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Original Research Paper

Evaluation of Auditory Working Memory in Abacus Trained Children Using Auditory N Back Test

Medical Science

KEYWORDS : Auditory working memory, Auditory n back, Abacus learners.

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ABSTRACT

Abacus training leads to improvement in mathematical skills. Learning mathematics is learning associated with memory. One of the frequently used test to measure the auditory working memory skills is the auditory n back test. The present study was undertaken to investigate the effect of abacus training on auditory working memory using auditory n back test. 24 male children in the age range of 10-12 years were divided into 2 groups. Group 1 consisted of 12 subjects with no abacus learning experience and Group 2 consisted of 12 subjects who were abacus trained for a minimum of 1 year. Auditory 2 back test was administered on them. Results indicated that abacus trained children performed better than abacus untrained children. The improved memory scores obtained by abacus trained children showed the skill of memory retention in this group.

INTRODUCTION

Abacus is a Latin word that has its origins in the Greek words abax or abakon(meaning "table" or "tablet"). An abacus instrument allows performing basic mathematical operations. Abacus instrument is made up of a frame with vertical rods on which beads move up and down. This device also consists of a horizontal bar also termed as reckoning bar or beam which divides the abacus into upper and lower portions. Two fingers, the index finger and thumb are used to perform calculations in abacus. Index finger is used to move the four units beads up and down and the thumb is used to move one-unit bead up. These movements are performed simultaneously with two fingers. Abacus experts manipulate the beads in their head to perform calculations.

Figure 1: Basic abacus instrument with number representation

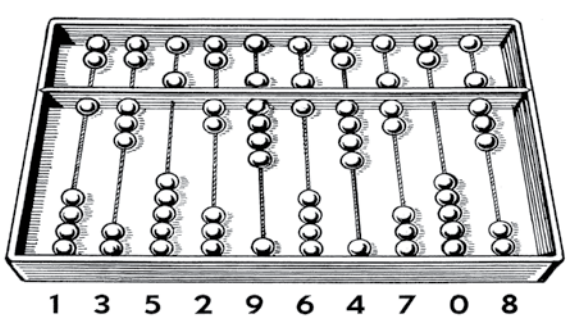


Figure 1 shows the basic abacus instruments and the bead position for each number. According to Bhaskaran (2006), abacus helps to visualize and manage calculations with large numbers. While performing mathematical calculations in abacus, children use both hands to move the beads. The quick communication between the hands and brain stimulation promotes quick, balanced and whole brain development (Bhaskaran, 2006). Sokol etal., 1991 reported that mental calculation involves well-learned procedures, problem-solving skills, and dependence on working memory. Shizuko Amaima (2001) reported that the first effect of abacus learning is improvement of numerical memory and improvement of memory in spatial arrangement.

"Working memory" (WM) refers to the ability to hold on to pieces of information until the pieces blend into a full thought or concept i.e. it refers to the limited capacity system that allows simultaneous storage and processing of temporary information (Baddeley, 1974). Based on the type of stimuli, working memory can be classified as visual working memory and auditory working memory. Auditory memory is the ability to process information presented orally, analyze it mentally and store it to be recalled later. Visual memory refers to the recollection of visual information whereas auditory memory is the recollection of things that were heard.

There are various methods to measure auditory working memory skills. Auditory N-Back is one of the frequently used methods to measure auditory working memory. Kirchner (1958) first reported N back test. This test requires codification, temporary storage and response, as it is necessary for the individual to update and maintain information continuously in the WM to readily access it (Gonçalves & Mansur 2009). N back test consists of a set of number of stimulus. A stimulus that meets the n back criteria for a match is called a target. In this test, a series of stimuli are presented, and the subject must signal whenever the current stimulus matches the one that was presented n steps back in the list. Variation in the n (example 1 back, 2 back etc) can be used to assess individual's levels of processing capacity. In 1 back test, participants are required to respond with the next to last stimulus that was presented. In few studies, stimulus sequences are manipulated to include match trials and nonmatch trials which is also termed as lure trials. Lure trials are those trials in which the current stimulus in not in the correct serial position to be a match but still is same as the one presented recently (example in a 2 back test the second number 7 in the sequence 3-7-3-5-7 is a lure as it matches the number presented 3 back).

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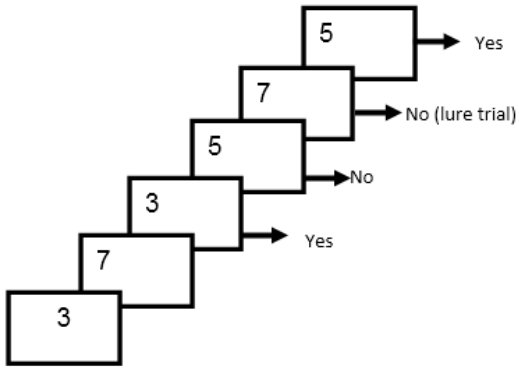


Figure 2: **Example of an auditory 2 back test**

Figure 2 shows an example of stimulus sequence of auditory 2 back test and the expected responses. Research over the few decades have demonstrated that performance in the working memory tasks is predictive of achievement in mathematics (Geary, Hoard, Nugent & Byrd-Craven, 2007). Studies also have shown that abacus increases the ability of children in performing mathematics calculation. Learning mathematics is learning associated with memory. Though a number of studies have proved the influence of abacus in improving mathematical skills, very limited studies have been done to study its influence on auditory working memory. Hence the present study was undertaken to investigate the effect of abacus training on auditory working memory. Aim of the study was to study the effect of abacus training on auditory working memory by using auditory N back test.

