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The Effect of Brain Training Game (Lumosity) on Cognitive Functions (Memory, Concentration and Reaction Time) to Private Medical College Student in Malaysia – Randomized Controlled Trial (RCT)

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Abstract

Brain training is a program or activity which claims to improve a cognitive ability or general capacity by repeating certain cognitive tasks over a period of time. Well-defined cognitive processes and abilities that are trained by brain training games are speed of information processing, attention, memory and problem-solving. These functions are best to be referred as human cognitive function which involve in our daily life executive function. There are many ways to enhance the cognitive function; one of them is by practising brain training games. This study was done to determine the effect of brain training games on memory, concentration and reaction time among the medical students of private medical college, Malaysia. A randomized controlled trial was conducted on this research. The study was held in Melaka Manipal Medical College (MMMC), Muar campus in Johor, Malaysia from June 2019 to July 2019. A total of 40 students participated in this study. After signing their informed consent, they were randomly assigned to either the intervention group (brain training game) or control group (did not play any brain training games at all). The intervention group played the braining training game (Lumosity) about 15 minutes for 5 days. All participants were assembled in the computer laboratory and asked to perform the specific cognitive tests before and after the training. The specific cognitive tests are visual memory, verbal memory, number memory, concentration and reaction time. From this study, we found that there is no significant difference between the brain training group and control group however there was a significant improvement (p value of 0.003) in only visual memory between pre-test and post-test of brain training group but no significance in verbal memory, number memory, concentration and reaction time. In regards to visual memory score, the mean of post-test of intervention group was 9.90 which was higher than the pre-test of intervention group that had mean score of 8.90. The finding of the present study shows that there is improvement of visual memory after playing brain training games. While, there is not much different in the students who don't play brain training games.

Keywords

Randomized Controlled Trial (RCT), Brain Training Games, Cognitive Function

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1. Introduction

In this globalization era, video gaming has been a growing remarkably, over the past 20 years [1]. Currently video games are available on numerous devices for the consumers. These devices can be consoles (Xbox or PS4), mobile devices such as mobile phone (smart phone) or personal computer [2]. Video game exercise is one of the brain training modules for people with increasing age [3, 4]. Some studies have cited that playing video games could also

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improve cognitive function in people with increasing age [5-8]. Besides, the number of brain enhancing games have increased over time. There are several brain training games currently accessible free to everyone, either online or from local newspapers and magazines. For example, brain enhancing games such as Sudoku and crossword puzzles are always available in local newspapers and magazines. Brain age or Tetris are also brain enhancing video games which show an improvement in cognitive function in individuals [9].

Recently a study also suggested that different types of tasks offered through video games improve the reaction time. Improvements are also seen in other areas of skills such as multitasking, ability to track numerous items simultaneously and ability to analyse information in a short period of time [10]. However, young adults nowadays are easily addicted to video games [11] which leads to multiple adverse effect such as poor social behavior towards their friends and family [12], sleep related problems and also cardio-metabolic disorders. [13]

Brain training games are an emerging method for improving cognitive training [14]. Brain training is a program or activity which claims to improve a cognitive ability or general capacity by repeating certain cognitive tasks over a period of time [15]. Well–defined cognitive processes and abilities that are trained by brain training games are speed of information processing, attention, memory and problem–solving [16]. Brain training apps such as Lumosity or Elevate, are being used by tens of millions of people worldwide but when placed under scientific survey, the benefits of such brain training games turn out to be controversial. For example, some studies have found that brain-training games improve the "executive functions, working memory, and reaction time" of young adults while others hail the benefits of such games for preserving cognitive health in seniors [17]. Moreover, previous studies have shown that younger adults have a great possibility of improving cognitive functions by performing cognitive training and video games than in older adults [18].

Lumosity is selected as the brain training game for this study. Lumosity website consists of assessments, games and training courses that are based on real science. It is being used as a technology programmed for investigating the effect of cognitive training in different populations. Lumosity is the most beneficial online game for cognitive enhancement that provides brain training exercises which improves memory, concentration and reaction time of any age [19, 20]. Some research results show that this brain training can improve a wide variety of basic cognitive skills – from attention and memory to fluid intelligence and mathematical skills. Core Brain Training, Peak Performance, Student and Medical Conditions are the courses in the Lumosity website. Student courses are designed to help students to achieve better performance in their education. The brain training games have been shown to help students improve on tests of reading and calculation [20]. Study shows 97% of people who train with Lumosity for at least 10 hours see increase in their Brain Performance Indexes (BPIs) [22]. Some of the research using Lumosity did not show any significant pre-test and post-test differences [21-24]. However, it remains unclear whether there are effects of playing the brain training game on cognitive functions in healthy medical students.

