

# The Efficacy of A Nootropic Supplement on Information Processing in Adults: A Double Blind, Placebo Controlled Study

Andrea Utley<sup>1\*</sup>, Yadira Gonzalez<sup>2</sup> and Carlie Abbott Imboden<sup>1</sup>

<sup>1</sup>Andrea Utley is a Reader in Motor control, learning and development in the School of Biomedical Sciences, Faculty of Biological Sciences, University of Leeds, UK

<sup>2</sup>Yadira Gonzalez's is a food scientist who worked as research assistant in the School of Food Science before moving to Marlow foods to investigate texture and formulation of confectionery products, UK

<sup>3</sup>Ms Carlie Abbott is a research assistant in the School of Biomedical Sciences, Faculty of Biological Sciences, University of Leeds, UK

**\*Corresponding author:** Andrea Utley, Andrea Utley is a Reader in Motor control, learning and development in the School of Biomedical Sciences, Faculty of Biological Sciences, University of Leeds, UK

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## ABSTRACT

**Background:** Nootropics are substances that are considered to improve numerous aspects of cognitive functions such as decision making, concentration, focus and memory. They have gained popularity in the last few years but despite this there is still limited research on their overall efficacy and effectiveness.

**Objectives:** This study aimed to investigate the efficacy of a nootropic, Mind Lab Pro, on the performance of simple reaction time (SRT), choice reaction time (CRT) and anticipation, in a group of healthy adults.

**Methods:** The study employed a pseudo randomised, double blinded, placebo-controlled design. A total of 105 healthy individuals completed the study with 61 in the experimental group and 44 in the control group. Participants completed an SRT, CRT and anticipation task pre and post taking Mind Lab Pro supplement or a placebo for 30 days.

**Results:** Results found that the control group did not statistically improve in any of the tasks ( $p > 0.05$ ), whilst the experimental group improved in SRT ( $p < 0.001$ ), CRT ( $p < 0.001$ ), and anticipation scores ( $p = 0.001$ ). Additionally, there was a significant difference in SRT, CRT and anticipation scores found between the experimental and control group ( $p < 0.001$ ,  $p = 0.002$  and  $p = 0.004$  respectively).

**Conclusion:** The control group did not statistically improve in any of the tasks ( $p > 0.05$ ), whilst the experimental group improved in SRT ( $p < 0.001$ ), CRT ( $p < 0.001$ ), and taking a nootropic has resulted in significant improvements for the experimental group when performing information processing tasks.

**Keywords:** Anticipation; Choice Reaction Time; Mind Lab Pro; Nootropics; Simple Reaction Time

**Abbreviations:** SRT: Simple Reaction Time; CRT: Choice Reaction Time; IQR: Interquartile Range; MS: milliseconds; HEI: Healthy Eating Index

## Introduction

Across the world, the use of supplements has increased dramatically in the last 20 years [1,2]. In the United States alone, it is reported that 25% of the population take some form of supplement. However, in the United Kingdom this rises to 45 %, making it the largest population of dietary supplement usage worldwide. The growth of the supplement market globally is expected to continue to rise at an annual growth rate of 6% from 2017 to 2025 [1]. While supplements can be used to correct micronutrient deficiency or maintain an adequate intake, over-the-counter supplements are most often taken by people with no clinical signs or symptoms of deficiency. Interestingly, people who use supplements tend to have a better overall diet quality than those who do not use them and their nutrient intake from foods mostly meets recommended intake levels [3]. There is also widespread use of supplements at all levels of sport and a prevalence of 60–90 % supplement use is reported among high-performance UK athletes, including juniors under the age of 18 [4].

Much of the recent growth has been in supplements that claim to provide cognitive benefits. These supplements are known as 'Nootropics'. Nootropics are especially popular with 18–30-year-olds who are keen to enhance their cognitive function [5,6]. Nootropics are also employed for several clinical populations including Parkinson's and Alzheimer's [7]. In this study we consider the efficacy of taking Mind Lab Pro a nootropic that contains 11 ingredients (Table 1). These ingredients have been well researched in terms of the impact they have on cognitive functions such as attention, multi-tasking and focus. Each nootropic currently available varies in terms of the ingredients but there is some commonality across products. Mind Lab Pro contains 250 mg of Citicoline which has been found to improve memory and attention by activating biosynthesis in the neural membranes and increasing specific hormone levels in the central nervous system to protect cell membranes [5,8,9]. Bacopa Monnieri has been found to increase dendritic branching and pruning, which in turn can lead to improved cognitive function [9], specifically in older patients.

