JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : http://10.14710/jkd (dmj).v12i2.36921
JKD (DMJ), Volume 12, Number 2, March 2023 : 49-54

COMPARISON OF CAFFEINE INTAKE AND BRAIN TRAINING EFFECT ON PERFORMANCE INTELLIGENCE

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Abstract

Background: Intelligence is the ability to comprehend complex ideas and reasoning. Caffeine is a psychoactive substance that is known to possess an effect on improving cognitive function, memory, and attention. Brain training is a digital training process which holds the purpose of enhancing cognitive function. **Objective**: This study aimed to compare the effect of caffeine and brain training on performance intelligence. **Methods**: This research is an experimental study with two groups pretest and posttest design. The research sample was the college students of Faculty of Medicine, Universitas Diponegoro (n=42) aged between 18-22 years old, which then categorized into: the caffeine group (n=21) which received 50 ml once daily of caffeinated beverage for two weeks, and brain training group (n=21) which received 30-minute-session of NeuroNationTM brain training every day for two weeks. Performance intelligence was measured before and after treatment by using The Raven Progressive Matrices test. The statistical analysis used was The Mann-Whitney test and The Wilcoxon test. **Results**: The average score of performance intelligence on the group caffeine treatment increased from 48,81±9,30 to 55,90±2,95 (p<0,001). In brain training group, increased from 54,95±1,91 to 57,29±1,68 (p<0,001). The two groups were tested for Mann-Whitney Test and it was found that the caffeine group's performance intelligence score was significantly higher than brain training (p = 0.005). **Conclusion**: There was a significantly higher increase performance intelligence score shown in the caffeine group rather than in the brain training group.

Keywords: *brain training, caffeine, NeuroNation™, performance intelligence, Raven Progressive Matrices test,*

INTRODUCTION

Intelligence holds an important role in all kinds of life aspects because the performance of intelligence can predict academic achievement, work performance, health, morbidity, and mortality accurately.[1,2] Intelligence is the ability to think, solve problems, and learn, causing differences between individual abilities in overcoming challenging situations. Intelligence is integrated with cognitive functions, including perception, attention, memory, language,and planning.[2] Several researches have been done to improve intelligence performance.

One of the factors influencing cognitive function and intelligence is nutritional intake. Methylxanthine class, especially caffeine, is known to improve cortical activities leading to increased awareness, delayed tiredness, and improved cognitive, memory, and attention functions. This mechanism happened through mesopotin cholinergic neuron activation by A1 receptor antagonists. Caffeine is an active ingredient contained in coffee, tea, chocolate, soda, and energy drinks.[3] Electrophysiology studies showed that caffeine could accelerate new information processing and improve the speed of new stimulus process.[5,6] Therefore, the effect was usually not on memory performance of the brain, but on increasing general knowledge and the ability to think logically.

Besides proper nutritional intake, increasing cognitive function and intelligence can also be achieved with brain training. Brain training is a digital training process aims to improve, rehabilitate, or maintain cognitive function.[7] Brain training is often presented in the form of games, therefore noninvasive, easily accessible, interesting, and popular in every age group. Previous studies concerning the brain training effect produced varied results. Few stated that brain training can increase cognitive function in adults and elders related to dementia[8] and other psychiatric disorders[9]. Others stated that brain training does not influence cognitive function.[10]

Intelligence measurement was done by observing real behaviours, which is a manifestation of rational thinking, self-adaptation to the environment and problem-solving. Instruments used are the following: Weschler Intelligence Test[12], Stanford-Binet Intelligence Test[13], Kaufman Brief Intelligence Test[14], Cattell Culture Fair IQ Test[15], Raven

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Progressive Matrices[16], Haselbauer Intelligence Test[17], Carter Intelligence Test[18], and others.