The aim of this study is to evaluate the effectiveness of brain training games on concentration, memory and reaction time on students in private medical college in Malaysia. In addition, we made a hypothesis that in healthy medical students, brain training game improve the attention, concentration, memory and reaction time. Individuals who play the brain training games frequently is known to have reduced risk of developing dementia [25]. By carrying out this research, we hope that young adults who frequently play brain games are able to strive better in their cognitive function.

2. Methodology

2.1. Study Design, Study Setting, Study Time, Study Population

A randomized controlled trial parallel study was conducted on the effect of Brain Training games on cognitive function with respect to memory, concentration and reaction time among undergraduate students of private medical college, Malaysia.

Melaka Manipal Medical College (MMMC), Malaysia has 2 different campuses. One campus based in Muar, Johor and another campus based in Malacca. The Muar campus offers MBBS Semester 6 & 7. On the other hand, the campus in Malacca offers Bachelor of Dental Surgery (BDS), Foundation in Science (FIS) and MBBS Semester 8, 9 & 10. This study was carried out in the month of June to July 2019 in MMMC Muar campus which includes only students of semester 6. The population of MMMC students in semester 6 were 148, out of which only 40 participants from semester 6 were invited.

2.2. Sample Size

A total of 40 students participated in this study. The participants were randomized into 2 groups of 20 each, one as the experimental group 1 (plays brain training games) and the other as the control group 2 (do not play any games). The sample size was calculated by the formula shown as below.

Formula 1: Sample Size Calculation with Mean and Standard Deviation of Two Groups

$$n \geq \frac{\left(Z_{1-\frac{\alpha}{2}}+Z_{1-\beta}\right)^2 (\sigma_1^2+\sigma_2^2/r)}{(\mu_1-\mu_2)^2} \quad (1)$$

Based on previous study [18], we calculated the sample size with the data given as following:

a. Alpha (α) = 0.05

b. Beta (β) = 0.2

c. Mean in group 1 (μ_1) = 83.75 [memory]

d. Standard deviation in group 1 (σ_1) = 9.06 [memory]

e. Mean in group 2 (μ_2) = 68.27 [memory]

f. Standard deviation in group 2 (σ_2) = 16.3 [memory]

g. Ratio (Group 2 / Group 1) = 1

The minimal sample size needed for group 1 was 12 and group 2 was 12. The minimal total sample size needed was 24. Drop-out percentage allowed for this study was 10%.

Formula 2: Sample Size Calculation excluding Dropout Percentage

$$n_{final} = \frac{n_{calculated}}{1-dropout\%} = \frac{12}{1-0.1} = 13.3 \quad (2)$$

Therefore, the minimum sample size needed for our study in each group was 14 after considering drop-out percentage. However, we decided to take 20 samples in each group to maximize the sample size.

2.3. Sampling and Randomization

Sampling method chosen was non-probability sampling. Non-probability sampling is a sampling technique in which the researcher selects samples based on the subjective judgment rather than random selection.

The inclusion criteria in this study are medical students from semester 6 (between the ages of 18 to 30) in private medical college. The gender for this study were also divided equally to minimise selection bias. The exclusion criteria included those who had systemic diseases, psychiatric problems, any alcohol or drug consumption 24 hours before the test and those who were on any medication that interfered with mental functions (antidepressants, antihistamines, and benzodiazepines and other central nervous agents).

The method of randomization chosen was stratified and block randomization (which can be referred to Figure 1). We obtained a sample size of 40 participants of 20 males and 20 females and used stratified randomization to obtain a sample group of each of the two groups. One group was instructed to play the selected brain training game for 15 minutes per day for 5 days which was the experimental group consisting 10 males and 10 females and the other group was instructed not to play any games through the 5 days which was considered as the control group consisting 10 males and 10 females. Participants were randomly assigned in to the intervention and control group using block randomization. There were 20 sets of 2 unique number per set with the range from 1 to 2 where number 1 indicating intervention group and number 2 indicating control group (which can be referred to Table 1). Randomization was done using randomizer.org.

