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ABSTRACT

Following the reestablishment of peace in war-torn Liberia, a door-to-door mental health epidemiological study sampling of 500 Liberian civil war survivors living in Monrovia was implemented in July 2010. Under the supervision of a clinical psychologist, surveys assessing demographics, posttraumatic stress disorder (PTSD), depression and war trauma experiences were administered to roughly equal numbers of men and women by volunteers working for a local nongovernmental organization. From an evolutionary perspective, two hypotheses were tested based on previous research findings that linked PTSD symptoms to olfactory experiences. First, it was predicted that olfactory-related trauma would be positively correlated to higher reports of intrusive traumatic memories. Second, it was predicted that olfactory-related trauma would be positively correlated to the number of reported symptoms of hyperarousal. A Pearson's correlation analysis revealed that both hypotheses were supported at a $p < .05$ or better. Treatment implications for the use of olfactory stimuli in exposure therapy are discussed herein.

KEY WORDS Olfaction; Trauma; Posttraumatic Stress Disorder; PTSD; Memories

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"Your memory is a monster; you forget—it doesn't. It simply files things away. It keeps things for you, or hides things from you and summons them to your recall with will of its own. You think you have a memory; but it has you!"

—John Irving, *A Prayer for Owen Meany*

War, in its capacity for human atrocity, is by definition a monstrous event. The Liberian civil wars in particular, which spanned the period between 1989 and 2003, were dubbed by the U.S. Department of State Bureau of African Affairs as "Africa's bloodiest civil wars" (U.S. Department of State 2012)." A savage conflict that killed an estimated 250,000 people and drove nearly a million more into refugee camps across West Africa, this ongoing civil engagement has been called by historians "an uncivil war" and "the cannibals' war" because of the inhuman savagery demonstrated by both government and rebel troops against civilians. Anecdotal evidence of massive genocide, cannibalism, torture, rape, and murder of women and children is provided in the accounts of individual survivors. The purposes of the current study were to document the traumatic events witnessed by 500 randomly sampled Liberian civil war survivors living in the capital city of Monrovia, and to assess the experience of these monstrous events on the incidence of intrusive memories.

Olfaction and Traumatic Memories

Trauma is defined by the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision (DSM-IV-TR) as an event "that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others… [and] the person's response involved intense fear, helplessness or horror" (American Psychiatric Association 2000)."

Many people who witness traumatic events experience memory-related difficulties as a consequence of their exposure (Cordón et al. 2004). This memory impairment may take two forms—difficulty in recalling certain traumatic memories or haunting by these unpleasant recollections, taking the form of intrusive thoughts, dreams or flashbacks to the event(s). Recent research has suggested that olfactory (odor) stimuli may be particularly likely to result in emotional experiences of past events (Zald and Pardo 1997), including the symptoms consistent with traumatic stress disorders (for example, intrusive memories, avoidance of reminders of the event, and hyperarousal).

Of the sensory systems, olfaction has been most strongly linked with emotional experiences through prior learning and has a powerful evolutionary basis. As part of the survival mechanism, children begin learning to associate odors with events and even emotional states very early in development, and those initial associations to odors may remain intact over a lifetime (Lawless and Engen 1977; Poncelet et al. 2010). Exposure to pleasant odors, odors that have been previously associated with good experiences, results in a positive mood. Conversely, exposure to unpleasant odors, odors that have been previously associated with negative experiences, results in a negative emotional state (Ehrlichman and Halpern 1988; Vernet-Maury et al. 1999). The ability of odors to alter

our emotional states is the reason why aromatherapy can induce a relaxed state and why the smell of apple pie can provide comfort.

Odors can encourage specific memories of past experiences, in addition to altering moods (Herz 1998; Pointer and Bond 1998; Schab 1990). Memories that are cued by odors are more emotional and vivid in nature than memories that are recalled from other sensory cues (Herz and Cupchik 1992; Herz 2004). This is also true of traumatic memories; refugees from Cambodia and Khmer have reported flashbacks of war following exposure to odors that were experienced during traumatic events (Hinton et al. 2004a; Hinton et al. 2004b). Vietnam War veterans have similarly reported re-experiencing traumatic occurrences in the presence of odors that were experienced during war (Kline and Rausch 1985). This link between olfaction and traumatic memories suggests that trauma symptoms of intrusion may be stronger for events that have an olfactory association.

