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ORIGINAL ARTICLE

The Psychomotor Effects Of Brahmi And Caffeine On Healthy Male Volunteers

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Background: Brahmi enhances cognitive processes including comprehension, memory and recall. Caffeine is undoubtedly the most widely used psychoactive substance in the world.
Aim: To compare the psychomotor performance of brahmi and caffeine.
Setting: Postgraduate Department of Pharmacology and Therapeutics of a Medical college
Material and methods: 40 healthy male medical student volunteers were given Brahmi (250 mg) or Caffeine (100 mg) twice a day after meals for 16 weeks. Two types of psychomotor performance tests were conducted on the subjects at 0 (before the consumption of drug), 2, 4, 6, 8 and 12 weeks. Instrumental tests included a Simple Reaction Time Task (SRT), a Multiple Choice Reaction Time Task (MCRT), a Critical Flicker Fusion Threshold Task (CFFT) and a Tracking Performance Task (TPT) whereas, non -instrumental tests included a Digit cancellation task (DCI), a Memory test (MT) and a Mental arithmetic task (MAT).
Results: Out of these subjects, two dropped out from the caffeine group due to unpleasant side effects at week 2. At 16 weeks, Brahmi caused significant decrease in the MCRT score than caffeine ($P<0.05$), while at 12 and 16 weeks, Brahmi significantly improved the CFFT score than caffeine ($P<0.05$). After 8 weeks onwards, Brahmi caused significant increase in the DCT score than caffeine ($P<0.05$). MT scores were significantly better in the caffiene group than in the Brahmi group at 12 weeks ($P<0.001$).Brahmi showed significant increase in the MAT score than caffeine in 8, 12 and 16 weeks ($P<0.05$).
Conclusion: From the results of the present study, we conclude that Brahmi can prove to be a supplement of utmost utility to improve cognitive functions.

Key Words: Brahmi, cognitive functions, caffeine.

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Introduction

Brahmi (Bacopa monniera) has a long history of use in ayurveda for treating a number of disorders like anxiety, poor memory, epilepsy, insomnia and asthma. [1],[2] It has been tested as a nootropic that enhances cognitive processes including comprehension, memory and recall. The ethanolic extract of Bacopa has been used to increase the activity of antioxidative enzymes (e.g superoxide dismutase, glutathione peroxidase and catalase) in the frontal cortex, striatum and hippocampus of rats. [3] Bacopa also increases the level of serotonin, a brain chemical, to promote relaxation.[4] Caffeine is undoubtedly the most widely used psychoactive substance in the world. Caffeine, a xanthine alkaloid compound, is a CNS stimulant having the power to temporarily ward off drowsiness and restore alertness. In the present study, we

compared the psychomotor performance of brahmi and caffeine in healthy male volunteers.

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Material and Methods

The study was carried out on 40 healthy male medical student volunteers in the age group of 25 ± 5 years in the Postgraduate Department of Pharmacology and Therapeutics of a Medical college. Prior to inclusion in the study, the volunteers were evaluated for general physical and systemic examinations and biochemical estimations like renal function test, liver function test, lipid profile and fasting blood sugar, haematological estimations like haemoglobin, TLC, DLC, urine and stool examination. Subjects with a history of renal or hepatic diseases, consumption of CNS affecting drugs for four weeks before starting the trial, smoking and alcohol consumption for the last four weeks prior to the drug administration, any intake of caffeine drinks 24 hours prior to the study or during the study and abnormality in answering the Eysenck personality questionnaire, were excluded from the study.

Forty male subjects fulfilling the above criteria were selected for the study after taking their informed consent. The subjects were trained daily for several days for psychomotor performance tests till their performance reached a stable level. All volunteers were randomly allocated into 2 groups. All the volunteers were evaluated for the pre drug scores on their psychomotor performance at 0 day. One of the following drug schedules was administered for 16 weeks:-

Group 1- Brahmi (250 mg) twice a day after meals

Group 2- Caffeine (100 mg) twice a day after meals

Each group was evaluated for post drug scores on the psychomotor performance tests at 2, 8 and 16 weeks and any reported adverse drug reactions were recorded.

