

Olfaction as a Traumatic Reminder in Posttraumatic Stress Disorder: Case Reports and Review

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Background: Memory for odors that are associated with intense emotional experiences is often strongly engraved. Odors are claimed to be more closely connected to affect than other sensory experiences. They can serve as potent contextual cues for memory formation and emotional conditioning and can also serve as cues for olfactory flashbacks. Though trauma-related smells have long been noted by clinicians to be precipitants of traumatic memories in patients with posttraumatic stress disorder (PTSD), very few reports have been published that document this.

Case reports: We review olfactory memories and olfactory flashbacks by presenting 3 cases that illustrate the role of olfaction in PTSD. In these cases olfaction is either a precipitant of PTSD symptoms or an important component of reexperiencing.

Discussion: In PTSD, seemingly nonspecific cues have the potential to precipitate traumatic memories with strong emotional components. These conditioned responses in PTSD are hypothesized to be mediated by specific brain areas, i.e., amygdala, hippocampus, and orbitofrontal cortex. Questions about smells as a traumatic reminder should be part of the routine assessment of intrusive memories in PTSD. In addition, smells may have the potential to provide cues to exposure situations in therapy or to facilitate de novo conditioning.

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Odor memory is unique in the sense that it is different than other modalities of memory. Odor memory is independent of other types of memory and is long lasting, with a resistance to decay over long intervals.^{1,2} This view, known now as the “Proustian” view, also holds that odor memory is excellent for odors associated with significant autobiographical experiences.³ The relationship between olfaction and autobiographical memories appears to be stronger when the experiences are more significant and emotionally charged. Moreover, this relationship suggests that odors are more closely connected to affect and emotion than are other sensory experiences.^{3–5} While an abundance of animal studies have supported these notions, there is little human empirical research^{6,7} and an almost complete absence of clinical studies in this field. The human studies that have been performed all have pointed to the capacity for odors to serve as context cues, which are thought to underlie the formation and retrieval of content-dependent odor-evoked autobiographical memories.^{8–10}

Specific trauma-related smells (e.g., blood, napalm, diesel) have long been noted by clinicians to be precipitants of anxiety and fear-related memories in patients with posttraumatic stress disorder (PTSD).¹¹ However, only one paper reports about this phenomenon.¹²

Olfactory flashbacks in PTSD can be disabling phenomena due to the intrusive nature of the memories. A wide variety of cues are mentioned as precipitants of flashback phenomena, varying from experiences with little and transient emotional disturbance to emotional responses that last longer and that evoke symptoms like anxiety, nervousness, nausea, and guilt. These symptoms can be mild but in some cases can be accompanied by dramatic fear and avoidance behavior. No data on prevalence of olfactory flashbacks are available.

This article reviews 3 cases of PTSD (DSM-IV) in patients for whom trauma-related smells provided direct and powerful cues of trauma-related memory. The cases illustrate the potential of olfactory stimuli to trigger symptoms of PTSD and the phenomenon of olfactory hallucination as a type of flashback in PTSD.

CASE REPORTS

Case 1

A 55-year-old veteran reported that since the Vietnam War, the smell of diesel had been particularly upsetting for

him. According to his experience, he had been particularly sensitive to smells throughout his life. Living in the countryside as a boy, he reported he could smell animal cadavers from a great distance.

Having been deployed to Vietnam in 1967 as a paramedic, he was involved in providing first aid to injured soldiers on the front. As there were many casualties, he also was involved in transporting casualties and removing dead bodies or body parts of victims. When a camp relocated, it was common for the soldiers to burn their excretions, a procedure for which they used diesel fuel. Sometimes they even had to burn dead bodies or body parts, also using diesel fuel. The patient was in charge of these procedures. The smell of burning diesel has had a profound impact on him since then.

He returned to the United States and developed symptoms of PTSD. For many years his wife had unsuccessfully tried to send him to a treatment program for his sleeping problems, frequent nightmares, irritability, and gradually worsening social isolation. When asked about his flashbacks, he reported a disabling impact of smells, specifically, the smell of diesel and burning rubber. These smells precipitated intrusive memories of the war. He always avoided driving behind trucks on the highway and timed when he needed to get fuel at a gas station to avoid being unexpectedly exposed to the smell of diesel of large trucks. It was not that he disliked the smell itself, but the smell always caused upsetting feelings and made him feel uncomfortable, nauseated, and sometimes guilty, depending on the memories that were triggered.