**Table 1:** Contents and dosage of Mind Lab Pro for two capsules.

Nutrition Facts	Amount per Serving
Vitamin B6	2.5 mg
Vitamin B9	100 mcg
Vitamin B12	7.5 mcg
Citicoline	250 mg
Bacopa Monnieri	150 mg
Organic lion's mane mushroom	500 mg
Phosphatidylserine	100 mg
N-Acetyl	175 mg
L-Theanine	100 mg
Rhodiola Rosea	50 mg
Maritime Pine Bark Extract	75 mg

However, it has also been seen to help Alzheimer patients and improve memory, focus and attention in the elderly [7,10,11]. Another study noted improvements in attention and memory in healthy medical students from taking 150mg of Bacopa Monnieri for six weeks [12]. Other ingredients in Mind Lab Pro such as Lion's Mane Mushroom, Tyrosine and Phosphatidylserine has also been found to improve memory and attention in a variety of contexts for a range of healthy and unhealthy populations [13-16]. Reductions in fatigue and stress have also been found in studies looking at the impact of taking Rhodiola Rosea in healthy populations [17,18] as well as cognitive improvements in adults with physical and cognitive difficulties [19]. Studies on L- Theanine [20], Maritime pine bark extract [21], and N-Acetyl [22] also report improvement in cognitive functions in healthy adults. Vitamins such as B6, B9 and B12 support multiple functions within the central nervous system which may help to maintain brain health, intellectual performance and cognitive functioning [23,24]. It has been shown that vitamin B6 supports many important brain functions such as biosynthesis of neurotransmitters, receptor binding, macronutrient metabolism and gene expression [3].

Lower vitamin B6, B9 and B12 levels have also been associated with increased rates of cognitive decline [25,26]. The use of B vitamins is clearly an important means of maintaining cognitive function and this is especially true for healthy individuals [27]. Mind Lab Pro and indeed other nootropics clearly contain a range of ingredients that research indicates could benefit cognitive function in a variety of ways. Our ability to make cognitive decisions, focus and concentrate, forms a large component of our daily living. A person's ability to identify appropriate stimulus then select an appropriate response and to transfer this into an action or a response is often referred to as information processing [28]. In this study we looked at simple reaction time (SRT), choice reaction time (CRT) and anticipation; the use of which has a longstanding tradition in human experimental psychology [29]. These measures provide information on how we can process and respond to one or multiple stimuli and how we are able to focus and make the correct decision about when to move or respond [30]. SRT and CRT experiments are an invaluable tool in psychology and neuroscience. These measures provide information on an individual's ability to make a decision and therefore provide an insight into perceptual and motor processes [31,32].

Regarding CRT, the time taken for a person to make a decision increase as the number of choices increase logarithmically [33,34]. There are many examples in our daily lives of when we produce movements that are reliant on how we process information and anticipate change in the environment [35-37]. This includes activities such as road crossing, driving, working machinery, mobile phone use, playing computer games and playing a variety of sports [38,39]. Many studies that have investigated how age effects SRT, CRT and anticipation, finding greater levels of variability in older than younger individuals especially when performing visual processing task [40-42]. Other factors such as fatigue and neurological conditions also result in slower reaction and anticipation times [43]. There are a

variety of nootropics available such as Alpha Brain, Mind Lab Pro, Modafinil, Noocube and Qualia. Research has been conducted on all of these products other than Mind Lab Pro and these studies report benefits in memory, attention, executive function and learning from taking nootropics [44-47]. (O'Hare, et al. [48]) stress the importance of further empirical studies to examine the efficacy of nootropics especially in university aged students. Therefore, in this study we aimed to examine the efficacy of Mind Lab Pro on improving cognitive functions in adults by examining their performance of SRT, CRT and anticipation tasks.

## Methods

The following section outlines the methods employed in this study. Ethical permission was gained from the Faculty of Biological Sciences ethics committee at the University of Leeds (BIOSCI 20-017).