Raven Progressive Matrices (RPM) test is an instrument used to measure intelligence. RPM presents questions using pictures in the form of figures and abstracts design, therefore expected to not be biased by cultural factors. This test explores the ability of someone to understand and determining the relationship of given pictures and improves systematic thinking and considered culture fair test because it minimizes certain cultures influence. The RPM test comprises of two aspects, standard and advance. Standard aspect includes the assessment of spatial reasoning ability, the ability of someone to understand the concept of space; the ability to analyze, integrate, seek, and understand the relationship system of each part; and the ability in accuracy, which is the ability of someone to calculate. Meanwhile, in the advanced aspect, the assessment is done on spatial ability, inductive thinking, and perception.

METHODS

This research is an experimental study with two groups pretest and posttest design. Subjects were young adults registered as a student in the Faculty of Medicine, Diponegoro University, during the time of study. A total of 42 subjects were chosen according to inclusion criteria which are 18-22 years old, capable to operate smartphone, has GPA of 2.5-3.5, understand English, and willing to participate in this study and exclusion criteria which are subjects with a history of head trauma or injury, psychiatric disorder, gastrointestinal disorders, hypertension, a musculoskeletal disorder that complicates the use of computer, had or currently use Neuronation™ application and routinely do brain training. The subjects were divided into the caffeine group and the brain training group.

All subjects were checked for intelligence performance score measured using Raven Progressive Matrices. This test consists of 60 questions divided into five series, done in 30 minutes and addressed for individuals aged 6-65.

Group I were given 50 mg caffeine orally every day for two weeks, meanwhile group II was asked to do brain training using NeuroNation™ application in their smartphone for 30 minutes every day for two weeks. Memory score measurements using Raven Progressive Matrices were rechecked after treatment.

The results of Saphiro-Wilk test regarding the difference of intelligence performance before and after caffeine or brain training showed non-normal distribution, therefore hypothesis were tested with Wilcoxon test. The results of Saphiro-Wilk test regarding the difference of intelligence performance between groups with caffeine and brain training showed non-normal distribution, therefore hypothesis were tested with Mann-Whitney test.

RESULTS

Intelligence performance score before and after treatment in caffeine group and brain training group is shown on table 1.

Table. 1 Pre and Post Test Score of The Intelligence Performance

Score	Caffeine	Brain Training	p*
Pre Test	49.81 ± 9.30	54.95 ± 1.91	0.018
Post Test	55.90 ± 2.95	57.29 ± 1.68	0.144
p**	< 0.001	< 0.001	-
Post Test – Pre Test	6.09	2.33	0.005

*Mann-Whitney test
**Wilcoxon test

Results showed an increase of intelligence performance score means before and after treatment in both groups. In caffeine group, there is an increase of means from 49.81 ± 9.30 to 55.90 ± 2.95 which means that there is an increase of intelligence performance after treatment. Wilcoxon test showed that the intelligence performance score increase in caffeine group was significant ($p < 0.001$). Distribution of intelligence performance score before and after treatment in caffeine group is shown in Figure 1.

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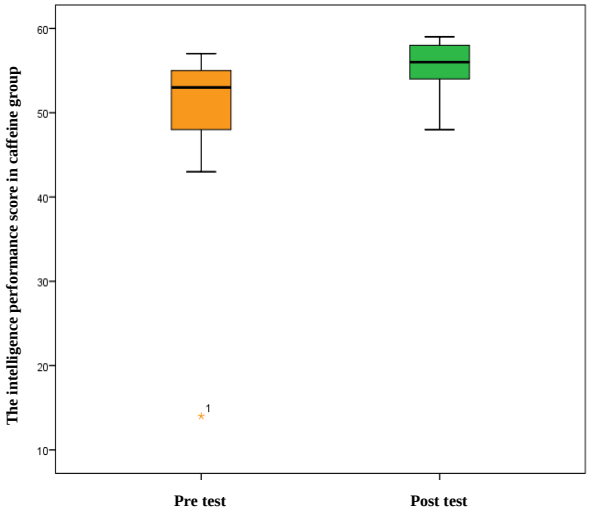

Figure 1. Comparison of intelligence performance score before and after caffeine treatment

In the brain training group, there is an increase of means from 54.95 ± 1.91 to 57.29 ± 1.68. Wilcoxon test showed that the increase of intelligence performance score in brain training group was significant ($p < 0.001$). Distribution of intelligence performance score before and after treatment in brain training group is shown in Figure 2.

