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RESEARCH ARTICLE

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Efficacy of the nootropic supplement Mind Lab Pro on memory in adults: Double blind, placebo-controlled study

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Abstract

Objectives: This study aimed to investigate the efficacy of taking Mind Lab Pro, a plant-based nootropic on memory in a group of healthy adults. Auditory, visual, visual working memory, immediate and delayed recall (DR) were assessed.

Methods: The study employed a pseudo randomised, double blinded, placebo-controlled design. A total of 49 healthy individuals completed the study with 36 in the experimental group and 13 in the control group. Participants ranged between 20 and 68 years with a mean age of 31.4 ± 14.4 years. Pre and post taking either the Mind Lab Pro supplement or placebo for 30 days. All participants completed the Wechsler Memory Scale Fourth UK Edition (WSM-IV UK).

Results: We found that the experimental group significantly improved in all memory subtests assessed ($p < 0.05$) whilst the control group only significantly improved in auditory memory and immediate recall ($p = 0.004$ and $p = 0.014$ respectively). A significant difference in immediate and DR was also found between the control and experimental group ($p = 0.005$ and 0.034 respectively).

Conclusion: The use of Mind Lab Pro for 4 weeks improves memory with the experimental group significantly improving in all sub areas of memory as assessed by the WSM-IV UK.

KEYWORDS
memory, Mind Lab Pro, nootropics, recall, WMS-IV UK

1 | INTRODUCTION

Regardless of age we are often concerned about the quality and efficiency of our memory. Memory is concerned with the facts and experiential details that people consciously call to mind as well as knowledge that can be drawn on without effort or even awareness (Chatham & Badre, 2015). In the field of psychology, memory is defined as the ability to encode, store, and retrieve information (Squire, 2009). There are many types of memory with three main categories outlined by psychologists: sensory, short term and long term (Zlotnik & Vansintjan, 2019). In addition, working memory is a term also used with Miller et al. (2018) referring to it as the 'sketchpad of conscious thought' (pp. 466). Working memory can be considered the platform where we hold and manipulate thoughts and is foundational to the organisation of goal-directed behaviour (Chatham & Badre, 2015). There are a range of widely used memory tests available including the Rey Auditory Verbal Learning Test, the California Verbal Learning Test, the Camden memory test and the

Wechsler Memory Scale (Uttl, 2005). They vary and have strengths and weaknesses with various studies considering their validity, reliability, and ceiling effect for memory assessment (Kent, 2017; Soble et al., 2019; Uttl, 2005). There is no one memory test that is considered perfect in terms of assessing memory (Kent, 2017). However, the Wechsler Memory Scale-1 was introduced 70 years ago and has been the most widely used standardised memory battery for over 50 years. Since its introduction, the test has been revised three times, with the last revision in 2009. The new version has been well received and the six sub components enable an in-depth analysis of varying aspects of memory (Kent, 2017). Although there are some criticisms around auditory memory (AM) and performance validity for the Wechsler Memory Scale Fourth UK Edition (WMS-IV UK) it does provide an assessment of different aspects of human memory (Chlebowski et al., 2011).

As a result in this study we use the WMS-IV UK Fourth UK Edition (WSM-IV UK) which includes subcategories of memory including: AM, visual memory (VM), visual working memory (VWM), immediate recall (IR) and delayed recall (DR). The WMS-IV UK is a revised version of the WMS (1945) developed by David Wechsler. The battery is designed to clinically measure different forms of human memory (Chlebowski et al., 2011). There are two batteries contained within the WSM-IV UK, one for individuals aged 16–69 and an older battery for individuals aged 65–90. The subcategories enable a broad assessment of memory which we felt was of value for this study. Research has indicated that the WMS–IV UK is an improved, and more valid instrument especially in the evaluation of auditory and VM compared to previous versions of the scale (Hoelzle et al., 2011; Kent, 2017). Auditory memory is our ability to remember orally presented information after a delay in time (Zimmermann et al., 2016). Visual memory is our ability to remember visually presented information which could be a picture or a series of numbers. Presented in isolation, AM and VM are simply our ability to remember information presented in different ways and this often occurs in our daily lives (Kozak et al., 2021). Other subcategories of memory employed in the WMS-IV UK involve more complex demands on memory where an individual may have to consider multiple stimuli and manipulate information. Visual working memory looks at an individual's capacity to manipulate visual information in short term memory. Researchers interested in the capacity of VWM have considered factors such as how many items we can store in VWM while simultaneously conducting a visual search (King & Macnamara, 2020). Immediate recall looks at an individual's ability to remember both visual and oral information immediately after it has been presented. Finally, DR is an individual's ability to remember both visual and oral information after a delay. Individuals are often focused on their ability to remember information after a delay in time and studies have considered how age, diet and lifestyle may influence DR (Crespo et al., 2015; Galioto & Spitznagel, 2016; Kliegel & Jäger, 2006). Memory loss and forgetting, of course, is normal and happens every day and over time. With advancing age, some decline in memory ability is typical; other factors such as stress and fatigue also impact our ability to remember (Crespo et al., 2015; Dominguez & Barbagallo, 2018). We use a variety of strategies for coping with memory loss and remembering in general. This can include using memory aids such as alarms, calendars, reminder notes, or routinising the placement of those objects at risk of getting lost such as keys. Another solution that persons are increasingly turning to in order to improve their memory is supplement use (Cave et al., 2019; Roe & Venkatramanan, 2021; Sharif et al., 2021; Venkatramanan et al., 2016).