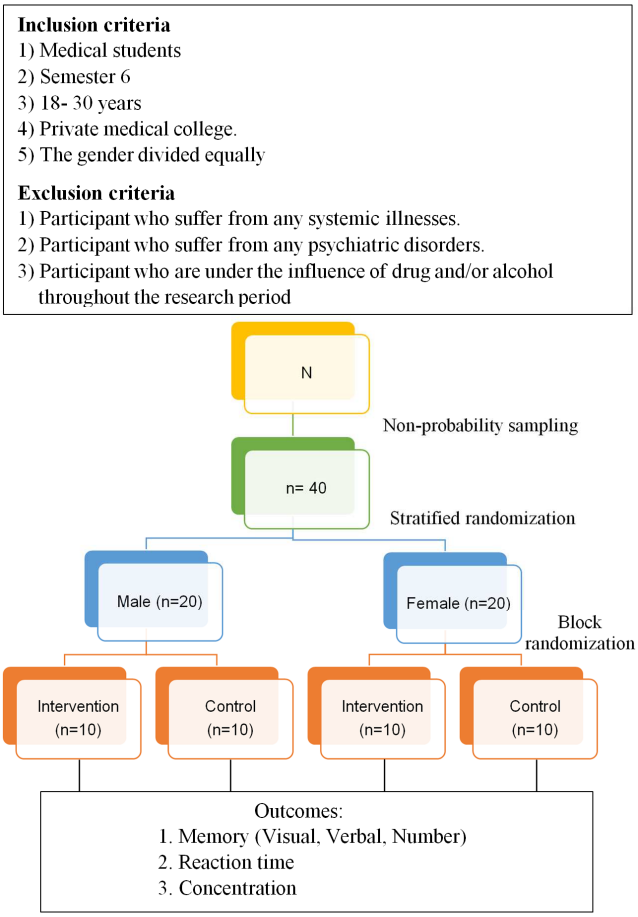

Figure 1. Flow chart showing the method of sampling from total population.

Table 1. Block randomization using randomizer.org.

2, 1	2, 1	1, 2	1, 2	2, 1
2, 1	1, 2	2, 1	2, 1	2, 1
1, 2	1, 2	1, 2	2, 1	1, 2
2, 1	1, 2	1, 2	2, 1	2, 1

20 sets 2 unique numbers per set range from 1 to 2

2.4. Intervention and Follow up

40 participants were gathered at the computer lab and their demographic data was collected such as roll number, name, age, gender and ethnicity after which a briefing was done; they were required to access "https://www.humanbenchmark.com" and "https://www.testmybrain.org/" and perform the given tasks at their best effort. Each of the results shown were recorded and everyone was allowed to dismiss. The duration of the pre-test was roughly about 20 minutes.

Testmybrain.org is a test that provide a measuring tool to evaluate different section of human cognitive function such as cognitive speed, continuous concentration, test of multiple memory types and reading the minds in the eyes [26, 27]. For humanbenchmark.com, this test includes several of assessment which consist of number memory, reaction time, verbal memory, visual memory, hearing and typing. [28, 29].

For the intervention group, 20 of the participants were instructed to play the brain training game which was https://www.lumosity.com/en/ for 15 minutes per day for 5 days consecutively. They were required to play the games during their free time in each of the day regardless day or night. Basically, Lumosity is an online program consisting of games claiming to improve memory, attention, flexibility, speed of processing, and problem solving [19, 20]. Meanwhile for the control group, they were instructed not to play any games.

During the follow up period, which was after 5 days, all participants were assembled again in the computer lab for the post-test. They were given the same test which were "https://www.humanbenchmark.com" and https://www.testmybrain.org/. Then their results were recorded for comparison between the intervention group and control group.

2.5. Data Collection

A total number of 40 students of private medical college participated in this study. After getting the informed consent, the participants were assigned into 2 groups of 20 students each as a random basic. One group of the participants, known as intervention group, was asked to play a brain training game (Lumosity) for 15 minutes per day for 5 consecutive days. Another group of participants known as the control group was instructed not to play the brain training game (Lumosity). Cognitive function tests that were assessed are memory, concentration and reaction time. Cognitive function test was conducted for both groups of participants before and after intervention. Under memory test, visual memory, verbal memory and number memory were included. Memory and reaction time were assessed using Human Benchmark online test. Concentration were assessed using Test My Brain online test. The scores of these tests before and after training were compared. The scores of intervention group and control group were compared.

2.6. Data Processing & Analysis

Data was tabulated using Microsoft Excel version 2013. We used Epi info software (7.2 version) and GraphPad to calculate data collected. Descriptive statistics we used for our studies were mean, standard deviation (SD), frequency percentage.

Mean and standard deviation (SD) of data were used to calculate results of memory, concentration and reaction time test. Frequency percentage was calculated for categorical data which is gender. The p value and 95% confidence interval were calculated to locate any significance in results. The level of significance, α was set at 0.05, where any value more than 0.05 indicated non significance.

Table 2. Independent Variable, Dependent Variable and Statistical Test.

Independent Variable	Dependent Variable	Statistical Test
Brain training game vs Control	- Memory (number, visual, verbal)	Unpaired t-test
	- Concentration	Unpaired t-test
	- Reaction time	Unpaired t-test

Table 3. Independent Variable, Dependent Variable and Statistical Test.