Neural Underpinnings of Traumatic Memories

The limbic system is considered to be the brain's emotional center, as well as a portion of the brain that is critical to memory formation (LeDoux 1993; Scoville and Milner 1957). Several regions of the brain have been implicated in the regulation of emotional arousal. Specifically, the locus coeruleus (LC) is a key brainstem region involved in arousal and is highly responsive to excitatory stimuli, including those that activate the hypothalamic-pituitary-adrenocortical (HPA) pathway. Within the limbic system, the amygdala and hippocampus are linked respectively to the processing of emotional responses and memory (Cahill and McGaugh 1998; Scoville and Milner 1957). Individuals with posttraumatic stress disorder (PTSD) exhibit impairments in hippocampal-dependent memory and reduced hippocampal volumes while amygdala function appears enhanced (Gilbertson et al. 2002; Sapolsky 2002, 2003).

Of further interest, the amygdala and portions of the hippocampal complex are recipients of olfactory information entering the brain. Such close anatomical ties between the olfactory system and limbic system structures further suggest a role for odor in emotional memories. Examination of patients with neuropsychological disorders such as Alzheimer's disease and HIV-associated dementia has provided additional support for the idea that odors are linked to memory (Devanand and Michaels-Marson 2000; Gilbert, Barr, and Murphy 2004; Martzke, Kopala, and Good 1997). Furthermore, humans who have sustained hippocampal damage show impaired memory for odors, again demonstrating that olfactory information is processed in limbic system structures important for memory formation (Levy, Hopkins and Squire 2004).

Hypotheses

Consistent with the literature on traumatic stressors and post-event recall, it was hypothesized that among Liberian war survivors, the symptoms of intrusive memories and hyperarousal would be greater following exposure to an olfactory-related trauma stimulus than to a nonolfactory traumatic event. Specifically, it was expected that there

would be a positive and significant correlation between the percentage of olfactory-related traumatic events and the number of intrusive symptoms (recurrent and distressing recollections, dreams or nightmares about the event, flashbacks or hallucinations, and psychological distress/reactivity upon exposure to cues that resemble the event) experienced by the sample population. Furthermore, the intrinsic link that has been established between sensory processing of smells and the functioning of the hippocampus suggests that olfactory stimulation may also affect physical symptoms of traumatic stress (such as difficulty sleeping, irritability, difficulty concentrating, hypervigilence, and exaggerated startle response). It was therefore hypothesized that a positive and significant correlation would exist between the percentage of olfactory-related traumatic events and the number of hyperarousal symptoms reported by participants.

Methods

Participants

Participants were 486 residents of the capital city of Monrovia, Liberia (242 men and 244 women; mean age 37.77, SD 12.83). Forty-one (41) percent of participants reported that they were either married or living with someone; another 18.6 percent were divorced, separated, or widowed; and the remaining 39.4 percent reportedly had never married. A full 80 percent of participants identified as having experienced one or more traumatic events in their lifetime. Roughly 54 percent of participants met full criteria for diagnosis of PTSD.

Epidemiological sampling commenced in summer 2010 in Monrovia and its surroundings, as this region is where the majority of the population currently resides. Postwar Monrovia has been described by the Liberian minister of mental health, Dr. Ellen B. George Williams, as a melting pot of the 15 Liberian counties. The city has been divided into ten vernacular districts, each roughly representative of the current population according to the Liberian 2008 population and housing census (Liberian Institute of Statistics and Geo-Information Services 2009). These districts included Duala, Waterside/Westpoint, Red Light, Central Monrovia, Jorgbointown/Sinkor, Old Road/Congortown, Elwa/Robertsfield Highway, 72nd/Double Bridge, Double Bridge/Barnersville Junction, and New Georgia/Stockton Creek. Catchment data collection was conducted by 20 Liberian lay trauma counselors trained by the primariy investigator (PI) and affiliated with the Pan African College (PAC) for Peace and Conflict Resolution in Liberia. To promote confidentiality and full disclosure of sexual trauma, men in the study were interviewed exclusively by male researchers and women were interviewed exclusively by female researchers. Unannounced field adherence checks were performed by the PI on either the first or second day of data collection, and each field researcher received constructive feedback on his or her interpersonal behaviors and conformance to standardized methods of scale administration. A total of 500 surveys were collected, coded, and analyzed for the current study.

