Experimental Lessons Learned Indicate Methods in Simulating Battlefield Malodors in Training Need Further Refinement

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ABSTRACT

Military training stresses the value of "train as you fight", and has increasingly embraced multi-sensory training applications, to include the sense of smell. Yet the science behind adding relevant malodors to training events is not mature; indeed, there is little evidence that adding odors will help trainees overcome any potential issues and/or improved performance. In order to examine whether pre-exposing trainees to a malodor improved performance and/or alleviating human performance issues, an experiment at the United States Military Academy at West Point, NY randomly assigned 180 cadets in a between-groups experimental design with control. Each cadet performed a medical evacuation order task under assigned experimental conditions. Findings with respect to soldier performance, stress, escape behavior, and the physiology of olfactory adaptation are reported. In addition, the research contributes to the use of the Atmospheric Quality Scale as a qualitative odor reporting technique and Electrodermal Activity via wrist-worn sensors in pseudo-field environment. Outcomes and lessons learned provide future olfactory researchers considerations for design and testing of alternative training methodologies.

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INTRODUCTION

Bunker (1978) observes that "the relationship between simulation realism and training effectiveness is far from simple. Realism itself is not a simple scalar; there are types of realism, and functions of realism must be considered in [multidimensional] space." Though experience may only address functions within a multidimensional space, the field of experiential learning, with over 89,000 peer reviewed journals on the topic, supports "experience as the source of learning and development" (Kolb, 2015). With these limitations, Army live training attempts to "be realistic" (Milley & Esper, 2018) and "replicate an actual operational environment as closely as possible" (U. S. Army, 2016) with the expectation that experiencing realism in training would result in improved performance during subsequent battlefield experiences. Live field training simulates a broad range of threats including chemical/biological protective mask training (Ritchie, 1992) where tear gas is used in a single short training event to simulate a variety of airborne chemical, biological, and nuclear contaminants (O'Hern, Dashiell, & Tracy, n.d.). Recent research attempts to improve battlefield realism in training include simulated battlefield malodors (Booth-Kewley & McWhorter, 2014; Johnson et al., 2014; Milham et al., 2017).

While not an immediate threat to life, battlefield malodors may pose a threat due to degraded performance on a complex task (Rotton, 1983) during critical battlefield time periods such as the "Platinum 10 minutes" (Bendall & Parsell, 2015). Malodors may also increase stress (Ousey & Roberts, 2016; Schiffman & Williams, 2005), anger (Schiffman & Williams, 2005), confusion (Schiffman & Williams, 2005) and escape/avoidance (Asmus & Bell, 1999; Smeets & Dalton, 2005). Respirators offer some limited blocking of malodors (Oberg & Brosseau, 2008), but soldiers, medics and other first responders often do not have respirators or simply do not use either respirators or chem/bio protective masks to block malodors (Krueger & Banderet, 1997; Li et al., 2005). As a potential alternative to respirators or masks, olfactory adaptation may desensitize a soldiers' olfactory system to a specific odorant through prolonged and/or multiple exposures to the odor (Dalton, 2000; Mainland, Lundström, Reisert, & Lowe, 2014; Stuck, Fadel, Hummel, & Sommer, 2013). Based on the success of a single prolonged exposure to a malodor during a pilot test (Pike, Proctor, and Burgess, 2017), this research explores the impact on soldier performance, stress, escape behavior, and the physiology of olfactory adaptation that a single treatment phase of Malodor Exposure Training has in a subsequent phase of malodor exposure.

Desensitization to odor is usually measured by *perceived intensity*, a quantified estimate of the odor's intensity, and *detection threshold*, the concentration at which the odor is first detected (B. Berglund, Berglund, Engen, & Lindvall, 1971; Dalton, 1996, 2000; Dalton & Wysocki, 1996). Within a clinical setting, odorant concentration (parts per million) traditionally defines detection threshold (Abraham, Sánchez-Moreno, Cometto-Muñiz, & Cain, 2011). Those measures may not always be applicable to a field setting typical of military training.