The use of supplements has dramatically increased in the last 20 years (Asher et al., 2017; Wu et al., 2014). In the United States it is reported that 25% of the population take some form of supplement. The number of daily UK supplements users now sits at almost 20 million—up 19% since the last survey in 2019, making it the largest population of dietary supplement users worldwide. Currently 71% of the world's adults are reported to be taking food supplements with one in three claiming that the pandemic was the catalyst (Ulery, 2022). The growth of the supplement market globally is expected to continue to rise at an annual growth rate of 6% from 2017 to 2025 (Asher et al., 2017). Supplements can be used to correct micronutrient deficiency or to maintain an adequate intake; commonly available supplements are most often taken by people with no clinical conditions or symptoms of deficiency. It has also been noted that people who use supplements tend to have a better overall diet quality than those who do not use them, with their nutrient intake from their regular diet meeting recommended levels (Zhang et al., 2020). There has also been a global increase in the demand for vegan food and plant based nootropics are therefore popular and considered an appropriate supplement to the vegan diet (Bakaloudi et al., 2021).

Supplements known as 'nootropics' that claim to provide cognitive benefits make up much of the recent growth in supplements sales. There are a variety of nootropics available such as Alpha Brain, Mind Lab Pro, Modafinil, Noocube and Qualia Mind. Nootropics are believed to have the capacity to enhance cognition in humans, specifically memory, focus and attention (Onaolapo et al., 2019). Other than Mind Lab Pro research has been conducted on the products listed above with studies reporting benefits in memory, attention, learning, and executive function (Battleday & Brem, 2015; Snow et al., 2021; Solomon et al., 2016; Stough et al., 2015). Solomon et al. (2016) demonstrated benefits to memory of taking Alpha Brain, with the emphasis on verbal recall. Modafinil was shown to improve cognitive function in healthy participants (Battleday & Brem, 2015) and Snow et al. (2021) report that nootropics have the potential to prevent memory loss. Nootropics are especially popular with the 18–30-age group who are keen to improve and maintain their cognitive ability, especially memory (McCabe et al., 2005; Smith & Farah, 2011). There is also evidence from wider research of the positive impact that the typical ingredients found in nootropics have on cognitive functions such as memory, multi-tasking and focus (Deijen et al., 1999; Kumar et al., 2016; Lewis et al., 2021; Morgan et al., 2010; Saitsu et al., 2019). O'Hara et al. (2023) has stressed the importance of further studies on the efficacy of nootropics especially in 18–20 year olds. In this study we were particularly interested in the nootropic Mind Lab Pro, the contents and dosage of Mind Lab

Pro for two capsules can be seen in Table 1. Mind Lab Pro contains 150 mg of *Bacopa monnieri*, which has been found to enhance cognitive function by facilitating dendritic branching and pruning (Gareri et al., 2015), specifically in older patients. Additionally, it has also been seen to help Alzheimer patients and improve memory, focus and attention in the elderly (Calabrese et al., 2008; Goswani et al., 2011; Sadhu et al., 2014). It has also been found to enhance cognitive function in the younger population; a 6-week study on healthy medical students noted improvements in attention and memory from taking 150 mg of *B. monnieri* for 6 weeks (Kumar et al., 2016). Studies have also reported benefits to IR and working memory form taking *B. monnieri* (Calabrese et al., 2008; Pase et al., 2011; Sadhu et al., 2014; Stough et al., 2008). Mind Lab Pro also contains 250 mg of *Citicoline*, a substance which has been found to improve memory by increasing specific hormonal levels and activate biosynthesis in the central nervous system to protect cell membranes in healthy and unhealthy populations (Gareri et al., 2015; McGlade et al., 2012; Nakazaki et al., 2021). Nootropics such as Alpha Brain and Noocube also contain *B. monnieri* and also report benefits to memory. Other ingredients in Mind Lab Pro such as *Lion's Mane Mushroom* (500 mg), and *Phosphatidylserine* have also been found to improve memory and attention in a variety of contexts for a range of healthy and unhealthy populations (Saitsu et al., 2019; Steenbergen et al., 2015; Tabassum et al., 2012; Thomas et al., 1999). *Phosphatidylserine* has also been found to improve memory in individuals reporting to have memory issues and research states that it supports human cognitive functions, including the formation of short-term memory, the consolidation of long-term memory and the ability to create new memories (Glade and Smith., 2015; Kato-Katooka et al., 2010). Studies looking at the impact of taking *Rhodiola rosea* in healthy populations have found positive benefits to short term memory (Cropley et al., 2015; Darbinyan et al., 2000). Other ingredients such as *L-Theanine* and *Maritime pine bark extract* and *N-Acetyl* also report improvement in cognitive functions and memory in healthy adults (Belcaro et al., 2014; Hidese et al., 2019; Lewis et al., 2021). *L-Theanine* is a common ingredient found in a range of nootropics. Mind Lab Pro also contains vitamins B6, B9 and B12 which support multiple functions within the central nervous system. For example, vitamin B6 has been found to support brain functions which may help cognitive functioning, including biosynthesis of neurotransmitters, receptor binding, macronutrient metabolism and gene expression (Zhang et al., 2020). Vitamin B12 also provides evidence for cognitive enhancement. Lower vitamin B12 levels have been associated with increased rates of cognitive decline, and it has been suggested that supplementation of the diet with various vitamins and minerals is a means of maintaining cognitive function and can even prevent cognitive disorders including dementia (Hasbaoui et al., 2021; Rutjes et al., 2018). Vitamin B12 is also an essential nutrient that can be missing from vegan diets, nootropics are a good source of B12 (Bakaloudi et al., 2020; Niklewicz et al., 2022). Mind Lab Pro therefore clearly contains a range of ingredients that research indicates could benefit memory in a variety of ways.