Participants were contacted through door-to-door solicitation and by investigators located at major public markets in each region. All participants were 18 years or older

and were Liberian nationals. After granting informed consent, participants were asked to complete a brief demographic sheet and a PTSD screener (taken from the Structured Clinical Interview for DSM-IV; First et al. 2002). Descriptions of traumatic events were transcribed by interviewers and then grouped by category according to the posttraumatic diagnostic scale (PDS) criteria published by Foa and colleagues (1997). (See Table 1 below.) These categories were then coded as either olfactory or nonolfactory stimuli by a trained research assistant; determinations of olfactory stimuli were based upon direct exposure to trauma incidents that involved distinctive pungent odors such as blood, decay, excrement, smoke, or gunpowder/explosives. The ratio of olfactory to total trauma experiences was calculated for each individual, and this number was used to represent olfactory experiences in all statistical analyses. All interviews and measures were administered in English (the official language of Liberia). Participants were compensated for their participation with payment equivalent to $1 US.

Examples of most common types of trauma are provided in the chart below. (Warning: the descriptions provided are graphic and may be disturbing to the reader).

Murder of a family member:	"They killed my pregnant wife and children before me."; "I saw the rebels kill my nephew by cutting off his privates with a knife"; "During the war, my father was beheaded by rebels in my presence because he worked for the Liberian government"; "All four of my children were buried alive by rebels"; "The rebels killed my babies in my presence; they were crying."
Death of a family member:	"I heard that three of my sisters died by hunger"; "My uncle died by snake bite."
Murder of a stranger:	"Two boys were taken from the line; the rebels stripped them naked and beat them to death in my presence"; "A man was buried alive in my presence"; "I witnessed people being butchered and cooked for eating."
Combat:	"I was forced to join the fighting group and saw horrible things"; "I witnessed a rocket kill a boy and shatter him into pieces"; "I was hit by particles of a mortar that was in the jungle."
Fire with death:	"I saw a fire accident with a pregnant woman dying in it"; "I burned a human being alive."
Other:	"The rebels whipped my father and told him to have sex with the ground and I was told to dance"; "I slept with dead bodies; while escaping from rebels I saw dead bodies in pools of blood."

Table 1. Frequencies of Trauma Categories by Type

Description	Frequency	Olfactory	Description	Frequency	Olfactory
Accident—self	19	No	Accident—others	58	No
Disaster—self	0	No	Disaster—others	3	No
Assault, nonsexual, by acquaintance—self	4	No	Assault, nonsexual, by acquaintance—others	0	No
Assault, nonsexual, stranger—self	25	No	Assault, nonsexual, stranger—others	18	No
Assault, sexual, by acquaintance—self	3	Yes	Assault, sexual, by acquaintance—others	1	No
Assault, sexual, stranger—self	16	Yes	Assault, sexual, stranger—others	23	No
Combat—self	19	Yes	Combat—others	52	Yes
Statutory rape—self	0	Yes	Statutory rape—others	0	Yes
Imprisonment—self	5	Yes	Imprisonment—others	0	Yes
Torture—self	11	Yes	Torture—others	11	Yes
Life-threatening illness—self	2	Yes	Life-threatening illness—others	8	Yes
Death of a family member or close friend, not natural, not murder	34	No	Death of a family member or close friend, natural	11	No
Death of a family member or close friend, specified	67	No	Murder, unspecified	43	Yes

(Continued on next page.)

Table 1. Frequencies of Trauma Categories by Type, cont.