He reported:

This morning, I noticed local firefighting equipment on the road just past my home. The fire police let me pass since our house is on the corner. Arriving home, I found my wife out on the back deck watching a fire that was about 300 feet away. This is when I noticed the smell of burning rubber, together with a faint smell of fuel oil or diesel oil.

My wife stated she was worried about me because I was standing on the deck as if I was daydreaming for some minutes without responding to her. The smell brought to my mind the image of this burning amtrac, again so vivid. The amtrac was hit. The front door/ramp was open, both crew hatches were open and pouring out smoke and flame. Thick, black, acid smoke was boiling out of the troop compartment. There was an overpowering smell of burning rubber. I remember that smell and what it looked like that day vividly.

There was nothing I could have done to save the people in the amtrac. Fifteen Marines and 3 crewmembers died there that day. I felt the same hopelessness as I felt that day. I felt bad in my stomach, got a headache, and had a feeling of futility or finality when I thought about that incident.

One day later he wrote:

I did not sleep well last night; tossed and turned most of the night. I felt as though I was in a state of pre-sleep. Still have

a headache since yesterday. I went to the spare bedroom so I would not wake my wife. That smell of rubber is still in my mind.

With no effort, the memory of the amtrac came back with associated affect. When these flashbacks occurred, it always took him some time to recuperate, and he noticed his nervousness, irritability, and efforts to stop thinking of all the other Vietnam memories that came along.

Case 2

A 34-year-old man reported episodes of olfactory hallucination based on a traumatic experience when he was working as a paramedic in the fire department of a small town. He had witnessed a young man die due to a tire explosion while the man was assembling one of the wheels of a car in a garage. Upon arriving at the scene and examining the man, he noticed that the injured man's face was completely blown away. When he tried to resuscitate and ventilate the injured man, he could not find the man's mouth. Instead, the injured man vomited out of his completely destroyed face and onto the patient's own face and clothes. The patient called for assistance and the injured man was transported to the hospital.

He remembered he felt disgusted. He cleaned off the vomit that had penetrated his clothes. Despite a plan to go back to his station, several hours after this incident, the patient was found by the police in his car in the middle of an intersection. He was dissociated and derealized and was unaware of what he was doing there. Later, after he returned home, he remembered he did not eat for 2 days, as he was still struggling with the bad smell. He reported intrusive memories while eating, had nightmares about the incident in which he saw the blown away face, and gradually realized that it affected him in such a way that he felt more distant from other people. In particular, it was the foul, sour smell of the vomit that had a profound impact on him.

For many years afterward, he felt as if he was reliving the scene on several occasions. He would become nauseated and irritable, with a vague sort of sadness, and he would feel the same disgust as he had felt originally at the time of the incident. He had always cautiously avoided talking about the incident. Eight years after this incident, he reported he had never been able to completely get rid of the smell of the traumatic scene. Nonspecific smells could make him nauseated—something he had never experienced before the incident.

During a recent invitation to teach about emergency medicine in front of a class, one of the students asked him if his experiences as a paramedic changed his life. He had never talked about this specific incident with anyone. Despite the fact that he had witnessed other deaths later in his career, he forced himself to talk about the tire incident, assuming it might help him and assuming the students

might find it an appropriate illustration of the demanding nature of the job. He felt exposed but ready to bring it up and talk about it. He was surprised, however, to sense the recurrence of the foul smell that he could not handle well. Again, it lingered on in his mind for days, and, again, images were vivid and powerful. He dreamt about the scene and felt he had never adequately coped with the impact. Later, he reported he had become aware of how much he was bothered by foul smells in general, even though they had nothing to do with the incident and were sometimes perceived when they were not even present, as far as he could tell. He reported that since the incident, these phenomena had always bothered him and that he therefore wanted to admit himself for treatment.

Case 3

A 53-year-old woman was admitted to a psychiatric unit. During the first weeks of admission, she was frequently found to be frightened, disoriented, and derealized after she had locked herself in a closet in her room. During these episodes, she frequently demonstrated self-destructive behavior by cutting herself on her arms with a knife. Her behavior made close observation necessary. Interviewing the patient revealed that the hallucination of a smell precipitated these events. This was confirmed in nurse reports, which told that the patient frequently reported that she hallucinated a typical smell, which for her, indicated an oncoming flashback: "At 10:30 p.m., patient was ready to process the incident (locking herself in a closet); she reported she hallucinates a smell and this indicates an oncoming flashback. I reported she can come to staff if this happens to get help." On another occasion: "Patient reported smelling leather, Old Spice, and alcohol and said that it triggered her."