Therefore, in this study we aimed to examine the efficacy of Mind Lab Pro on improving memory in adults by examining their performance on the Wechsler Memory Test pre and post 1 month of taking the supplement compared to a control group who took a placebo.

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

Abbreviations: mcg, microgram; mg, milligram.

2 | METHODS

Full ethical permission was gained from the University of Leeds, Faculty of Biological Sciences ethics committee (BIOSCI 20-017).

2.1 | Participants

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 20 and 69 (ii) able to understand simple instructions and sign informed consent and (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; and (iv) any known medical conditions or illness. A total of 49 healthy individuals completed the study with 36 in the experimental group and 13 in the control group. Participants ranged between 20 and 68 years with a mean age of 31.4 in line with other studies and giving a balance between younger and older participants. The experimental group consisted of 36 participants with $n = 27$ females and $n = 9$ males with a mean age of 32.7 years old and an age range from 20 to 68 (SD = 15.8). The control group consisted of $n = 9$ females and $n = 4$ males with age ranging from 20 to 45 ($x = 27.9$ years old, SD = 9.5). 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, Reedy et al. (2018). The experimental group had a mean score of 60.1 ± 8.3 and the control group had a mean score of 70.25 ± 6.65. The higher the score the healthier the diet (Krebs-Smith., 2019). There was some drop out of participants due to them contracting Covid-19 and as a result 4 participants who were in the control group could not complete the post tests and were removed from the study.

2.2 | Procedures

Participants were given an information sheet explaining the research and detailing the ingredients of the supplement. Participants were then given time to ask any questions, and written consent was then obtained. The study was double blind 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 WMS-IV UK test pre- and post-30 days of taking either Mind Lab Pro or a placebo (microcrystalline cellulose). Completing the WMS-IV UK took around 60 min in total and participants did not report any difficulties in understanding the tasks or completing them. 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. 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. The experimental group and control group did not meet and the bottles for each group were identical. All result score scripts from the memory test were marked by the same researcher to ensure consistency and checked by another researcher to ensure accuracy. This was done to ensure that the data was reliable when scoring the drawing task that for part of the WMS-IV UK (Drozdick et al., 2018).

2.3 | Tasks

Participant's memory scores were assessed using the WMS-IV UK Fourth UK Edition (WSM-IV UK). In this study we only used the battery for individuals aged 16–69. The WSM-IV UK contains a total of seven subtests; with the first of these is a brief cognitive status exam. However, this was not used in this study as it was not deemed necessary for the participants involved and it is optional. Table 2 outlines the six subtests in the WMS-IV UK and explains what the participants were asked to do for each section.

TABLE 2 Subtests that participants completed for the WSM-IV UK.

Subtest	Explanation
Logical memory	Participants are told two short stories. After each story, they were asked to repeat as much information about the each of the story (logical memory I). After 20–30 min, the participants were asked to recall the stories for the delayed recall aspect (logical memory II). Both stories were marked out of 25
Verbal pairs associates	Participants were read 14-word pairs, some of which made sense, and other which did not. After all pairs were read out, the examinee would read out the first word of each pair, and the participant was to answer with the correct word pair. This was repeated four times, with word pairs read out in different order each time to avoid learning (verbal pairs associates I). After 20–30 min, the examinee would again say the first word of each pair, and the participant had to answer with the correct pair (verbal pairs associates II)
Visual reproduction	Participants were shown a design for 10 s, and after the time elapsed, the design was hidden and participants were asked to draw the design from memory. A total of five designs were shown to the participant (visual reproduction I). After 20–30 min, participants were asked to draw all five designs from memory (visual reproduction II). After this, a recognition task was completed, where the participant had to choose the design they saw previously from six similar designs
Designs	Participants were shown a grid with 4–8 unfamiliar designs for 10 s, and then asked to select the correct design from a set of cards and place in a grid in the same place as they previously saw. The participant would get marks for selecting the correct design and for the design to be placed in the correct position
Spatial addition	Participants were shown sequentially two grids with blue and red circles for 5 s each design. After both designs were shown, the participant was asked to place the certain colours that coincided with the correct positioning of the coloured circles: a blue circle if there was a blue circle shown on only one of the grids, a white circle if a blue circle was shown in the same place on both grids, and to ignore the red circle
Symbol span	Participants were shown a series of abstract designs that ranged from 1 to 7 long for 5 s, and then asked to select from a selection of designs the correct designs in order

On completion of the Wechsler Memory Scale the tests were scored and five index scores derived from them including: AM, VM, VWM, IR and DR (Figure 1).

2.4 | 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 were described using either means and standard deviation, or medians (*M*) and interquartile range (IQR) for parametric and non-parametric data respectively. The first analysis assessed if there was an improvement from pre- to post-test results of AM, VM, VWM, IR, and DR of the control and experimental groups separately. If the data was normally distributed, a paired samples dependent test was completed to see if there were significant improvements from pre- to post-scores in the individual groups with $p \leq 0.05$ considered statistically significant. If data violated the Shapiro Wilk test, the non-parametric equivalent, a Wilcoxon signed-rank test was used, again with $p \leq 0.05$ considered statistically significant.

