IFSCC 35TH CONGRESS
FRANCE_CANNES 15-18 SEPT 25
THE FUTURE IS SCIENCE
ifscc2025.com

*IFSCC 2025 full paper (**IFSCC2025-1779**)*

# *"Objectivation and quantification of the emotional benefits of fragrances on focal attention"*

**Céline Carrasco-Douroux[1]*; Manon Descoubes[1]; Arnaud Aubert[2]; Francis Vial[2]**

1. Applied Research Scent & Care, Symrise, Clichy, France; 2. Neuroscience Research, Eurofins, Tours, France.
* Symrise, 15 rue Mozart 92110 Clichy, France, +33 1 55 46 27 00, celine.carrasco-douroux@symrise.com

## 1. Introduction

The modern work environment is often characterized by multitasking, continuous digital interruptions, and high cognitive loads, leading to frequent mental fatigue and reduced productivity [1; 2]. In response, researchers and industries have explored various cognitive enhancement strategies, ranging from taking particular drinks or foods to mindfulness techniques [3; 4].

Indeed, several articles mention the benefits of relaxation and meditation on concentration. Mindfulness meditation, for example, promotes a calm mental state and reduced stress, allowing one to pay attention to the present moment. Practicing mindfulness meditation for several days or weeks has been shown to improve certain attentional abilities, such as selective and sustained attention [5; 6; 7; 8]. Selective attention refers to the ability to focus on a specific stimulus or task while ignoring irrelevant or distracting information. This is improved through the intentional redirection of focus in meditation, which strengthens the ability to filter out distractions and prioritize relevant stimuli. Sustained attention, on the other hand, is the capacity to maintain focus and consistent performance over an extended period of time. This can be improved through regular meditation by training the practitioner to maintain focus over longer periods and to detect lapses in attention more effectively. Listening to classical or relaxing music has also been shown to be effective in improving concentration and memory, and reducing mental fatigue [9; 10]. Previous studies have reported that exposure to natural environments reduces stress and promotes attentional restoration [11]. According to these articles, a relaxed state or the use of relaxing stimuli would be effective for improving concentration.

In contrast, energy-inducing stimuli such as caffeine and energy drinks may also improve attentional capabilities by acting on working memory and reaction time [12; 13]. In the same way, cocoa consumption may be beneficial for improving energy level and cognitive performance [14]. Several articles mention that mental fatigue impairs attentional performance, highlighting the importance of fatigue management to maintain optimal concentration [15; 16]. The use of energizing stimuli is then also justified to help improve cognitive performance.

The literature has provided us with several tools to boost concentration but the role of olfactory stimulation, as a non-invasive method for improving concentration, has not yet been fully investigated. For instance, the effects of caffeine ingestion are well documented in the literature [17; 18], but the benefits of its smell have hardly been studied. An article nevertheless mentions that inhalation of coffee fragrance can also improve quality of memory, speed of memory, and mood score of alertness [19]. Recent research suggests that certain essential oil may have a direct impact on attentional processes. Peppermint and rosemary essential oils have been associated with increased attentional capabilities and improved memory retention [20]. Similarly, citrus-based scents, such as lemon and orange, have been linked to enhanced task performance and reduced mental fatigue [21; 22]. Even if the cognitive processes involved are not yet well understood, these findings suggest that fragrances could play a role in modulating cognitive performance.

To summarize, two complementary mechanisms can enhance attentional capabilities: increasing alertness to sustain focus over time on one hand and achieving a sufficient state of relaxation to reduce inner agitation and improve selective attention on the other hand. In this context, three perfumes were developed from raw materials providing alertness and relaxation. The three fragrances (named “Focus 1”, “Focus 2” and “Focus 3”) were evaluated with a proven improving sleep fragrance (negative control named “Musk”) versus a control (odorless solvent). A multidisciplinary approach combining attention-based cognitive tasks and psychological assessment has been set up to study the effect of these olfactory stimuli on attentional capabilities. Participants had to fill in questionnaires before and after discovering for two minutes one of the fragrances sprayed in the test room. The questionnaires consisted of three different tasks: Stroop task, Trail Making Test (TMT) and D2-R Test. Several parameters are studied with these tasks such as selective attention, cognitive flexibility or processing speed. Electroencephalography (EEG) was also used, before and after fragrance discovery, for measuring electrical activity in the brain and particularly for assessing attentional functions and vigilance. It was hypothesized that the three fragrances might have a positive impact on attention. The objective of the negative control evaluation was to test the methodology.