Two types of psychomotor performance tests were conducted on the subjects at 0 (before the consumption of drug), 2, 4, 6, 8 and 12 weeks. The instrumental tests included a Simple Reaction Time Task (SRT), a Multiple Choice Reaction Time Task (MCRT), a Critical Flicker Fusion Threshold Task (CFFT) and a Tracking Performance Task (TPT), whereas, the non -instrumental tests included a Digit cancellation task (DCI), a Memory test (MT) and a Mental arithmetic task (MAT).

Simple Reaction Time (SRT) Task

The instrument consisted of two separate units; the first known as the stimulus controlling unit from which the presentation of four different coloured visual stimuli were regulated by pressing appropriate corresponding knobs. This unit also recorded automatically the time taken to respond to the stimulus.

The second unit consisted of a panel and a base. Four different coloured stimuli (Red, yellow, green and blue) were displayed on the panel and corresponding push buttons were present at the base. Visual stimuli were displayed to the subject by the investigator operating the stimulus controlling unit in another chamber. The coloured visual stimuli were presented to the subject at regular intervals and the subjects had to respond by pressing the key. The responding times to different stimuli were noted to an accuracy of 1/100th of a second. At each session, 20 such readings were taken and the mean of these readings was recorded in milliseconds.

Multiple Choice Reaction Time (MCRT) Task

The monitor of this apparatus had ten rows of coloured lights, each row having ten lights of red, yellow and green colours. The base of the equipment had buttons for respective colours. The equipment had an option for two programmes; each having a different sequence of appearance of the coloured light. The time taken for the response was displayed at the back of the equipment and the investigator categorized the responses into correct, delayed correct and wrong.

The subject was presented with a particular type of coloured light at a given time and he was supposed to press the corresponding button within 0.5 seconds. Such responses were recorded as correct responses. If the response

occurred within 0.5 to 0.8 seconds then it was designated as delayed correct and if the wrong button was pressed, then the response was recorded as wrong. The total sum of correct, delayed correct, and wrong responses were subtracted from 100 to get the number of missed responses. At one sitting, four trials were recorded, two with each programme. The error index was calculated from the mean of these four trials.

The error index was calculated by the following formula: -

Error index (Ei) - Number of delayed responses + No. of wrong responses x 2 + no of missed responses x 3.

Critical Flicker Fusion Threshold (CFFT) Task

This task was carried out on the 'Maq Lab' digital critical flicker fusion threshold apparatus, a well-established neurophysiological technique that reflected the cortical function, especially of the occipital and the parietal lobe. This equipment consisted of two units; first, the viewer unit from where four light emitting diodes are viewed by the subject and the second unit which was operated by the investigator who controlled the frequency threshold. The investigator increased or decreased the frequency of the coloured lights from flicker to fusion or vice versa and the frequencies were recorded in hertz.

After a fixed period of accommodation, the frequency was increased and decreased progressively until the subject recorded a change in his flicker perception. The subject was tested five times with increasing frequency and fives times with decreasing frequency and the mean of these ten readings was calculated.

Tracking Performance Task (TPT)

The TPT score was measured on the 'Maq Lab' tracking task apparatus. It was a basic measure of the visual-motor co-ordination performance. The subject was presented a circular moving light on a screen and he had to track it with the hand held photocell stylus .The speed of moving light was 10 revolutions per minute around a circular track. The total time fixed for a single task was 30 seconds and five readings were noted in each session .The target rate per minute was calculated (the time for which the stylus remained on the target) according to the following formula;

$$\text{Target rate per minute} = \frac{\text{Target time}}{30} \times 60$$

Digit Cancellation Task (DCT)

In a matrix of 400 digits, a particular digit was randomly distributed 40 times in the whole sample. The subject had the task of cancelling the specified digit as many times as possible in 30 seconds. Target digits were altered in subsequent sessions and the numbers of the cancelled digits were recorded in each session.

