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Effect of abacus training on critical flicker fusion frequency threshold among primary schoolchildren

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ABSTRACT

Objectives: The concept of neuronal plasticity has been considerably studied to know how long-lasting changes are associated with brain's capacity to be shaped or sculptured by experience. Potential cognitive benefits of abacus training have been proved by various studies indicating it to be a promising tool in improving cognitive abilities including arithmetic abilities, visuospatial and working memory. Critical flicker fusion happens when the individual can no longer differentiate between changing visual stimuli. It can be modulated by behavioural or psychophysical techniques. The objectives of the study were to evaluate the effects of abacus training on critical flicker fusion frequency (CFFF) threshold.

Materials and Methods: CFFF threshold (CFFFT) was measured in 60 school students studying third and fourth standard (30 trained in abacus and 30 not trained in abacus) using portable software-based apparatus.

Results: The mean scores of abacus trained individuals were significantly higher compared to those who were not trained.

Conclusion: Since higher CFFFTs can absorb more visual information, increasing their threshold might lead to cognitive improvement and better academic performance. Abacus trained individuals showed significantly higher critical fusion frequency threshold.

Keywords: Abacus trained, Primary school students, Critical flicker fusion frequency threshold, Sweep gen

INTRODUCTION

The concept of neuronal plasticity has been considerably studied to know how long-lasting changes are associated with brain's capacity to be shaped or sculptured by experience. Human brain has illimitable capacity to adjust to environment and synaptic changes during neuronal development are thought to be conditioned by genetic and environmental influences.

Abacus, a traditional calculation device, conventionally used among Asian population to comfortably perform mathematical calculations inclusive of addition, subtraction, multiplication and others. It represents visuospatial location of beads that are systematically arranged.[1] In mental abacus, precise arithmetic operations are performed rapidly by visual representation of an abacus (a physical calculation device) in one's mind.[2]

Recently, the possible cognitive benefits of training students in abacus have been proved by various psychological studies indicating it to be a promising tool in enhancing cognitive abilities including arithmetic calculations and visuospatial working memory.[3,4]

The critical flicker fusion frequency (CFFF) is the frequency at which a flickering stimulus is perceived to be fixed, with higher values suggesting greater perceptual accuracy.[5] Critical flicker fusion happens when the individual can no longer differentiate between changing visual stimuli.[6]

Initially, it was thought that peripheral visual pathway is mainly responsible for fusion of flickering stimulus, however, in both animal and human subjects, electrical recording at various levels of the visual pathway has hinted that the eye itself responds at greater frequencies than that of frequencies procured by behavioural or psychophysical techniques, and are hence not the confined factor in regulating CFFF.[5] Recent studies have also affirmed that having black tea, coffee and caffeinated water which are known to cause energetic arousal augments CFFF threshold (CFFFT).[7]

Furthermore, recent articles suggests increased CFFFT among individuals who played video games since their childhood.[8] Since studies pertaining to abacus training have ascertained behavioural refinement in cognitive functions through functional and structural changes in the brain, we tried to investigate the effect of abacus training on CFFFT.

MATERIALS AND METHODS

The study included 60 school students of third and fourth standard (30 trained in abacus and 30 not trained in abacus) of mean age group 8–9 years enrolled at an urban school in Karnataka. The students were briefed about the procedure and were requested to participate in the study after seeking permission from the principal of the respective school. Before administering the test, a brief history was taken and students with a history of mental illness, emotional disturbances, internalising/externalising disorders, colour blindness, on medication that stimulate or depress central nervous system and specific learning disabilities were excluded from the study.

CFFF was measured using a portable software-based apparatus. The software which we used was Sweep Gen.

Description of the software

Sweep Gen is software developed by David Taylor, Edinburg. It turns a computer into an Audio Oscillator and Sweep Generator that can be used for testing audio and preparing frequency response plots. Sweep Gen uses a sound card in the computer to generate accurate sine waves.

Description of the apparatus

The apparatus consisted of red LED lamp of 5 mm diameter which can be lit at various frequencies in the range of 10–60 Hz. It was placed against the white background. After a short practice phase, each participant were asked to sit in front of the apparatus kept at a distance of 30 cm at the subject's eye level. To begin with, the red light was made to flicker at low frequency of 10 Hz and then the flickering frequency was gradually increased at the rate of 1.5 Hz/s.