METHOD

Participants

24 male children in the age range of 10-12 years participated in the study. They were divided into 2 groups; Group 1 consisted of 12 subjects with no abacus learning experience & Group 2 consisted of 12 subjects who were abacus trained for a minimum of 1 year. The two groups were paired for age and handedness. The subjects had the hearing thresholds within 15dBHL between 250-8000Hz. Auditory 2 back test was administered on them.

Stimulus

Stimuli for this test was prepared by using 5 numbers in kannada in which few numbers were repeated to make a string of 11 numbers. Stimuli consisted of match trials, non match trials and lure trial. A native female Kannada speaker was instructed to read these sequences of digits with an inter stimulus sequence interval of 2 seconds and they were recorded using a digital voice recorder.

Procedure

The study was carried out in quiet and distraction free environment where the subjects were seated comfortably on a chair next to clinician. The recorded stimuli were presented to each subject at their most comfortable level through loudspeaker which was connected to a laptop. The subjects were presented with a sequence of stimuli and the task consists of indicating when the current stimulus matches the one from 2 steps earlier in the sequence. After presentation of 3rd number, child had to start responding for each number. Subjects have to remember the position of the number, two turns back and so on. Instruction given to the subject was as follows "I will be presenting you a series of numbers auditorily. You have to listen to these numbers and say 'yes' if the stimulus was repeated 2 steps back and say 'no' if the stimulus was not repeated. You have to start responding after presentation of 3rd number".

Scoring

Correct response was given a score of 1 and incorrect response or no response was given a score of 0. Number of correct responses was noted. The data collected from participants was tabulated.

RESULTS

The scores obtained on auditory 2 back task by both groups were subjected to statistical analysis using SPSS 17. Descriptive statistics were obtained for both groups. The mean scores obtained for abacus untrained male children (Group 1) was 6.3 with a standard deviation of 1.49 and for abacus trained male children (Group 2) it was 7.8 with a standard deviation of 0.83.

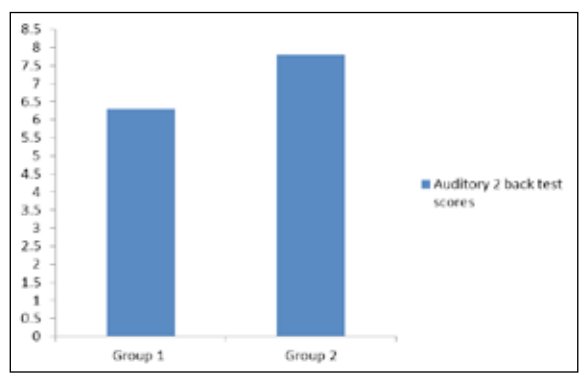


Figure3: Mean and Standard deviation (S.D) of auditory 2 back test scores across two groups.

Figure 3 shows that mean scores of auditory 2 back test were better for abacus trained children compared to abacus untrained children. The scores obtained by group 1 and group 2 were further compared using independent sample t-test. The result indicated that there was a significant difference ($p<0.05$) on performance of the task between the two groups. The abacus trained male children performed better than that of abacus untrained male children in the auditory 2 back task.

DISCUSSION

Successful performance in the auditory 2 back task requires the subjects to rehearse the set of stimulus in the memory. This also requires the subject to drop items that are no longer relevant from memory (the items that is 2 stimulus back), add new items as each is presented and assign proper back tag to the memory. This task involves maintaining the correct sequence of the stimulus in the working memory while response is processed and executed. The improved memory scores obtained by abacus trained children shows the memory retention and recall in this group which may be due to learning experience. Abacus learning experiences may also affect the pattern of cerebral specialization. The right hemisphere engages in mental calculation for the abacus trained children where the left hemisphere contributes to mental calculation in normal children having no experience of abacus learning (Hatta & Ikeda, 1988). This study is in support of the study done by Hattano & Osawa (1983) wherein they reported that abacus experts can recall 13 to 20 digits in both forward and backward reproduction. Abacus trained children may have a particular algorithm and by long time practice may acquires knowledge of procedures and memory retention. Similar findings was

reported by Stigler (1980) where in author stated that abacus experts have a greater memory span for auditorily presented digits. Shanthala (2011) gave a neurophysiological explanation for improved memory scores in abacus trained children. She reported that interiorization of abacus skill might have induced changes at the synaptic connections resulting in synaptic plasticity which might induce long term potentiation and consolidation of memory.

CONCLUSION

The results showed that abacus learning not only increases the ability of children performing arithmetic calculation but also improved the auditory working memory consistently. This may also help them perform better in subjects other than mathematics, as their ability to retain auditory inputs has improved. Abacus training may improve the children's cognitive skills which further show an improvement in learning.

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