Mental Arithmetic Task (MAT)

The test was conducted according to the method described by Stone (1984). The subject was presented with a sheet containing 30 addition and 30 subtraction sums of three digit numbers and the total duration of 2 minutes was permitted for each exercise. Written calculations were not permitted and the subject had to complete as many sums as possible in the above specified time period. The number of sums attempted and the number of wrong answers were recorded.

Memory Test (MT)

A set of ten names of unrelated objects was read out to the subject and 1 minute was given to memorize them. After 20 minutes, the subject was asked to recall and write down as many objects as possible and his answer was recorded.

Statistical Analysis

The data obtained in each group at 2, 4,8,12 and 16 weeks were compared with pre drug values obtained at 0 day and values of different regimes were also compared in between. After the completion of the study, the data was analyzed with the help of Computer Software Microsoft Excel Windows. Mean ± SD were calculated for qualitative variables for all the four groups. Paired 't' test was used to evaluate

the statistical significance within a group from 0 to 16 weeks. Unpaired "t" test was used to compare the values between the two groups. 'P' values equal to or less than 0.05 were considered to be statistically significant.

Results

Out of these subjects, two dropped out from the caffeine group due to unpleasant side effects at week 2. Brahmi caused a significant decrease in SRT from the 4th week onwards. There was a significant decrease from the baseline score of -0.03 at 2 weeks (P=0.079), -0.10 at 4 weeks (P=0.003), -0.13 at 8 weeks (P<0.001),-0.14 at 12 weeks (P<0.001) and -0.14 at 16 weeks (P< 0.001). The maximum decrease was observed at 16 weeks [Table/Fig 2]. The pretrial SRT score of volunteers receiving caffeine was 0.66 ± 0.10. After caffeine intake, these was decrease in the SRT score of -0.004 at 2 weeks (P>0.05), -0.03 at 4 weeks (P<0.001), -0.13 at 8 weeks (P<0.001), -0.13 at 12 weeks and -0.13 at 16 weeks. The maximum decrease in score was seen at the 12th week. The MCRT baseline score was 136.6 ± 13.94 in the brahmi group and it was reduced by -6.12 at 2 weeks (P>0.05), -14.44 at 4 weeks (p<0.001), -19.42 at 8 weeks (P< 0.001) , -23.2 at 12 weeks (P <.001) and -24.6 at 16 weeks (P<0.001) .The maximum reduction in the MCRT score was seen at 16 weeks. The score of the error index also decreased significantly from 4 weeks onwards in the caffeine group. There was a decrease from the baseline score of -0.50 at 4 weeks (P<0.001), -7.194 at 8 weeks (P<0.001), -7.264 at 12 weeks (P<0.001) and -7.381 at 16 weeks (P<0.001). Maximum reduction was observed at 16 weeks [Table/Fig 3].

(Table/Fig 1). Base line characteristics of male healthy volunteers (Mean ±SD)

Characteristics	Brahmi(n=20)	Caffeine(n=18)
Age (years)	22.55±1.191	22.55±1.191
Weight (kg)	64.24± 4.54	64.5 ± 3.97
Pulse(beats /min)	72.3 ± 4.8	72.9 ± 6.1
Blood pressure(mm Hg)- Systolic	123± 7.6	124.5 ± 5.89
Diastolic	82.4 ± 3.5	83.3 ± 3.52
Haematological : Hb	12.4 ±1.20	12.8 ± 0.987
TLC	8426 ±713.7	8289 ±746.8
Blood sugar(fasting) (mg/dl)	84.4 ±11.3	85.43 ± 10.6

For all parameters P value between two groups>0.05.