### Participants

A total of 105 healthy individuals completed the study with 61 in the experimental group and 44 in the control group. Participants were recruited from the local community using posted advertisements and web-based adverts. Potential participants were screened for eligibility by the researcher with the inclusion Criteria Including:

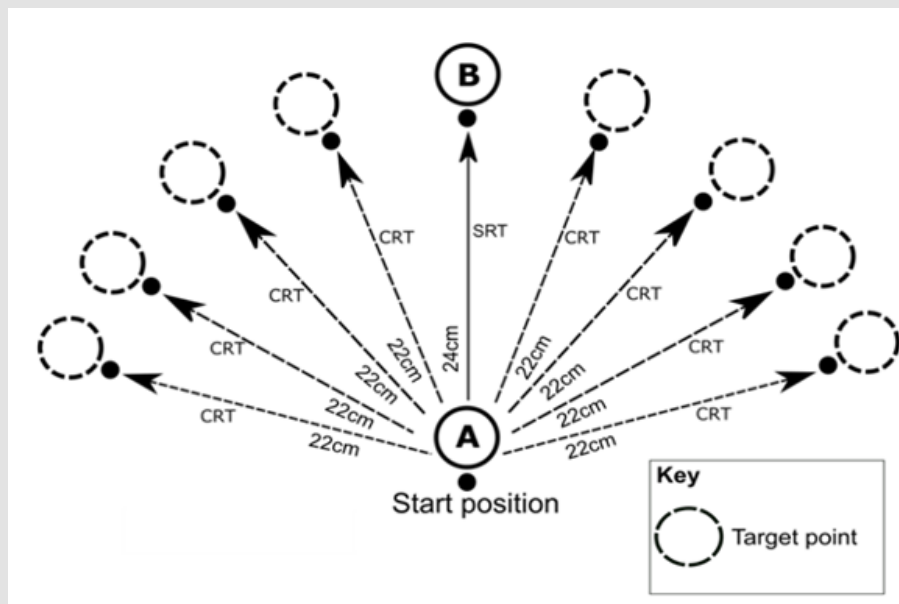
- i) Aged between 21-70.

- ii) Able to understand simple instructions and sign informed consent.
- iii) Able to travel to the university for data collection.

Exclusion Criteria Included:

- i) Any visual or auditory condition.
- ii) Currently taking any medication.
- iii) Currently taking any supplements or vitamins.
- iv) Any known medical conditions or illness.

In the experimental group, females and males were involved ( $n = 35$  and  $n = 30$  respectively), with a mean age of 31 years old and an age range from 21 to 68 ( $SD = 12.9$ ). The control group included females ( $n=22$ ) and males ( $n =22$ ), with a mean age of 30 years old and an age range from 21 to 67 ( $SD = 11.5$ ). The participants were all from varied educational and socioeconomic backgrounds and with no underlying health conditions. Participants were also asked to complete the healthy eating index (HEI) which is a scoring metric that can be used to determine overall diet quality [49]. The experimental group had a mean score of 63.2 with a standard deviation of 9.0 and the control group had a mean score of 65 with a standard deviation of 2.5. The higher the score then the healthier the diet [50].



**Figure 1:** Reaction Timer set up with the position of the light/stimulus indicated for both simple and choice conditions.

### Tasks

The first task was a simple reaction time task (SRT), where participants had to respond to one stimulus (a light) and produce a discrete response once the stimulus was presented. Participants knew in advance which light would be illuminated and were instructed to move their finger as quickly as possible from point A

to B (Figure 1) when the light above point B was illuminated. The second task was a choice reaction task (CRT) where participants had to respond to a stimulus with eight alternatives (Figure 1). For CRT they therefore had to respond to one of eight lights and move from point A to the illuminated light (one of eight) and press the sensor below it. In both SRT and CRT, the time taken from the

stimulus having been illuminated to the first initial movement was recorded in milliseconds (ms). The final task was an anticipation task using a Bassin timer (Figure 2) to measure anticipation response in seconds (s). Participants were instructed to watch a light as it travels down a runway. They had to anticipate the light reaching the target (finish) and press a button to coincide with the arrival of the light at the target. For the anticipation task the runway speed was set at

30 miles per hour with a cue delay of two to three seconds (the cue was a warning light; refer to Figure 2, where the black dot represents the warning light which was illuminated before the runway lights came on in a sequence). The Reaction Timer and Bassin Timer are produced by Lafayette Instruments and this equipment has been used in numerous studies [51,52].

