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The Effect of Jigsaw Puzzles Compared to Colouring on Brain Cognitive Function Among Medical Student

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Abstract

Cognitively stimulating leisure activities has been known to give benefits to a certain brain function. In medical school, continuous concentration and fast response is needed by the students. Jigsaw puzzles and coloring are age-friendly and easily available activities. The aim of this research is to determine whether jigsaw puzzles and colouring activities are helpful in improving the brain cognitive activity. A pilot randomized controlled trial was conducted from December 2019 to January 2020 in Melaka Manipal Medical College, Muar Campus, Johor, Malaysia. Demographic data were collected using questionnaire, including inclusion and exclusion criteria. We recruited volunteers to select sample and participants were randomized into intervention group and control group by block randomisation. Cognitive functions were measured, in terms of concentration and reaction time, before and after interventions were introduced. Mean and standard deviation values for pre-intervention and post-intervention score, mean difference, P-value and 95% confidence intervals were derived from paired t-test and unpaired t-test. Overall, 20 medical students were introduced with a session of jigsaw puzzle activity and another 20 medical students were introduced with colouring activity. It was found out that there is an improvement in reaction time of both intervention and control group but it is insignificant when analysing the data by using paired t-test. Surprisingly, in paired t-test as well, there is a decline in concentration in the intervention group but this finding is not significant as well. However, there is a significant improvement in concentration for the control group after the intervention after a paired t-test was done. Therefore, we recommend that jigsaw puzzle is still a good practice for general population to regularly indulge in leisure problem solving activities such as jigsaw puzzles and colouring for smaller children as it would benefit them in the long run.

Keywords

Jigsaw Puzzles, Colouring, Cognitive Function, Cognitive Stimulating Leisure Activity (CSLA), Randomized Controlled Trial, Medical Students

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1. Introduction

The huge requirement of cognitive function usage among practitioners in the medical field in order to maintain a good quality of health care service delivery is undeniable. Therefore, it is essential to continuously engage in cognitively challenging activities. A professor from the University of Exeter Medical School, Dr Anne Corbett, who was involved in a research investigating beneficial outcome of regular cognitively challenging activities has proposed that sharper performances can be seen in range of tasks assessing memory, attention, reasoning in people who regularly engaged with puzzles such as crosswords and Sudoku. [1] To

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further support the statement, a study was conducted which concluded that there is a reduced risk of cognitive function impairment in the future if there is a continuous engagement to cognitively challenging activities. [2] There are many studies [3-6] that were done on how beneficial are cognitive activities but most of these activities require high financial costs, digital or electronic devices and also more structured which causes lower interest among the participants. [2] It has been proven that certain educational games does have neurocognitive benefits such as "games that heavily tap executive control processes such as working memory are thought to induce positive plastic changes in these cognitive processes and their underlying prefrontal network". [7] However, there is an alternative way to enhance the cognitive function which is much more enjoyable and theoretically gives almost the same benefits as these cognitively challenging activities done in earlier studies. [2] The puzzle that we are going to use in this trial is jigsaw puzzle. This puzzle consists of many irregularly shaped pieces that will form a picture, when properly assembled together. [8] It was named so due to the history, which a picture originally attached to wood or paperboard, and eventually cut into its pieces using a jigsaw. [8] It may take a very long time to complete a single jigsaw puzzle as it could be very complicated. [8] This is because it could be made into numerous number of pieces. [8] Jigsaw puzzle has been around for many years. According to American Jigsaw Puzzle Society, the very first jigsaw puzzle was produced at around 1760, by a London engraver and mapmaker, John Spilsbury. [9] Jigsaw puzzles remained one of the essential educational tools until about 1820. [9] After many years, jigsaw puzzles became very famous at around 1920s and 1930s, where companies like Chad Valley and Victory in Great Britain and Einson-Freeman producing a variety of puzzles, to reflect both the desire for sentimental scenes, enthusiasm for the new technologies in rail and shipping. [9]

Jigsaw puzzle has become a popular game to the world ranging from younger age groups to older age groups. [10] One of the main reasons why jigsaw puzzle has become so popular is that it has different levels of difficulty where the amount of puzzle pieces increase with its difficulty making it suitable for all age groups. [10] Besides, having jigsaw puzzles for fun, it requires concentration and problem solving ability of the brain. [14] It is visually stimulating thus making it more interesting to connect each puzzle piece based on its colours or pictures. [11] There is a lot of games that can stimulate brain activities such as sudoku which is known to have a positive effect on concentration [11]. Whether jigsaw puzzles are able to give a positive effect on the cognitive function of the brain is what we are going to find out in this research. [11] According to Dr Sandra Bond Chapman, a cognitive neuroscientist, there is a possibility that brain teasers may only train a specific function of our brain which is required to solve these games. [12] Furthermore, there is a limited number of available studies with limited insight on this correlation. [13] It is understandable as jigsaw puzzles are not standardised and existed in various forms of sizes, colours of the pieces, shapes, pictures, stimuli and even numbers. [14] This further gives us the opportunity to conduct a RCT study on this subject. [13]

In 2017, a SHARE-based analysis was conducted to study the linkage between cognitively stimulating leisure activity (CSLA) with its effects on cognitive function. [15] The study concluded that CSLA is a potential source of activity which has a positive effect on cognitive function in a way it delays cognitive decline. [15] There is also a study conducted on which types of leisure activities that can stimulate cognitive functioning of the brain. According to the study, activities like board games and reading were proven to reduce the risk of developing cognitive impairment. [16] However, another study shows that these CSLA need to be frequently done in order for its cognitive stimulating properties to take place. [17] The benefit of cognitive activities also include helping brain performance in those who have lower education levels and poorer memory. [18] Besides, another study was conducted in 2012, stating the effects of cognitive style on digital jigsaw puzzle. According to Prensky, our brain prefers learning by playing games. [19] Games that are challenging and inventive are able to stimulate interest among people and motivate them to learn from feedback. [20] A research before had propose that problem solving strategies gives great effects on learning results. [21]

Furthermore, previous studies done on animals have shown that neuroplasticity or the potential of our brain to adapt to a changing environment by altering the neural connectivity and brain function give an insight that enriched environment experiences induced increase in hippocampal activity. [22] These cognitive exercises were found to improve delayed memories and language better, if computerised brain exercise was used instead. However, this trend was found to be positive after regular and frequent exercise. [23] On the other hand, to some extent it was found out that colouring activities can help to improve cognitive response time in children. [24] However, the effect on adult is still unknown. Besides that, colouring has shown positive effect on constructive behavior creating an environment of content and stress free. [25] Thus, we decided to give colouring to control group because of its presumed minimal effect on cognitive function in adults.

