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THE EFFECTS OF PEPPERMINT ON ENHANCING MENTAL PERFORMANCE AND COGNITIVE FUNCTIONING, PAIN THRESHOLD AND TOLERANCE, DIGESTION AND DIGESTIVE PROCESSES, AND ATHLETIC PERFORMANCE

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"If someone offers you a breath mint, accept it."

--H. Jackson Brown, Jr.

INTRODUCTION

Anecdotal references to the peppermint plant (Mentha piperita) have existed for centuries. Peppermint itself is a hybrid of both spearmint (Mentha Spicata) and water mint (Mentha Aquatica), and has square stems, pointed dark green or purple oval leaves, and lilac-colored flowers. The peppermint plant contains over 40 distinct chemical compounds (including menthol, menthone, and menthyl acetate), and has been proven safe for consumption (both in its plant and essential oil stages) in toxicological investigations (Nair, 2001).

A casual internet search of "peppermint" will produce a wide variety of claims concerning its use and efficacy. For example, chewing the leaves of the peppermint plant, or applying the essential oils of peppermint, have been touted as an analgesic, anti-inflammatory, antiseptic, anti-infectious, antimicrobial, antispasmodic, astringent, carminative, digestive, expectorant, febrifuge, fungicidal, nervine, vasoconstrictor, decongestant, stimulant, cognitive enhancer, and stomachic.

While the mints in our grandmother's purse and the candy canes hanging on the holiday tree may actually produce such wide-range effects, this review will focus on the available scientific evidence, leaving myth and folklore aside. Specifically, it will examine the effects of peppermint on improving mental performance and cognitive functioning, pain threshold and tolerance, digestion and digestive processes, and athletic performance.

MENTAL PERFORMANCE AND COGNITIVE FUNCTIONING

White (1998) suggested that cognitive enhancement is not only possible through some fundamental means, but that it occurs every day. Through substances such as sugar and caffeine, memories and their recall are persistently strengthened and enhanced (Rusted, 1994). Additionally, Driskell, Copper, and Moran (1994) showed that basic mental practice (ie., cognitive rehearsal of a task prior to performance) significantly enhances the processing and retention of information.

Researchers have also shown that specific odors aid in an individual's recall of information that was originally learned in the presence of that odor (Hoffman, 1987; Lavabre, 1990; Price, 1991; Smith, Standing, & de Man, 1992; Valnet, 1982). This has been termed "context-dependent learning." The simplest explanation for context-dependent learning is that certain aspects of the environment tend to cue one's recall of important information. Thus, odors can remind people of past experiences, important exam information, or even one's favorite restaurant. Ultimately, the environment in which a person learns has a huge impact on his or her ability to encode information and recall it upon demand.

According to Göbel, Schmidt, and Soyka (1994), the combination of peppermint oil, eucalyptus oil, and ethanol increases cognitive performance. Based on this evidence, Sullivan, Warm, Schefft, Dember, O'Dell, and Peterson (1998) had 20 participants with brain injury and 20 control participants perform a sustained vigilance task. The task was to indicate "critical signals" on a computer screen, much like is required of air traffic controllers when they are attempting to locate planes in relation to each other. During the task, participants received periodic infusions of either unscented air or air scented with peppermint. When presented with the peppermint odorant, the control condition participants made fewer errors and were more attentive to the task. In addition, exposure to the scent of peppermint brought about comparable scores for both the control group and the brain injury group.

More recently, Zoladz, Raudenbush, and Lilley (2004) have examined the effects of peppermint odor on augmenting cognitive performance. The study was divided into two phases: Phase I investigated the effects of retronasal (ie., through the mouth) odorants, while Phase II investigated the effects of orthonasal (ie., through the nose) odorants. During Phase I, participants completed cognitive tasks on a computer-based program called Impact® under five "chewing gum" conditions (no gum, flavorless gum, peppermint gum, cinnamon gum, and cherry gum). The Impact® software assesses a wide range of cognitive abilities, such as word discrimination, attention, verbal recognition memory, visual recognition memory, visual processing speed, retention memory for novel symbols, reaction time, impulse control/response inhibition, working memory, and visual-motor response speed. During Phase II, participants completed the Impact® software tasks under four odorant conditions (no odor, peppermint odor, jasmine odor, and cinnamon odor), delivered via low flow (1.3 L/min) oxygen through a nasal cannula. Peppermint odor, administered either retronasally or orthonasally, improved participants' scores on tasks related to attentional processes, virtual recognition memory, working memory, and visual-motor response speed. In addition, participants rated their mood and level of vigor higher, and their level of fatigue lower, in the peppermint condition. Administration of cinnamon odor, either retronasally or orthonasally, also lead to increases in attentional processes, virtual recognition memory, and working memory, although to a lesser degree than peppermint odor. No effects were found for cherry or jasmine.