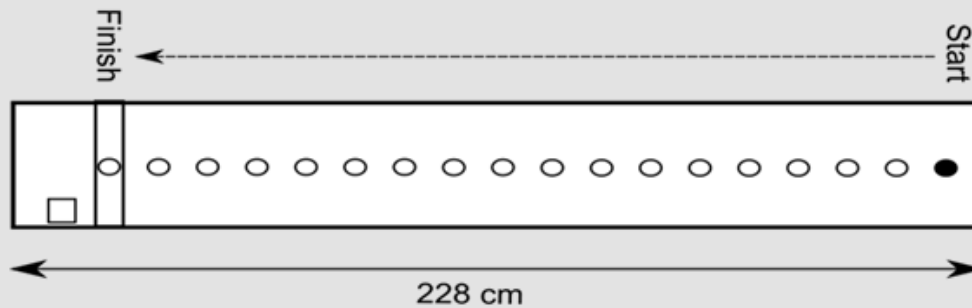


Figure 2: Bassin Timer.

## Procedures

Participants were given an information sheet explaining the research and detailing the ingredients of the supplement. Participants were given time to ask any questions and written consent was then obtained. The study was double blinded with participants pseudo randomly assigned to receive Mind Lab Pro or a matched placebo control. We ensured that the experimental group and control group were evenly matched in terms of age, gender and socio-economic group. This was completed by a separate research assistant to ensure the examiner did not know which group each participant was in. Each participant completed the tasks pre- and post- 30 days of taking either Mind Lab Pro or a placebo (microcrystalline cellulose). The Mind Lab Pro given was the same as that commercially available and participants were asked to follow the manufacturers recommendation of two capsules per day, preferably taken with food in the morning. As each bottle of Mind Lab Pro contains 60 capsules a period of 30 days was selected, enabling each participant to take the whole 60 capsules, other research has also employed a time scale of 30 days [47,48]. The experimental group and control group did not meet and the packaging for each group were identical. Participants took around twenty minutes to complete the required tasks and the order of completing these was rotated across participants to counterbalance for learning. Participants were given a demonstration of each task followed by three practice trials and then three trials were recorded for each task. The mean time for SRT, CRT and anticipation was used for the analysis. The order of completing the tasks was counter balanced in order to reduce any learning effect, so some participants started on anticipation other on SRT or CRT.

## Statistical Analysis

All statistical analysis was completed using IBM SPSS Statistics V27. A Shapiro-Wilk statistical test was performed on all the results to assess normality, with  $p \geq 0.05$  considered normally distributed data. Continuous data was described using either means (SD) or medians (M) and interquartile range (IQR) for parametric and non-parametric data respectively. Firstly, we assessed if there was an improvement from pre to post test results of SRT, CRT and anticipation of the control and experimental groups separately. If the data was normally distributed, a paired samples dependent t-test was completed to see if there were significant improvements from pre to post scores in the individual groups. If data violated the Shapiro Wilk test, the non-parametric equivalent, a Wilcoxon signed-rank test was used, with  $p \leq 0.05$  considered statistically significant. The main analysis was to assess if there was any significant difference of SRT, CRT and anticipation scores between the control and experimental group. If data was normally distributed, a mixed modal ANOVA was used. If data violated the Shapiro Wilk test, a new variable was created, which was the change of scores from pre to post test. The non-parametric alternative Kruskal Wallis then assessed the difference between the control and experimental group with  $p \leq 0.05$  considered statistically significant