(Table/Fig 2) Effects of Brahmi in various study parameters (n=20)

Visits► Parameter ▼	0WEEK Mean ±SD (95% CI)	2WEEK Mean ±SD (95% CI)	4WEEK Mean ±SD (95% CI)	8WEEK Mean ±SD (95% CI)	12WEEK Mean ±SD (95% CI)	16WEEK Mean ±SD (95% CI)
SRT	0.66± 0.11	0.61± 0.13 (0.004- 0.077)	0.52± 0.13 (0.039-0.160) p=0.003	0.52± 0.11** (0.079- 0.191)	0.52± 0.12** (0.097- 0.201)	0.529± 0.12** (0.101- 0.191)
MCRT	137.8+12.01	135.4+12.24 (1.142- 11.16) P=0.019	131.3+11.96** (7.188 - 21.7)	130.7+12.22** (13.28 - 25.55)	130.6+12.58** (17.04 - 29.41)	130.5+12.05** (18.9 - 30.35)
CFFT	34.29 ± 2.53	34.38 ± 2.54 (1.824- -0.302) P=0.009)	34.71± 2.59 (1.826- -0.333) (p=0.007)	35.28 ±2.41** (1.915- -0.632)	35.26 ±2.54** (2.273 - -0.895)	35.3 ±2.54** (2.51 - -1.018)
TPT	24.13 ± 5.83	25.98 ± 6.32 (2.322- 0.399)	31.64 ± 8.26** (6.436 - -4.034)	31.89 ±8.39** (8.058- -6.084)	31.72 ±8.15** (8.619- -6.378)	31.82 ± 7.91** (9.048- -6.604)
DCT	19.83 ± 2.53	21.67± 2.528 (1.679 - -0.32) P=0.006	22.33 ± 2.42** (2.156- -1.044)	22.39± 2.33** (2.822- -2.178)	22.44± 2.28** (2.832- -2.18)	22.67± 2.40** 3.242- -2.186)
MT	7.44 ± 1.09	8.389± 1.24 (0.730- 0.03)	8.94± 0.88* (1.132- -0.267) P=0.003	9.33± 1.02** (1.19 - -0.409)	9.22 ± .87** (1.304 - -0.696)	9.16± 0.98** (1.52 - -1.08)
MAT-ADD	13.78± 4.13	15.33± 4 (2.002- -0.785) P=0.007	16.11± 4.1** (2.273- -0.895)	15.94± 5.33** (2.277- -0.895)	16 ± 4.33** (2.23- -0.845)	16.28± 4.99** (2.277- -0.899)
MAT-SUB	17.39± 2.76	18.94 ± 2.83* (2.02- -0.885) P=0.01	19.89 ± 2.90** (2.002- -0.785)	20.56 ± 3.25** (2.602- -0.985)	20.28± 3.15** (2.50- -0.785)	20.56± 3.24** (2.602- -0.985)

Simple Reaction Time Task=SRT, Multiple Choice Reaction Time Task =MCRT, Critical Flicker Fusion Threshold Task=CFFT, Tracking Performance Task=TPT, Digit cancellation task -DCI, Memory test=MT and Mental arithmetic task =MAT, ADD=addition, SUB= substraction, CI=95% confidence interval for difference, **P<0.001.

(Table/Fig 3) Effects of Caffeine in various study parameters (n=18)