In a nutshell, a research question entitled 'How do problem solving activities such as jigsaw puzzle affect concentration and reaction time among medical students?' has been formulated. Therefore, a randomised controlled trial has been

planned carefully to determine the effect of jigsaw puzzle on reaction time and concentration compared to coloring among medical students. The hypothesis of this study was problem solving activities such as jigsaw puzzles improve concentration and reaction time compared to colouring among medical students.

2. Methodology

2.1. Study Design, Setting, Study Time, Population

A pilot randomised controlled trial was done among undergraduate medical students in MMMC from December 2019 to January 2020. MMMC offers MBBS, BDS and FIS programmes. Undergraduate students under MBBS program were selected for this trial. In MBBS programme there are a total of 5 semesters for clinical years in Muar and Melaka campus, Malaysia. The number of students in Muar campus is 300 students whereas in Melaka is 350 students totaling to approximately 650 students from both campuses.

2.2. Sample Size

We recruited 40 undergraduate students. Among the 40 participants, 20 participants were given two jigsaw puzzles and the remaining 20 participants were given two pictures for coloring for 30 minutes.

2.3. Sampling and Randomization

We called 40 volunteers of MBBS program. Our inclusion criteria were undergraduate medical students of any age, gender and ethnicity. The students who provided the written informed consent were included. As for the exclusion criteria, each participant must not consume alcohol the night before intervention and evaluation. We also excluded participants who are smoking due to nicotine effect to one's brain which could tamper the result of intervention. Those who slept less than 5 hours the night before were also excluded from this study. Those who are taking medications such as antidepressant and any participants with medical conditions such as migraine, depression or schizophrenia were also excluded from this study.

The randomization method that we used is block randomization. 40 participants are divided into two groups namely intervention group and control group by using a webpage called randomizer.org. The 40 participants were randomized into 20 sets where each set consists of 2 participants that are either in intervention group or control group. As for the intervention group, the jigsaw we used was two 54-pieces puzzles that could be found online in a puzzle website. For the control group, we gave each participant two pictures to be coloured by them.

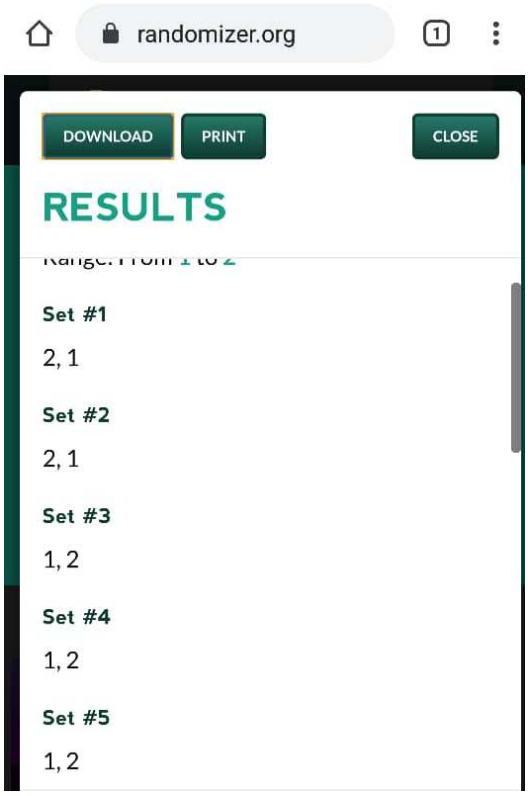

Figure 1. The software application (randomizer.org) used to conduct the block randomization.

Table 1. Block randomisation used to divide 40 participants of the study into 2 respective groups.

Set	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	2,1	2,1	1,2	1,2	1,2	2,1	1,2	2,1	1,2	2,1	2,1	2,1	1,2	2,1	1,2	1,2	2,1	2,1	1,2	1,2

1 - jigsaw puzzle
2 - colouring

Table 2. The inclusion and exclusion criteria taken into consideration in recruiting the participants.

Inclusion criteria	Exclusion criteria
Undergraduate students of any age	Students who consumed alcohol the night before
Written informed consent given	2) Students who smoke frequently
Students of any gender	Students with less than 5 hours of sleep the night before
4) Students of any race	Students who have any medical conditions
Students of any nationality	Students who are on any type of daily medications

