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Cognitive Enhancement using Odor

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Abstract: Cognitive Enhancement refers to the procedure by which the abilities or capacities of a healthy brain can be improved further through improvement of processing system of brain. The dictionary meaning of enhancement says "enhancement is to raise to a higher degree". Thus enhancement can be done by using some kind of interventions like music, odor, meditation, brain wave entrainment. In this research, we use odor as an intervention. Olfaction plays a very important role in extending or amplifying the core capacities of the mind.

1. Introduction

Many neuropsychiatric disorders occur on a spectrum that comprisesregular levels of functioning. This raises the question: if medicines can recover cognition in people with cognitive deficiency, what can they do for normal healthy people? This questions points to what is cognitive enhancement. The process of cognitive enhancement needs some interventions. In this research, we are concentrating on odor as an intervention.

After carrying out cognitive assessment by certain techniques, the next step is to carry out the process of cognitive enhancement using some sort of intervention [1]. We use the odor of lemon in this research. How important smell is in determining what we do and do not like? Many researchers have worked in this concern.

2. Olfaction

Olfaction or olfactory perception is the sense of smell. This sense is facilitated by dedicated sensory cells of the nasal cavity of vertebrates, which can be reflected equivalent to sensory cells of the antennae of invertebrates. In humans, olfaction happens when odorant molecules bind to full sites on the olfactory receptors. These receptors are used to observe the occurrence of smell. They come together at the glomerulus, a construction which conveys signals to the olfactory bulb (a brain assembly above the nasal cavity and beneath the frontal lobe). Many vertebrates, comprising most reptiles and mammals, have two distinct olfactory systems—the main olfactory system, and the accessory olfactory system (used mainly to detect pheromones). For air-breathing animals, the main olfactory system identifies instable chemicals, and the accessory olfactory system notices fluid-phase chemicals. Olfaction and taste are forms of chemoreception. The chemicals that arouse the olfactory system at very low concentrations are called odorants. Volatile small molecule odorants, non-volatile proteins, and non-volatile hydrocarbons may all yield olfactory sensations. Some animal species are able to smell carbon dioxide in minute concentrations. Taste sensations are triggered by small organic molecules and proteins.

2.1 How brain detects odor

Smell is first response to stimuli. It alarms us to fire before we realise flames. But although smell is a simple sense, it's also at the front of neurological investigation. Scientists are still determining how humans pick up odorants, understand them and process them as smells.

Smell, like taste, is a chemical sense professed by sensory cells called chemoreceptors. When an odorant arouses the chemoreceptors in the nose that perceive smell, they permit electrical impulses to the brain. After that the brain construes patterns in electrical activity as exact odors and olfactory feeling becomes insight - something we can distinguish as smell. The only other chemical system that can quickly identify, make sense of and memorize new molecules is the immune system.

But smell, more so than any other sense, is also closely related to the parts of the brain that process emotion and associative learning. The olfactory bulb in the brain, which sorts sensation into perception, is part of the limbic system - a system that comprises the amygdala and hippocampus, structures vital to our behavior, mood and memory. This link to brain's emotional center makes smell an appealing edge in neuroscience and behavioral science.

2.2 How the sense of smell works

The sense of smell is a chemical sense. They are called chemical senses because they notice chemicals in the environment, with the alteration being that smell works at intensely larger distances than that of taste. The process of smelling goes more or less like this:

• Vaporized odor molecules moving in the air touch the nostrils and melt in the mucus (which is at the start of each nostril).

• Under the mucus, in the olfactory epithelium, dedicated receptor cells called olfactory receptor neurons perceive the odor. These neurons are proficient of noticing thousands of different odors.

• The olfactory receptor neurons convey the information to the olfactory bulbs, which are situated at the back of the nose.

• The olfactory bulbs has sensory receptors that are a part of the brain which send messages directly to: the most primitive brain centers where they effect emotions and memories, and

• “Higher” centers where they adjust conscious thought (neo-cortex).

• These brain centers recognise odors and access memories to remind us about places, people, or events connected with these olfactory sensations [2].

