ABSTRACT:

My research examines the relationship between olfaction, memory, and emotion and its practical and clinical implications. Our sense of smell is often taken for granted, but its ability to trigger powerful emotions and memories has been widely documented in the literature. Olfactory associative learning has been studied in a wide range of areas, including rats, school children, dental patients, and soldiers with PTSD.

There is a close and complex relationship between olfaction, memory, and emotion. This paper will examine this relationship, and its possible real life implications. The relationship between olfaction, memory, and emotion has been described in the literature as the Proust effect. The Proust effect maintains that odor-evoked memories of meaningful autobiographical experiences are powerful and emotional.¹

Marcel Proust (1915), the phenomenon’s namesake wrote the following in his novel *Swann’s Way*:

> When from a long-distant past nothing subsists, after the people are dead, after the things are broken and scattered, still, alone, more fragile, but with more vitality, more unsubstantial, more persistent, more faithful, the smell and taste of things remain poised a long time, like souls, ready to remind us, waiting and hoping for their moment, amid the ruins of all the rest; and bear unaltering, in the tiny and almost impalpable drop of their essence, the vast structure of recollection.²

Many people have an anecdote about an emotional, personal memory triggered by an odor. For example, the smell of a specific perfume, baking cookies, a rose, or burning leaves can cause some to feel pleasant emotions and remember a specific moment in their life. Odors may also trigger negative emotional reactions and memories, depending on personal
experiences. The smell of burning leaves may evoke a warm pleasurable memory of a fall day in the country for one person; it might evoke negative painful memories and emotions for another person who was burned by a bonfire as a child. The Proust effect would account for these strong memories and emotions by the olfactory cues associated with these experiences.

One explanation for the Proust effect may be that olfaction is connected to the amygdala, which is where emotional associative learning takes place in humans.³ Olfactory processing and the assigning of affective value to stimuli both take place in the orbital frontal cortex, which provides further explanation of the memory aspects of the Proust effect.⁴ These close physiological connections help account for the relationship between olfaction, memory, and emotion. Researchers have further studied this relationship in animals as well as humans.

Several studies have shown support for the Proust effect. One conducted by Herz (1996) found that when memories were evoked by odors they were more emotional than verbally cued memories.⁵ Researchers have also found that when an individual is exposed to a neutral odorant that is paired with an adverse or pleasant stimuli, the two become associated or conditioned, and that odors can have a profound impact on emotional states, based on past experiences.⁶ ⁷ ⁸

Paschal and Davis (2002) conducted a study of olfactory-associated learning in rats. They measured rats’ startle responses when paired with conditioned odorant stimuli. They paired an ambient odor (i.e., the conditioned stimuli) in a petri dish under the cage with foot shocks. For 1–40 days after the conditioning was completed the rats displayed significant potentiated startle responses to a noise paired with the odor compared to rats who were not trained to associate the odor with the foot shocks. The authors note that in most studies the effects of an odor-conditioned stimulus wore off after 40 days.⁹ Testing in rats has shown that they are quite susceptible to associative learning through olfactory stimulation, but not auditory or visual stimuli. Olfaction is an important sensory system for rats and other mammals because “it is critical for reproductive and appetitive behavior, as well as for fear and avoidant responses”.¹⁰ In this study the rats learned that the odor was associated with an adverse stimulus and were more likely to startle than those who had not been conditioned to the stimulus. Other studies have found similar results for olfactory associated learning in rats.¹¹
Researchers have also examined olfactory associated learning with emotion in humans. Having dental work done or even the thought of visiting a dentist can be an emotionally and physically traumatic experience for some individuals. Robin, Alaoui-Ismaïli, Dittmar, and Vernet-Maury (1998), examined the effects of dental office odorants, specifically eugenol (from cements used in restorative dental work), on participants’ automatic nervous system (ANS) responses (e.g. heart rate and skin temperature). The ANS response analysis they used has previously been found to be “reliable and efficient at characterizing each individual's emotional reactivity to odorants”. The study exposed participants to the odorants and compared the ANS responses of participants who stated that they were fearful of dental care with participants who stated that they were not fearful. The researchers found that participants who were fearful were more likely to report the smell of eugenol as unpleasant and also showed “stronger autonomic reactivity” when the odor was inhaled. The fearful dental patients with higher ANS responses (i.e., more discomfort and fear) associated the smell of eugenol with painful memories of their visits to the dentist.

Many of the human studies have focused on associative learning when a neutral or novel unconditioned odorant stimulus was paired with a negative stimulus. Fewer have focused on learning with positive stimuli. Chu (2008) examined olfactory conditioning in children. The study contained three groups of children who were identified as low-achieving and lacking self-confidence. Each group took three tests: a base line test, an experimental or control test, and a retest of the baseline test. Group A was exposed to an ambient odor and their test (which they believed to be intended for older students) was easy and thus guaranteed success. Group A's test scores showed significant improvement compared to group B, which was exposed to a different odorant than the original odorant at retesting, and group C, which was not exposed to any odorants. The authors describe the improvements in group A as being due to the conditioned stimuli (the odor). The results suggest that group A was more inclined to be successful because they associated the odor during the final testing with the success in the prior test. Essentially the conditioned stimuli (the odorant presented at testing and retesting of baseline) helped improve their scores though associative learning. Studies have found that olfaction can become a conditioned stimulus in animals as well as humans, and that it can induce negative affect as well as positive affect.
Researchers have begun to examine olfactory associative learning in patients with post-traumatic stress disorder (PTSD). However, the literature is still extremely limited. Many patients with PTSD report having strong emotional and physiological reactions and often have flashbacks (i.e. vivid emotionally linked memories) that are triggered by specific conditioned odorants.\textsuperscript{18} According to Vermetten and Bremner, the mental health community has long acknowledged the phenomenon of trauma-related odorants serving as triggers or cues for flashbacks in patients with PTSD. Patients’ odor-cued flashback reports have ranged from mild and transient emotional disturbances to longer lasting and more distressing emotional disturbances.\textsuperscript{19} Although the mental health community is aware of the role that olfaction may play in triggering flashbacks in individuals with PTSD, there have been few studies that have investigated this relationship in humans. In fact, the prevalence rate of PTSD patients with olfactory-cued flashbacks is not even known.\textsuperscript{20}