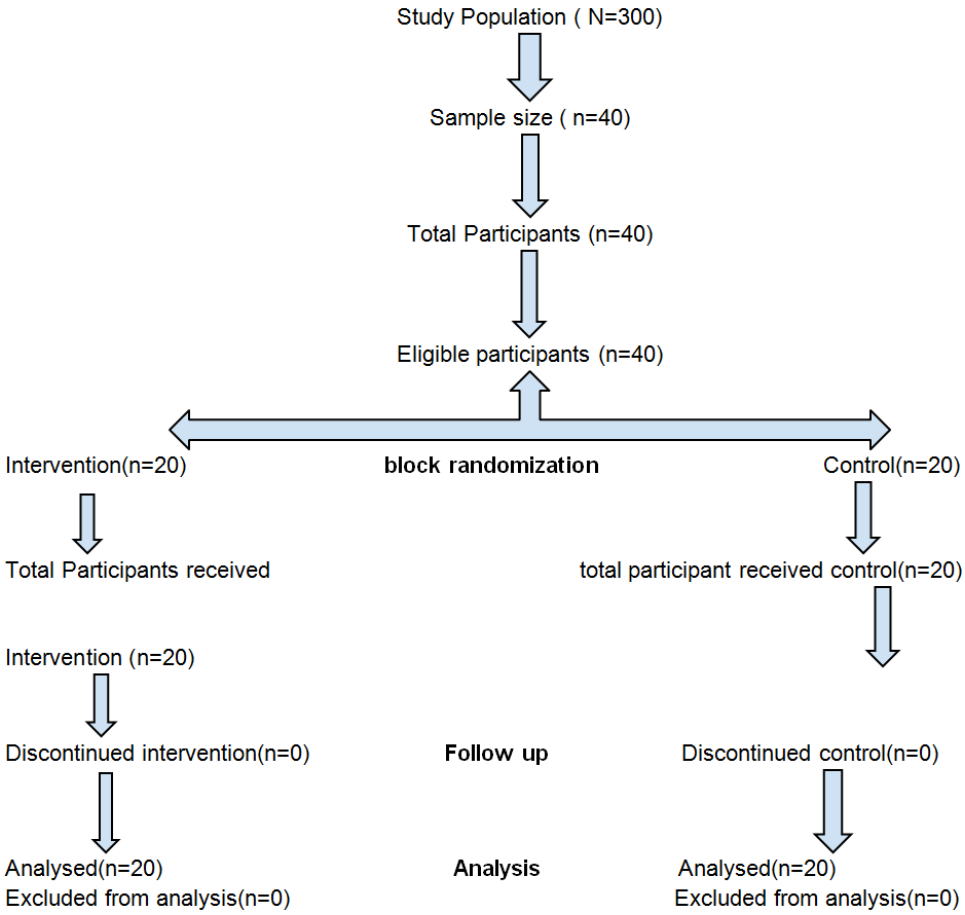

Figure 2. Consort Flow Diagram.

Based on the consort flow diagram, 40 participants were eligible to participate in this study. All the participants met the inclusion criteria. Hence, a total of 40 participants were randomized in this study. 20 participants were randomized into the intervention group, which had to complete two jigsaw puzzles on ‘’Jigsaw explorer’’ and 20 other participants were randomized into the control group, which had to colour two pictures. There were no discontinued intervention in this study. For the analysis, no one was excluded in both the intervention and control group.

2.4. Intervention Procedure

2.4.1. Pre Intervention

All 40 participants were given a written consent form and they were notified about the purpose and procedure of the study. All the participants were qualified after had been filtered based on our including and excluding criteria for this study. Their reaction time and concentration time were tested using websites “humanbenchmark.com” and “testmybrain.org” respectively. Time limit to complete the test was not set. The results are recorded in Microsoft Excel.

2.4.2. During Intervention

The interventions for this study consisted of jigsaw puzzles and colouring. All the 40 participants were divided into either one group using block randomisation method. For the jigsaw puzzle intervention group, two jigsaw puzzles were given to each participant in this group. The puzzle is a 54-piece puzzle which was done online on “Jigsaw Explorer” website and the puzzles chosen were “Timid Cat Jigsaw Puzzle” and “Fruit and Seeds Jigsaw Puzzle”. For the coloring group, each of them had done two coloring tasks given on hard copies. The pictures chosen were shown as below. Colour pencils were provided and participants were free to choose how to colour the pictures based on their own creativity. The time limit given for both groups to complete the tasks was 30 minutes.

2.4.3. Post Intervention

After both groups had done with their tasks, all participants’ reaction time and concentration were again assessed using websites “human benchmark.com” and “testmybrain.org”. The results were recorded in Microsoft Excel. Before they left, their satisfaction level of this study were asked and they were given a scale from 1-5 in which 1 indicating very not satisfied while 5 indicating very satisfied. The scores were recorded as well.

Figure 3. Timid Cat Jigsaw Puzzle.

Figure 4. Fruit and Seed Jigsaw Puzzle.

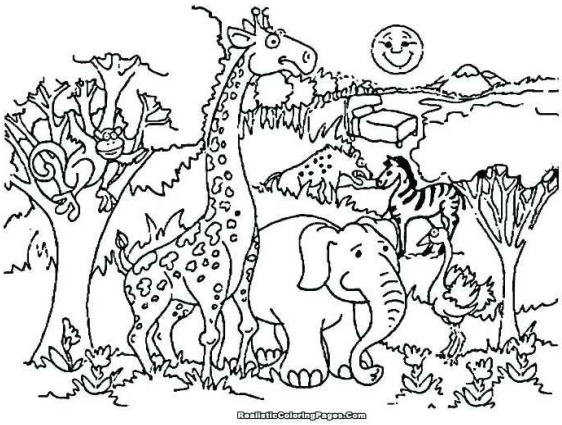

Figure 5. Picture 1 used for colouring for control group.

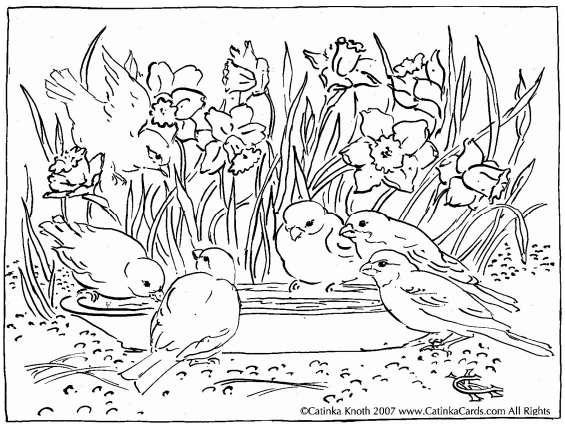

Figure 6. Picture 2 used for colouring for control group.