In outdoor mass casualty events or wartime battlefields, the sheer number of decaying bodies with spilled excrement, blood, decaying and possibly burned flesh may enable malodor intensity to persist over a large open area. In open air field training, malodors may be simulated using odor delivery systems distributed across the training area. From an experimental perspective, open air malodor simulation is not only expensive, but wind and other environmental factors often fail to result in a uniform malodor intensity in the training or testing area. Pike, Proctor, and Burgess (2017) explored simulating a battlefield malodor in a tent as well as validated protocols and collection techniques for such an approach. Their pilot experiment indicated a single prolonged exposure to a malodor may desensitize a soldier to the malodor. Results further indicated a soldier in a tent may experience weaker, transient malodors (e.g., perspiration of co-workers, transient smells from objects in the environment) that may comingle with the malodor of interest, but tents reduce malodor dispersion while also achieving uniform malodor intensities. The study also validated detection time (Dalton, 2000) as a proxy for detection threshold and found it more relevant to time critical military tasks. Pike et al. (2017) also alluded to electrodermal activity data (EDA) as a more promising measure of stress than inconsistent traditional heart rate or blood pressure, a finding later supported by Anusha, Joy, Preejith, Joseph, and Sivaprakasam (2017). EDA has a long and continued history of research as a tool for measuring stress; see for example Kirkpatrick (1972), Berguer, Smith and Chung (2001), and Boucsein (2012). Burnt flesh is a malodor of interest as it may have immediate as well as long term impacts on soldiers, based on veterans suffering post-traumatic stress disorder indicating that the smell of burnt or burning flesh is a common source of anxiety (D. C. Beidel, personal communication, February 14, 2013).

REASERCH APPROACH

This research used a between groups experimental design with control to model exposure during training to a simulated burnt flesh malodor and exposure to that same malodor in a subsequent phase, such as might occur in a battlefield. Table 1 depicts experimental conditions.

TABLE I. Malodor Exposure Experimental Conditions, by Phase.

Condition	**Malodor Exposure**	
	Training Phase	**Subsequent Phase**
Malodor Exposure Training	Yes	Yes
No Malodor Exposure Training	No	Yes
Control	No	No

Null hypotheses assumed equivalence between phases within a group and equivalence between groups within a phase. If a malodor treatment during training was effective in ameliorating subsequent battlefield issues, selected anticipated hypotheses or alternative hypotheses of interest were:

H1: Between phase differences within the Malodor Exposure Training group: participants experiencing the malodor during both an initial training phase and a subsequent phase, would exhibit less stress, less avoidance behavior, and/or higher task performance during the subsequent phase, than observed in the training phase.

H2: Between Malodor Exposure Training and No Malodor Exposure Training group within phase differences: participants in the Malodor Exposure Training condition would exhibit less stress, less avoidance behavior, and/or higher task performance than participants in the No Malodor Exposure Training condition during the subsequent phase.

H3: Between Malodor Exposure Training and Control group within phase differences: participants in the Malodor Exposure Training condition would exhibit similar stress, avoidance behavior, and/or task performance during the subsequent phase as participants who were not subjected to the malodor during the training or the subsequent phase (i.e., the Control condition).

The duration of each phase was 12 minutes. The speed and intensity of malodor release was constant in all phases. With two phases, no more than five minutes between phases, and pre and post protocols, the entire experiment duration was less than an hour for all participants.

Materials and Methods

This research utilized materials and methods identified in (Pike et al., 2017), with the following exceptions:

1. Profile of Mood States, heart rate, and blood pressure data were not collected.
2. Tents subject to odor were set up outside.

3. ScentAir ScentPop odor delivery systems were placed in a box with a tube to allow control of malodor dispersal by an outside observer.
4. The complex task involved completion of a four-scenario exam based on the medical evacuation ("9-Line") order.

Participants

Cohen (1992) recommends a total of 156 participants for a three-group analysis to achieve α=.05, ß=.2 with medium effect size (ANOVA 52 participants per group). The United States Military Academy (USMA) made 180 cadets (140 male, 38 females, (two did not report gender), median age 18.7) available, who were primarily taking freshman-level psychology courses at West Point, New York. The 79%:21% male-to-female ratio was in line with USMA's 80% male:20% female ratio ("CollegeNavigator: United States Military Academy," n.d.). Participants were offered extra credit to participate in the study. Participants were excluded for the following criteria: prior military service; previous exposure to burnt or burning human flesh; use of tobacco products in the last four hours; currently taking cold or flu medication; having a cold, allergies, flu, or other illness that might affect the sense of smell during the previous two weeks; younger than 18; senior or junior class standing; and anosmia. A small number of sophomores, who had similar recent training as the freshman on the complex task, were allowed to participate. Administrators gave USMA staff a number of time slots to advertise for sign-up each day. These time slots were randomly assigned to one of the three conditions the day before researchers received the list of participants. In this way, administrators, USMA staff, and cadets were all blinded to which condition a cadet would be assigned.