The main analysis was to assess if there was any significant change of AM, VM, VWM, IR and DR scores between the control and experimental group. If data was normally distributed, a mixed modal ANOVA was used, with $p \leq 0.05$ considered statistically significant. If data violated the Shapiro Wilk test, a new variable was created, which was the change of the scores from pre- to post-test. The non-parametric alternative Kruskal Wallis then assessed the difference between the control and experimental group, again with $p \leq 0.05$ considered statistically significant.

3 | RESULTS

Results are presented for the five index scores with comparisons made pre and post taking Mind Lab Pro or the placebo for 30 days. Additionally, comparisons were made between the two groups, to see if there was a significant difference in the scores between the control and experimental group.

3.1 | Auditory memory

The control group did not violate the Shapiro Wilk test ($p > 0.05$) and therefore a dependent *t* test was used to see if there was an improvement between pre and post-test. Results showed that the control group did significantly improve from pre to post-test ($t(1) = -3.446$, $p = 0.004$), from 42.67 ± 8.4 to 52.36 ± 8.8 (Figure 1a). The experimental group 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. Results showed that the experimental group did significantly improve from pre-test (*M*: 42 [IQR: 32.25, 47.75]) to post test (*M*: 53 [IQR: 49, 56.75]) ($Z = -4.473$, $p < 0.001$) (Figure 2a). Comparisons were made between the groups, as the data violated the Shapiro Wilk test for normality, a new variable was created to assess the difference between the groups. The change from pre to post test was then assessed. The non-parametric Kruskal Wallis test found that there was not a significant difference in AM between the control and experimental group ($\chi^2(1) = 1.087$, $p = 0.297$) (Figure 2b).

3.2 | Visual memory

The control group did not violate the Shapiro Wilk test ($p > 0.05$) and therefore a dependent *t* test was used to see if there was an improvement between pre and post-test. Results showed that the control group did not significantly improve from pre to post-test ($t(1) = -1.567$, $p = 0.138$), from 48.25 ± 11.57 to 51.75 ± 10.98 (Figure 2a). The experimental group 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. Results showed that the experimental group did significantly improve from pre (*M*: 32 [IQR: 27.25, 39.25]) to post-test (*M*: 53 [IQR: 49, 56.75]),

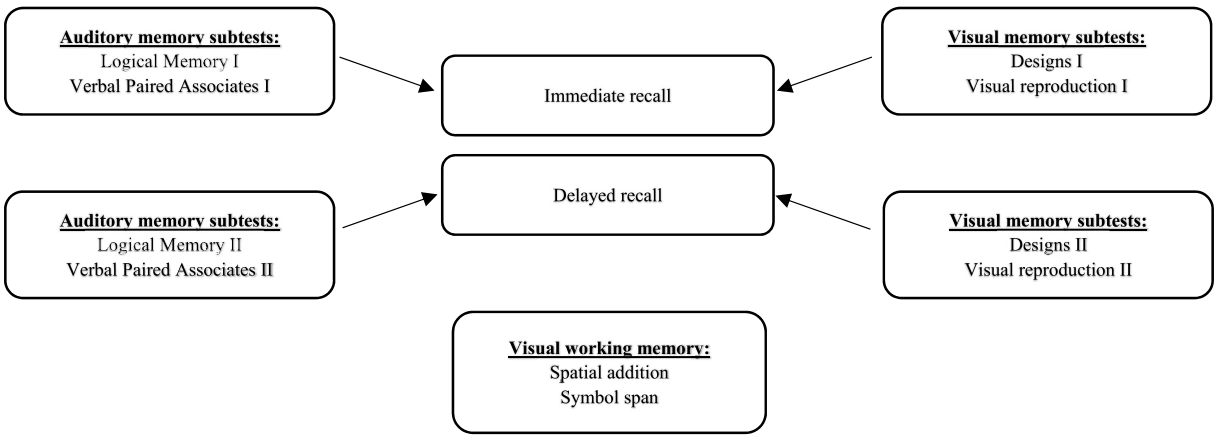

FIGURE 1 The framework of how the score of each form of memory was derived from the subtests using the WSM-IV UK. *Source*: Adapted from the WSM-IV UK administration and scoring manual.

($Z = -4.473$, $p < 0.001$) (Figure 3a). Between group comparison were made and as the data violated the Shapiro Wilk test for normality, a new variable was created to assess the difference between the groups. The change from pre- to post- test was then assessed. The non-parametric Kruskal Wallis test found that there was not a significant difference in VM between the control and experimental group ($\chi^2(1) = 3.668$, $p = 0.055$) (Figure 3b).

3.3 | Visual working memory

The control group did not violate the Shapiro Wilk test ($p > 0.05$) and therefore a dependent t test was used to see if there was an improvement between pre- and post-test. Results showed that the control group did not significantly improve from pre- to post-test ($t(1) = -0.524$, $p = 0.608$), from 20.81 ± 4.75 to 20.19 ± 5.06 (Figure 3a). The experimental group did not violate the Shapiro Wilk test ($p > 0.05$) and therefore a dependent t test was used to see if there was an improvement between pre- and post-test. Results showed that the experimental group did significantly improve from pre- to post-test ($t(1) = -2.158$, $p = 0.038$), from 19.11 ± 4 to 20.72 ± 5.04 (Figure 4a). Regarding the between group comparison, as the data did not violate the Shapiro Wilk test for normality, a mixed modal ANOVA was used. It was found that there was not a significant difference in VWM between the control and experimental group ($F(1,44) = 2.354$, $p = 0.132$) (Figure 4b).