2.5. Data Collection

Before the study began, all participants were provided with the written informed consent. Then, their demographic profile which consists of their age, gender and ethnicity were all recorded. We made sure to exclude any participant who fulfilled the exclusion criteria which had been described earlier. After that, all eligible participants were asked to answer some tests in order to determine their concentration level and also their reaction time. The test used to determine the reaction time were done at the "humanbenchmark.com" website. As for the concentration part, it was tested using website called ''testmybrain.org". The results of the assessment were recorded as the pre intervention data. Next, the interventions which were colouring and completing the puzzles were done for about 10 to 15 minutes per puzzle or colouring sheet. After completing all tasks, another session of reaction time and concentration testing were done in order to obtain the post intervention data. Their satisfaction level towards their performance had been recorded after the study. They were given scale of 1-5 scores for the satisfaction level, where;

Table 3. Indication of each score from 1 to 5 given by participants at the end of the trial.

SCORE	INDICATION
5	Very satisfied
4	Satisfied
3	Neutral
2	Not Satisfied
1	Very not satisfied

2.6. Data Processing and Analysis

In this study, we used Microsoft Office Excel 1997-2003 and Epi Info Version 7.1 to process and analyse the data collected from the trial. Raw data from the pre-intervention and post-intervention assessment of concentration and reaction time of all participants was collected and entered into Microsoft Office Excel 1997-2003. The demographic data as well as the inclusive and exclusive criteria were collected such as gender, ethnicity, age, physical and mental exercise, sleep duration, alcohol intake, smoking habits, medical conditions and medication taken regularly. The frequency and percentage of the variables in intervention and control group were calculated and computed by using Epi Info Version 7.1. The mean, mean difference and standard deviation of pre-intervention and post-intervention scores were analysed by using Epi Info Version 7.1 and GraphPad.com. Meanwhile, inferential statistics which is 95% confidence interval, t-statistics with degree of freedom and P-value which is the test for significance of differences were calculated by using GraphPad.com. P value of less than 0.05 was considered to be statistically significant.

Table 4. Statistical tests used for each variable.

Intervention	Outcome	Statistical Analysis
Jigsaw puzzles vs colouring	Concentration and reaction time	Unpaired t-test
Before vs after in intervention group	Concentration and reaction time	Paired t-test
Before vs after in control group	Concentration and reaction time	Paired t-test
Jigsaw puzzle vs colouring	Satisfaction	Unpaired t-test

2.7. Ethical Considerations

Participants of this study had chosen to participate in our study willingly none was coerced into participating. A written consent was taken from each participant voluntarily. The consent form consists of important and relevant details of the study. Detailed explanation and its requirements are also stated in the form. The participants were allowed to withdraw themselves from the study whenever they needed to. Participants were notified earlier from the beginning of the study that all the data collected and information provided by them will be kept private and confidential. This study was approved by the Research Ethics Committee, Faculty of Medicine, Melaka Manipal Medical College, Muar Campus, Johor, Malaysia.

3. Results

A total of 40 students participated in this study and were randomized into two groups, which was intervention group who had to solve jigsaw puzzles (n=20) and control group who had to colour pictures (n= 20). Table 5 shows the baseline characteristics between the intervention group (jigsaw) and the control group (colouring). The mean age of participants in the intervention group was 22.45 (SD=0.99), while in the control group, the mean age was 22.15 (SD=1.42). For the aspect of gender, female participants were 60% in the intervention group and 55% in the control group. Generally, majority of the participants were Malay and Chinese, which represented by 65% in the intervention group and 75% in the control group. Most of the participants were Malaysians in which the intervention group and the control group consisted of 85% and 85% respectively. Based on the physical exercise, the majority of participants have habits of running and jogging, which contained 55% in the intervention group and 60% in the control group. For mental exercise, most of the participants had no involvement, which was 60% in the intervention group and 55% in the control group. All the participants (100%) had slept at least 6 hours before the night of study in both groups. All the participants (100%) had no alcohol consumption before the night of study in both groups. Besides, all the participants (100%) had no habit of smoking in both groups. There is no participant had any history of medical conditions such as flu, migraine, depression, schizophrenia or history of taking medicines such as antibiotics, antidepressants, antihistamines, NSAIDS. As for the supplements taken, the majority were not taking any supplements which represented by 80% both in the intervention group and control group.

Table 5. Baseline characteristics between intervention group receiving jigsaw puzzles (n=20) and the control group receiving colouring pictures (n=20).

a. Demographic data

Variables		Intervention group (n=20) n (%)	Control group (n=20) n (%)	Total (n=40) n (%)
Age (years)	18-21	2 (10)	7 (35)	9 (22.5)
	22-25	18 (90)	13 (65)	31 (77.50)
	>26	0 (0)	0 (0)	0 (0)
Gender	Female	13 (65)	11 (55)	24 (60)
	Male	7 (35)	9 (45)	16 (40)
Ethnicity	Malay	7 (35)	5 (25)	12 (30)
	Chinese	6 (30)	10 (50)	16 (40)
	Indian	4 (20)	2 (10)	6 (15)
	Others	3 (15)	3 (15)	6 (15)
Physical exercise	Running	5 (25)	6 (30)	11 (27.5)
	Jogging	6 (30)	6 (30)	12 (30)
	Sports	3 (15)	3 (15)	6 (15)
	Others	1 (5)	3 (15)	4 (10)
	None	5 (25)	2 (10)	7 (17.5)
Mental exercise	Meditation	3 (15)	2 (10)	5 (12.5)
	Puzzle solving (eg. Sudoku, crossword)	3 (15)	5 (25)	8 (20)
	Others	2 (10)	2 (10)	4 (10)
	None	12 (60)	11 (55)	23 (57.5)
Sleep duration in the previous night (hours)	1-4	0 (0)	0 (0)	0 (0)
	5-9	19 (95)	20 (100)	39 (97.5)