Factors of Interest

Task performance, stress, escape/avoidance behavior, and olfactory adaptation were the factors of primary interest.
The research measured performance on a complex task as percentage of correct responses on a written exam of the standard 9-line medical evacuation request procedure. This procedure has been identified as a human-life issue in recent operations in Afghanistan (Midla, 2004; Pizzola, 2010), perhaps due to the stress arising from "first impression of a battlefield injury" (Midla, 2004). The request procedure is taught as part of basic soldier skills to freshman cadets ("Prospectus: West Point," n.d.). Two evacuation procedure exams, one for the training phase and another for the subsequent phase, both of similar difficulty, were developed. Each evacuation procedure exam consisted of four scenarios, ordered from easiest to most difficult. Two administrators graded cadet exam performance using a rubric developed by retired Army combat medics.

Using the methodology presented in Boyce, Goldberg, and Moss (2016), the research measured stress using the skin conductive responses (SCRs) component of the Electrodermal Activity Data (EDA) acquired via wrist-worn Q-Sensors. The actual measure used for analysis of stress was the number and percentage of subjects who experienced one or more SCRs during a 30 second window, 15 seconds before and after the subject's announcement of detection of an odor. The window allowed for delayed reaction to the odor.

The research measured Escape/Avoidance behavior from the malodor as: (1) number of participants who left the experiment early: and (2) number of participants who refused to participate in a (notional) follow-on experiment.
The research measured olfactory adaptation in terms of odor detection time and end of phase perceived intensity. Detection time equaled the difference in seconds between when the odor machine was turned and when a participant claimed to detect a distinct change in odor. Perceived intensify equaled the subjective ratings from the Atmospheric Quality Scale (AQS) (Rotton, Frey, Barry, Milligan, & Fitzpatrick, 1979). The AQS intensity scale consists of four contrasting subscales: Bland-Pungent, Weak-Strong, Moderate-Intense, and Impotent-Potent. Each subscale had a 1 – 7 rating, with the lower end reflecting Bland, Weak, Moderate, or Impotent. The overall intensity ratings thus had a range of 4 – 28, with 4 reflecting the minimum intensity and 28 reflecting the maximum intensity.

Conduct of the Experiment

The Army Research Laboratory Institutional Review Board approved the research and the USMA Experimental Psychology department granted subject availability. The experiment took place during fall semester 2016 and spring semester 2017.

Random assignment of subjects resulted in 60 cadets (45 male) experiencing the Malodor Exposure Training condition, 59 cadets (50 male) experiencing the No Malodor Exposure Training condition, and 61 cadets (44 male) experiencing the Control condition. Upon arrival, subjects were met by a research administrator who obtained informed consent, performed a test for anosmia using "Sniffin' Sticks" (Sorokowska, Albrecht, Haehner, & Hummel, 2015), and had the subjects complete demographics form and an initial Atmospheric Quality Scale (AQS) (Rotton, 1983). Subjects were fitted with a "Q-Sensor" (Noordzij, Scholten, & Laroy-Noordzij, 2012) to measure EDA. Subjects were then taken to a 10' x 10' tent, with a table, lamp, laminated guide to aid in completing the medical evacuation order exam, and chairs for the subject and administrator. Subject were instructed to let the administrator know when there was a significant change in the odor in the tent. After receiving instructions, subjects began taking the exam. After two minutes, an assistant outside the tent turned on a ScentPop and pushed a hose from a box housing the ScentPop inside the tent. An odor canister was connected to the ScentPop in compliance with the fore mentioned experimental design. ScentPop machines in no odor phases had no odor canister and simply blew non-scented, ambient air. Twelve minutes after entering the tent, or ten minutes after the ScentPop was turned on, the administrator had the subject stop the exam. The subject was led outside and given an AQS to rate the atmosphere in the first tent. This process was repeated in a second tent. After completing a final AQS, the administrator retrieved the Q-Sensor, and debriefed and dismissed the participant.