Visits► Parameters ▼	0WEEK Mean ±SD (95% CI)	2WEEK Mean ±SD (95% CI)	4WEEK Mean ±SD (95% CI)	8WEEK Mean ±SD (95% CI)	12WEEK Mean ±SD (95% CI)	16WEEK Mean ±SD (95% CI)
SRT	0.59± 0.10	0.55± 0.10 (-0.006 - 0.015)	0.49± 0.12** (1.101- 0.445)	0.45± 0.11** (0.061- 0.1103)	0.44± 0.10**(0.1114 to 0.1675)	0.44± 0.09**(0.1076 to 0.1692)
MCRT	136.60+13.94	130.5+17.74 (0.068- 1.324)	122.2+23.14 **(3.369 - 5.875)	117.2+20.78** * (4.735- 9.876)	113.4+19.78** (4.734 to 10.02)	112+18.73**(4.955 to 10.03)
CFFT	34.61 ±1.90	35.67 ± 1.63 (0.175- 0.012)	35.69 ± 1.25** (0.653- 0.2813)	35.88 ±1.4** (1.175 - -0.8)	36.2 ± 1.48**(1.184 to -0.7439)	36.38 ±1.63**(1.233 to -0.769)
TPT	24.78 ±1 6.17	26.19 ± 7.16* (3.409 to - 0.288) p=0.023	30.02 ± 7.64** (9.529- - 4.384)	31.85 ± 7.17** (9.624 - - 5.897)	32.28 ± 7.15**(8.875 to -5.303)	32.61 ± 7.27**(9.295 to -6.078)
DCT	20.15 ± 2.11	21.1± 2.61** (2.323 - - 1.343)	21.75± 2.35** (3.268 - - 1.732)	22.65 ± 2.15** (3.045 - - 2.066)	23 ± 2.94**(3.317 to -1.905)	23 ± 2.75**(3.62 to -2.047)
MT	7.65 ± 1.13	8 ± 1.11** (1.305 to - 0.583)	8.35 ± 1.59** (1.807 - - 1.193)	8.45 ±1.14** (2.397 - - 1.38)	8.65 ± 1.22** (2.214 - - 1.341)	8.9 ± 1.21**(2.256 to -1.188)
MAT-ADD	14.85± 1.72	15.45± 1.93** (2.323 - - 1.343)	15.65 ± 1.59** (2.423 - - 1.443)	16.5 ± 1.70** (3.223 - - 1.943)	17.55± 1.95** (3.623 - - 2.043)	18.25± 3.11** (4.002 - -2.343)
MAT-SUB	15.17± .51	18.1± 3.04** (4.002 - - 2.343)	18.35 ± 2.79* (4.021--- 2.43)	18.9 ± 2.80** (4.602 - - 2.608)	18.85± 2.96** (4.600 - - 2.608)	19.1 ± 3.14** (4.8 - -2.8)

Simple Reaction Time Task=SRT, Multiple Choice Reaction Time Task =MCRT, Critical Flicker Fusion Threshold Task=CFFT, Tracking Performance Task=TPT, Digit cancellation task -DCI, Memory test=MT and Mental arithmetic task =MAT, ADD=addition, SUB= substraction, CI=95% confidence interval for difference , **P<0.001.

Brahmi increased the critical flicker fusion frequency score throughout the study period. The score was increased from a mean value of 34.61 ± 1.90 by +1.06 at 2 weeks (P<.05), +1.08 at 4 weeks (P<0.05), +1.27 at 8 weeks (P<0.001), +1.58 at 12 weeks (P<0.001) and +1.76 at 16 weeks (P<0.001) [Table/Fig 2].

The modification in the CFFT score was statistically significant from the 2nd week onwards, and remained constant from 8th week onwards. The CFFT score also showed significant improvement from 4 weeks of the study in the caffeine group. From a mean baseline score of 34.29 ± 2.53, it was increased by +0.08 at 2 weeks (P>0.05), +0.41 at 4 weeks (P<0.001), +0.98 at 8 weeks (P<0.001), +0.96 at 12 weeks (P<0.001) and +1.0 at 16 weeks (P<0.001). The maximum improvement was seen at 16 weeks.

Brahmi caused a significant increase in the TPT score from the 2nd week of the study. There was significant increase in the score from the baseline score of +1.41 at 2 weeks (P<0.05), +5.23 at 4 weeks (P<0.001), +7.07 at 8 weeks (P<.001), +7.49 at 12 weeks (P<0.001) and +7.82 at 16 weeks (P<0.001). The maximum increase in theTPT score was observed at 16 weeks. There was significant increase in the TPT score from the mean baseline score of +1.84 at 2 weeks (P<0.05), +7.51 at 4 weeks (P<0.001), +7.76 at 8 weeks (P<0.001), +7.08 at 12 weeks (P<0.001) and +7.68 at 16 weeks (P<0.001) in the caffeine group .The increase in the score was maximum at 8 weeks of the study [Table/Fig 3].

The DCT score was found to be increased throughout the study period from a mean baseline value of 20.150 ± 2.11 to 21.1 ± 2.614(+0.95) at 2 weeks (P<0.05), 21.75 ± 2.359 (+1.6) at 4 weeks (P<0.001), 22.65 ± 2.159(+2.5) at 8 weeks (P<0.001), 23 ±2.94 (+2.85) at 12 weeks (P<0.001) and 23 ± 2.753 (+2.85) at 16 weeks (P<0.001) in the brahmi group. The improvement in the DCT score was statistically significant from the 2nd week onwards, with maximal improvement at 12 weeks.