Subjects were instructed to raise their hand when the light appeared constant or steady. The frequency at which light stimuli appeared constant was noted. To confirm the observation made, the frequency of stimulation was decreased and subjects were instructed to report when the light appeared flickering. An average of three recordings was taken as the final value.

Statistical analysis

The scores were expressed as mean ± standard deviation. Mean scores of the two groups were compared by unpaired Student's *t*-test. $P < 0.05$ was considered statistically significant.

RESULTS

The mean scores of abacus trained individuals were significantly higher compared to those who were not trained in abacus [Table 1].

DISCUSSION

Stimulus-related changes are known to occur at different areas of the central nervous system, which also include neural networks and neurocytes. Substantial evidences suggest that skill training can lead to long term, reproducible changes in brain activity and structure.[9]

Available data also propose that through practice and training the deficits in cognitive control may be reinstated. Neuroimaging studies have explained the way the brain acquits itself in response to practice or training for a particular task and were thought to be an excellent tools in this endeavour.[10]

Abacus training has been thought to function as a brain stimulant. It simultaneously utilises both the left and right brain. Learning abacus at an early age helps to activate the nervous system of young children. Abacus-based mental calculation (AMC) training has received considerable attention in the field of neuronal plasticity induced by indoctrination as it mediates calculations in a visual-spatial format. Compared to physical abacus, individuals after

Table 1: CFFFT among abacus trained and untrained individuals.

Parameter	Abacus	Non-abacus	*P* value
CFFFT	38.89±1.11	38.06±1.36	0.019*

*P<0.05-Statistically significant. CFFFT: Critical flicker fusion frequency threshold

long-term AMC training are able to perform and complete arithmetic operations more rapidly and accurately. Evidences from functional MRI studies infer that AMC trained individuals exhibit enhanced activation in some brain regions including fusiform gyrus, inferior parietal lobule and occipital gyrus. Anatomical MRI studies also ascertain the structural plasticity caused by training.[11]

Several behavioural and neuroimaging studies have attempted to inspect the neural relationship in calculation approach employed by individuals trained in abacus and have reported bilateral dorsal premotor cortex, inferior parietal lobule and superior parietal lobule activation during mental calculation and digit memory tasks among individuals using abacus for calculation.[12]

About 20% of the human cerebral cortex constitute parietal lobe and the posterior parietal cortex, which are located at the junction of multiple sensory regions, projecting to various cortical and subcortical areas known to be involved in a variety of cognitive functions.[13]

Furthermore, enhanced average fractional anisotropy in whole-brain fibre tracts, corpus callosum, left occipitotemporal junction and right premotor projection was proved in the earlier studies involving individuals trained in abacus suggesting amplified integrity in white matter tracts related to motor and visuospatial processes and a visuospatial representation for digit memory.[14,15]

The CFFFT is an interesting concept in the psychophysiology of vision. It is the least frequency of continuous flicker that is recognised as a fixed source of light. It depends on a number of factors including the area, position and light-adapted state of the retina. It also depends on wavelength, waveform, light-dark ratio of the stimulating light, luminance, the duration of exposure and the size of the pupil. Age and other constitutional factors have also been taught to influence the frequency of threshold.[16] Evidences also confirm that CFFF requires visual integration, visuomotor skills and decision-taking process.[17]

The present study showed a statistically significant increase in CFFFT among abacus trained individuals compared to individuals who were not trained.

The possible explanation for increase in the threshold among abacus trained individuals apart from peripheral visual mechanisms includes cerebral activation resulting from abacus training and the cellular mechanisms that lead to cerebral activation dependent on N-Methyl-D-Aspartate receptor-dependent neurotransmission.[18]

The results of the present study are supported by findings of Carmel *et al*. which confirmed greater brain activation in regions of frontal and parietal cortex previously related to visual awareness.[19]

Our study is also supported by the findings of Turner whose findings suggest that critical fusion frequency is known to be affected by centrally acting drugs that lead to brain activation and findings of Chiranjeevi whose findings suggested increased CFFFT among video game players.[8,16]

CFFFT appears to be a useful research tool for cognitive change overtime and higher CFFFTs can take in more visual information per unit time. It also allows an individual to consciously track fast-moving objects more precisely. Since brain that responds faster are plausibly capable of displaying faster rates of subjective experience, it is necessary to emphasise on the beneficial effects of abacus training on child's cognitive development. Further, awareness programs regarding the benefits of abacus training need to be organised so that parents encourage their children to exhibit willingness to learn abacus as an after class supplemental mathematics education.