Independent Variable	Dependent Variable	Statistical Test
Before Vs After	- Memory (number, visual, verbal)	Paired t-test
	- Concentration	Paired t-test
	- Reaction time	Paired t-test

2.7. Ethical Consideration

The participants were informed about the aim and procedures of this study. A written consent form was distributed to all the participants who volunteered to join the research prior to the study. Participants were informed that they have the right to withdraw from the study at any stage if they wish to do so. The privacy of research participants and confidentiality of research data were ensured. Incentive was given to each participant at the end of the research. The study was approved by the Research Ethics Committee, Faculty of Medicine, Melaka-Manipal Medical College (MMMC), Malaysia.

3. Results

Table 4. Participant demographics between brain training game (n=20) and control (n=20).

Variables	Control (n = 20)	Intervention (n = 20)	Total
	n (%)	n (%)	n (%)
Age (years)			
Mean (SD)	22.30 (0.92)	22.25 (1.91)	22.28 (1.48)
Gender			
Male	10 (50)	10 (50)	20 (50)
Female	10 (50)	10 (50)	20 (50)
Race			
Indian	8 (40)	3 (15)	11 (27.50)
Chinese	5 (25)	7 (35)	12 (30)
Malay	4 (20)	5 (25)	9 (22.50)
Other	3 (15)	5 25)	8 (20)
Nationality			
Malaysian	18 (90)	15 (75)	33 (82.50)
Non Malaysian	2 (10)	5 (25)	7 (17.50)
Smoking			
Yes	2 (10)	1 (5)	3 (7.5)
No	18 (90)	19 (95)	37 (92.5)

Variables	Control (n = 20)	Intervention (n = 20)	Total
	n (%)	n (%)	n (%)
Alcohol			
Yes	0 (0)	1 (5)	1 (2.5)
No	20 (100)	19 (95)	39 (97.5)
Duration of sleeps (hours)			
Mean (SD)	6.33 (2.10)	6.35 (1.09)	6.34 (1.65)
Caffeine intake			
Yes	12 (60)	12 (60)	24 (60)
No	8 (40)	8 (40)	16 (40)
Medication			
Yes	2 (10)	0 (0)	2 (5)
No	18 (90)	20 (100)	38 (95)
Mental exercise			
Yes	1 (5)	2 (10)	3 (7.5)
No	19 (95)	18 (90)	37 (92.50)
Physical exercise			
Yes	11 (55)	13 (65)	24 (60)
No	9 (45)	7 (35)	16 (40)

Table 1 shows participant's demographic data from intervention and control group on effect of brain training game towards memory, reaction time and concentration. The number of participants from control group and intervention group was 20 people each and total participants in this study was 40 people. The average age of participant in control group was 22.30 (0.92SD) while participant from intervention group was 22.28 (1.48SD).

For the gender of participant in this study. Participants from control group and intervention group was each divided equally into 20 persons consist of male and female respectively. So, total male participants in this study was 20 person and female were 20 persons.

Among participants from control group, 40% were Indians, 25% were Chinese, 20% were from Malays and 15% were from another ethnicity. Among participant from intervention group, 15% of participants were from Indian, 35% were from Chinese, 25% were from Malays and 25% were from another ethnicity. While for the nationality of participants in this study, majority of them are from Malaysia which is 33 persons (82.5%) and Non-Malaysian only consist of 7 persons (17.5%) in which 2 persons in control group and 5 persons in intervention group.

For smoking habit of participant, almost all of the participants do not smoke which is 37 persons (92.5%) and only 7.5% smoker made up of 2 persons in control and 1 person in intervention group. While for the alcohol intake in last 24 hours, none of the participants in control group took alcohol, while only 1 person in the intervention group took alcohol.

By looking at duration of sleep for participants in both group, there is not much significant different in them. The mean of duration of sleep for control group was 6.33 hours with standard deviation of 2.10 while mean of duration of sleep for intervention group was 6.35 with standard deviation of 1.09.

Meanwhile for caffeine intake of participants, 24 people of them took caffeine in which half of them from control group and half of them in intervention group. And for the non-caffeine intake participants, the figures also constant which 8 people of them each do not take caffeine in control and intervention group.

In addition, for medication intake for the past 24 hours before the study been done, 95% of them did not take any medication and only 5% of them took medication which all of them are from control group. For the mental exercise, 92.5% of the participant did not practice as such, only 7.5% of them consist of 1 person from control group and 2 persons from intervention group respectively.

Finally, 55% of participants in control group did exercise in the last week while 45% of them did not. And for the intervention group, 65% of them did exercise while 35% of them did not.

Table 5. Memory, reaction time and concentration between intervention and the control group before intervention.