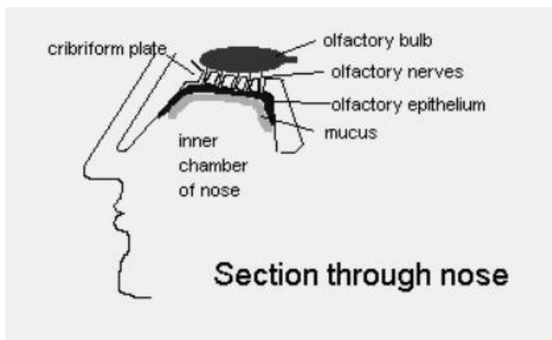

Figure 1. Section through nose

3. Effects of different Odors

Hironobu Kamimuraet. al. considered both psychological and physiological parameters to explore the effects of odors on human body during a footbath. The study used two odors: lemon and hinoki on human body while the subjects took footbath. The subjects were 10 healthy college students. The researchers divided the experiment into two parts. The first part was the baseline period of 5 minutes. In this part the subjects simply remained seated. During the second period the subjects continued to remain seated with their feet immersed in a footbath for 11 minutes. At the same time the subjects were exposed to different odors. Lemon was used as ‘pleasant’ odor and Hinoki was used for the odor termed ‘Japanese bath’. The results of our experiments showed that the use of both lemon and Hinokiodors significantly increased body temperature (36 degree). Using Graphical modeling a correlation was observed between the use of different odors and subjects’ impressions of the heat of the water in the footbath. Use of both the pleasant and Japanese bath odors showed a prominent effect on the subjects’ physiological and psychological presentation. Particularly *at 36 degree Hinokiodor has a good amount of relationship to physiological parameter, at 40 degree lemon odor has a nice relationship with physiological parameter* [3].

The same authors **Hironobu Kamimura**et. al. studied the effects of lavender and peppermint odors on human body at 36^{o} C and 40^{o} C. The study was carried out while the subjects took footbath. The subjects were 12 healthy college students. First of all, baseline was taken for 5 minutes during which the subjects remained ideal. During the second period the students continued to remain seated and immersed their feet in a footbath for 11 minutes. At the same time the students were exposed to different odors. Peppermint was used as a ‘refreshing’ odor and lavender was used a ‘relaxing’ one. The results of the research showed that the use of peppermint resulted in a notable increase in energy expenditure as compared with the absence of odors. On the other hand, lavender resulted in a significant decrease on energy expenditure and O2Hb: cerebral blood flow. Thus, *lavender odor affected the Parasympathetic nerve system, while peppermint had an inverse effect on the sympathetic nerve system.At 40°C the lavender odor also showed a prominent effect on the subjects' physiological and psychological performances* [4].

Hidenori Tanaka et. al. studied the effects of lavender during a cognitive task. It was explored whether the auditory cognitive processes affect mental stress of listener. Some pre-experiments were conducted before the main one. The pre-experiments were made to achieve” time responses of secretory immunoglobin A (s-IgA) in response to stimuli. The main experiment was to observe the response of salivary s-IgA during repetitive auditory cognitive task and the effect of odor (lavender) on the response. 10 healthy subjects were asked to perform the task in which subjects must continuously respond to a particular auditory stimuli amongst three kinds of stimuli, three times repeatedly being exposed to the odor of lavender. After each task, it follows 3 minutes interval with no task. Before and after each task, saliva samples were collected. As a result, *s-IgA secretion rate enlarged during the repetitive cognitive task in odorless state. In odor condition, the average value of s-IgA secretion rate was always more than that during the repetitive task without odor*[5].

T. Hongratanaworakit and G. Buchbaueret. al. observed human behaviour and physiological reactions to inhalation of sweet orange oil. The main objective of the research was to investigate the effects of this fragrance compound on physiological parameters as well as self-evaluation in healthy human subjects following inhalation. Physiological parameters recorded were breathing rate, blood pressure, skin temperature, and heart rate. Self-evaluation was measured in terms of attentiveness, alertness, calmness, mood, relaxation, and energy. Furthermore, the fragrance was rated in terms of pleasantness, intensity, and effect. *Sweet orange oil caused noteworthy growths in heart rate as well as in subjective alertness, which are likely to signify a stimulating effect of the oil.* These findings deliver scientific proof for the use of sweet orange oil in aromatherapy for the relief of mild forms of depression and stress in humans [6].