Variables		Intervention group (n=20) n (%)	Control group (n=20) n (%)	Total (n=40) n (%)
	>9	1 (5)	0 (0)	1 (2.5)
Consumption of alcohol in the previous night	Yes	0 (0)	0 (0)	0 (0)
	No	20 (100)	20 (100)	40 (100)
Smoking habit	Yes	0 (0)	0 (0)	0 (0)
	No	20 (100)	20 (100)	40 (100)
Regular medications intake	Yes (eg. antibiotics, antidepressants, antihistamines, NSAIDS, others)	0 (0)	0 (0)	0 (0)
	No	20 (100)	20 (100)	40 (100)
Medical condition	Yes (eg. flu, migraine, depression, schizophrenia, fever, others)	0 (0)	0 (0)	0 (0)
	No	20 (100)	20 (100)	40 (100)
Regular supplements intake	Yes (eg. multivitamins, protein, fish oil, chicken essence, creatinine, anabolic steroids)	4 (20)	4 (20)	8 (20)
	No	16 (80)	16 (80)	32 (80)

Table 6. Comparison of reaction time and concentration between intervention group (jigsaw puzzle) and control group (coloring) along with the participants' satisfaction level after the intervention assessed by online test ("human benchmark.com" and "testmybrain.org").

Outcome variables		Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
		Jigsaw (n=20)	Coloring (n=20)			
Reaction time	Before intervention	341.2 (91.73)	314.4 (64.8)	26.80 (-24.04 to 77.79)	1.07 (38)	0.293
	After intervention	330.05 (73.2)	301.25 (70.34)	28.80 (-17.15 to 74.75)	1.27 (38)	0.212
Concentration	Before intervention	82.51 (13.47)	79.59 (19.38)	2.92 (-7.767 to 13.6)	0.55 (38)	0.584
	After intervention	81.38 (18.00)	89.64 (9.58)	-8.26 (-17.5 to 0.97)	-1.81 (38)	0.078
Satisfaction		4.30 (0.86)	4.25 (0.64)	0.05 (-0.44 to 0.54)	0.21 (38)	0.836

Unpaired t-test

Table 6 shows the comparison of pre-intervention and post-intervention score of reaction time and concentration between intervention group (jigsaw puzzle) and control group (colouring) along with the participants' satisfaction level after the intervention.

Before the interventions were introduced, the mean (SD) of the reaction time score for the intervention group (jigsaw puzzle) was 341.2 (91.73). Meanwhile, the mean (SD) of the reaction time score for the control group (colouring) was 314.4 (64.8). By interpreting the data prior to interventions, the mean difference of reaction time score between intervention group (jigsaw puzzle) and control group (colouring) was 26.80. The 95% confidence interval for reaction time score was -24.04 to 77.79 which means the difference in reaction time score before interventions between intervention group and control group was not significant. The t-statistics (df) of reaction time score for both groups prior to interventions was 1.07 (38). The P-value computed for the reaction time score was 0.293. This indicates that there is no significant difference in reaction time score before interventions between intervention group and control group.

Before the intervention, the mean (SD) of the concentration score for intervention group (jigsaw puzzle) was 82.51 (13.47). On the other hand, the mean (SD) of the concentration score for control group (colouring) was 79.59 (19.38). This means that there is a mean difference of 2.92 for concentration score between intervention group and control group. Furthermore, the 95% confidence interval of concentration score was -7.767 to 13.6 which indicates that the difference in concentration score before interventions was not significant between intervention group and control group. Other than that, the t-statistics (df) of concentration score for both groups prior to interventions was 0.55 (38). The P-value computed for the concentration score was 0.584 which further supported earlier statement that there is no significant difference in concentration time before interventions between the intervention group and the control group.

After the interventions, the mean (SD) of reaction time score in the intervention group (jigsaw puzzle) was 330.05 (73.2). On the other hand, the mean (SD) of reaction time score in the control group (colouring) was 301.25 (70.34). With this information, the mean difference of reaction time score calculated between intervention group and control group was 28.80. The 95% confidence interval for reaction time score was -17.15 to 74.75 which indicates that there is no significant difference in reaction time after interventions between intervention group and control group. The t-statistics (df) of reaction time score after interventions was 1.27 (38). In addition to that, the P-value computed for reaction time score after the interventions was 0.212. This means there is no significant difference in reaction time score after intervention between intervention group and control group.

Meanwhile, the mean (SD) of concentration score in intervention group (jigsaw puzzle) after the intervention was 81.38 (18.00). On the other hand, the mean (SD) of concentration score in the control group (colouring) after the intervention was 89.64 (9.58). This indicated that there is a mean difference of -8.26 in concentration score between intervention and control group after the interventions.

Moreover, the 95% confidence interval for concentration score was -17.5 to 0.97 which concluded that there is no significant difference in concentration score after interventions between intervention group and control group. The t-statistics (df) of concentration score after interventions was -1.81 (38). Furthermore, the P-value computed for concentration score after the interventions was 0.078 which indicates that there is no significant difference in concentration score after interventions between intervention group and control group.

At the end of the trial, after the interventions, satisfaction level of the participants were taken and collected. The mean (SD) of satisfaction level between intervention group (jigsaw puzzle) and control group (colouring) were 4.30 (0.86) and 4.25 (0.64) respectively. The mean difference between the intervention group and control group was calculated. The mean difference was 0.05 with 95% confidence interval of -0.44 to 0.54. This indicates that there is no significant difference in satisfaction level between intervention group and control group. The t-statistics (df) was 0.21 (38). Furthermore, the P-value computed was 0.836. This further supported earlier statement which indicates that there is no significant difference in satisfaction level between intervention group and control group.

Table 7. Comparison of pre-intervention and post-intervention score of reaction time and concentration in the intervention group (jigsaw puzzle).

Outcome variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Before	After			
Reaction time	341.2 (91.73)	330.05 (73.20)	11.15 (-16.87 to 39.17)	0.83 (19)	0.415
Concentration	82.51 (13.47)	81.38 (18.00)	1.13 (-7.09 to 9.35)	0.29 (19)	0.776

Paired t-test

Table 7 shows the comparison of reaction time and concentration score before and after intervention in the intervention group who had to solve a jigsaw puzzle.

