fruit pictures. 4) "Where is the carrot ?" maze game required the children to take a rabbit to a carrot safely without coming across a wolf. 5) Picture spin game arranged two pictures to be shown side by side. Then, the picture on the right was moved to four different directions (one direction at a time) while one picture remained fixed; the subjects were finally asked whether the stars in the two pictures were on the same locations or not. For example, a picture of one bear with a star on the left was shown side by side with a picture of a similar bear with a star on the left. The picture on the right was then moved to be at the top position, and then the examiner asked the children if the star in the two pictures were at the same location.

The Index of Item-Objective Congruence (IOC) of the designed board games was tested by three experts, including one child and adolescent psychiatrist and two clinical psychologists; the validity was at "fair" level.

Statistical analysis

Descriptive statistics such as mean ± standard deviation were conducted using SPSS Statistics version 21 software. Wilcoxon signed-rank test was used to compare between pre - and post-test scores of the experimental group. Unpaired student *t* - test was used to compare post -test scores between the experimental and control groups.

Results

The majority of participants (70%) were male; 43.3% were four years old; 50% were studying in kindergarten 1; 76.7% had no congenital diseases (congenital diseases included heart valve regurgitation, thalassemia, paleness, atopic dermatitis and attention-deficit hyperactivity disorder is undergoing treatment); and 76.7% were adopted because of broken-family reasons. Average length of stay at the foundation for children was 2.5 years.

The mean of pre-test visuospatial working memory scores of the experimental group was 2.80 ± 0.78, representing the normal level. After board games

training, the mean scores increased to 3.73 ± 1.03, representing the normal level. Meanwhile, the mean of visuospatial working memory scores of the control group at the first measurement was 2.33 ± 1.18, representing the below normal level; at the second measurement was 2.47 ± 1.06, representing the below normal level. The mean of pre-and post test visuospatial working memory scores of the experimental group after having received board games training designed to improve visuospatial working memory was significantly higher than the scores prior to the training ($P < 0.01$) (Table 1). Additionally, the mean of visuospatial working memory scores of the experimental group having received board games training designed to improve visuospatial working memory was significantly higher than the scores of the control group having received general board game training ($P < 0.01$) (Table 2).

Discussion

According to the study of effects of board games to enhance visuospatial working memory in preschool children, results revealed that the mean of post-test visuospatial working memory scores of preschool children having received the board games training was higher than the pre-test scores and higher than the scores of those in the control group who had never received the board games training. These results indicated that board games designed to enhance visuospatial working memory effectively improved visuospatial working memory in preschool children in the foundation for children. This study developed the board games based on visuospatial sketchpad, an important component of Baddeley's multi-component theory [1 - 2], which was responsible for storing information about image, image position, movement, direction, and object features (form and color). Besides, preschool children benefit from playing game. For example, Gade M, *et al.* [7] investigated visuospatial working memory training in preschool children in which the experimental group received the training using two-dimensional Corsi block-tapping task software. It was found that after the training, the score of the experimental group was significantly higher than the control group ($P < 0.05$). Likewise, Grunwalth KH, *et al.* [10] studied the improvement of working memory in preschool children with low-birth weight applying Cogmed JM computer-based program. The results showed that the participants who had received working memory training through Cogmed JM. acquired significant increased scores in all dimensions. Similarly, Nelwan E, *et al.* [11] examined limited near and far transfers effects of Jungle Memory working memory training on learning mathematics in children with attentional and mathematical difficulties and discovered that the experimental group receiving Jungle Memory (JM) training prior to Math Garden (MT) had higher mathematical skills than the group that had no prior JM training or had no previous training at all. These findings revealed that visuospatial working memory training in preschool children provided better outcomes

Table 1. Comparing between the means of pre- and post-test visuospatial working memory scores in the experimental and control group.

Sample	Pre - post test	Mean	SD	*P* - value
Experimental group	Pre - test	2.80	0.78	0.004
	Post - test	3.73	1.03	
Control group	Pre - test	2.33	1.18	0.564
	Post - test	2.47	1.06	

Table 2. Comparing the means of post-test visuospatial working memory scores between the experimental and control group.

Measure	Sample (n = 30)	Mean	SD	*P* - value
Block span	Experimental group	3.73	1.03	0.002
	Control group	2.47	1.06	

compared with children receiving no training. In addition, Cockcroft K.'s study[5] found that visuospatial working memory training in preschool children was more effective than the training in adolescents or adults because preschool children used more of visuospatial working memory than verbal processing. Both board games and computer software training to enhance visuospatial working memory share a similar objective – to improve visuospatial working memory in order to effectively influence positive learning outcomes in the classroom.

Conclusion

Board games effectively increase visuospatial working memory in preschool children, resulted in better learning for children in the classroom. Thus, board games should be applied as additional activities for preschool children.

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Conflict of interest

The authors, hereby, declare no conflict of interest.

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