In an interview about these hallucinations, the patient related these smells to a traumatic experience when she was 16 years old. She had been brutally gang-raped at a cemetery. The perpetrators had tied her to a cemetery grave. She was able to get the knife of one of the perpetrators, stab one of the rapists, and run away, not knowing if she had killed him. She had disclosed the rape only to her mother who had corroborated her story to be true. She had burned her bloodstained clothes and apparently repressed the rape. However, she always felt upset and uneasy when actually smelling leather, alcohol, and Old Spice aftershave. She reported she had never consciously linked this to the rape.

The patient had a 12-year history of psychiatric illness with several hospital admissions. She was first hospitalized at age 41, shortly after her husband, from whom she had just divorced, died. She started to report nightmares and at times felt flooded with emotions. She became depressed, irritable, and suicidal. At that time, she was first diagnosed with severe major depression, without psychotic features, according to DSM-IV criteria. Later on,

posttraumatic symptoms became clearer, as did depersonalization, derealization, amnesic episodes, and identity confusion and alteration. Her trauma history included sexual abuse with unwanted teenage pregnancy and physical abuse by her mother and different stepfathers, including being beaten with a stick to the point of bleeding. After having spent 11 years in a stable marriage and working as a nurse, she divorced and had to give up her job due to back pain problems.

Since staff on the unit became aware that certain smells were pivotal in the patient's reports of flashbacks, it was hypothesized that some smells could have an opposite effect. So, when the patient was found locked in the closet again, she was approached with fresh coffee grind and the scent of vanilla. This had a surprisingly positive effect. The patient responded to the scents; they redirected her attention, reduced the derealization, and helped reduce the acute fear, and therewith, the intensity of the flashback. Since the effect was so remarkable, the procedure using the same smells was applied proactively in group treatment when exposure was part of therapy. Some days after this intervention, a nurse report read, "had 1 dissociative episode in goals group, with which she could only be helped with an olfactory stimulus." A later report read, "patient left group; patient stated that she had begun to smell something from the past and almost had a flashback." A report 1 day later read, "during the group, patient had 2 episodes of flashback needing staff intervention for reorientation . . . being proactive, patient was given the suggestion to hold the coffee grind during the meeting to help with her olfactory hallucinations."

DISCUSSION

It is our clinical experience, and that of many other therapists, that smells can be powerful precipitants of traumatic memory in PTSD. The cases presented here illustrate that memory for smells in PTSD is quite specific and long lasting and that it is context- and state-dependent. In addition, the cases illustrate how smells can influence symptoms of PTSD and play a role in the pathophysiology of the disorder.

In the first case of a Vietnam War veteran, exposure to the smell of burnt rubber and diesel precipitated traumatic memories of the war combined with emotions of helplessness and guilt. In order to cope with these symptoms, the patient had adopted a habit of avoiding the smell of diesel as much as possible. More than 30 years after the war, he suffered from PTSD, of which one of the symptoms was his inability to block or suppress the negative impact of trauma-related smells. The second and third cases illustrate the relatively rare phenomena of olfactory hallucination. These entail the discrete perception of an odor that is not objectively present.¹³ Olfactory perception in the absence of an obvious cue has been described in patients

with migraine,¹⁴ epilepsy,¹⁵ psychosis,¹⁶ and depression.¹⁷ Both olfactory perception and olfactory hallucination can be elaborated upon and differentiated between in these disorders through linkage with specific biographical recollections (e.g., “the smell of the aftershave of my father”).¹⁸ Olfactory hallucinations are experienced with an “as if” or “just like” quality to patients’ perception of odorants (the foul and putrid smell of vomit, the smell of leather and aftershave), which categorizes the experiences as pseudo-hallucinations.¹⁹ The patients presented in cases 2 and 3 did not suffer distortions of smell. Neither of them suffered from epilepsy. The smells were typically experienced as sudden and intrusive. In both cases, the hallucinated smells precipitated a traumatic memory with associated affect. In the third case, the olfactory hallucinations were part of vivid intrusive memories that presented themselves as dissociative episodes and flashbacks.