The reaction time was assessed by using ''Human benchmark'' before and after the intervention. Before the intervention was introduced the mean value for reaction time score was 341.2 (SD= 91.73) while the mean value for reaction time score after the intervention was 330.05 (SD= 73.20). The mean difference (95% CI) and t-statistics (df) were 11.15 (-16.87, 39.17) and 0.83 (19) respectively. Thus, 95% CI value is not significant. The p-value is 0.415 which is also not significant. Hence, there is no significant difference in the reaction time score of the participants before and after the intervention was given.

The concentration was assessed using "'Test my brain'' continuous concentration before and after the intervention. Before the intervention, the mean value for concentration score was 82.51 (SD= 13.47) while the mean value for concentration score after jigsaw was solved by participants was 81.38 (SD= 18.00). The mean difference (95% CI) and t-statistics (df) were 1.13 (-7.09 to 9.35) and 0.29 (19) respectively. Therefore, 95% CI value is not significant. The p-value is 0.776 which is also not significant. Hence, there is no significant difference in the concentration score of the participants before and after the intervention.

Table 8. Comparison of pre-intervention and post-intervention score of reaction time and concentration in the control group (coloring).

Outcome variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Before	After			
Reaction time	314.40 (64.8)	301.40 (70.34)	13.15 (-6.05 to 32.35)	1.43 (19)	0.168
Concentration	79.60 (19.377)	89.65 (9.587)	10.04 (-17.06 to -3.034)	3.00 (19)	0.007

Paired t-test

Table 8 shows the comparison of pre-intervention and post-intervention score of reaction time and concentration in the control group (colouring).

The reaction time was assessed by using ''Human benchmark'' before and after the intervention in the control group where the participants were required to colour two specific images provided. Before the intervention, the mean (SD) value for reaction time score was 314 (SD=64.8). On the other hand, the mean (SD) value for reaction time score after the intervention was 301.40 (SD=70.34). The mean difference for reaction time score was computed and gave a value of 13.15 with 95% confidence interval of -6.05 to 32.35. This indicates that there is no significant difference in reaction time score in the control group participants, before and after the intervention. The t-statistics (df) was 1.43 (19). The P-value calculated for reaction time score was 0.168. This further supported earlier statement which stated that there is no significant difference in reaction time score in the control group, before and after intervention.

Concentration was assessed using "'Test my brain'' under the heading "Continuous concentration" before and after the intervention which was colouring. The mean (SD) for concentration score before and after intervention in the control group were 79.60 (19.377) and 89.65 (9.587) respectively. Mean difference was then calculated from these values. The mean difference was 10.04. 95% confidence interval was -17.06 to -3.034 which indicates that there is a significant difference in concentration score in the control group between

before and after intervention. The t-statistics (df) calculated was 3.00 (19). The P-value computed was 0.007. This means that there was a significant difference in concentration score between before and after intervention in the control group.

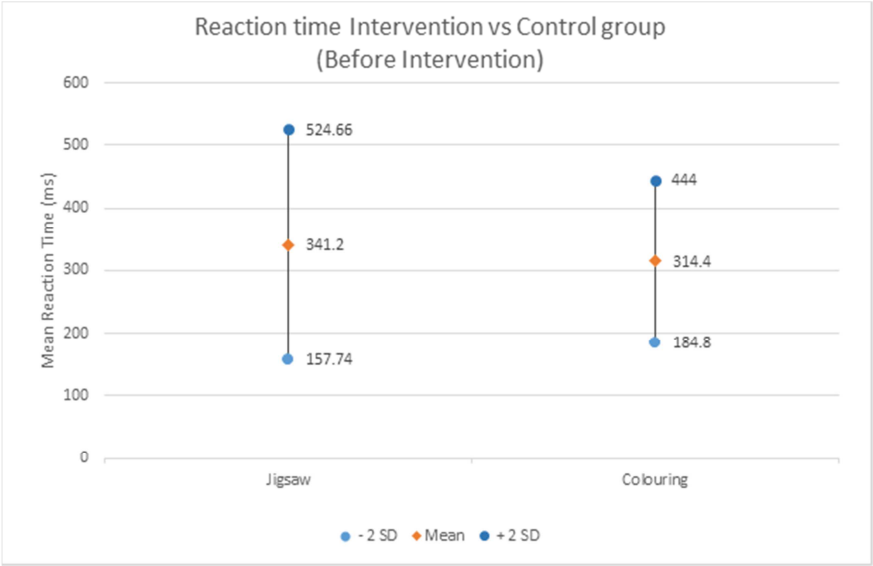

Figure 7. Reaction time intervention vs control group before intervention.

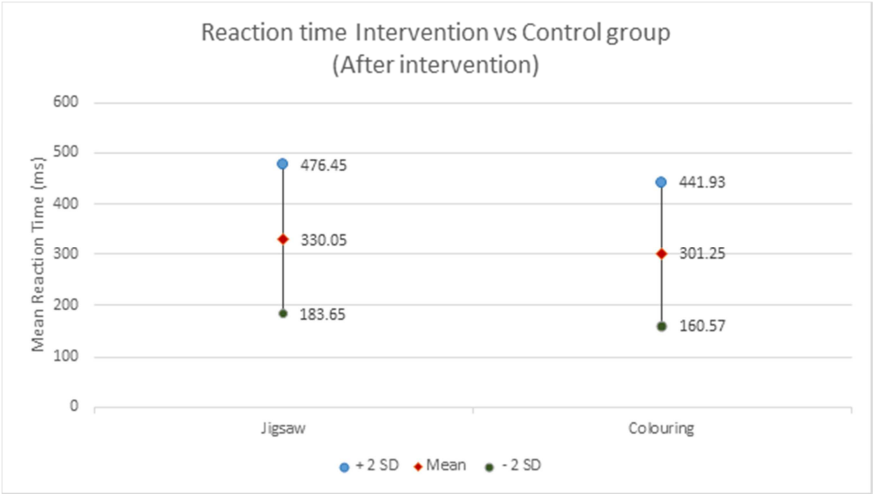

Figure 8. Reaction time intervention vs control group after intervention.