A study conducted by Barker, Grayhem, Koon, Perkins, Whalen, and Raudenbush (2003), assessed whether such increases in cognitive performance through peppermint odor administration would also impact actual office-work clerical tasks. Participants completed three clerical tests--typing, memorization, and alphabetization--in either a non-odored or a peppermint-odored condition. Typing performance was measured using the TypingMaster© program, which presented the participant with a list of nonsensical letter combinations, which the participant then recreated to the best of his/her ability. The program measured typing duration, gross speed, accuracy, and net speed. An electronic memory device was used to measure memory, for which a sequence of lights and tones is initiated and the participant is required to recreate the sequence. For the alphabetization task, 30 words, each beginning with the letter "b" were alphabetized. A significant difference was found in the gross speed, net speed, and accuracy on the typing task, with peppermint odor associated with improved performance. Alphabetization ability also improved significantly in the peppermint odor condition, although there was no significant difference in memorization.

PAIN THRESHOLD AND TOLERANCE

The implications of modifying pain threshold and tolerance to the human population are immense, particularly given that pain is claimed to be the most costly health problem in America (NINDS, 2000). Low back pain accounts for 93 million workdays lost every year and costs over $5 billion in health care. The majority of patients in intermediate or advanced stages of cancer suffer moderate to severe pain, with more than 800,000 new cases of cancer diagnosed each year in the US (and some 430,000 people dying). Arthritis pain affects 20 million Americans and costs over $4 billion in lost income, productivity, and health care. At least 40 million Americans suffer chronic, recurrent headaches and spend $4 billion a year on medications. Migraine sufferers alone account for 65 million workdays lost annually. In short, the annual costs of pain, including direct medical expenses, lost income, lost productivity, compensation payments, and legal charges, are close to $50 billion (NINDS, 2000).

If certain odors diminish the pain response, a variety of non-pharmacological adjuncts to pain control could be developed, without the concerns of chemical interactions or drug addiction. In addition, quality of life might be raised for individuals suffering from acute pain, as well as decreasing the amount of money and resources currently allocated to pain-related health care.

Mellier and colleagues (Jahangeer, Mellier & Caston, 1997; Mellier, Bezard & Caston, 1997) found that positively hedonic odors decrease the pain response in mice, while negatively hedonic odors increase the pain response. Thus, the stage was set for the possibility of peppermint odor to modify the pain response.

A significant analgesic effect with a reduction in sensitivity to headache was produced by a combination of peppermint oil and ethanol (Göbel, Schmidt, & Soyka, 1994). Mauskop (2001) found that the external application of peppermint extract raised the pain threshold in humans. Further, Davies, Harding, and Baranowski (2002) note a case study of a 76-year-old woman whose pain had been resistant to standard therapies. The application of peppermint oil to her skin resulted in a significant decrease in her pain, with the duration of analgesia lasting between 4 and 6 hours after application.

Raudenbush, Koon, Meyer, and Flower (2002) had participants undergo a cold pressor test and report their pain level using a 0-10 scale every 30 seconds, to a maximum of 5 minutes. The cold pressor test involved submersing the hand and forearm into a circulating water bath maintained at 3 degrees Celcius. During testing, participants wore nasal cannulas which administered either low-flow oxygen, peppermint odor plus oxygen, or jasmine odor plus oxygen. Physiological measures (heart rate, blood pressure, and oxygen saturation) were recorded throughout the protocol. Participants then completed three questionnaires. The first questionnaire was the NASA-TLX (NASA Task Load Index; Hart & Staveland, 1988), which is a subjective scale of mental and physical workload. This multi-dimensional scale measures specific components of workload in a given task along three dimensions related to demands imposed on the participant by the task (mental, physical, temporal) and three dimensions related to the interaction of the participant and the task (effort, frustration, performance). The second questionnaire was the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971). This instrument contains a list of 65 adjectives concerning current mood and provides sub-scale scores related to fatigue, vigor, and anxiety. Finally, participants completed the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushere, 1970). This inventory consists of 40 statements related to anxiety.

The results indicate that peppermint and jasmine odor significantly decreased ratings of pain over time and increased overall pain tolerance. Participants also reported reduced mental, physical, and temporal workload requirements, decreased effort and frustration, and increased performance and vigor in the odorant conditions. Physiologically, odorant administration resulted in an increase in oxygen saturation and pulse, and a decrease in blood pressure.

DIGESTIVE AND DIGESTIVE-ASSOCIATED PROCESSES

One of the earliest recorded accounts of peppermint's efficacy in the digestive process came from Necheles and Meyer (1935), who found that the ingestion of peppermint reduces gastric secretions. Since that time, several studies have found positive effects of peppermint in the digestive and digestive-associated processes.

Taken after a meal, peppermint has been found to reduce indigestion and colonic spasms by reducing the gastrocolic reflex (Asao, Mochiki, Suzuki, Nakamura, Hirayama, Morinaga, Shoji, Shitara, & Kuwano, 2001; Spirling & Daniels, 2001), and thus serves as an aid to digestion (Goerg & Spilker, 2003; May, Kohler, & Schneider, 2000). Peppermint has also been found to effect gastroduodenal motility (Micklefield, Greving, & May, 2000), and relieve symptoms of irritable bowl syndrome (Kline, Kline, DiPalma, Barbero, 2001; Liu, Chen, Yeh, Huang, Poon, 1997; Pittler & Ernst, 1998; Sagduyu, 2002). For those individuals already suffering from gastronomical distress, the administration of peppermint has been found to relieve some of the associated nausea (Tate, 1997).