These examples illustrate that (1) olfactory memories can be deeply embedded and (2) the long-term effect of the memory of smells related to traumatic events can manifest itself upon reexposure to the original cues and can lead to a (conditioned) response, which (3) in PTSD, does not extinguish with time. In addition to memory precipitation, the third case report offers an example of a possible intervention using familiar and comfortable smells to assist the patient to redirect attention and regain orientation in time, place, and person. This idea is congruent with popular ideas in aromatherapy, which uses smells for their possible therapeutic effect.²⁰ While the scientific basis of this treatment is not yet provided and popular claims are made that tend to overestimate these effects, new research is promising, e.g., in the use of olfaction as an anticonvulsant therapy.²¹ Several smells have proven to serve the purpose of redirecting attention. Coffee is just one choice of odor that usually is appreciated for its pleasant quality and is not as pungent as, for example, ammonia, which is often used in emergency medicine and sports to test for consciousness and enhance alertness.

Olfaction as a Representational Aspect of Memory

The “instinctive” responsiveness to odors can convey a wide array of emotions, and it is thought to be constant throughout the life of an individual, with neural pathways established early in development.²² Odors are said to influence mood by evoking powerful experiences of pleasure or displeasure, enhancing alertness, or facilitating relaxation. In addition to these emotional and unconscious responses, odors can evoke context- and state-dependent autobiographic memories^{23–25} with associated affect.²⁶ As demonstrated by Herz and Cupchik,⁷ odor-evoked memories were found to be more emotional than verbally-cued memories. Odor-evoked memories seem to have the capacity to dissociate the emotional and representational aspects of memory.²⁷ Whereas pleasant smells usually refer

to positive memories, this hedonic congruency does not seem to be essential if the representation is strong. It is remarkable that with respect to memory (and the precipitating effect of this particular type of sensory experience), olfaction seems to be an almost forgotten system in clinical research. Emphasis is given to the visual and auditory memory systems. Moreover, most studies about olfactory memory fail to integrate their findings with current cognitive theories,²⁷ are typically performed in healthy individuals, and do not control for the environment.²⁸

Neural Systems in Olfactory Processing

The effects of olfaction on emotional memories reflect a strong functional relationship of olfaction to the parts of the brain involved in memory and emotion. The conditioned responses that can be elicited by smell are most likely mediated by limbic and neocortical brain areas, i.e., hippocampus, amygdala, and orbitofrontal cortex. Olfactory information is projected from the olfactory bulb to the primary olfactory cortex, which is composed of the anterior olfactory nucleus, the olfactory tubercle, the piriform cortex, the amygdala, the periamygdaloid region, and the entorhinal cortex. From there, the primary olfactory cortex projects to secondary olfactory regions including the hippocampus, ventral striatum and pallidum, hypothalamus, thalamus, orbitofrontal cortex, agranular insular cortex, and cingulate gyrus. Olfactory brain regions, such as the piriform cortex, are involved in amygdala-driven processes and suggest that strong stimulation of this nucleus interferes with activity in the limbic system.^{29,30}

The amygdala plays a crucial role in conditioned fear and anxiety, as well as in the area of attention.³¹ It is placed at a relatively high level of sensory integration for olfactory stimuli. The amygdala has a role in the hedonic or emotional processing of olfactory stimuli.³² Amygdaloid discharges are accompanied by an increase in odor intensities. On the other hand, lesions of the amygdala reduce the perceived intensity of an olfactory stimulus. It is not surprising that, until rather recently, procedures such as stereotaxic amygdalotomy were performed to treat persistent olfactory hallucinations.³³ Recent findings show that both the amygdala and the perirhinal cortex participate critically in the acquisition and expression of fear-conditioned responses to an olfactory-conditioned stimulus.³⁴

In humans, the hippocampal region of the brain is crucial for declarative or episodic memory for a broad range of events.³⁵ These include temporal, spatial, and situational features of episodic memories. Several experimental animal studies have investigated the role of the hippocampus in memory and olfaction. Recent research has shown that the hippocampal system is critical to a memory representation based on encoding relations among multiple perceptions, and other brain systems support performance adaptations based on encodings of individual stimuli.^{36,37} Studies also suggest that the hippocam-

pus is not essential in memory for single odors but is critical for the formation of representations of relations among odor memories, the expression of odor memories in novel situations, and associations between sequential events that constitute elements of an episodic memory.³⁸⁻⁴⁰