Outcome Variables	Intervention	Control	Mean difference (95%CI)	t (df)	P value
	Mean (SD)	Mean (SD)			
Total Memory	59.05 (21.30)	61.0 (27.07)	-1.95 (-17.54, 13.64)	-0.25 (38)	0.802
Visual Memory	8.9 (1.41)	9.6 (1.64)	-0.7 (-1.68, 0.28)	-1.45 (38)	0.155
Verbal Memory	41 (19.19)	42.45 (25.87)	-1.45 (-16.03, 13.13)	-0.20 (38)	0.842
Number Memory	9.15 (2.58)	8.95 (2.33)	0.2 (-1.77, 1.77)	0.26 (38)	0.798
Reaction Time	341.45 (81.49)	342.4 (103.85)	-0.95 (-60.71, 58.81)	-0.03 (38)	0.975
Concentration	73.98 (13.34)	75.36 (12.56)	-1.379 (-9.67, 6.92)	-0.34 (38)	0.739

Table 2 shows the mean scoring and standard deviation (SD) between those who played Brain games (Intervention group) and the control group who not played Brain games, mean difference, 95% confidential interval, t value, degree of freedom and P value for total memory, visual memory, verbal memory, number memory, reaction time and concentration before intervention.

There was not a significant difference of total memory score between the two groups due to the P value of total memory was 0.802 which was more than the level of significance (0.05) and the 95% confidence interval value for total memory is between -17.54 and 13.64 where zero was within the range. The participants who played Brain games had a mean score of 59.05 and Standard Deviation (SD) of 21.3 for

the total memory test while the control group had a mean scoring of 61 and a standard deviation (SD) of 27.07.

The visual memory score for those who played Brain games had a mean score of 8.9 and Standard Deviation (SD) of 1.41 while for the control group had a mean score of 9.6 and a Standard Deviation (SD) of 1.64. The P value of visual memory was 0.155 which was more than the level of significance (0.05) and the 95% confidence interval value for visual memory was between -1.68 and 0.28 where zero was within the range therefore there was not a significant difference of visual memory score between the two groups.

Regards to verbal memory score, the mean of verbal memory score for participants who played Brain games was 41 and the Standard Deviation (SD) was 19.19. The mean verbal memory score of the control group who not played Brain games was 42.45 and the Standard Deviation (SD) was 25.87. There was not a significance in verbal memory score between the two groups due to the P value of verbal memory was 0.842 which was more than the level of significance (0.05) and the 95% confidence interval value for verbal memory was between -16.03 and 13.13 where zero was within the range.

The number memory score for those who played Brain games had a mean score of 9.15 and Standard Deviation (SD) of 2.58 while for the control group had a mean score of 8.95 and a Standard Deviation (SD) of 2.33. The P value of number memory was 0.798 which was more than the level of significance (0.05) and the 95% confidence interval value for number memory was between -1.77 and 1.77 where zero was within the range therefore there was not a significant difference of number memory score between the two groups.

The mean of reaction time for participants who played Brain games was 341.45ms and the Standard Deviation (SD) was 84.49ms. Mean of reaction time for the control group who not played Brain games was 342.4ms and the Standard Deviation (SD) was 103.85ms. The P value of reaction time was 0.975 which was more than the level of significance (0.05) and the 95% confidential interval value for reaction time was between -60.71 and 58.81 where zero was within the range therefore there was not a significance in reaction time between the two groups.

The concentration for those who played Brain games had a mean score of 73.98 and Standard Deviation (SD) of 13.34 while for the control group had a mean score of 75.36 and a Standard Deviation (SD) of 12.56. There was not a significant difference of concentration score between the two groups due to the P value of concentration was 0.738 which was more than the level of significance (0.05) and the 95% confidence interval value for concentration was between -9.67 and 6.915 where zero was within the range.

Table 6. Memory, Concentration and Reaction Time between Intervention and Control after Intervention.

Outcome Variables	Intervention Mean (SD)	Control Mean (SD)	Mean difference (95% CI)	t (df)	P value
Total Memory	64 (29.81)	64 (22.12)	0.00 (-16.80, 16.80)	0.00 (38)	0.999
Visual memory	9.90 (1.65)	9.75 (1.29)	0.15 (-0.80, 1.10)	0.32 (38)	0.751
Verbal Memory	45 (29.51)	44.60 (20.51)	0.40 (-15.87, 16.67)	0.05 (38)	0.961
Number Memory	9.10 (2.10)	9.65 (2.06)	-0.55 (-1.88, 0.78)	-0.84 (38)	0.408
Concentration	81.05 (13.49)	75.23 (18.70)	5.83 (-4.62, 16.27)	1.13 (38)	0.266
Reaction Time (ms)	294.15 (68.61)	292.95 (73.31)	1.20 (-44.25, 46.65)	0.05 (38)	0.958

Table 3 shows the mean scoring and standard deviation (SD) between those who played brain training game (Intervention group) and the control group who not played brain training game, mean difference, 95% confidential interval, t value, degree of freedom and P value for total memory (visual, verbal and number), visual memory, verbal memory, number memory, reaction time and concentration after intervention.