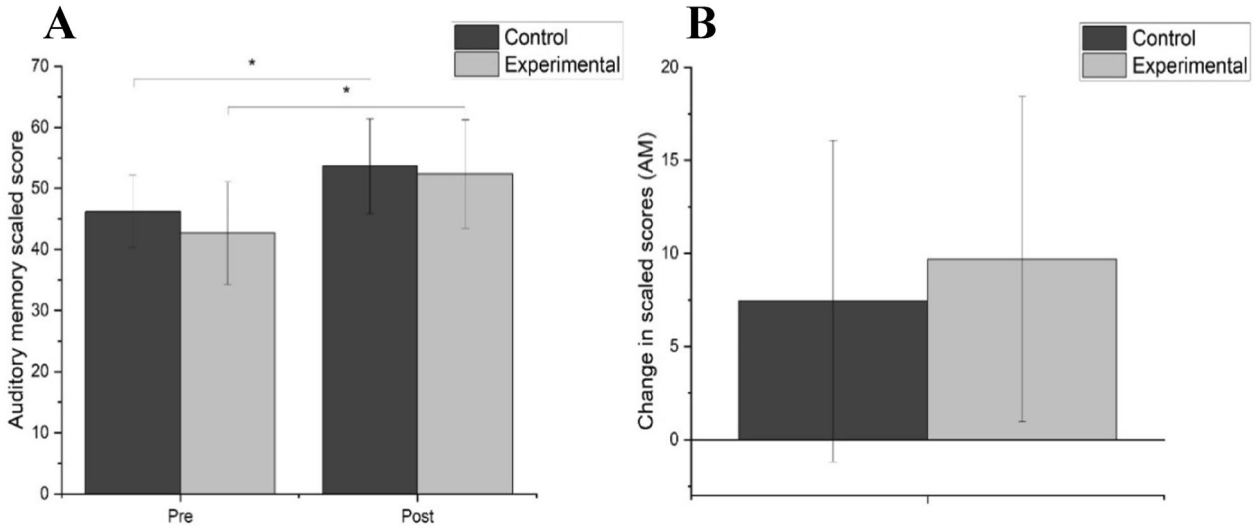

FIGURE 2 (a) Pre and post-test results of AM, for the control and experimental group. Error bars signify standard deviation. *Highlights a significant improvement in AM in the experimental group ($p < 0.001$) and control group ($p = 0.004$). (b) Change in AM from pre to post test, comparing the control and experimental group. Error bars signify standard deviation. AM, auditory memory.

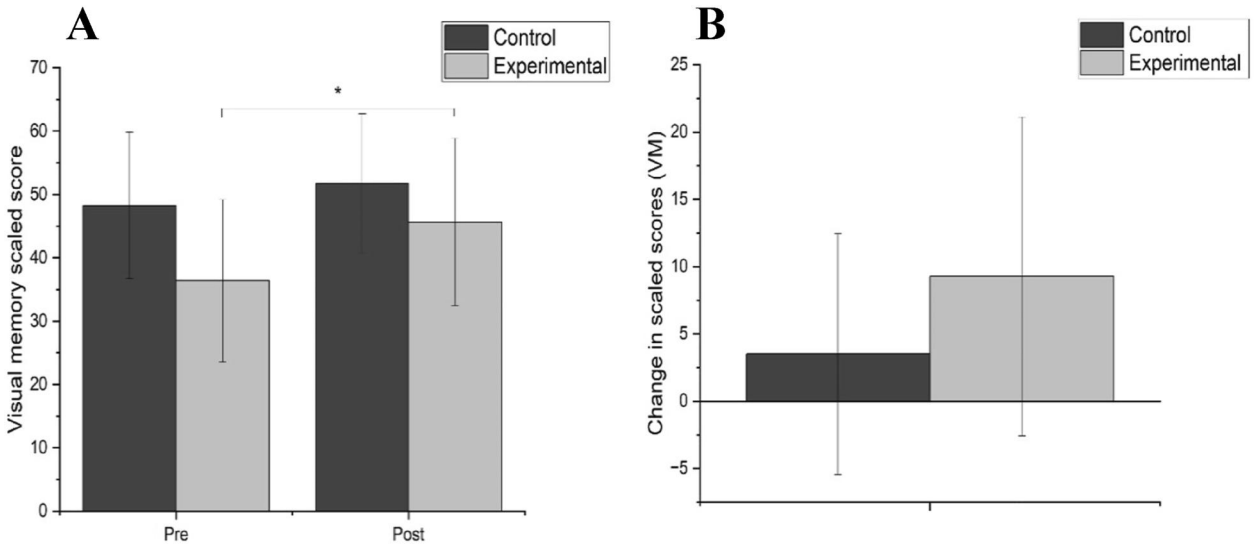

FIGURE 3 (a) Pre and post-test results of VM, for the control and experimental group. Error bars signify standard deviation. *Highlights a significant improvement in VM ($p < 0.001$). (b) Change in VM from pre to post test, comparing the control and experimental group. Error bars signify standard deviation. VM, visual memory.