There was a significant increase in the DCT score from the mean baseline score of 19.83 ± 2.53 to 21.67 ±2.521 (+1.833) at 2 weeks (P<0.001), 22.33 ± 2.425 (+2.5)at 4 weeks (P<0.001), 22.39 ± 2.33(+2.556) at 8 weeks (P<0.001), 22.44 ± 2.281(+2.61) at 12 weeks (P<0.001) and 22.67 ± 2.40(+2.83) at 16 weeks (P<0.001) in the caffeine group. Maximum increase was observed at the 16th week.

Brahmi showed significant improvement on the MT score after the 4th week till the end of the study. The mean baseline score was increased by +0.35 at 2 weeks (P>0.05), +0.7 at 4 weeks (P<0.05), +0.8 at 8 weeks (p<0.001), +1 at 12 weeks (P<0.001) and +1.25 at 16 weeks (P<0.001). The MT score increased significantly from 4 weeks onwards, with the maximum score in the 16th week.

Caffeine caused a significant improvement in the MT score from the 2nd week of the study. From the mean baseline score of 7.44 ± 1.097, there was a significant increase of +0.94 at 2 weeks (P<0.001) , +1.50 at 4 weeks (P<0.001), +1.88 at 8 weeks (P<0.001), +1.77 at 12 weeks and +1.72 at 16 weeks (P<0.001). The peak effect was observed at 8 weeks [Table/Fig 3] . There was a significant increase in the MAT score from the mean baseline score of 17.4 ± 2.501 to 18.9 ± 2.693(+1.5) at 2 weeks (P<0.001) ,19.85 ± 2.87 (+2.45) at 4 weeks (P<0.001), 20.4 ± 3.185 (+3) at 8 weeks (P<0.001) , 20.1 ± 3.144 (+2.7) at 12 weeks (P<0.001) and 20.4 ± 3.251 (+3) at 16 weeks (P<0.001) in the brahmi group. Maximum increase was seen at 16 weeks. Caffeine showed statistically significant improvement in the MAT score from the 2nd week of the study. The mean baseline score increased from 17 ± 2.657 to 18.11 ± 3.142 (+1.11) at 2 weeks (P<0.001), 18.39 ± 2.953 (+1.389) at 4 weeks (P<0.001), 18.89 ± 2.948 (+1.889) at 8 weeks (P<0.001), 18.83 ± 3.015 (+1.833) at 12 weeks (P<0.001) and 19.17 ± 3.258 (+2.167) at 16 weeks (P<0.001).The peak score was obtained at 16 weeks.

Comparative Effect Of Brahmi And Caffiene On Various Parameters:

At 16 weeks, Brahmi caused significant decrease in the MCRT score than caffeine (P<0.05),
while at 12 and 16 weeks, Brahmi significantly improved the CFFT score than caffeine(P<0.05).

After 8 weeks onwards, Brahmi caused significant increase in the DCT score than caffeine (P<0.05).

MT scores were significantly better than Brahmi in the caffiene group at 12 weeks (P<0.001).

Brahmi showed significant increase in the MAT score than caffeine at 8, 12 and 16 weeks (P<0.05). All drug regimens were well tolerated. Only four volunteers reported adverse events in the caffeine group, with complaints of palpitation, insomnia, irritability and dyspepsia (one volunteer each).Palpitation and insomnia were observed before the 2nd week in two subjects and they dropped out from the trial. No adverse effect was reported with Brahmi.

Discussion

One of the major dilemmas faced by the human race is that their cerebral abilities diminish significantly with advancing age and is compounded by factors like emotional stress. There have always been efforts to identify the beneficial agents which could be used to alleviate debilitating disorders and retard mental deterioration. In this direction, pharmaceutical companies continue to invest enormous resources to identify such potentially beneficial agents.