The total memory score between the two groups was equal. The intervention group had a mean score of 64 and Standard Deviation (SD) of 29.81 while the control group had a mean scoring of 64 and a standard deviation (SD) of 22.12. The P value was ≥ 0.05 (level of significance) which was 0.999 and zero was within the range of 95% confidence interval (-16.80, 16.80), therefore there was no significant association between brain training game and memory.

The intervention group had a mean score of 9.90 and Standard Deviation (SD) of 1.65 while the control group had a mean scoring of 9.75 and a standard deviation (SD) of 1.29 for visual memory. The P value was ≥ 0.05 (level of significance) which was 0.751 and zero was within the range of 95% confidence interval (-0.80, 1.10), therefore there was no significant association between brain training game and visual memory.

The verbal memory for the intervention group had a mean score of 45 and Standard Deviation (SD) of 29.51 while the control group had a mean scoring of 44.60 and a standard deviation (SD) of 20.51. The P value was ≥ 0.05 (level of significance) which was 0.961 and zero was within the range of 95% confidence interval (-15.87, 16.67), therefore there was no significant association between brain training game and verbal memory.

The number memory score for those who were in intervention group had a mean score of 9.10 and Standard Deviation (SD) of 2.10 while the control group had a mean scoring of 9.65 and a standard deviation (SD) of 2.06. The P value was ≥ 0.05 (level of significance) which was 0.408 and zero was within the range of 95% confidence interval (-1.88, 0.78), therefore there was no significant association between brain training game and memory.

The concentration for intervention group had a mean score of 81.05 and Standard Deviation (SD) of 13.49 while for the control group had a mean score of 75.23 and a Standard Deviation (SD) of 18.70. The P value was ≥ 0.05 (level of significance) which was 0.266 and zero was within the range of 95% confidence interval (-4.62, 16.27), therefore there was no significant association between brain training game and memory.

The mean of reaction time for intervention group was 295ms and the Standard Deviation (SD) was 68.61ms. Mean of reaction time for the control group was 292.95ms and the Standard Deviation (SD) was 73.31ms. The P value was ≥ 0.05 (level of significance) which was 0.958 and zero was within the range of 95% confidence interval (-44.25, 46.65), therefore there was no significant association between brain training game and memory.

Table 7. Memory, reaction time and concentration of intervention group, before and after intervention.

Outcome Variables	Mean (SD)		Mean difference (95% CI)	t (df)	P value
	Pre-Test	Post-Test			
Visual Memory	8.90 (1.41)	9.90 (1.65)	-1.00 (-1.61, -0.39)	3.45 (19)	0.003
Verbal Memory	41.00 (19.19)	45.00 (29.51)	-4.00 (-16.57, 8.57)	0.67 (19)	0.513
Number Memory	9.15 (2.58)	9.10 (2.10)	0.05 (-1.00, 1.10)	0.10 (19)	0.921
Total Memory	59.05 (21.30)	64.00 (29.81)	-4.95 (-17.86, 7.96)	0.80 (19)	0.432
Reaction Time	341.45 (81.49)	294.15 (68.61)	47.30 (-2.81, 97.41)	1.98 (19)	0.063
Concentration	74.24 (13.20)	81.05 (13.49)	-6.81 (-14.99, 1.39)	1.74 (19)	0.099

Table 4 shows the mean scoring, standard deviation, mean difference, 95% confidence interval, t value, degree of freedom and P value for visual memory, verbal memory, number memory, total memory, reaction time and concentration of pre-test (before intervention) and post-test (after intervention) of the intervention group.

The pre-test mean was 8.90 and post-test mean was 9.90 which showed an observed difference in visual memory. The value of standard deviation was 1.41 for pre-test and 1.65 for post-test. The P value of visual memory was 0.003 which was less than the level of significance (0.05) therefore there was a significant difference between the pre-test (before intervention) and post-test (after intervention) results of visual memory. The 95% CI value for visual memory was between -1.61 and -0.39 where zero was not within the range therefore was considered as a significant difference between the pre-test (before intervention) and post-test (after intervention) results of visual memory.

The pre-test mean was 41.0 and post-test mean was 45.0 which showed an observed difference in verbal memory. The value of standard deviation was 19.19 for pre-test and 29.51 for post-test. The P value of verbal memory was 0.513 which was more than the level of significance (0.05) therefore there was no significant difference between the pre-test (before intervention) and post-test (after intervention) results of verbal memory. The 95% CI value for verbal memory was between -16.57 and 8.57 where zero was within the range therefore was considered as a non-significant difference between the pre-test (before intervention) and post-test (after intervention) results of verbal memory.