3.4 | Immediate recall

The control group 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. Results showed that the control group did significantly improve from pre-test (*M*: 48 [IQR: 43.75, 53]) to post- test (*M*: 49.5 [IQR: 45, 62]), ($Z = -2.449$, $p = 0.014$) (Figure 4a). The experimental group 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. Results showed that the experimental group did significantly improve from pre- (*M*: 37 [IQR: 33, 40.75]) to post- test (*M*: 47.5 [IQR: 39, 52]), ($Z = -4.991$, $p < 0.001$) (Figure 5a). With regards to the comparison between the control and the experimental group, the data violated the Shapiro Wilk test for normality, so a new variable was created to assess the difference between the groups. The change from pre- to post- test was then assessed. The non-parametric Kruskal Wallis test found that there was a significant difference in IR between the control and experimental group ($\chi^2(1) = 3.747$, $p = 0.05$), from 38.47 ± 9 to 48.17 ± 9.59 (Figure 5b).

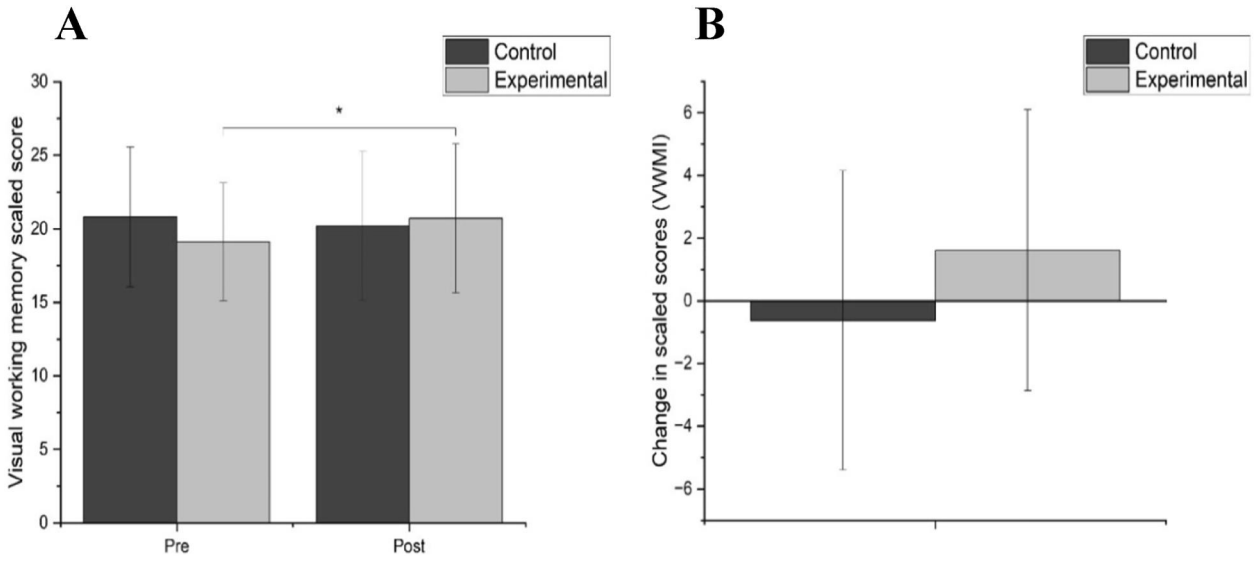

FIGURE 4 (a) Pre and post-test results of visual working memory (VWM), for the control and experimental group. Error bars signify standard deviation. *Highlights a significant improvement in VWM ($p = 0.038$). (b) Change in VWM from pre to post test, comparing the control and experimental group. Error bars signify standard deviation. VWM, visual working memory.