## Results

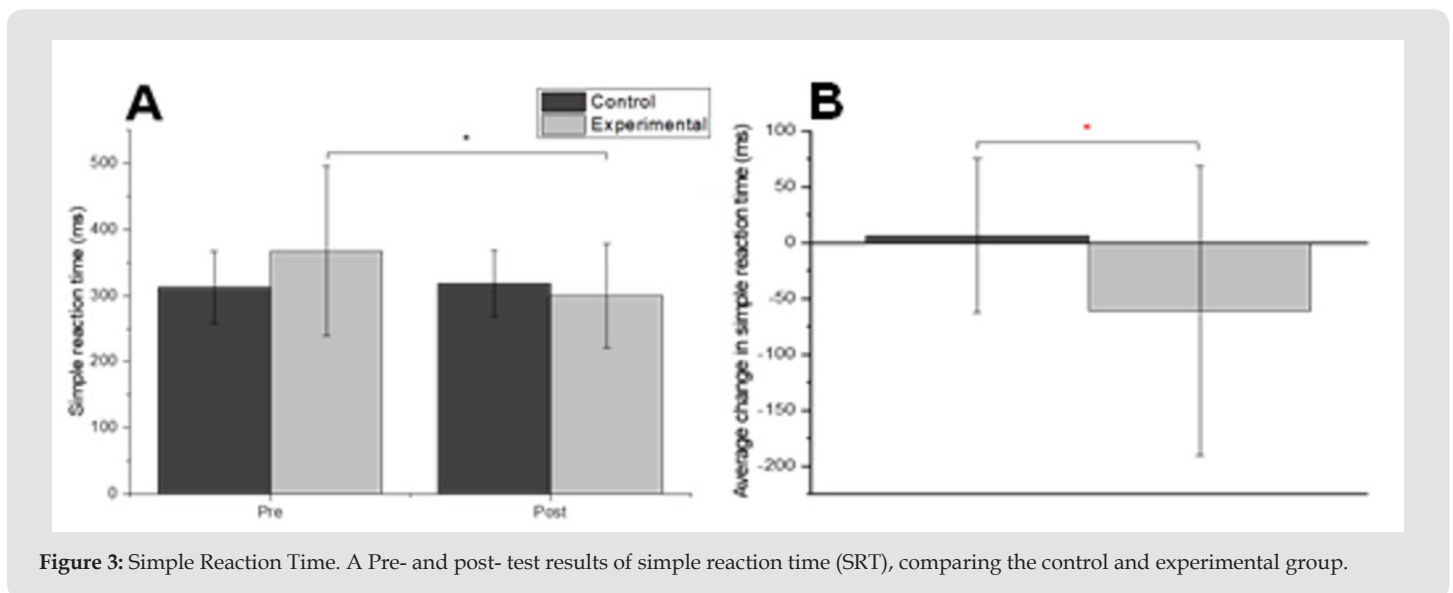
Participants reported good compliance with taking the supplement twice daily. In the experimental group four participants reported that they had missed two days and two participants reported that they had missed one day. A total of five participants failed to complete the post-tests (three from the experimental group and two from the

control group) due to contracting Covid-19. Isolation laws therefore prevented them from attending and they were removed from the study. It should be noted that even if results were non-parametric, the medians and interquartile range are reported, however all graphs are displayed as means and standard deviations of simple and choice reaction time and anticipation.

### Simple Reaction Time

The control and experimental groups SRT scores did violate the Shapiro Wilk test ( $p > 0.05$ ) and therefore a Wilcoxon signed rank test