Hiroshi Yamada et. al. researched on the performance and physical responses during an attention shift task with grapefruit and skatoleodor presentation. Performance and physiological responses while execution of an attention shift task were compared between grapefruit odor, skatole, odorless air presentation. Ten male students participated in this experiment. They performed 15 min digit detection task three times which required quick attention shift. During the task, 1 min odor was presented three times. EEG and near infrared spectroscopy were supervised through the experiment. Also, it presented physiological values of oxy-Hb, deoxy-Hb and beta wave component. *The number of correct responses and reaction time were better in both grapefruit and skatole presentation than in odorlessair.While grapefruit presentation, oxy-Hb increased that indicated activated brain function, also it was observed only in grapefruit presentation at left forehead. Increased beta wave component that reflects relaxation, was found in grapefruit presentation at F4 (left middle forehead), while decreased beta in skatoke presentation.* These findings suggest grapefruit acts as an activator, while skatole as a sedative [7].

Takayuki Koike et. al. studied the effects of odorant presentation on changes in cognitive interference and brain activity during a counting stroop task. Cognitive task for longer duration increases subject's psychological loadings because of extracting ordered answer from visual stimuli. The present study examined how sporadic odorant presentation during cognitive task donates to cognitive function and statement of psychological loadings. Ten subjects were instructed to perform counting stroop task that repeatedly counts the pieces of digits displayed on a monitor. The task consisted three tasks that the digits and the number were consisted (task1), non-consisted (task2), and both the former tasks combined (task3). The duration of each task was four minutes, and thus subjects totally performed the tasks for 12 minutes. Four kinds of odorant stimuli (non-odor, lemon, peppermint and skatole) were used in this study and each odor was presented after beginning of each task for one minute. Behavioral results, rate of content of alpha, beta, delta and theta waves from EEG, and oxygenated haemoglobin concentration (ΔO2Hb) were measured and compared between each odor condition. Behavioral results, the reaction time and the percentage of questions answered correctly, ΔO2Hb in right hemisphere related to pleasant emotion, and rate of content of alpha wave were significantly increased when peppermint and skatole were presented. The findings indicated that intermittent odor presentation induced pleasant emotion and increased cognitive function and state of concentration, regardless of odors [8].

Rob W. Holland, MerelHendriks and HenkAartsobserved the non-conscious effects of odors. Three studies discovered whether odor can influence people's cognition and conduct without their being consciously aware of the stimulus. In two studies, it was verified and established that when participants were unremarkably exposed to citrus-scented all-purpose cleaner, the mental convenience of the performance concept of cleaning was enhanced, as was indicated by faster identification of cleaning-related words in a lexical decision task and higher frequency of listing cleaning-related activities when describing expected behavior during the day. Finally, a third study recognised that the simple exposure to the scent of all-purpose cleaner caused participants to keep their direct environment cleaner during an eating task. Awareness checks showed that participants were ignorant of this influence [9].

Anne L. James explored the effects of odor on Compliance and Willingness to Volunteer. The study aimed on the effects of lavender and peppermint ambient odor on compliance and volunteerism. Sixty undergraduate students contributed by answering a questionnaire that had been saturated or not saturated with odor. Helping behavior was judged by the participants' willingness to take part in a brief telephone survey and to mail back food labels. Noteworthy results were obtained for odor on both compliance and willingness to volunteer. As a result, *the peppermint group to be significantly more compliant and willing to volunteer than the lavender group and significantly more willing to volunteer than the no odor group* [10].

Mark Moss et. al. used the aromas of peppermint and ylangylang. This study provides indication for the impression of the aromas on aspects of cognition and mood in healthy contestants. One hundred and forty-four volunteers were randomly consigned to conditions of ylang-ylang aroma, peppermint aroma, or no aroma control. Cognitive performance was calculated using the Cognitive Drug Research computerized assessment battery and mood scales were completed before and after cognitive testing. *Peppermint was found to enhance memory whereas ylang-ylang impaired it, and elongated processing speed.* In terms of subjective mood peppermint increased alertness and ylang-ylang decreased it, but meaningfully increased calmness. These results offer support for the contention that the aromas of essential oils can yield significant and characteristic effects on both subjective and objective assessments of aspects of human behaviour [11].