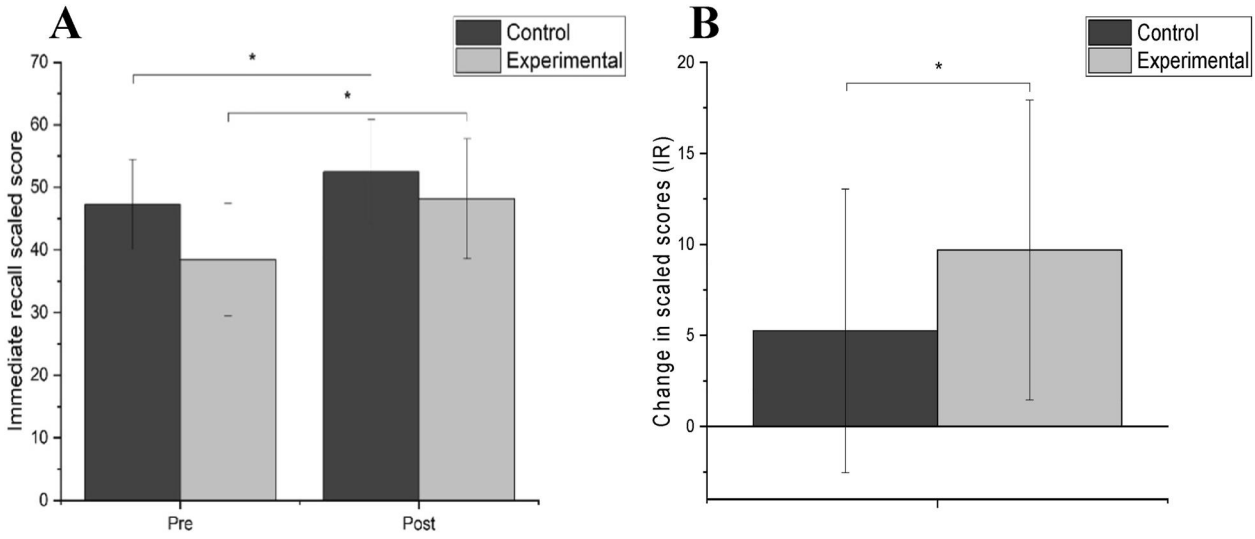

FIGURE 5 (a) Pre and post- test results of IR, for the control and experimental group. Error bars signify standard deviation. *Highlights a significant improvement in IR in the experimental group ($p < 0.001$) and control group ($p = 0.014$). (b) Change in IR from pre to post test, comparing the control and experimental group. Error bars signify standard deviation. *Highlights a significant difference in IR scores between control and experimental group ($p = 0.05$). IR, immediate recall.

3.5 | Delayed recall

The control group did not violate the Shapiro Wilk test ($p > 0.05$) and therefore a dependent t test was used to see if there was an improvement between pre- and post-test. Results showed that the group did not significantly improve from pre- to post-test ($t(1) = -2.035$, $p = 0.060$), from 48 ± 9.38 to 51.81 ± 8.83 (Figure 5a). The experimental group 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. Results showed that the experimental group did significantly improve from pre- test (*M*: 38 [IQR: 33, 44]) to post- test (*M*: 48 [IQR: 41.5, 55.75]) ($Z = -4.646$, $p < 0.001$) (Figure 6a). Between group comparison violated the Shapiro Wilk test for normality, so a new variable was created to assess the difference between the groups. The change from pre- to post- test was then assessed. The non-parametric Kruskal Wallis test found that there was a significant difference in DR between the control and experimental group ($\chi^2(1) = 4.473$, $p = 0.034$), from 40.61 ± 10.17 to 49.83 ± 9.75 (Figure 6b).

Summary, it was found that from the pre to post test the experimental group significantly improved in all memory subtests in contrast to the control group who only significantly improved in AM and IR. When examining the significance of the change from pre to post a significant difference in immediate and DR was found between the control and experimental group.

4 | DISCUSSION

This study assessed the impact of taking the nootropic Mind Lab Pro on memory of healthy adults. As stated by O'Hara et al. (2023) there are few studies that have examined the efficacy of nootropics and this study does add to the research in this area. It was found that there was a significant improvement in all subcategories of memory using the WMS-IV UK for the experimental group taking Mind Lab Pro (AM: $p < 0.001$, VM: $p < 0.001$, VWM: $p = 0.038$, IR: $p < 0.001$, DR: $p < 0.001$). In addition, the significance of the change for the experimental group was more marked in IR and DR. These findings are in line with previous research on nootropics and studies on the specific ingredients found in Mind Lab Pro. It is difficult to determine which ingredients may be more beneficial to memory. However, ingredients such as *B. monnieri*, *Citicoline* and *L-Theanine* have been found to benefit IR and working memory (Calabrese et al., 2008; Pase et al., 2011; Sadhu et al., 2014; Stough et al., 2008). Other ingredients such as *Lion's Mane Mushroom* and *Phosphatidylserine* have been shown to generally benefit memory (Crook et al., 1991; Mori et al., 2009). These ingredients are commonly found in other nootropics such as Alpha Brain, Modafinil, Noocube and Qualia Mind and these products have also been associated with improvements in memory (Battleday & Brem, 2015; Snow et al., 2021; Solomon et al., 2016; Stough et al., 2015).

Immediate recall (pre to post) improved in both the experimental and control group ($p < 0.001$ and $p = 0.014$ respectively) whilst DR only improved in the experimental group ($p < 0.001$), as seen in Figure 6a. However, it was interesting to note that there was a significant difference found between the change in IR and DR between the control and experimental group ($p = 0.05$ and $p = 0.034$ respectively), seen in Figures 5b and 6b. The experimental group had a more significant change. It can therefore be assumed that the use of Mind Lab Pro significantly improves memory in relation to recall tasks be that immediate or delayed. Alpha Brain has also shown benefits to delayed verbal recall after taking the product for 6 weeks (Solomon et al., 2016). *B. monnieri* and *Citicoline*—as already discussed has been shown to benefit IR (Calabrese et al., 2008; Pase et al., 2011; Sadhu et al., 2014; Stough et al., 2008). There is varying evidence suggesting how numerous factors including age and diet can influence DR (Crespo et al., 2015; Galioto & Spitznagel, 2016; Kliegel & Jäger, 2006). The HEI showed that the experimental group had