## 2. Materials and Methods

### *2.1. Participants*

The study involved a population of 33 people, ranging in age from 19 to 67, with an average age of 43 years old. Volunteers have to be in good health with no non-stabilized pathology likely to interfere with the study.

### *2.2. Products*

After analyzing the literature, we noticed that attention could be improved by stimuli that were either energizing (coffee, energy drinks) or relaxing (meditation, classical music, etc.). In this way, we developed three fragrances using raw materials with a positive impact on energy and relaxation. The emotional benefit on relaxation and energy of each of the raw materials used in this study has been previously evaluated by neuroscience methods combining verbal and non-verbal responses of volunteers (vocal analysis, verbatim, psychometric scales, etc.). We wanted to identify the optimum ratio between energy and relaxation to develop fragrances that would improve concentration. To be able to conclude on the reliability of the protocol, we also used a neutral control (odorless condition) and a negative control, the *Musk* fragrance, previously tested for its benefits on relaxation and improvement of sleep quality. It was hypothesized that the sleep scent would not be energizing enough to boost attentional abilities. The fragrances studied are described in the table below.

**Table 1.** Percentage of fragrance raw materials (FRMs) with emotional benefits (previously tested) in the scented fragrances studied

| Product | % of FRMs with ENERGIZING benefit | % of FRMs with RELAXING benefit |
|---|---|---|
| *Focus 1* | 62 | 40 |
| *Focus 2* | 62 | 45 |
| *Focus 3* | 61 | 79 |
| *Musk* | 0 | 82 |

The olfactory stimuli were diluted 10% in alcohol.

Volunteers had to come on five different days to evaluate one condition per day (four olfactory stimuli and the control). The rooms were ventilated between each condition to avoid any olfactory pollution. During each appointment, the subject discovered the fragrance after the technician sprayed it four times in the evaluation room. Each participant had two minutes to discover the odor before answering the various tests. Fragrances were presented in a random way.

*2.3. Procedure*

In order to obtain reliable and objective results, a battery of tests was set up. This included cognitive tests (tests of focused attention: Stroop test, TMT and d2-R) as well as brain activity assessment (EEG).

The protocol used is shown in Figure 1.

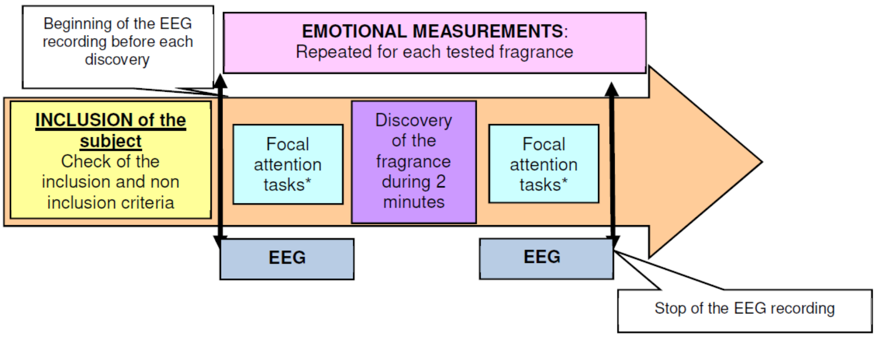



**Figure 1.** Protocol used to study the impact of olfactory stimuli on focused attention

*2.3.1. Stroop test*

The Stroop Test is a widely used neuropsychological assessment tool designed to measure selective attention, cognitive flexibility, and processing speed. The test is based on color-word interference since participants are shown a list of color names where the ink color does not match the word (e.g., the word "red" printed in blue ink) and are required to name the ink color, not the word. In the version used here, participants were asked to write the first letter of the ink color in which the word was printed in the associated boxes (Figure 2).


**Figure 2.** Example of answer sheet for the Stroop Test

The studied parameters are the number of responses and the number of errors to verify the strategy of each subject (e.g. quickness vs. precision).

### *2.3.2. Trail Making Test (TMT)*

The Trail Making Test (TMT) is a neuropsychological assessment used to evaluate cognitive functions, particularly attentional capacities, cognitive flexibility, and processing speed.