ATHLETIC PERFORMANCE

Since mood, physiological arousal, and athletic performance are highly related in a variety of sport contexts (Morgan, O'Connor, Ellickson & Bradley, 1988; Newby & Simpson, 1994, 1996; Reilly, 1977; Totterdell, 1999), Raudenbush, Meyer, and Eppich (2002) attempted to determine whether the changes in mood and physiology brought about by odor administration would have any effect on athletic performance.

In their study, athletes performed a 15 minute treadmill exercise stress test under each of four odorant conditions (peppermint, jasmine, dimethyl sulfide, or a non-odored control condition) delivered via a nasal cannula. Athletes began their treadmill testing at 1.7 mph on a 10% grade and progressed to the point of 5 mph on a 18% grade, which is a modified version of the Bruce Protocol (Bruce, 1963; 1967). Participants also completed the NASA-TLX (Task Load Index; Hart & Staveland, 1988) and the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971).

Peppermint odor administration significantly reduced perceived physical workload, temporal workload, effort, and frustration. Self-evaluated performance was also greater in the peppermint condition, and participants rated their level of vigor higher, and their level of fatigue lower. No effects were noted for the jasmine condition, however, administration of dimethyl sulfide lead to a decrease in mood.

Based on these results, Raudenbush, Corley, and Eppich (2001) attempted to determine if actual physical tasks would be augmented by the administration of peppermint odor. In the testing phase, athletes performed four tasks: 1) dynamometer hand grip, 2) a 400 meter dash, 3) push-ups to exhaustion, and 4) 20 basketball free- throw shots. Participants performed the protocol twice, each time under a different odor condition. Condition one consisted of the placement of a peppermint odorized adhesive strip under the participant's nose. Condition two was identical, with the exception that the adhesive strip was odor-free. The peppermint odor condition resulted in increases in running speed, hand grip strength, and number of push-ups, but had no effect on more skill-related tasks, such as basketball free-throw shots.

Raudenbush, Smith, Graham, and McCune (2004) assessed whether the degree to which athletes inhale peppermint odor affects such aspects as motivation, energy, fatigue, reaction time, confidence, and performance during the course of a basketball season. Male and female Division II basketball players were provided with a peppermint inhaler (Peak Performance™ Sports Inhaler™) for use during practice and game play. At the conclusion of the basketball season, the athletes completed a questionnaire which measured their level of peppermint inhaler use, as well as the effects of the peppermint inhalation on various aspects of athletic performance. The level of peppermint use was used to determined group placement for statistical analyses. Higher levels of peppermint inhalant use were associated with self-reported increases in motivation, energy, speed, alertness, reaction time, confidence, and strength. Levels of fatigue and frustration were lower in the high-use group. In addition, athletes' ratings of their competitive advantage over opponents and ratings of overall performance were significantly enhanced.

The above findings have also been replicated when the odor of peppermint was added to drinking water during a workout (Schuler, Rawson, & Raudenbush, 2004). In this study, athletes performed a 15 minute treadmill stress test (as noted above). At 3 minute intervals, 50 mL of beverage (peppermint water, unadulterated water, or Gaterade® sports drink) were consumed. In the control condition, no beverage was consumed. Both the peppermint drink and Gaterade® sports drink lead to greater ratings of personal performance and increased mood.

The mechanism of action for athletic augmentation may reside in changes in brain activity. Kimura, Mori, Suzuki, Endo, Kawano (2001) examined the effects of odors on changes in EEG after a monotonous stress task known as the Uchida-Kraeppelin test. The participants were exposed to one of four odors (peppermint, bergamot, lavender, sandalwood) and a non-odored control condition. The non-odored control condition was associated with an increase in _ and _ amplitude. Peppermint odor significantly increased _$_1$ and _$_2$ amplitudes compared with the other odors, and raised level of arousal, suggesting that peppermint odor may prevent a reduction of arousal level after the stress task.

Other explanations, however, are also possible. Umezu, Sakata, and Ito (2001) have found that the injection of peppermint into mice significantly increases ambulatory activity, thus serving as a central nervous system stimulant. In addition, the inhalation of peppermint odor facilitates the breathing process as measured by a Vitalograph AsmaPLAN+™ Peak Flow Meter (Raudenbush & Zoladz, 2003). After inhalation of peppermint odor, participants were found to increase their nasal force, thus providing more oxygen-rick blood which could be used for sustaining physical performance.

CONCLUSIONS

The administration of peppermint odor has undoubtably played a dramatic role in promoting a greater quality of life for many individuals. Experimental evidence concerning the effects of peppermint continue to grow. With peppermint's ability to enhance both cognitive and athletic performance, most likely a variety of new products will soon be marketed which capitalize on the all-natural, non-pharmaceutical properties of peppermint. In addition, research will begin examining the effectiveness of peppermint-based analgesics for mild to moderate pain reactions. Candy cane anyone?

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