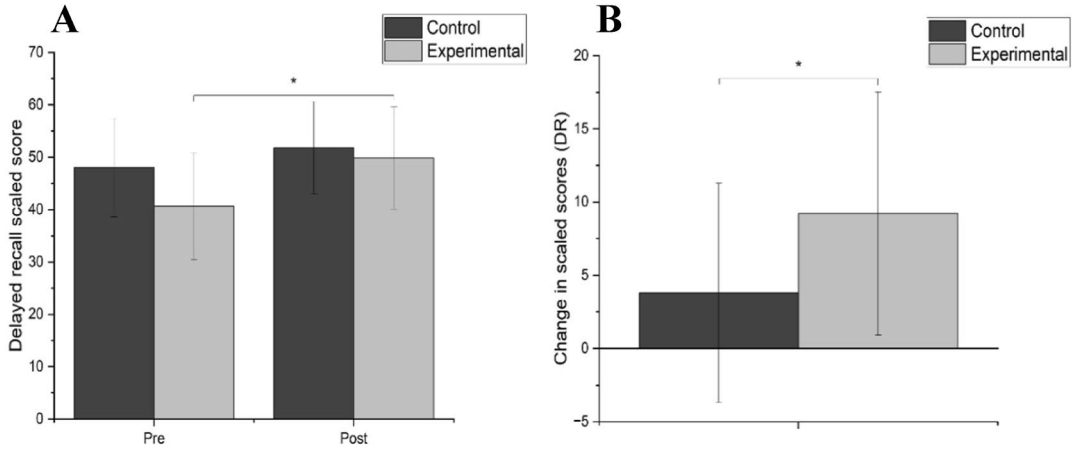

FIGURE 6 (a) Pre and post-test results of DR, for the control and experimental group. Error bars signify standard deviation. *Highlights a significant improvement in DR ($p < 0.001$). (b) Change in DR from pre to post test, comparing the control and experimental group. Error bars signify standard deviation. *Highlights a significant difference in DR scores between control and experimental group ($p = 0.034$). DR, delayed recall.

a better diet than the control group and, as we balanced age across the two groups, it is encouraging to see a significant improvement in the experimental group. Other studies looking at nootropics, such as Alpha Brain have also found improvements in particular types of memory. Alpha Brain has been shown to improve verbal recall (Solomon et al., 2016). A further factor that may have contributed to the significance found for both immediate and DR is how the WMS-IV UK subcategories are set out (Figure 1). Immediate and DR are composed of all the different forms of memory that were assessed, and the experimental group did show a significant difference across all subsets of the WMS-IV UK.

This study found benefits for memory for the experimental group taking the nootropic. There was a significant improvement in VM and VWM in the experimental group, but not the control group ($p < 0.001$ and $p = 0.138$ respectively), as seen in Figure 3a. This could be because specific ingredients in Mind Lab Pro such as *B. monnieri* provide positive effects on spatial memory. This was also found by Stough et al. (2008) who noted significant improvements in spatial working memory after 90 days of taking 300 mg per day of *B. monnieri*. Kairalla (2011) states that this is caused by an upregulation of cholinergic regulation and creates antioxidant effects in certain areas of the brain associated with spatial memory. Other ingredients such *Lion's Mane Mushroom and Phosphatidylserine* have also been found to improve memory and attention in a variety of contexts for a range of healthy and unhealthy populations (Saitsu et al., 2019; Steenbergen et al., 2015; Tabassum et al., 2012; Thomas et al., 1999). *Phosphatidylserine* has also been found to improve memory in individuals reporting to have memory issues helping with short-term memory and the consolidation of long-term memory (Glade & Smith, 2015; Kato-Katooka., et al., 2010). *R. rosea* has also proved to have positive benefits to short term memory (Cropley et al., 2015; Darbinyan et al., 2000). Other ingredients such as *L-Theanine* and *Maritime pine bark extract* and *N-Acetyl* also report improvement in cognitive functions and memory in healthy adults (Belcaro et al., 2014; Hidese et al., 2019; Lewis et al., 2021). *L-Theanine* is a common ingredient found in other nootropics such as Alpha Brain and Qualia Mind. It may well be that a range of ingredients taken in combination as found in nootropics such as Mind Pro Lab is a credible method of improving memory.

Interestingly, the control group improved significantly in AM and IR ($p = 0.004$ and $p = 0.014$). But this change was not as significant as it was for the experimental group. Auditory memory as previously mentioned, is the ability to remember orally presented information after a delay in time (Zimmermann et al., 2016). Results showed that there was a significant improvement from pre- to post- test in both the experimental and control group ($p < 0.001$ and $p = 0.004$ respectively). However, logical memory, a subtest during the WMS-IV UK that assesses AM has been found to have a low performance validity test, which can lead to the WMS-IV UK being inappropriate for use from an evidence-based perspective (Soble et al., 2019). This could then also be an explanation as to why AM was significantly improved in both the control and experimental group.

4.1 | Limitations

We must consider that there may be a learning effect when using the WMS-IV UK for reassessment after 1 month (Hall et al., 2010) and some questions around validity of some aspects of the test (Soble et al., 2019). However, it is still encouraging that the experimental group showed significant improvement in all aspects of memory assessed by the WMS-IV UK. It would have been useful to gain more in depth dietary and lifestyle information about the participants and to increase the number of participants. There was some drop out of participants due to them contracting Covid-19 and collecting the data during a period when Covid rates were increasing was challenging. Further research would be beneficial to allow further exploration of differing aspects of cognitive functions.

5 | CONCLUSION

This study demonstrates that there are potential benefits to memory in taking a nootropic- in this instance Mind Lab Pro. Memory significantly improved in all areas of memory assessed by the WMS-IV UK for the experimental group. This was especially true for immediate and DR which improved after taking Mind Lab Pro for 1 month. Immediate and DR are often view as important aspects of memory as they are associated with remembering names and places and where we have put objects such as car keys. Further research is now needed to consider the benefits to individuals of differing ages and also the long terms effects of taking nootropics on a range of cognitive functions.

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CONFLICT OF INTEREST STATEMENT

The University of Leeds conducted this study independently and Opti Nutra funded the research. The sponsors had no access to or influence on the data from this project.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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