One such plant that has been used to restore debilitating conditions is Bacopa monniera or Brahmi.

In the present study, a comprehensive battery of tests which comprised of instrumental and non-instrumental tests, were chosen to obtain a broad coverage of perceptual, motor and intellectual functions. These tests have been identified as being the most sensitive tests [5].

Brahmi shortened the reaction time from 2 weeks onwards, with its peak at 16 weeks (P<0.001). These findings indicate that Brahmi helps to respond quickly to stimulus. Our results are in accordance with the study by Stough et al (2001) who reported that on chronic use of Brahmi, there was significant improvement in the speed of visual information processing and reaction time[6]. Earlier, Bacopa had been found to produce improvement in perception and reaction time without any side effects in school children aged 6-8 years [7].

Caffeine (100 mg) administration produced significant decrease in SRT from 4 weeks onwards and remained of the same magnitude throughout, with maximum reduction at 16 weeks (p<0.001) as reported earlier [8],[9],[10]

MCRT is a psychomotor test which not only measures the latency of sensori-motor coordination, but also has the ability to recognize stimulus and the decision ability to react.Therefore, in addition to sensori-motor co-ordination, it measures attention monitoring abilities. The effects of Brahmi on MCRT which were calculated as the error index, revealed that its effects significantly decreased from 4 weeks, with maximum beneficial effects at 16 weeks (P<0.001). This means that Brahmi not only improves SRT, but also the complex reaction time where the critical processing for detection perception, recognition, decision making and integration, are involved. Our findings are in agreement with Kidd et al, who in their three months study have also observed that Brahmi improves reaction, performance time and immediate memory [7].

There was reduction in the MCRT score after the use of caffeine (100 mg) in comparison to the baseline score from 4 weeks onwards. Maximum reduction was observed at 12 weeks. Similar results have been published by Haskell et al, who observed that complex tests like digit vigilance reaction time and numeric working memory reaction time showed improvement [10]. However, Judelson et al have observed no significant improvement in the number of correct responses or the mean latency of the response in four choice reaction time tasks [11]. This could be due to the short duration of their study and procedural disparity than in our study.

CFFT is a measure of the central mechanism involving cortical arousal or integration and is a

more direct measure of CNS activity.

Brahmi caused improvement in CFFT from the 2nd week onwards, with maximum effects at 16 weeks (P<0.001). Stough et al have also reported improvement in CNS integrative tests, like the speed of visual information processing which is measured by AVLT [6].

The results of the present study with caffeine showed significant improvement from the 4th week (P<0.001) and showed peak improvement at 16 weeks (P<0.001) in CFFT test. There are however numerous other reports where no effect of caffeine on CFFT has been found. [12],[13] However, in these studies short course high dose of caffeine was given (≤500 mg) in contrast to our study in which small doses of caffeine were administered for 16 weeks.

However, in contradiction to our results, Hindmarch has reported a dose dependent reduction in CFFT with an acute dose of 4 mg/Kg and 8 mg/Kg of caffeine, which were given to healthy subjects at night and were tested on the following morning [14]. This discrepancy to our results can be explained on the basis that high doses given at bed time disrupted sleep, leading to fatigue on the following morning and resulted in the impairment of CFFT.

The most basic measure of Visio-motor performance is the tracking task which offers a mean of assessing divided attention and the response output mechanisms required for fine motor control.

The effect of Brahmi on TPT improved significantly from the 2nd week (P<0.05) and was maximum at 16 weeks (P<0.001) in the present study. However, the effect of caffeine improved from the 2nd week onwards and the maximum effect was seen at 8 weeks (P<0.001). The increase in the TPT score was not significant after 8 weeks, which indicates that the effect of caffeine was not generally long lasting on the parameters.