Rats have even been found to exhibit PTSD-like symptoms (e.g., heightened muscle tension and diurnal hyper-vigilance) cued by trauma-related olfactory stimuli.\textsuperscript{21} Nelson, DeMartini, and Heinrichs (2010) conducted a study that examined the effects of a traumatic experience (i.e., aggressive interaction with another male rat) that was paired with an odor cue. They used male rats (residents) that were each paired in a cage with a female rat, and had established normal reproductive and territorial behaviors.\textsuperscript{22} Then they placed another male rat (intruder) in the cage. Within 20-120 seconds the resident rats threatened, chased, and pinned the intruder down. In the experimental group, researchers put a dab of a novel odor (peppermint or coconut) on the residents back before the intruder was placed in the resident’s cage. They measured muscle tension and diurnal hyper-vigilance in the experimental and control groups at baseline, and at 1, 2, and 4 weeks after the traumatic experience. They found that when the experimental intruder rats were re-exposed to the conditioned odor they exhibited significant increased muscle tension and an increase in locomotor activity compared to the control group who had not been exposed to the odorant.\textsuperscript{23} The rats who experienced a traumatic experience that was paired with an ambient odor exhibited PTSD-like symptoms when re-exposed to the ambient odor.

A collection of three case reports described by Vermetten and Bremner (2003) illustrate the nature in which trauma related odors can trigger flashbacks in symptoms with PTSD. One of the cases was of a
55-year-old Vietnam veteran. He was a paramedic in Vietnam and some of his duties included using diesel fuel to burn the soldiers’ excretions when they moved camp, as well as sometimes even bodies or body parts. After his tour was over, he went back home and developed PTSD. Among other symptoms, the smell of diesel and burning rubber, and the memories and emotions that the smells evoked were difficult for the veteran to deal with. The smells would trigger intrusive thoughts and memories that could make “him feel uncomfortable, nauseated, and sometimes guilty”. He avoided situations where he would be likely to encounter these smells. The researchers stated that ever since the traumatic events happened in his life, the impact of the related smells was still powerful enough to change his emotional state.

Few empirical studies have looked at the relationship between olfaction and PTSD flashbacks, and there are currently no specific treatments for patients that address olfactory-triggered flashbacks. There are two experimental treatment options for PTSD that involve olfactory associative learning. One alternative treatment created and researched by Abramowitz and Lichtenberg (2010) examined the effects of hypnotherapeutic olfactory conditioning (HOC) on Israeli veterans (n=56) whose symptoms included PTSD olfactory-triggered flashbacks. The HOC treatment included hypnosis, mental imagery, and the use of pleasant smelling essential oils, and consisted of six sessions lasting 90 minutes each. In the first session, the patients thought of pleasant memories while they were exposed to the essential oils. In later sessions hypnosis was used with mental imagery of the traumatic event and exposure to the pleasant essential oils. The study used a small nonrandomized trial and has not been replicated. The treatment was found by the Department of Veterans Affairs-Veterans Health Administration researchers to provide “little evidence of broad potential efficacy in PTSD.”

Another example of an experimental treatment program for patients with olfactory-triggered flashbacks is specifically targeted to treat veterans with PTSD who served in the wars in Iraq and Afghanistan. The program is called Virtual Iraq and uses virtual reality exposure therapy with olfactory stimuli (e.g. smells of ethnic cooking, smoke, etc). Empirical studies support the efficacy of exposure therapy as a treatment option for PTSD, especially when combined with cognitive behavioral therapy. The efficacy of the Virtual Iraq program has not been published to date, but the initial trials did show some “positive clinical outcomes” for
participants (n=20). More research is still needed about using virtual reality exposure therapy to treat PTSD.

There are many reasons for examining the relationship between olfaction, memory, and emotion. The studies discussed in this paper show that humans are more susceptible to olfactory associative learning than one may originally believe. Robin et al. (1998) found that patients who were fearful of dentists had strong negative emotional reactions to the smell of dental office odorants. There may be opportunities for future researchers to find ways to use olfaction to make visiting the dentist a potentially less frightening experience for dental patients. Also, researchers could possibly build on Simon Chu’s (2008) study and further examine the potential of ambient odors in the classroom as a means to improve students’ confidence and scores.

While many people have experienced the Proust effect at some point in their lives, olfactory-triggered flashbacks in individuals with PTSD may be an extreme example of this phenomenon. Two potential treatments for PTSD that incorporate olfaction were also discussed in this paper. More empirical research is still needed on the relationship between olfaction and PTSD in humans, and before an olfactory related treatment is developed the mental health community should at least find the prevalence rate of reported odor-triggered flashbacks. Emotional olfactory associative learning is a process that is often taken for granted but is widely documented in animals as well as humans. There is much potential for future research to further our understanding of the relationship between olfaction, memory, and emotion. It has been nearly 100 years since Marcel Proust first wrote about the subtle, yet powerful abilities of our sense of smell and its emotional memory-provoking capacity. It will most likely be many more years before we come to fully understand this relationship.

ENDNOTES


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Vermetten & Bremner


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