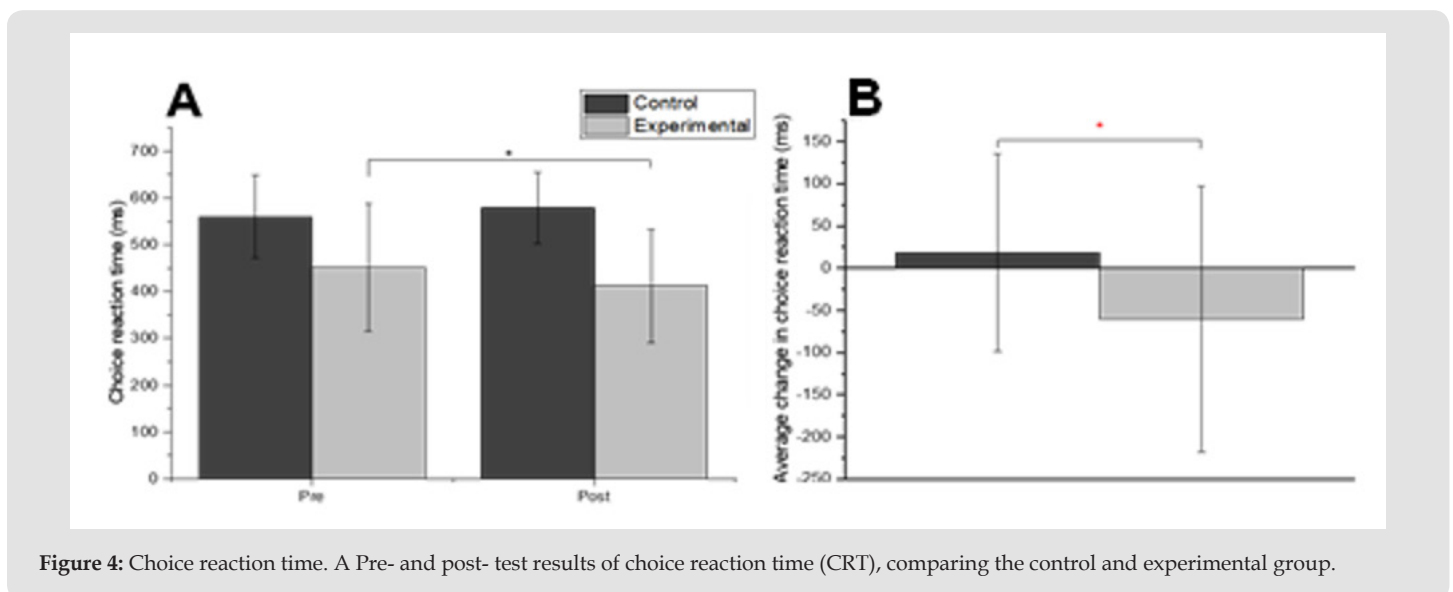
was used to see if there was an improvement between pre and post-test scores. Results showed that the control group did not significantly improve from pre-test (M: 309.5 (IQR: 264, 365.75)), to post test (M: 318.5 (IQR: 283,359.5)), ( $Z = -.502, p = 0.616$ ), whilst the experimental group did improve from pre-test (M: 330.5 (IQR: 289, 398)) to post test (M: 290 (IQR: 248.75, 340.5)), ( $Z = -4.267, p < 0.001$ ) (Figure 3A). For the comparison between the control and experimental group the Kruskal Wallis test found that there was a significant difference in SRT scores between the control and experimental group ( $\chi^2(1) = 13.516, p < 0.001$ ) (Figure 3B).



**Figure 3:** Simple Reaction Time. A Pre- and post- test results of simple reaction time (SRT), comparing the control and experimental group.

Note: \*Highlights a significant improvement in SRT ( $p < 0.05$ ). B Average change in simple reaction time (SRT) scores, comparing the control and experimental group.

\*Highlights a significant change in simple reaction time (SRT) between the groups ( $p < 0.001$ ).



**Figure 4:** Choice reaction time. A Pre- and post- test results of choice reaction time (CRT), comparing the control and experimental group.

Note: \*Highlights a significant improvement in CRT ( $p < 0.05$ ). B Average change in choice reaction time (CRT) scores, comparing the control and experimental group.

\*Highlights a significant change in choice reaction time (CRT) between the groups ( $p = 0.002$ ).