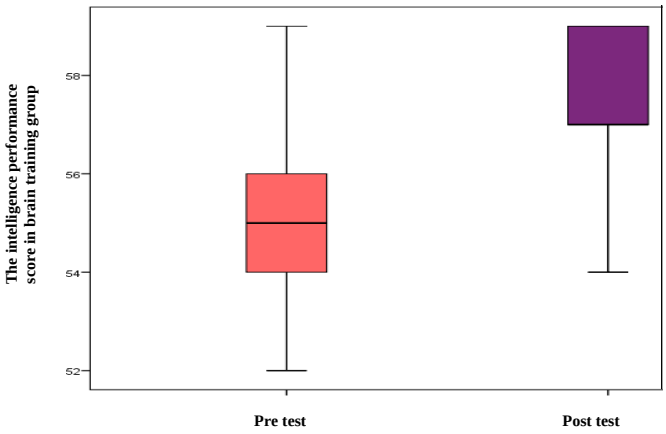

Figure 2. Comparison of intelligence performance score before and after brain training treatment

Results showed an increase of intelligence performance score means before and after treatment in both groups. The difference of intelligence performance score was higher in caffeine group, which is 6.095, meanwhile brain training group showed 2.33. Mann-Whitney test results showed that there is a significant difference between both groups ($p = 0.005$). Distribution of difference (delta) of intelligence performance score before and after treatment based on treatment groups is shown on Figure 3.

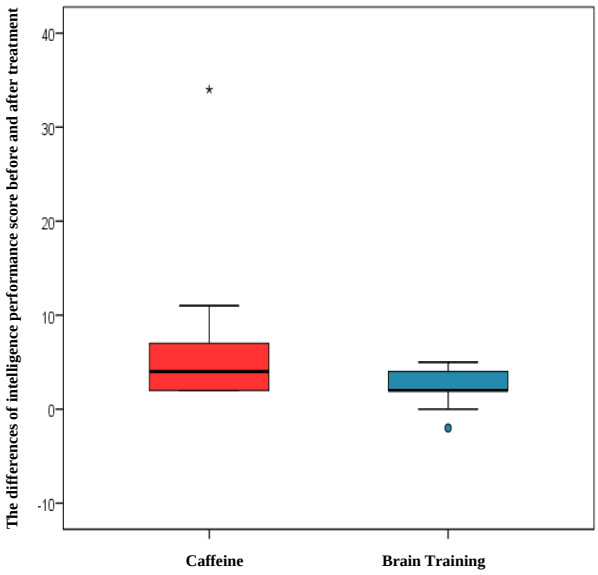

Figure 3. Chart showing the comparison of intelligence performance score difference before and after treatment

DISCUSSION

Results showed a significant increase in intelligence in both the caffeine and brain training groups after being tested using the Wilcoxon test. This result was in accordance with the hypothesis, which is an increase of intelligence performance scores measured with the Raven Progressive Matrices test before and after treatment. Mann Whitney test was done to compare both groups, which showed that caffeine group has significantly higher results compared to brain training group. This result was not in accordance with the minor hypothesis of this study.

In this study, caffeine significantly improved intelligence performance. Subjects in caffeine group were given ready-to-drink coffee containing 50 mg of caffeine to be consumed every day for 2 weeks. This was in accordance with previous studies which stated that caffeine can improve cognitive, memory, and attention function in low awareness situations.[4] This happened because caffeine interacts with dopamine system. Adenosine receptor inhibition can potentiate dopamine neurotransmission, thus modulating reward system. Adenosine receptor antagonists can influence

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cognition process by activating dopamine receptor. The activation of dopamine receptor will improve work achievements using work memory.[19] Dopamine effect can also improve attentiveness, learning, awareness, and other cognitive factors.[20] Those aspects were the aspects of intelligence performance, therefore caffeine indirectly increases intelligence performance.