Description	Frequency	Olfactory	Description	Frequency	Olfactory
Murder of a family member or close friend	212	Yes	Murder of a stranger	53	Yes
Forced to kill, family member or close friend	2	Yes	Forced to kill, stranger	6	Yes
Cannibalism	14	Yes	Drowning	15	No
Fire incident	45	Yes	Fire incident with death	48	Yes
Other	175	TBD			

Measures

The Structured Clinical Interview for DSM-IV Axis I Disorders (SCID) is a series of semi-stuctured interview modules used for making DSM-IV Axis I diagnoses. Although the schedule was designed for clinical diagnosticians, non-clinician research assistants who have extensive experience with the study population have been successfully trained to administer the screener. Research assistants in the current study were given three full days of training and were evaluated on their diagnostic accuracy by the PI following training.

The SCID is broken down into separate modules corresponding to categories of diagnoses; in the current study, only the PTSD module was administered. Most sections begin with an entry question that allows the interviewer to "skip" the associated questions if criteria are not met. For all diagnoses, symptoms are coded as 3 = present, 2 = sub threshold, or 1 = absent. A diagnosis of PTSD is made following the recommended decision rules.

> Sample Question: I'd like to ask you a few questions about specific ways that it [the trauma] may have affected you. For example: did you think about (insert trauma) when you didn't want to, or did thoughts about (insert trauma) come to you suddenly when you didn't want them to?

Reliability and Validity

Reliability estimates for the SCID are high among well-trained raters who work and train together (as in the current study). The background of the interviewer (type of professional training), however, reportedly does not seem to affect reliability estimates significantly. Inter-rater reliability estimates range from .77 to a perfect 1.0, while test-

retest reliability ranges from .78 to 1.0 (Lobbestael, Leurgans and Arntz 2011; Zanarini and Frankenburg, 2001).

One of the most common standards used in psychological assessment studies is the "best estimate diagnosis." This standard involves collecting data over time (longitudinally) by trained experts using a variety of sources and survey respondents. Several studies using approximations of the best estimate diagnosis procedure found that the SCID demonstrated superior validity over standard clinical interviews (Basco et. al 2000; Fennig et al. 1994; Fennig et al.1996; Kranzler et al.1995; Kranzler et al. 1996).

Results

A Pearson's correlation analysis was used to assess the frequency ratio of olfactory-associated trauma experiences (M = .56, SD = .38) and the number of intrusive memory symptoms (M = 3.28, SD = 2.13), the number of hyperarousal symptoms (M = 2.95, SD = 2.15), and the number of avoidance symptoms (M = 3.94, SD = 2.85) reported on the SCID. According to the results of the analysis, as predicted in the hypotheses, a positive and significant correlation existed between the number of olfactory-associated trauma experiences and the number of intrusive memories reported by participants (Pearson's $r = .13$, $p < .01$), such that the greater the ratio of reported traumatic events with strong olfactory associations, the greater the number of intrusive memory symptoms also endorsed by the participants. A positive and significant correlation also existed between the number of olfactory-associated trauma experiences and the number of hyperarousal symptoms reported by participants (Pearson's $r = .11$, $p < .03$). Again, the higher the ratio of olfactory traumatic experiences, the higher the number of arousal symptoms endorsed. No relationship was identified between olfaction and other trauma symptoms, such as avoidance.

Discussion

The current study examined the relationship between traumatic stimuli with an olfactory component and the number of intrusive memory symptoms reported in a random sample of 500 Liberian war survivors. Consistent with the previous literature and the proposed hypotheses, it was found that a moderate positive correlation existed between traumatic events associated with the sense of smell and the number of intrusive memories, as well as the number of hyperarousal symptoms, experienced by participants in the sample population. The symptom groups of intrusion and hyperarousal are possibly linked by their roots in the unconscious fear-processing system. Thus, avoidance symptoms may well be processed by a conscious, or voluntary, cortical alarm pathway as described by Liddell et al. (2005). Nevertheless, there are several limitations to the current study.

First, although a significant positive correlation was established between the variables of interest, the nature of this relationship is not certain. A case of correlation does not necessarily indicate causation; it remains possible that any of the variables, olfactory experience, traumatic memories, and/or arousal symptoms may be the predictor

variable. Nonetheless, as suggested by Herz (2007), the order of occurrence—olfactory experience, emotional arousal, memory formation—would indicate that the traumatic stressor precedes the formation of the anxiety symptoms. It is also possible that a third, unidentified factor (such as psychological predisposition or personailty) is the link between the variables under examination. In future research, only a strict empirical design in which the sense of smell is manipulated experimentally would reveal the true direction of the relationship.