The pre-test mean was 9.15 and post-test mean was 9.10 which showed an observed difference in number memory. The value of standard deviation was 2.58 for pre-test and 2.10 for post-test. The P value of number memory was 0. 921 which was more than the level of significance (0.05) therefore there was no significant difference between the pre-test (before intervention) and post-test (after intervention) results of number memory. The 95% CI value for number memory was between -1.00 and 1.10 where zero was within the range therefore was considered as a non-significant difference between the pre-test (before intervention) and post-test (after intervention) results of number memory.

The pre-test mean was 59.05 and post-test mean was 64.00 which showed an observed difference in total memory. The value of standard deviation was 21.30 for pre-test and 29.81 for post-test. The P value of total memory was 0.432 which was more than the level of significance (0.05) therefore there was no significant difference between the pre-test (before intervention) and post-test (after intervention) results of total memory. The 95% CI value for total memory was between -17.86 and 7.96 where zero was within the range therefore was considered as a non-significant difference between the pre-test (before intervention) and post-test (after intervention) results of total memory.

The pre-test mean was 341.45 and post-test mean was 294.15 which showed an observed difference in reaction time. The value of standard deviation was 81.49 for pre-test and 68.61 for post-test. The P value of reaction time was 0.063 which was more than the level of significance (0.05) therefore there was no significant difference between the pre-test (before intervention) and post-test (after intervention) results of

reaction time. The 95% CI value for reaction time was between -2.81 and 97.41 where zero was within the range therefore was considered as a non-significant difference between the pre-test (before intervention) and post-test (after intervention) results of reaction time.

The pre-test mean was 74.24 and post-test mean was 81.05 which showed an observed difference in concentration. The value of standard deviation was 13.20 for pre-test and 13.49 for post-test. The P value of concentration was 0.099 which was more than the level of significance (0.05) therefore there was no significant difference between the pre-test (before intervention) and post-test (after intervention) results of concentration. The 95% CI value for concentration was between -14.99 and 1.39 where zero was within the range therefore was considered as a non-significant difference between the pre-test (before intervention) and post-test (after intervention) results of concentration.

Table 8. Memory, reaction time and concentration of control group during the period of the study.

Outcome Variables	Mean (SD)		Mean difference (95% CI)	t (df)	P value
	Pre-test	Post-test			
Visual Memory	9.60 (1.64)	9.75 (1.29)	-0.15 (-0.68, 0.38)	0.59 (19)	0.562
Verbal Memory	42.45 (25.87)	44.60 (20.53)	-2.15 (-13.61, 9.31)	0.39 (19)	0.699
Number Memory	8.95 (2.33)	9.65 (2.06)	-0.70 (-1.45, 0.05)	1.97 (19)	0.064
Total Memory	61.00 (27.07)	64.00 (22.11)	-3.00 (-14.83, 8.83)	0.53 (19)	0.602
Reaction Time	342.40 (103.85)	292.95 (73.31)	49.45 (13.64, 85.26)	2.89 (19)	0.009
Concentration	75.36 (12.56)	75.23 (18.70)	0.13 (-7.547, 7.814)	0.03 (19)	0.971

Table 5 shows the mean scoring, standard deviation, mean difference, 95% confidence interval, t value, degree of freedom and P value for visual memory, verbal memory, number memory, total memory, reaction time and concentration of pre-test (before intervention) and post-test (after intervention) of the control group.

The value of pre-test mean was 9.60 and post-test mean was 9.75 for visual memory with standard deviation of 1.64 and 1.29 respectively. The P value of visual memory was 0.562 which was more than the level of significance (0.05) therefore there was no significant difference between the pre-test (before intervention) and post-test (after intervention) results of visual memory. The 95% CI value for visual memory was between -0.68 and 0.38 where zero was within the range therefore was considered as non-significant difference during the period of study and the results of visual memory of the control group.

The value of pre-test mean was 42.45 and post-test mean was 44.60 for verbal memory with the standard deviation of 25.87 and 20.53 respectively. The P value of verbal memory was 0.699 which was more than the level of significance (0.05) therefore there was no significant difference between during the period of study and the results of verbal memory of the control group. The 95% CI value for verbal memory was between -13.61 and 9.31 where zero was within the range therefore was considered as a non-significant difference during the period of study and the results of verbal memory of the control group.

The value of pre-test mean was 8.95 and post-test mean was 9.65 for number memory with the standard deviation of 2.33 and 2.06 respectively. The P value of number memory was 0.064 which was more than the level of significance (0.05) therefore there was no significant difference during the period of study and the results of number memory of the control group. The 95% CI value for number memory was between -1.45 and 0.05 where zero was within the range therefore was considered as a non-significant difference during the period of study and the results of number memory of the control group.

The value of pre-test mean was 61.00 and post-test mean was 64.00 for total memory. The P value of total memory was 0.602 which was more than the level of significance (0.05) therefore there was no significant difference during the period of study and the results of total memory of the control group. The 95% CI value for total memory was between -14.83 and 8.83 where zero was within the range therefore was considered as a non-significant difference during the period of study and the results of total memory of the control group.