In this study, brain training can significantly improve intelligence performance. This result was supported by previous studies which stated that brain training can significantly increase cognitive in term of reaction, attention, and short-term memory in groups treated with brain training for 10-12 weeks.[21] The results of this study is also in accordance with a study conducted by Jaeggi et al which stated that brain training can improve fluid intelligence.[22]

Brain training in this study is accomplished by using NeuroNation™ application for 30 minutes every day for 2 weeks. The application was divided into 4 parts, which is numeracy, reasoning, memory, and perception where all of these parts train different abilities as follows[23] :

1. Rotator, training logical thinking and focus
2. Trail tracker, training processing speed and logical thinking
3. Chain reaction, training memory and mental math
4. Color craze, training will power and flexibility
5. Path finder reverse, training memory and visuospatial
6. Path finder, training memory and visuospatial

Those trainings were focused on the abilities around visuospatial, analysis, inductive thinking, perception, searching and understanding relationship system between parts, and the ability in accuracy in calculating in which all of them are components of intelligence performance.

Intelligence performance especially fluid intelligence can be improved by continuous training as an individual thinking and reasoning pattern, regardless of experience. Moreover, if someone is trained to do a specific task, then that person will only improve the ability to do those tasks because only the associated brain area which control that function is developing. Improvements of several intelligence performance aspects trained by brain training can by applied to daily life.[22,23]

Improvement of cognitive function after brain training occurs because the brain is stimulated to continuously think and solve problems, thus new synapses will form individual way of thinking. Brain stimulated frequently to think and solve problems will form new synapses which will leave memory track that will help form new thinking pattern.

This memory track is influential in forming individual memory function, briefly hold and process relevant new or stored data to be used immediately transiently placed in temporary memory, therefore can evaluate incoming data according to context. This integrative function is very important for thinking, planning, and assessing abilities, therefore memory help individuals to think logically and carefully planning next moves, which are a part of intelligence.[24-26]

Based on the results of this study, caffeine group showed higher improvement compared to brain training group. This is in accordance with previous studies which stated that there is an effect of low dose caffeine given in different doses (12.5 mg, 25 mg, 50 mg, and 100 mg) for 7 days to cognitive function which gave significant results in cognitive function improvement in test subjects. Even low dose given in 7 days is capable to improve cognitive function. This may explain why caffeine group showed higher intelligence performance improvement compared to brain training group.[27] The results of this study is also in accordance with previous studies which stated that brain training can affect cognitive after treatment for 10-12 weeks[21], some stated for 6 months[8], meanwhile this study only conducted training for 2 weeks. Borella *et al* stated that 2 weeks is enough to improve cognitive of an individual. Continuous brain training will improve certain neurocognitive function, therefore the duration of brain training which is only 30 minutes every day for 2 weeks is not enough to optimize intelligence performance score improvement in brain training group.

The limitation of this study is the lack of subject control. We faced some difficulties in observing subjects daily life that may biased this study. Moreover, the subjects were not quarantined during study, thus stressors or other clinical conditions may be different between subjects. The lack of control group in this study is also a limitation. In caffeine group, maximum control of caffeine intake in each individual was not achieved, condition of subject before and after caffeine consumption, duration taken to finish the coffee, and caffeine half-life were not controlled. Maximum brain training was also not achieved because of short duration of only 30 minutes every day for 2 weeks. The

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location or factors affecting the subjects comfort in doing brain training were also limited, the condition of subjects before or after eating to perform the training was not controlled, and the difference in time of training because of each subjects' own activities was also the limitation of this study. Further studies with quarantined subjects are needed to control diet and physical condition of subjects.

CONCLUSION

In conclusion, this study showed a difference in intelligence performance between subjects given 50 mg caffeine orally for 2 weeks and subjects given brain training for 2 weeks. Results showed a significant increase of intelligence performance in caffeine group and brain training group. Intelligence performance score increase was significantly higher in caffeine group compared to brain training group.

This study determines that there is an effect of caffeine consumption in intelligence performance, therefore consuming caffeine and doing brain training can be beneficial to students in the young adult group in improving intelligence performance. Further studies regarding caffeine and brain training effect to intelligence performance in other intelligence aspects with wider population, different duration, and different period interval are required. Moreover, subjects need to be quarantined in the same place in order to control diet and physical condition during experiments.

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