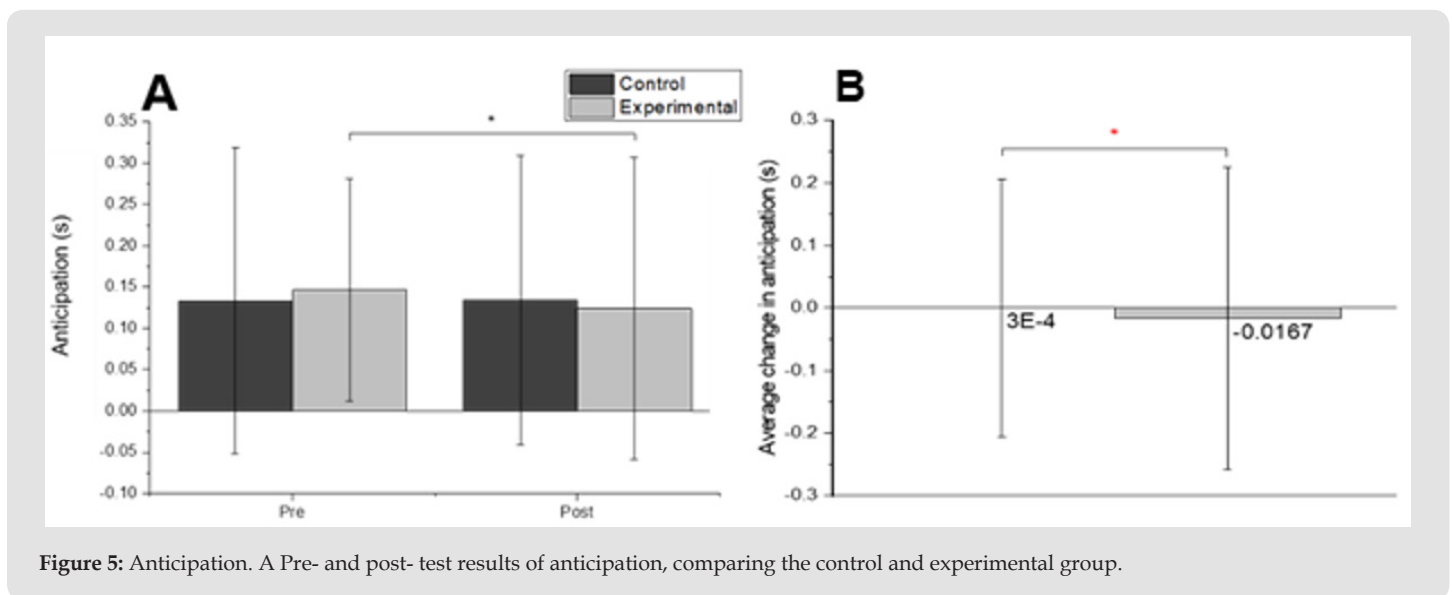


## Choice Reaction Time

CRT scores for both the control and experimental group violate the Shapiro Wilk test and therefore the Wilcoxon signed rank test was used. CRT scores did statistically improve in the experimental group ( $Z = -2.701$ ,  $p = 0.007$ ) from pre- test scores (M: 432.500 (IQR: 396.5, 489.25) to post- test scores (M: 388 (IQR: 328.75, 410.5)) (Figure 4A). For the control group there was no significant improvement from pre- test (M: 551 (IQR: 474.75, 658.5)) to post- test scores (M: 581 (IQR: 526.25, 640.75)), ( $Z = -0.689$ ,  $p = 0.491$ ). Between groups comparison found that there was a significant difference of CRT scores between the control group and experimental group ( $\chi^2(1) = 9.420$ ,  $p = 0.002$ ) (Figure 4B) and further subdivision of the experimental group revealed that there was a significant difference in CRT scores ( $\chi^2(2) = 26.207$ ,  $p < .001$ ).

## Anticipation

The control and experimental groups anticipation scores violated the Shapiro Wilk test ( $p > 0.05$ ) and Wilcoxon signed rank test was used to see if there was an improvement from pre to post-test. Anticipation scores improved from pre-test scores (M: 0.15 (IQR: 0.06, 0.19)) to post-test scores (M: 0.08 (IQR: 0.05, 0.17) in the experimental group ( $Z = -3.631$ ,  $p < 0.001$ ) (Figure 5A). Again, no significant improvement from pre-test (M: 0.051 (IQR: 0.029, 0.11) to post- test (M: 0.062 (IQR: 0.043, 0.1313) was found in the control group ( $Z = -1.021$ ,  $p = 0.307$ ). Between groups comparison found that there was a significant difference of anticipation scores between the control group and experimental group ( $\chi^2(1) = 8.124$ ,  $p = 0.004$ ) (Figure 5B).



**Figure 5:** Anticipation. A Pre- and post- test results of anticipation, comparing the control and experimental group.

Note: \*Highlights a significant improvement in anticipation ( $p < 0.05$ ). B Average change in anticipation scores, comparing the control and experimental group.

\*Highlights a significant change in anticipation scores between the groups ( $p = 0.0004$ ).