This test consists of two parts, A and B, and as it is a test of speed, the examiner must stress the importance of time and efficiency. Normally, the whole test can be completed in 5 to 10 minutes.

The technician first gives part A of the questionnaire, indicating the instructions orally. It consists of numbers from 1 to 25 circled and randomly distributed on a sheet of paper. The aim of the test is for the subject to connect the numbers in order, starting with 1 and ending with 25, in the minimum amount of time.

The technician writes down the time taken by the subject to complete part A. In the same way, the technician gives part B of the questionnaire, also giving verbal instructions. Part B is more complex than part A because it requires the subject to connect numbers and letters alternately (1-A-2-B-3-C, etc.) in as little time as possible. The technician writes down the time taken by the subject to complete part B. An example of training is given in Figure 3.

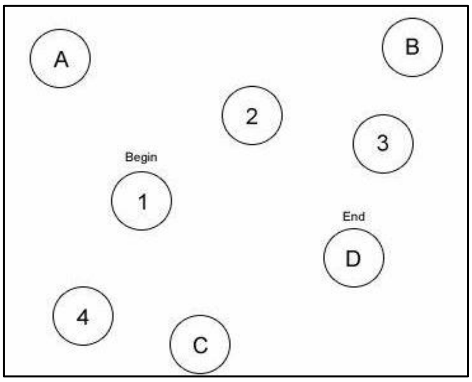



**Figure 3.** Example given in the TMT instructions

The studied parameters are the speed of execution and the number of errors.

### *2.3.3. D2R Test (D2R)*

The d2R Test, a revised version of the d2 Test of Attention, is a neuropsychological assessment designed to evaluate selective attention and mental concentration. It measures the ability to focus on relevant stimuli while ignoring irrelevant ones, as well as the speed and accuracy of processing. The test consists of identifying and crossing out target characters ('d' accompanied by 2 lines) from a large number of distracting characters. It therefore requires an effort of concentrated visual attention. Performance depends on the ability to discern details quickly and accurately. Figure 4 illustrates the questionnaire.

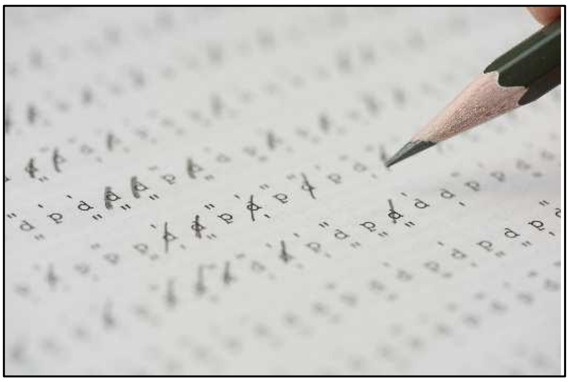


**Figure 4.** Example of sheet to complete for the D2R test

The studied parameters are the number of responses and the number of errors to verify the strategy of each subject (e.g. quickness vs. precision)

*2.3.4. Electroencephalography (EEG)*

Electroencephalography (EEG) is a non-invasive method of brain exploration that uses electrodes to measure the electrical activity of the brain. For this study, the measurement of the EEG signal was carried out using a system of 4 electrodes combined in a single device equipped with a wireless emitter: Muse wearable brain sensing headband.

The advantage is the lightness and the absence of wiring which does not obstruct the sensory experiences of the subject and therefore optimize the ecological validity of the data obtained. If the type of received signal does not allow a fine processing of evoked potentials, the definition of EEG oscillations is, however, sufficient to allow a fine characterization of cerebral rhythms and their brain distribution. It is particularly the characterization of alpha and beta rhythms, mainly in the frontal lobe, which will allow an interpretation in terms of activation or relaxation.

The EEG records various brain wave frequencies associated with different states of wakefulness and cognitive activity:

- Alpha waves (8-13 Hz): mainly observed during states of relaxation and wakefulness, particularly when the eyes are closed. A decrease in alpha activity is generally observed when attention is directed towards external stimuli.

- Beta waves (13-30 Hz): associated with active thinking, concentration and vigilance. An increase in beta activity is often associated with active cognitive processing and increased alertness.