The value of pre-test mean was 342.40 and post-test mean was 292.45 for reaction time with the standard deviation of 27.07 and 22.11 respectively. The P value of reaction time was 0.009 which was more than the level of significance (0.05) therefore there was no significant difference during the period of study and the results of reaction time memory of the control group. The 95% CI value for reaction time was between 13.64 and 85.26 where zero was not within the range therefore was considered as a significant difference during the period of study and the results of reaction time of the control group.

The value of pre-test mean was 75.36 and post-test mean was 75.23 for concentration with standard deviation of 12.56 and 18.70 respectively. The P value of concentration was 0.971 which was more than the level of significance (0.05) therefore there was no significant difference during the period of study and the results of concentration of the control

group. The 95% CI value for concentration was between -7.55 and 7.81 where zero was within the range therefore was considered as a non-significant difference during the period of study and the results of concentration of the control group.

4. Discussion

We conducted a randomised controlled trial regarding the effect of brain training games (Lumosity) on memory, reaction time and concentration among undergraduate medical students in Melaka Manipal Medical College (MMMC). A total of 40 participants were selected and were randomized into two groups of 20 which were the intervention group (plays Lumosity) and control group (don't play any games).

Currently there are numerous studies done regarding the association between brain training game and cognitive function [9, 10, 21-24]. Brain age or Tetris are brain enhancing video games which shows an improvement in cognitive function in individuals. The results of this study show that there is an improvement in cognitive function and processing speed but no effect on attention [9]. Recently a study also suggest that different tasks offered through video games improve the processing speed. Improvements are also seen in other areas of skills such as multitasking, ability to track numerous items simultaneously and ability to analyse information in a short period of time. The result showed a significant improvement in all executive functioning, processing speed measures especially trail making test and number comparison test but not on the visuospatial measures. [10]. However certain other studies suggested that there is no evidence that brain training game enhance performance on related tasks or that training improves cognitive performance [21-24].

Based on our hypothesis, we proposed that young adults who regularly play brain training games will have improvement in memory, reaction time and concentration compared to those who don't. Even though there was no significant difference of memory, reaction time and concentration between the intervention group (brain training game) and control group, the intervention group had higher visual memory, verbal memory, concentration and reaction time. The intervention group had a mean score of 9.90 which was higher than the control group which had a mean scoring of 9.75 for visual memory. The verbal memory for the intervention group had a mean score of 45 which was higher than the control group had a mean scoring of 44.60. But the mean number memory score for intervention group was 9.10 which was lower than the control group which had a mean scoring of 9.65. Moreover, the concentration for intervention group had a mean score of 81.05 which was higher than the control group which had a mean score of 75.23. Similarly, the mean of reaction time for intervention group was 295ms which was higher than the control group that was 292.95ms.

The previous studies done by Nouchi R. et al (2013) between brain age game and Tetris game, the working memory and reaction time are significant but concentration was insignificant [18]. From this study, the mean working memory of brain age game was 83.75 while Tetris game was 68.27. The mean reaction time of brain age game was 115.44 while Tetris game was 106.73. The mean concentration of brain age game was 37.69 while Tetris game was 37.13 [18].

In our intervention group, we found there was a significant improvement (p value of 0.003) in visual memory only between pre-test and post-test, while other results were not significant. Regards to visual memory score, the mean of post-test of intervention group was 9.90 which was higher than the pre-test of intervention group that had mean score of 8.90. Based on previous study, the results between pre-test and post-test of brain age group, the working memory, processing speed and concentration was significant. From this study, the mean working memory in pretest of brain age game was 70.06 while post-test was 83.75. The mean reaction time of brain age game was 106.81 for pre-test while in post-test mean score was 115.44. The mean concentration for brain age game was 35.69 for pre-test and 37.69 for post-test [18].

The strengths of our study were that the participants of the intervention group were able to play the game at their own convenience. The brain training game chosen was user friendly and had many variations from day to day that kept the players interested. Moreover, we had 0% dropout in this study. We had few limitations. In this study, we are able to recruit 40 students, therefore, we recommend that the study sample size should be increased to get more accurate readings. The duration of the intervention should also be increased as the time frame of 5 days used in our study was due to the limited time duration we had.

5. Conclusion

Based on our study, we found out that there is significance of brain training games on improving memory, concentration and reaction time among which only visual memory showed an improvement in the intervention group. Students who regularly play brain training games will have improvement in memory, reaction time and concentration compared to those who don't. Therefore, we conclude that brain training game improve the attention, concentration, memory and reaction time. We recommend that individuals who wish to improve their cognitive functions may attempt playing brain training games, like Lumosity, in order to improve their skills further.

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