Jean-Louis Millotet. al studied the effects of odors on reaction times of humans. The research equated the reaction times of subjects between ambient odor conditions both pleasant and unpleasant and a no odor condition. *The results showed that the reaction time in simple tasks (responses to visual or auditory stimulation) expressively decreased in the ambient odor conditions compared with the no odor condition* [12].

Hiroaki Tsujimotoet. al. predicted the feeling of subject under odor condition using physiological information. In this study, the researchers have measured an EEG activity of a subject who was exposed to odor. The influence of the odor stimulation by a chaotic analysis and a frequency analysis was computed. The affection of odor stimulation could be observed even if the subject did not consciously feel the odor. *The results showed that in the preferred odor stimulation the chaotic value of EEG data decreased slowly but it of the un-preferred odor stimulation dispersed.* The change of the feeling of subject by the odor stimulation was also explored and the feeling of subject by the more suitable several explanatory variates selected from physiological information could be predicted [13].

AshkanYazdaniet. al. observed the EEG alterations during pleasant and unpleasant odors. In this research, electroencephalogram (EEG) of five participants during perception of unpleasant and pleasant odor stimuli were analysed. The regions of the brain cortex that are active during discrimination of unpleasant and pleasant odorstimuli were also found. *It was shown that classification of EEG signals during perception of odor scan reveal the pleasantness of the odor with relatively high-accuracy* [14].

Tatsuya Iwaki and Mika Noshirostudied the EEG Activity over Frontal Regions during Positive and Negative Emotional Experience. It has been shown that frontal EEG activity has potential for estimating emotional state. Fifteen university students partook in both the image and odor stimulus periods. They were coached to adjust a dial to rate their subjective emotional intensity during the period between the onset of image/odor presentation and the offset of a blank screen presentation. Standard 21 channel electroencephalograms were acquired and analysed. After that laterality, coherence and frequency fluctuation of the alpha band of frontal EEG signals were compared amongst control, pleasantness and unpleasantness conditions. *The results indicated that both the laterality model and the frequency fluctuation model were able to estimate emotional state from frontal alpha band EEG activity.* However, the sensory modality of the stimulation influenced the laterality of frontal cortical activity, as indicated by a difference in the laterality index between the image and odor sessions [15].

Hironobu Kamimuraet. al. studied the effects of pleasant and unpleasant odor on recovery period after moderate exercise by different types of breathing. The subjects were nine healthy college students. The experiment was divided into three sessions. The first was the baseline period of six minutes. During this part, the subjects remained seated. During the second period the subjects exercised for twelve minutes on an exercise bike. In the final period, the subjects were seated again during which time they were exposed to a number of different odors. Students' breathing was also verified and checked, the breathing divided into either students' natural breathing cycle, or inhalation through the nose and exhalation through the mouth. Odors rated 'pleasant' by the students did not result in any changes in their respiratory metabolism. However, exposure to unpleasant odors resulted in significant change in the respiratory metabolism during the recovery period. *The results of the experiment suggest that the exposure to an unpleasant odor, combined with breathing in through the nose and out through the mouth, had a notable effect on the student's respiratory metabolism* [16].

H.Tsujimotoet. al. analysed EEG signals stimulated by pleasant and unpleasant odors. In this study, EEG activity of a subject who was exposed to the odor was measured and the influence of the odor stimulation by a chaotic analysis and a frequency analysis was computed. It could be considered to be measurable the affection of odor stimulation even if one is not conscious the odor. *The results showed that in the case of the pleasant odor stimulation the chaotic value of EEG data decreased slowly with a time but it of the unpleasant odor stimulation dispersed* [17].

4. Conclusion

Inhaling the appropriate fragrance can reduce stress, lift depression, hasten a good night's sleep, soothe your soul, or give you more energy. Nothing is more memorable than a smell. One scent can be unexpected, momentary and fleeting, yet conjure up a childhood summer beside a lake in the mountains. Keeping these points under consideration, odor is used can be used as an intervention to enhance the cognitive abilities. It can be concluded that with different effects of aromas an individual can look forward to extension of his/her cognitive abilities.

5. Future Scope

Effect of odor on various cognitive abilities like different emotion states will be studied on healthy engineering students. Odor of lemon shall be used for a short-time study of fifteen days.