CONCLUSION

In the present study, it is observed that individuals trained in abacus had significantly higher critical fusion frequency threshold than those who were not trained. Since higher CFF thresholds can absorb more visual information, increasing their threshold might lead to cognitive improvement and better academic performance.

Strength and limitations of the study

The results of the current study are engrossing enough to know the effect of abacus training on CFFFT. However, the current study is a pilot study which would establish a baseline for future studies.

Implications

It is necessary to further explore the clinical implications of the present study. Future studies should observe and prove the relationship between duration of training and CFFFT. Further studies are also required to understand the molecular mechanisms related to differences in CFFFT following abacus training.

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Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Wang CA. Review of the effects of abacus training on cognitive functions and neural systems in humans. Front Neurosci 2020;14:913.
2. Frank MC, Barner D. Representing exact number visually using mental abacus. *J* Exp Psychol Gen *2012*;141:*134*-49.
3. Wang C, Xu T, Geng F, Hu Y, Wang Y, Liu H, *et al*. Training on abacus-based mental calculation enhances visuospatial working memory in children. J Neurosci 2019;39:6439-48.
4. Na KS, Lee SI, Park JH, Jung HY, Ryu JH. Association between abacus training and improvement in response inhibition: A case-control study. Clin Psychopharmacol Neurosci 2015;13:163-7.
5. Vani PR, Nagarathna R, Nagendra HR, Telles S. Progressive increase in critical flicker fusion frequency following yoga training. Indian J Physiol Pharmacol 1997;41:71-4.
6. Eckert MA. Slowing down: Age-related neurobiological predictors of processing speed. Front Neurosci 2011;5:25.
7. Hindmarch I, Quinlan PT, Moore KL, Parkin C. The effects of black tea and other beverages on aspects of cognition and psychomotor performance. Psychopharmacology (Berl) 1998;139:230-8.
8. Endukuru C, Maruthy K, Deepthi T. A study of critical flickering fusion frequency rate in media players. Int J Multidiscip Res Dev 2015;2:499-502.
9. Li Y, Chen F, Huang W. Neural plasticity following abacus training in humans: A review and future directions. Neural Plast 2016;2016:1213723.
10. Kelly C, Foxe JJ, Garavan H. Patterns of normal human brain plasticity after practice and their implications for neurorehabilitation. Arch Phys Med Rehabil 2006;87 12 Suppl 2:20-9.
11. Weng J, Xie Y, Wang C, *et al*. The effects of long-term abacus training on topological properties of brain functional networks. Sci Rep 2017;7:8862.
12. Tanaka S, Seki K, Hanakawa T, Harada M, Sugawara SK, Sadato N, *et al*. Abacus in the brain: A longitudinal functional MRI study of a skilled abacus user with a right hemispheric lesion. Front Psychol 2012;3:315.
13. Behrmann M, Geng JJ, Shomstein S. Parietal cortex and attention. Curr Opin Neurobiol 2004;14:212-7.
14. Hu Y, Geng F, Tao L, Hu N, Du F, Fu K, *et al*. Enhanced white matter tracts integrity in children with abacus training. Hum Brain Mapp 2011;32:10-21.
15. Tanaka S, Michimata C, Kaminaga T, Honda M, Sadato N. Superior digit memory of abacus experts: An event-related functional MRI study. Neuroreport 2002;13:2187-91.
16. Turner P. Critical flicker frequency and centrally-acting drugs. Br J Ophthalmol 1968;52:245-50.
17. Balestra C, Machado ML, Theunissen S, Balestra A, Cialoni D, Clot C, *et al*. Critical flicker fusion frequency: A marker of cerebral arousal during modified gravitational conditions related to parabolic flights. Front Physiol 2018;9:1403.
18. Nardella A, Rocchi L, Conte A, Bologna M, Suppa A, Berardelli A. "Inferior parietal lobule encodes visual temporal resolution processes contributing to the critical flicker frequency threshold in humans. PLoS One 2014;9:98948.
19. Carmel D, Lavie N, Rees G. Conscious awareness of flicker in humans involves frontal and parietal cortex. Curr Biol 2006;16:907-11.

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