The ratio between beta and alpha rhythms (B/A ratio) serves as a key indicator of states of attention and alertness.

- High beta/alpha ratio: indicates heightened arousal, increased concentration and active cognitive engagement. This is often seen in tasks requiring sustained attention and a high mental workload.

- Low beta/alpha ratio: suggests a more relaxed state with less cognitive effort, potentially indicating reduced attention or sleepiness.

To increase the robustness of the computed power ratios, theta brain waves, generally observed during light sleep or deep relaxation, were also studied. In waking states, increased theta activity may indicate drowsiness, reduced alertness or mental wandering.

*2.4. Statistical Analyzes*

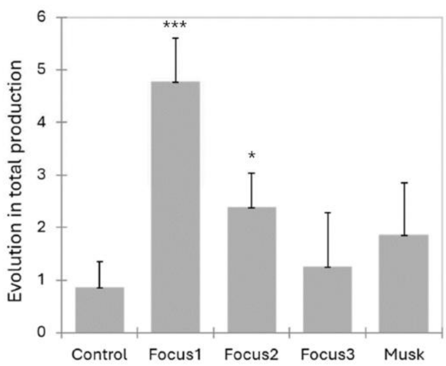
In order to decrease the relative weight of inter and intraindividual variability, and to increase statistical power, all analyzed variables represent the difference between pre-stimulation and post-stimulation.

T-tests were used to compare the results obtained in the presence of olfactory stimuli with those of neutral control (condition without odor).

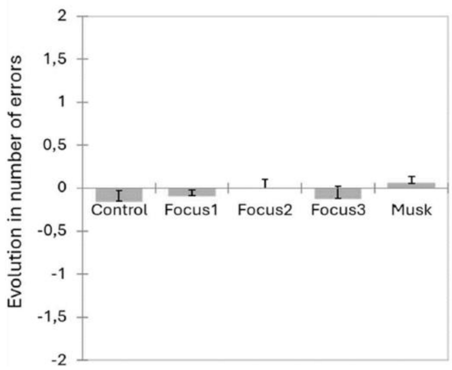
## 3. Results

### *3.1. Stroop test*

Figure 5 below illustrates the results obtained regarding the number of answers (i.e. production) and number of errors (i.e. precision). Production was significantly better in *Focus 1* (T-test p-value=0,0001) *& Focus 2* (T-test p-value=0,072) conditions compared to the odorless condition. Regarding the number of errors, no significant difference was observed between *Focus 1 & 2* conditions compared to the control condition. *Focus 3* and *Musk* conditions showed no significant difference in production or number of errors compared to the control.




(a)

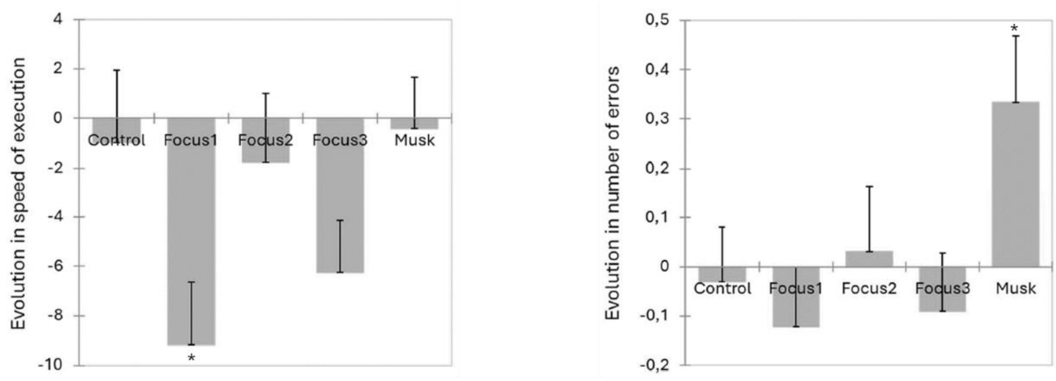



(b)

**Figure 5.** Stroop test results. Comparison of fragrance conditions to control condition based on the evolution in total production (a) and number of errors (b) between pre and post-stimulation. ****p-value < 0.01; **: p-value < 0.05; *: p-value < 0.1 by T-tests.*

### *3.2. Trail Making Test (TMT)*

Figure 6 below illustrates the results obtained in terms of execution speed and number of errors (i.e. accuracy). In the *Focus 1* condition, participants completed the test significantly faster than in the control condition (T-test p-value=0,058). No significant difference was observed regarding the number of errors between these two conditions. A significantly higher number of errors was observed with *Musk* compared to the control (T-test p-value=0,063) but the evolution in speed of execution was not significant. *Focus 2* and *Focus 3* fragrances showed no significant difference in either execution speed or number of errors compared with the odorless condition.