References

[1] Mandeep Singh, Smiti Sachdeva, "Cognitive Assessment Techniques", In press

[2] "The Sense of Smell: A Powerful Sense", available at https://www.tsbvi.edu/seehear/summer05/smell.htm

[3] Hironobu Kamimura, NoriakiKaneki, Takayuki Koike, Hiroshi Yamada, "Effects of Peppermint and Lavender Odors on the Human Body during a footbath at water temperatures of 36°C and 40°C", International Conference on Biometrics and Kansei Engineering, 2011

[4] Hironobu Kamimura, NoriakiKaneki, Takayuki Koike, Hiroshi Yamada, "The Graphical Modeling of the Physiological and Psychological Effects of Odors on the Human Body during a footbath", International Conference on Digital Object Identifier, pp. 69-74, 2010

[5] Hidenori TANAKA, Jun-ichi IMAI, Shusaku NOMUR, Noriaki KANEKI, Koji SHIMADA, Nobuyo KASUGA, Tomomasa NAGASHIMA, "Effects of the Odor of Lavender on the Change of Immunoglobulin A Level during Repetitive Cognitive Task", Journal of the Asian Design International Conference, Volume 1, 2003

[6] T. Hongratanaworakit, G. Buchbauer, "Human Behavioral and Physiological Reactions to Inhalation of Sweet Orange Oil", 3rd World Congress on Medical and Aromatic Plants for Human Welfare (WOCMAPIII), Chiangmai, Thailand, 2003.

[7] Hiroshi Yamada, NoriakiKaneki, Hironobu Kamimura, Takayuki Koike, "The performance and physical responses during an attention shift task with grapefruit and skatoleodor presentation", International Conference on Digital Object Identifier, pp. 66-68, 2010

[8] Takayuki Koike, NoriakiKaneki, Hiroshi Yamada, Hironobu Kamimura, "Effect of odorant presentation on changes in cognitive interference and brain activity during counting Stroop task", International Conference on Biometrics and Kansei Engineering, 2011

[9] Rob W. Holland, MerelHendriks and HenkAarts, "Smells Like Clean Spirit: Non-conscious Effects of Scent on Cognition and Behavior", Psychological Science, Volume 16, Number 9, pp. 689- 693, 2005

[10] Anne L. James, "The Effects of Odor on Compliance and Willingness to Volunteer", Journal of Undergraduate Psychological Research, Volume 1, 2006

[11] Mark Moss, Steven Hewitt, Lucy Moss, "Modulation of Cognitive Performance and Mood by Aromas of Peppermint and Ylang-Ylang", Intern. J. Neuroscience, 118, pp. 59–77, 2008, doi: 10.1080/00207450601042094

[12] Jean-Louis Millot, Ge´ rard Brand, Nade`geMorand, "Effects of ambient odors on reaction time in humans", Neuroscience Letters 322, pp. 79–82, 2002

[13] Hiroaki Tsujimoto, Masanori Tsutsumi and Syogo Nishida, "Prediction of Feeling of Subject under Odor Stimulation using Physiological Information", Proceedings - 19th International Conference - IEEE/EMBS Oct. 30 - Nov. 2, 1997

[14] AshkanYazdani, EleniKroupi, Jean-Marc Vesi, TouradjEbrahimi, "Electroencephalogram Alterations during Perception of Pleasant and Unpleasant Odors"

[15] Tatsuya Iwaki and Mika Noshiro, "EEG Activity over Frontal Regions during Positive and Negative Emotional Experience", International Conference on Digital Object Identifier, pp. 418-422, 2012

[16] Hironobu Kamimura, NoriakiKaneki, Kohji Shimada, Haruki Sasaki, "Effect of Pleasant and Unpleasant Odor on Recovery Period After Moderate Exercise by Different Types of Breathing", International Conference on Biometrics and Kansei Engineering, 2009

[17] H.Tsujimoto, M.Tsutsumi, NSaiwaki and S.Nishida, "Chaotic Analysis of EEG Activities Stimulated by Pleasant Odor and Unpleasant Odor", 18th Annual International Conference of the IEEE Engineering in Mcdicinc and Biology Society, Amsterdam 1996.