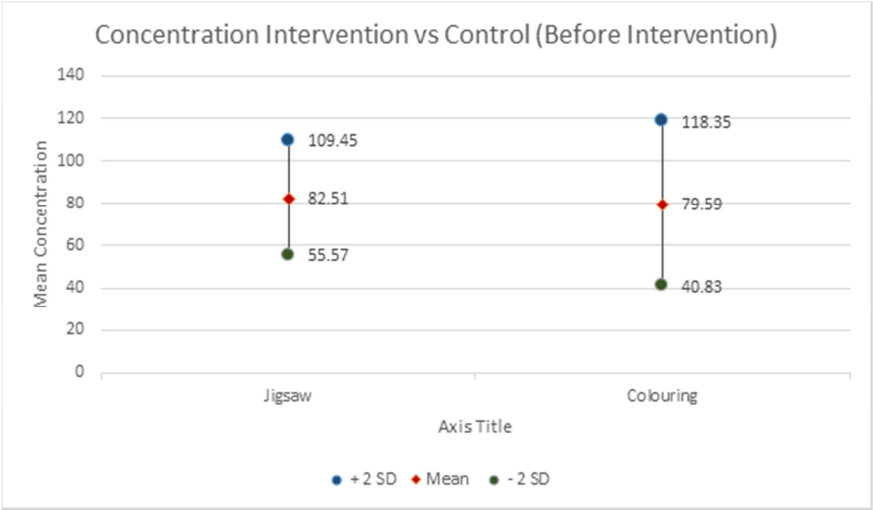

Figure 9. Concentration intervention vs control before intervention.

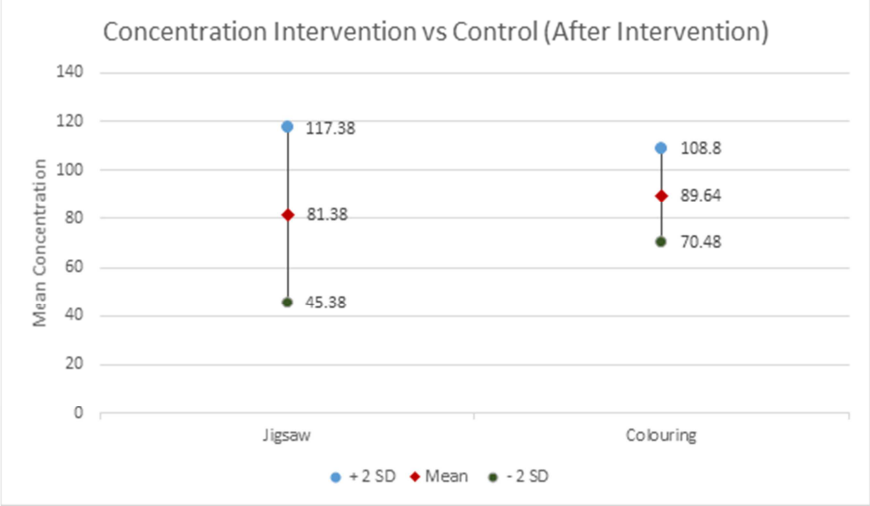

Figure 10. Concentration intervention vs control after intervention.

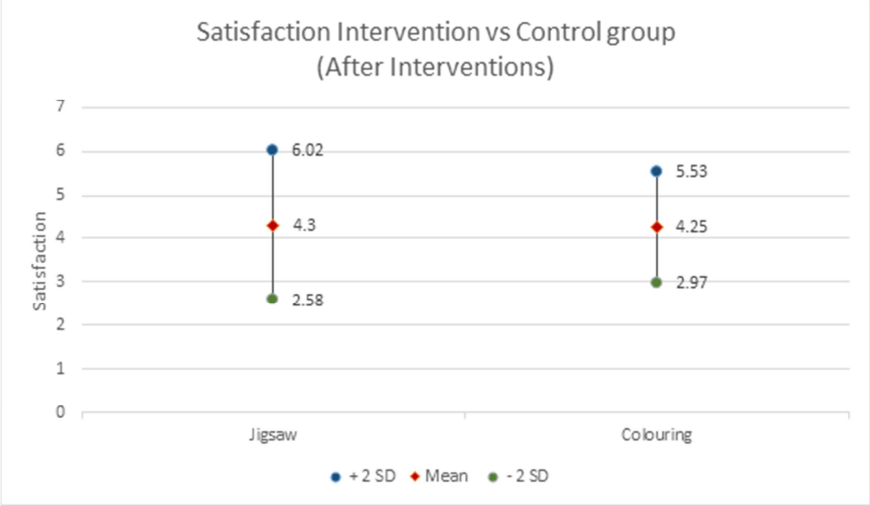

Figure 11. Satisfaction intervention vs control group after interventions were given.

4. Discussion

A pilot randomized controlled trial study parallel design was carried out among medical students to study the effect of jigsaw puzzles compared to colouring on cognitive function of the brain. Upon reaching the results of this study, it was evident that there was improvement in reaction time after a 30-minutes session of jigsaw puzzle solving activity and colouring as compared to before any interventions were introduced. However, even if improvements can be observed, the difference in reaction time between before and after interventions were introduced in both groups was not significant. As for concentration, it was improved in the control group after intervention, which was colouring activity, was introduced. Nonetheless, in the intervention group, concentration was deteriorated after introduction of jigsaw puzzle solving activity as it could be due to exhaustion experienced by the participants. However, there was no significant difference in concentration between before and after interventions in both groups. Based on a randomised controlled trial conducted previously on 100 cognitively healthy adults with minimum age of 50 years old in Ulm University, Germany, on jigsaw puzzles, this specific cognitively challenging activity taps multiple cognitive abilities and is a potential protective factor for cognitive aging. [26] The results of this trial showed that jigsaw puzzle solving skills improved significantly in the jigsaw puzzle group compared to the counseling group in the study. [26] The P-value computed for this study is significant, which further suggest that jigsaw puzzle is able to improve cognitive abilities. [26] In another study that had been conducted in Chicago, Illinois, United States of America studied about jigsaw puzzles, a longitudinal study, the relation between children's early puzzle play and their spatial skills was examined and investigated. [28] It was found that there was significant main effects of jigsaw puzzle play. The P-value was

significant hence indicating that children who played jigsaw puzzles had higher spatial scores than children who did not play jigsaw puzzles. [28]