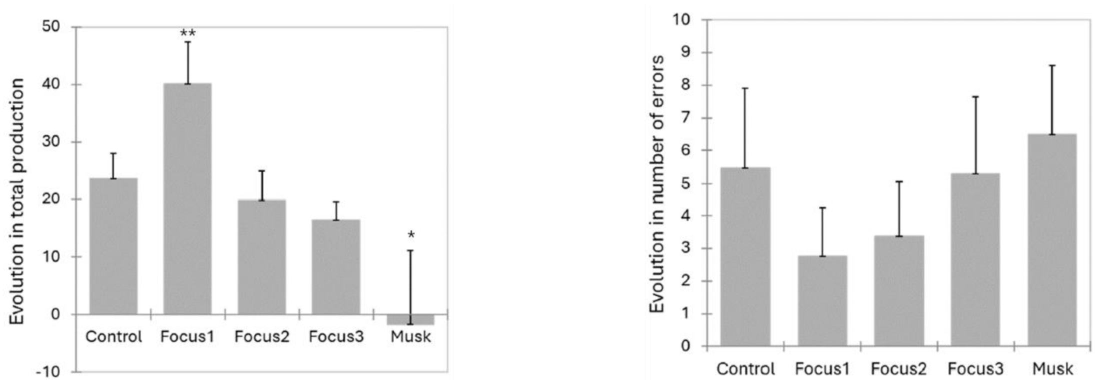



(a) (b)

**Figure 6.** TMT results. Comparison of fragrance conditions to control condition based on the evolution in speed of execution (a) and number of errors (b) between pre and post-stimulation. ****p-value < 0.01; **: p-value < 0.05; *: p-value < 0.1 by T-tests.*

### *3.3. D2R Test (D2R)*

Figure 7 below illustrates the results obtained in terms of output and number of errors (i.e. accuracy). Production was significantly better in *Focus 1* condition compared to the odorless condition (T-test p-value=0,047). A significantly lower production was observed with *Musk* compared to the control (T-test p-value=0,056). For *Focus 1* and *Musk* conditions, no significant difference was observed regarding the number of errors. *Focus 2* and *Focus 3* fragrances showed no significant difference in either execution speed or number of errors compared with the odor-free condition.




(a) (b)

**Figure 7.** D2R results. Comparison of fragrance conditions to control condition based on the evolution in total production (a) and number of errors (b) between pre and post-stimulation. ****p-value < 0.01; **: p-value < 0.05; *: p-value < 0.1 by T-tests.*

### *3.4. Electroencelphalography (EEG)*

Figure 8 below illustrates the results obtained for the power ratios calculated between beta, alpha and theta rhythms. The Beta/(AlphaxTheta) index was significantly higher with *Focus 1* (T-test p-value=0,0001) & *Focus 3* (T-test p-value=0,075) compared to the odorless condition. This translates into increased concentration and active cognitive engagement during stimulation with *Focus 1* and *3* compared to the no-stimulation condition (control). The Beta/(AlphaxTheta) index was significantly lower with *Musk* compared with the odorless condition (T-test p-value=0,001). This translates into reduced attention during stimulation with

*Musk* compared with no stimulation. *Focus 2* showed no significant difference in brain activity compared with the odor-free condition.