## Discussion

Results of the study indicated a significant improvement when performing all three tasks for the experimental group taking the nootropic ( $p < 0.05$ ), compared to those in the control group taking the placebo. Additionally, there was a significant difference in scores between the experimental and control group for SRT, CRT and anticipation ( $p < 0.001$ ,  $p = 0.002$  and  $p = 0.004$  respectively). The results of the current study therefore suggest that there are benefits to cognitive performance (processing information) when taking the nootropic Mind Lab Pro. In this study there has been a significant positive impact on information processing for the experimental group and given the nature of the tasks this would indicate improvements in focus, attention and decision making. It was also interesting to note that improvements in performance occurred after only 30 days of

regular consumption of the nootropic Mind Lab Pro. This is however in line with other studies on nootropics [47,48].

Simple reaction time is a measure that tells us about the ability of an individual to take in information from the environment and produce a rapid response [30-32,35]. In the case of SRT the individual must make a pre known response to one stimulus. As this is relatively a basic rapid movement, significant improvements in reaction time are generally difficult to obtained with the margins of improvement often being quite small [31,32]. Despite this, significant improvements were made by the experimental group from pre to post. It may be that ingredients such as Citicoline, Bacopa Monnieri, Lion's Mane Mushroom, Maritime pine bark extract, Tyrosine and Phosphatidylserine may have assisted participants focus and attention as found in previous studies [7,8,3,21]. As the control

group did not improve, it can be assumed that the improvement in SRT in the experimental group was not as a result of learning. In the choice reaction time task participants are faced with a more complex information processing situation in which they must deal with multiple stimuli alternatives before they respond.

This coincides with Hick's Law that establishes that reaction times increase logarithmically as the number of present stimuli increases [34,35]. As a task this has good contextual meaning, high processing demands and strong transfer to real life situations [31,32]. There was a significant improvement for the experimental group but not for the control group, and further analysis also revealed a significant difference in CRT scores between the control and experimental group. CRT tends to be more variable in older than younger individuals [42]. Therefore, the older individuals, who in the pre-tests were slower on average compared to those under thirty, might have had greater potential to improve. It was encouraging to see this in older participants as this has also been shown by other studies [48]. Citicoline, Bacopa Monnieri, Lion's Mane Mushroom, Tyrosine and Phosphatidylserine taken in combination have been shown to with improve focus and attention which is important when performing choice reaction type tasks [8,12,13,15]. The vitamins in Mind Lab Pro have also been shown to improve cognitive functioning especially in older populations [23,25,26]. This is in line with research that has also demonstrated the impact of particular vitamins on neural plasticity, specifically dendritic adaptation that can in turn enhance cognitive functioning [9].

The reported benefits of Citicoline, Bacopa Monnieri, Lion's Mane Mushroom, Tyrosine and Phosphatidylserine on focus and attention and the likely impact of the vitamins (B6/B9/B12) on cognitive function may account for improvements seen in anticipation [3,10]. Anticipation is a relatively complex task with participants having to rapidly process information and to produce a response at an appropriate time. In terms of anticipation there was improvement for the experimental group, but no significant improvement found in anticipation scores from pre to post tests in the control group.

The tasks in this study involved processing information which demands focus, attention and rapid decision making. It is difficult to determine whether one ingredient is more influential than another in enhancing the performance of the three tasks, or whether it is the contribution and combination of the several listed ingredients that gives the optimum results. We do recognise that one limitation was that at baseline, the control group was faster for simple reaction time, and this could have influenced our statistical analysis. However, this was not the case for choice reaction time and anticipation. In addition, although we did look at dietary intake it would have been useful to have more detail information on the participants dietary and life style habits. The study did have a good sample size, but the age range of participants may be considered a limitation and it would have been useful to have more participants in the 30-40 age group.

As data was gathered during the COVID pandemics recruitment of participants was more challenging. What is encouraging is that the

experimental group who took the supplements improved significantly in line with other studies on nootropics [44-46].

The results of this study may have wider implications for other populations such as the elderly or those working in environments where making decisions normally occurs under pressure, such as for those working as flight controllers. It would also be interesting to consider the efficacy of taking nootropics such as Mind Lab Pro on other aspects of human function such as their influence or contribution to memory. In addition, as recommended by O'Hare et al [48] it would be useful to consider further studies looking at the long-term efficacy of nootropics especially on younger age groups.

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## Declaration of Interest

None. The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in the paper. All data for the project is owned and held by the University of Leeds.

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