At the end of this study, it has shown that the reaction time before intervention is longer compared to the reaction time after intervention in terms of mean value. This indicates that there is an improvement since the reaction time is getting shorter after jigsaw puzzles activity was introduced. However, this result is not significant. On the other hand, the concentration observed after the intervention, jigsaw puzzle solving activity, was higher before the intervention compared to after the intervention. However, this results are again not significant. Meanwhile, the results for the control group in which colouring activity was introduced and done showed that the reaction time before the colouring activity was longer compared to the reaction time after the colouring activity in terms of mean value. Although the result is not significant, the overall improvement is quite good. As for the concentration, it increased significantly by comparing before colouring activity with after colouring activity. This result is proven before in a study involving undergraduates of psychology students by University of West England where participants with anxiety was given colouring activities as their intervention. [27] It was found that the state of anxiety has decreased significantly and mindfulness is increased significantly. In the same study, it was also shown that the attentivity of the participants were also increased significantly. As for this research, the reaction time was also shortens. In another research conducted by Guilio E. Lancioni, involving Alzheimer's patient, colouring activity managed to make the patients with Alzheimer's disease to minimise wandering besides promoting their constructive engagement ability. [25]

Since time was not favourable when this study was conducted, it had become one of our biggest hurdles. This trial was only done in one 30-minutes session in one day. The day was chosen based on the convenience of majority of the participants without considering the status of each and every participant on that day. Hence, there is a possibility that the result obtained in this study is due to the short-term effect of the intervention, which did not reflect on its long term effect on cognitive function. Besides that, the sample size was small and the study population was also restricted to one group of individuals only which was medical students. As a consequence, the findings in this study might possibly unable to be generalised to represent the population due to these limitations. Other than small sample size, 'humanbenchmark.com' was used in order to measure and quantify the reaction time and concentration of the participants as it was the most convenient tool available. However, this tool is not the most ideal medium to measure these variables. Last but not least, the interventions introduced in this trial were of different media where the jigsaw puzzles solving activity were done in computer while coloring activity were done in hardcopies. Prolonged screen time experienced by the participants in the intervention group could result to eye tiredness and physical exhaustion which eventually affected the outcome.

There are a few recommendations that could be included. It is possible that with these improvements, the hypothesis could be more justifiable. Firstly, a bigger sample size should be taken into account with the inclusion of a more diverse population. A larger sample size in further study could possibly obtain outcomes that are more reflective of the entire population. Ideally, this study should be conducted in a longer period in order to get the best possible outcome as a result of long-term effect of the intervention. The interventions should be consistently introduced for a few days or weeks in a row. Instead of using 'humanbenchmark.com' to measure the reaction time and concentration, a more sophisticated, standardised and accurate tool can be used in further study of this particular topic. In order to standardised the media for interventions, a real-life jigsaw puzzle pieces are preferred more rather than computed jigsaw puzzles. If both interventions, jigsaw puzzle solving activity and colouring activity, done with the same form of medium, the hypothesis would be more justifiable along with minimal error. In further study of this particular topic, collecting pre-intervention and post-intervention data on different days would be more representative of the population to prevent sensitisation of the tool used to measure reaction time and concentration. Even if this study did not justify the hypothesis stated earlier, it is still a good practice for general population to regularly indulge in leisure problem solving activities such as jigsaw puzzle as it would benefit them in the long run.

At the end of this study, we found out that there was improvement in reaction time for both jigsaw puzzle solving group and colouring group. Both of these groups showed shorter reaction time after interventions were introduced. However, this improvement is not significantly different in relation to the reaction time prior to interventions. Meanwhile, surprisingly, there is a decline in concentration as observed in the jigsaw puzzle group. Even if the expected improvement in concentration is not observed in the jigsaw puzzle group, the difference in figures, before and after intervention were introduced, is not significant. This study hypothesis suggested that there should be an improvement in after jigsaw puzzle solving activity in relation to reaction time and concentration as a measure of cognitive function. However, this expected improvement is not seen in our study,

especially in terms of concentration. This could possibly because of the exhaustion experienced by the participants from carrying out the study due to continuous and prolonged screen time exposure. On the other hand, the result for concentration in colouring group was an unexpected pleasant surprise. There was an improvement in concentration after a session of hands-on colouring activity which shows a significant difference between figures of before and after intervention.

5. Conclusion

In a nutshell, this study shows that the introduction of leisure activity such as colouring to medical students in this private medical college would result in significant improvement of cognitive function, more specifically concentration. Even if there is an improvement in reaction time, it was not as significant as concentration. Surprisingly, cognitively challenging leisure activities like jigsaw puzzle solving shows an insignificant increase in reaction time and decline in concentration. However, these findings are not conclusive as this study was only conducted in a duration of one day, with only 30-minutes session of intervention. An implementation of cognitively challenging leisure activities on a regular basis should be encouraged in the general population is a good practice as it is a form of inexpensive mental exercise and carries significant benefits in the long term. In addition to that, these forms of mental exercises are widely available with hundreds of variations which are suited to all range of ages. Even so, simple leisure activities like colouring which also stimulates the less scientific parts of our brain would also be beneficial as it was also proven to improve cognitive functions. This should be emphasised and made aware to the general population through social media and advertisements.

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