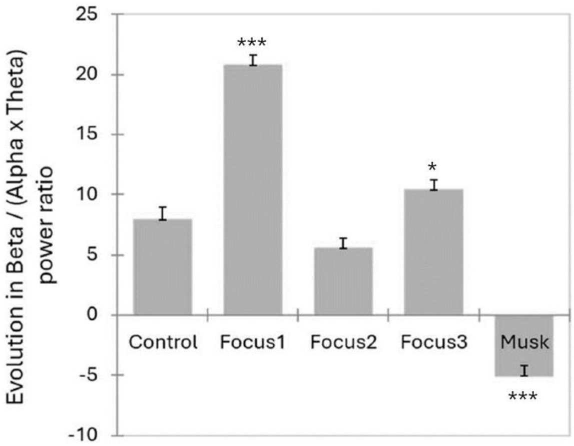



**Figure 8.** EEG results. Comparison of fragrance conditions to control condition based on the evolution in Beta / (Alpha x Theta) power ratio between pre and post-stimulation. ****p-value < 0.01; **: p-value < 0.05; *: p-value < 0.1 by T-tests.*

## 4. Discussion

The results, fairly consistent between the different methods, are summarized in Table 2. The *Focus 1* group is always associated with the best performance in terms of concentration and attention. Conversely, *Musk* is associated with the lowest performance, generally below the control condition (no fragrance), indicating an opposite effect on focal attention. The *Focus 2* and *Focus 3* fragrances seem less effective than *Focus 1* but still showed interest in certain tasks.

**Table 2.** Summary of results *(***: p-value < 0.01; **: p-value < 0.05; *: p-value < 0.1 by T-tests)*

| Methods | Statistical differences |
|---|---|
| STROOP TEST | **Focus 1** (***) & Focus 2 (*) **> Control** (production) |
| TMT | **Focus 1** (*) **> Control** (speed)<br>*Musk (*) < Control (errors)* |
| D2R | **Focus 1** (**) **> Control** (production)<br>*Musk (*) < Control (production)* |
| EEG | **Focus 1** (***) & Focus 3 (*) **> Control**<br>*Musk (***) < Control* |

Overall, the results are satisfactory. We can conclude from the results of the odorless control and the negative control (*Musk*) that the method is effective. The method implemented is therefore validated for the measurement of focused attention following olfactory stimulation. Of course, it would now be interesting to carry out this test on a larger scale, on more panelists, to confirm the results.

The purpose of this study was to examine whether olfactory stimuli can improve focal attention. Whether with the *Focus 1, 2* or *3* fragrance, positive results were shown, although the *Focus 1* accord seems to be the most effective in improving focal attention. This study has therefore enabled us to learn more about the development of fragrances to improve concentration. However, we cannot conclude on the most relevant relationship between the amounts of energizing and relaxing raw materials used in the formulas. In fact, *Focus 1 & 2* had the same ratio of beneficial ingredients (approximately 60% energy-inducing ingredients and 40% relaxation-inducing ingredients). Although the literature mentions that these two dimensions are relevant for improving attention, we are not yet sure of the rules to follow to develop fragrances with a positive effect on concentration [23]. In this case, two fragrances formulated according to the same guidelines did not achieve the same efficacy. It would now be interesting to study a larger number of combinations of fragrance ingredients to see if the ratio of energizing and relaxing-inducing ingredients really plays a role in increasing focal attention.

Although exploratory, this study enabled us to learn more about the development of scents to improve concentration. This opens new possibilities for the development of functional perfumes intended for use in contexts where cognitive performance is essential, such as workspaces or learning environments. Future research should aim to establish the robustness of these effects in real-world conditions. Such efforts could contribute to the emergence of a new generation of fragrances, designed not only for sensorial pleasure but also for cognitive enhancement.

## 5. Conclusion

This article examines the link between olfactory stimulation and concentration, drawing on findings from sensory science and cognitive psychology. Thanks to literature and the knowledge previously acquired on the emotional benefit of raw materials, we have been able to develop fragrances that enhance focal attention. These results have been proven through a multidisciplinary approach combining attention-based cognitive tasks (Stroop task, Trail Making Test (TMT) and D2-R Test) and physiological assessment (Electroencephalography (EEG)). Significantly better performance, in terms of focus and attention, was achieved in a fragrance condition compared to the control (odorless condition). These findings underscore the potential of olfactory stimuli as non-invasive modulators of emotional and cognitive states. This could open new avenues for the use of fragrances to support cognitive performance in daily life.

## 6. References

1. Dean, L., Churchill, B., & Ruppanner, L. (2021). The mental load: building a deeper theoretical understanding of how cognitive and emotional labor overload women and mothers. *Community, Work & Family*, 25(1), 13–29.

2. Malan, J. (2019). The influence of digital distraction on cognitive load, attention conflict and meeting productivity, Faculty of Commerce, Organisational Psychology.