Second, because this was a random sample, it was not standardized in terms of the nature or degree of trauma experienced by the individual. According to the dose-response relationship, chronic exposure to extreme stressors, or more horrific traumatic events, will have a stronger effect on an organism (Altshuler 1981). Neither chronicity of exposure nor nature of the trauma was quantified in the current study. It was therefore impossible to control for these variables in the analysis. Follow-up to this study would benefit from tracking the duration and level of intensity of each traumatic event, as reported by the interviewee.

Finally, coding for the olfactory experience was based on post-hoc interpretation of the traumatic events by a third-party rater. Although it is quite apparent that some traumatic events would have olfactory associations, such as the smell of smoke during a fire incident, other events are less clear. There may be unpredictable associations with a certain traumatic stressor that are contingent upon the environment in which the stressor occurs. For example, the memory of observing the rape of another person may be attached to a smell of salt air if it occurred near the ocean, or with the smell of garbage if it occurred near the local dump. These associations are unique to the individual and can be determined only on an idiographic basis. For this reason, future research would benefit from assessing the type and number of sensory experiences attached to traumatic events as reported by the individual who witnessed them.

Despite limitations to the current study, these findings are important to the clinical community on multiple levels. In terms of our understanding of the neuroprocessing of sensory information, clinicians are surprisingly unconcerned about the psychological implications for sense of smell and its emotional attachments. In a recent review of 26 emerging treatments for PTSD, Cukor et al. (2009) noted that olfactory exposure is used only as an adjunct to virtual reality therapy and does not take precedence in any other exposure-based treatment protocols. In an informal classroom survey, Kahn (2011) found that 94 percent of students in an introductory psychology class selected olfaction as the sense they would best be able to live without. Olfactory dysfunction often goes unreported, possibly due to the fact that some people do not realize that their sense of smell is impaired (Murphy et al. 2002).

Nevertheless, previous research on stress responses in rats exposed to cat-scented collars would suggest that exposure to the odor of predatory threat can elicit hiding and avoidance behaviors in the rodents (Liddell et al. 2005). The findings of the current study give further credence to the idea that olfaction is an important aspect of day-to-day functioning and that variations in olfactory ability should be treated with due

consideration to their emotional and psychological implications. These results contribute to the growing evidence linking olfactory experience to emotional memories and suggests the need to further investigate olfactory cues in a laboratory setting.

Along another line of thought, the powerful links between olfactory traumatic stressors and certain symptoms of PTSD suggest potential treatment implications using olfaction as a form of exposure therapy for clients with traumatic stress syndromes. By pairing an offensive smell that is associated with a traumatic stressor with a positive stimulus such as pleasant sights, sounds, or feelings, therapists may be able to condition their clients to emit more adaptive responses to previously aversive stimuli. To date, olfactory therapy is not addressed in the standard exposure treatment protocol for PTSD, yet the import of this sensory variable has been clearly established by virtual reality (VR) therapies (Cukor et al. 2009). Preliminary research in VR exposure therapy has indicated that the combination of real-time computer graphics with multiple sensory cues (including smell) may enable users to immerse themselves in a more realistic exposure environment and reduce dropout rates.

Lastly, the relationship between olfaction and powerful emotional experience would indicate potential for prophylactic treatments using temporary anosmia (blocking the sense of smell) for short-term exposures to traumatic events. Anosmia can be induced easily using anesthesia administered directly to the nasal cavity (Jorge, Marques, and Phillips 2010). For those people who are employed in jobs that increase their probability of exposure to traumatic stressors (soldiers, police, first responders, and airline crash investigators, for example), a temporary intervention that would involve blocking the sense of smell while under exposure to a traumatic stressor might decrease the incidence of PTSD in such populations. Working toward a goal of tertiary community intervention (through olfactory therapy) may ultimately prevent the long-term human consequences of traumatic exposure for millions of trauma survivors. Along this model of prevention, the best way to battle the monstrous is to ensure that the monsters are never created in the first place.

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