DCT is a measure of the perceptual processing of the central sensory information with regards to the current information and its matching with previously stored or pre-existing information. The analysis of the observation of the present study reveals that the DCT score was enhanced by Brahmi from 4 weeks onwards, with its peak at 16 weeks (P<0.001). Caffeine (100mg) showed significant increase in the DCT score from the 2nd week, with its peak at 16 weeks (P<0.001) as reported earlier. [13]

Short term memory is a limited capacity store of processed information which functions in a variable time period and is dependent on the demands of the task situation to assist stimulus recognition and processing. The limbic system is involved in learning and memory. The short term memory improved significantly in response to Brahmi from 4 weeks (P<0.05) and lasted throughout the study, with the maximum effect at 16 weeks (P<0.001). This observation is in conformity with the finding of Stough et al who evaluated the effects of Brahmi on memory and anxiety and found improvements in the memory rates and reduction in anxiety levels, with maximal effects evident after 12 weeks [6].

Roodenrys et al, have investigated the effect of Brahmi (300 mg) on the retention of new information i.e. recalling of a pair of unrelated words after a short delay and have found significant improvement on these tests. They suggested that it could be due to the antioxidant effect of Brahmi within the hippocampus area of the brain [15].

Jyoti and Sharma have shown that the co-administration of Bacopa significantly prevented the aluminum-induced decrease in SOD (Superoxide dismutase) activity,, as well as the increased oxidative damage to lipid and protein in the hippocampus part of the brain [16].

Kidd has demonstrated significant improvements in anxiety (P<0.005) and immediate memory span (P<0.01) when treated with Bacopa[13]. Joshi and Parle have also documented that Brahmi significantly improves

learning memory in young mice and that it even reversed the amnesia induced by both scopolamine and natural ageing [17]. They concluded that Brahmi significantly decreases whole brain acetycholinestrase activity and acts as a useful memory restorative agent in the treatment of dementia in the elderly.

The MT score improved by intake of caffeine from 2nd week onwards with peak beneficial effects at 8 weeks (P<0.001) as reported earlier [10],[13]. The observations from the present study show that caffeine a widely used psychomotive substance is a facilitator of the memory in the present dose in young adults. However, our results differ form the reports of Child E et al , who observed impaired memory tasks. But contrary to our study their was an acute trial where subjects were assessed 40 minutes after intake of 50, 150 and 200mg of caffeine.

MAT, a measure of central processing activity, improved significantly with Brahmi from 4 weeks till the completion of the study (P<0.001). This could be because of improved acquisition, retention and retrieval of learned tasks and the ability of Brahmi to reduce mental fatigue significantly [19].

The effects of caffeine on the MAT score (both addition and subtraction) revealed significant improvement from the 2nd week to the completion of the study (P<0.001). Our observations are closely related to that of Katy et al, who have documented that there was a significant increase on the rapid information processing task score with 250 mg of caffeine [13]. Smit et al have documented similar results of caffeine on the rapid information processing task with different doses of caffeine. These findings suggest that caffeine favourably affected the processing activity of CNS [9].

Brahmi being lipophilic, can easily penetrate the blood brain barrier and attain effective concentration in the CNS, thus leading to central effects. On comparison with caffeine, Brahmi was found to be the more effective of the two. No serious adverse events occurred during the present study.

Pravina et al have also observed no untoward effects in the trial of 23 subjects who were given Brahmi in doses of 300 to 450 mg for 30 days, which was identical to the dose used in the present study (500 mg) [20]. Caffeine leads to adverse drug reactions like palpitation, insomnia, dyspepsia and irritability. Caffeine is well known for a wide range of unpleasant physical and medical conditions including nervousness, irritability, anxiety, tremulousness, muscle twitching, insomnia and palpitation. Furthermore, its higher dose can lead to peptic ulcers and reflux esophagitis. [21].

To summarize, it can be said that Brahmi being lipophilic, can enter the brain and affect complex tasks in a favourable way, involving the central attentive and integration processes of the CNS to a varying degree However, caffeine, a know psychostimulant suffers from the disadvantage of causing insomnia, irritability, dyspepsia and palpitation in some subjects. This study suffers from the limitation of having a short duration (16 weeks) and therefore, the generalization and conclusion drawn from the present results need to be carefully evaluated in the diseased group on a chronic basis.

From the results of the present study, we conclude that brahmi can prove to be a supplement of utmost utility to improve cognitive functions.

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