3. Posner, M. I., Rothbart, M. K., & Tang, Y. Y. (2015). Enhancing attention through training. *Current Opinion in Behavioral Sciences*, 4, 1-5.

4. Dresler, M., Sandberg, A., Ohla, K., Bublitz, C., Trenado, C., Mroczko-Wąsowicz, A., ... & Repantis, D. (2013). Non-pharmacological cognitive enhancement. *Neuropharmacology*, 64, 529-543.

5. Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience*, 7(2), 109-119.

6. Zenner, C., Herrnleben-Kurz, S., & Walach, H. (2014). Mindfulness-based interventions in schools—a systematic review and meta-analysis. *Frontiers in psychology*, 5, 603.

7. Semple, R. J. (2010). Does mindfulness meditation enhance attention? A randomized controlled trial. *Mindfulness*, 1, 121-130.

8. Tang, Y. Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., & Posner, M. I. (2007). Short-term meditation training improves attention and self-regulation. *Proceedings of the national Academy of Sciences*, 104(43), 17152-17156.

9. Ázmi, M. T. F. B. K., Tse-Kian, N., & Rashid, F. N. (2023). Music matters: The role of background music in improving students' attention and learning outcomes. *International Journal (Toronto, Ont.)*, 10(3), 1898-1908.

10. Guo, W., Ren, J., Wang, B., & Zhu, Q. (2015). Effects of relaxing music on mental fatigue induced by a continuous performance task: behavioral and ERPs evidence. *PloS one*, 10(8).

11. Berto, R. (2014). The role of nature in coping with psycho-physiological stress: a literature review on restorativeness. Behav. Sci. 4, 394–409.

12. Giles, G. E., Mahoney, C. R., Brunyé, T. T., Gardony, A. L., Taylor, H. A., & Kanarek, R. B. (2012). Differential cognitive effects of energy drink ingredients: caffeine, taurine, and glucose. *Pharmacology Biochemistry and Behavior*, 102(4), 569-577.

13. Aniţei, M., Schuhfried, G., & Chraif, M. (2011). The influence of energy drinks and caffeine on time reaction and cognitive processes in young Romanian students. *Procedia-Social and Behavioral Sciences*, 30, 662-670.

14. Nehlig, A. (2013). The neuroprotective effects of cocoa flavanol and its influence on cognitive performance. *British journal of clinical pharmacology*, 75(3), 716-727.

15. Faber, L. G., Maurits, N. M., & Lorist, M. M. (2012). Mental fatigue affects visual selective attention. PloS one, 7(10), e48073.

16. Boksem, M. A., & Tops, M. (2008). Mental fatigue: costs and benefits. Brain research reviews, 59(1), 125-139.

17. Glade, M.J. (2010). Caffeine Not just a stimulant. *Nutrition*, volume 26, 932–938.

18. Kennedy, M.D., Galloway, A.V., Dickau, L.J. & Hudson, M.K. (2008). The cumulative effect of coffee and a mental stress task on heart rate, blood pressure, and mental alertness is similar in caffeine-naïve and caffeine-habituated females. *Nutrition Research*, Volume 28, 609-614.

19. Hawiset, T. (2019). Effect of one time coffee fragrance inhalation on working memory, mood, and salivary cortisol level in healthy young volunteers: a randomized placebo controlled trial. *Integrative Medicine Research*, 8(4), 273-278.

20. Aprianti, N. A. (2025). Aroma therapy in the learning process improves students' focus and memory. *Asian Journal of Multidisciplinary Research*, 2(2), 76-85.

21. Hawiset, T., Sriraksa, N., Somwang, P., & Inkaew, P. (2016). Effect of orange essential oil inhalation on mood and memory in female humans. *Journal of Physiological and Biomedical Sciences*, 29(1), 5-11.

22. Smith, A., & Nicholson-Lord, K. (2024). Effects of a lemon aroma on attention, reaction time and mood. *World Journal of Pharmaceutical Research*, 13(6), 840-858.

23. Shi, Y., Lyu, J., Candido, C., Miao, J. T., & Lian, Z. (2025). Experimental investigation on effects of odor types, concentrations, and release frequencies on cognitive performance. *Building and Environment*, 269, 112456.