H.M.,⁴¹ a patient with bilateral medial temporal lobe resection demonstrated normal performance on a battery of tests of odor detection, discrimination of intensity, and adaptation. In contrast, H.M. was unable to discriminate or identify odors in same-different discriminations and in matching-to-sample tasks. Although he could name common objects using visual or tactile cues, he could not identify them by smell. These results were thought to indicate that structures in the medial temporal lobe play a critical role in particular aspects of odor discrimination.

Recent findings³⁴ have demonstrated that an olfactory stimulus can serve effectively as a conditioned stimulus in fear conditioning. These findings have also demonstrated that the basic principles that govern the acquisition of emotional responses (e.g., odor avoidance behavior) that are conditioned to auditory and visual stimuli can be extended to the olfactory system.^{2,34} Since these olfactory-induced flashbacks can be understood in terms of Pavlovian conditioning, it also is logical that extinction trials have the potential to increase therapeutic gain⁴² or facilitate de novo conditioning in some cases.⁴³

On the basis of implications of a dysfunction of the fronto-limbic system in PTSD, Vasterling and colleagues⁴⁴ performed a study that tested olfactory identification in PTSD. They found that patients with PTSD demonstrated relative performance deficits in olfactory identification. This is a specific function of the lateral and posterior part of the orbitofrontal function. Individual cells located there commonly respond to only one odor.⁴⁵

Using Smells to Investigate Brain Activity in PTSD: Proust Revisited

Animal studies,^{46,47} and some human studies^{32,48,49} as well, show that smells can be used as a probe of orbitofrontal and medial prefrontal cortex. These are areas of interest in PTSD.³⁰ In addition to the amygdala, these cortical regions are also target areas of olfactory stimulation.⁵⁰ Findings from imaging studies of brain function in PTSD are consistent with dysfunction of the orbitofrontal and medial prefrontal cortex during presentation of traumatic cues. We have previously studied Vietnam War veterans with and without PTSD while exposing them to combat-related versus neutral slides and sounds.⁵¹ Vietnam War veterans with PTSD showed a decrease in blood flow in orbitofrontal and medial prefrontal areas that are known to modulate emotion and fear responsiveness through inhibition of amygdala responsiveness. These findings were in concordance with other activation studies using personalized narratives to induce anxiety and other PTSD symptoms that showed a relative failure of activation of the

orbitofrontal cortex in response to traumatic reminders of a visual and acoustic nature.^{52,53} These data are in line with recent positron emission tomographic findings indicating that judgments of hedonicity engage the orbitofrontal circuitry and increases in regional cerebral blood flow, whereas the detection itself and judgment of intensity and familiarity do not.⁵⁴ We therefore hypothesize that smells could be used in an activation paradigm in PTSD, looking at odor as a probe for orbitofrontal cortex activation. No published studies yet have used smell to investigate brain activity in patients with PTSD.

The Proustian viewpoint that strong emotional impact of an experience during encoding enhances odor-retrieval cue-effectiveness has not lost its truth.⁴ Not that there is much difference in odors compared with other stimuli to elicit accurate recall, but odor-evoked memories are always more emotional.⁵⁵ In addition, it appears that emotional saliency, rather than accuracy, is responsible for the impression that odors are superior reminders. A framework is beginning to emerge indicating that through amygdaloid discharge and in conjunction with failure of inhibition of orbitofrontal responsiveness, reexposure to olfactory cues (or hallucination of olfactory cues) can induce memories with the associated affect. On the basis of this viewpoint, and supported by clinical reports as we described here, we hypothesize that in situations of trauma, olfactory signals can be stored and linked to vivid traumatic memories that are mediated by altered orbitofrontal and medial prefrontal cortex and amygdala function.

CONCLUSION

Questions about smell as a traumatic reminder can help both patient and clinician unravel the complicated triggers that can induce flashbacks with associated negative affect. We recommend that olfactory flashbacks should be assessed in patients with PTSD. Olfactory memories can be an important part of the clinical presentation of PTSD because of their nature as powerful triggers and the difficulty in connecting the origin of the memory of the smell with conditioned behavioral responses.

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