Researchers closed odor canisters after each run, used canisters for a maximum of two hours daily, stored them in a cool place, changed them within two months, and ordered new canisters for each data collection trip, thus exceeding ScentAir specifications for maintaining consistency. Tent flaps were opened after each run to air out the odor. Researchers determined that two minutes was sufficient for a tent and clothing to be cleared of odor.

RESULTS

IBM Statistical Package for the Social Sciences (SPSS) version 24 and its symbology is used to report all descriptive and inferential statistics. Experimental statistically significant levels were reported when observed p values were below $\alpha = .05$, except when a Bonferroni correction for $n = 3$ for multiple comparisons was applied yielding $\alpha = .017$. Kolmogorov-Smirnov analysis of data indicated non-normal distributions in almost all categories and scales were often ordinal or categorical, hence non-parametric statistics were used to analyze data.

Performance of the Task

Table 2 presents training phase, subsequent phase, and differences (subsequent minus training) for median complex task performance scores (percentage correct), as well as Wilcoxon Matched Pairs Signed Rank (WMPSR) test significance.

TABLE 2. Condition-phase median exam scores and within subject differences between phases.

Phase / Condition	Test score percent correct: Training phase	Test score percent correct: Subsequent phase	Percentage Improvement (percentage points)	WMPSR Significance Within Condition α = .05
Malodor Exposure Training	63.889	77.083	13.194	.000
No Malodor Exposure Training	66.667	76.389	9.722	.014
Control	65.278	72.222	6.944	.000

Within group between phase WMPSR analysis showed all conditions significantly improved performance scores from the training phase to the subsequent phase indicating learning dominated outcomes. A Mann-Whitney U independent sample test showed no statistical significance for any between group within phase comparisons and prevented rejection of any between group null hypotheses of equivalence. The inference is that exposure to the burnt flesh malodor during the training phase does not improve performance during the subsequent phase any more than would otherwise be experienced without exposure to the malodor during training.

Stress

EDA data collection per cadet lasted between 35 and 42 minutes in duration and was, in many cases, “noisy”, with multiple drops to near zero. In some cases, the data could be cleaned manually, with drop values manually replaced with the mean EDA over the past 100 data points (12.5 seconds). However, some data files were noisy beyond the ability to clean manually. A MATLAB signal processing routine was used to clean these data files. After cleaning the data, we examined the data for SCRs within a 30-second window centered on the time a subject claimed to detect an odor. Figure 1 illustrates a participant who exhibited two SCRs highlighted within red boxes.

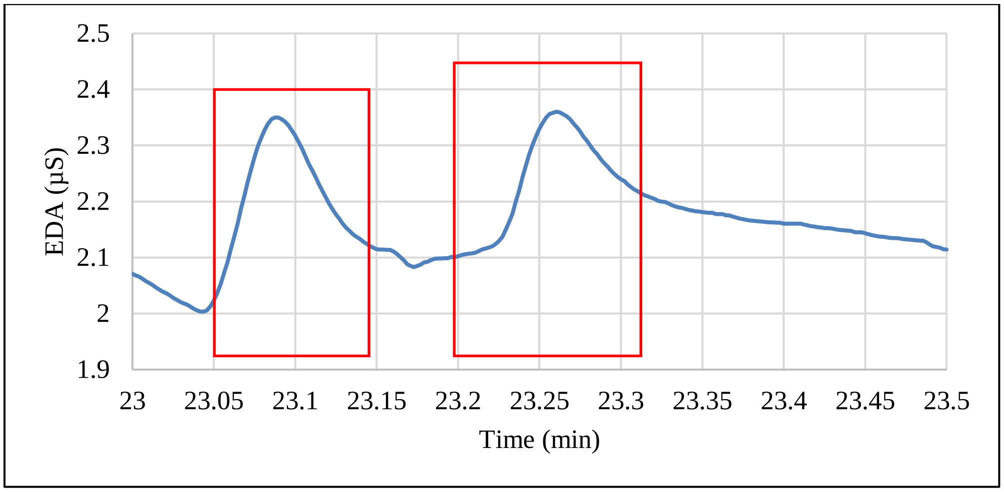

FIGURE 1. Participant B6 showing two SCR episodes.

Table 3 presents the number and percentage of subjects who experienced one or more SCRs within the window by condition and phase, along with Pearson’s chi-square analysis of statistical difference between training and subsequent phases.

TABLE 3. Pearson’s Chi-Square significance for related samples, number (percentage) of participants exhibiting one or more SCRs.

Condition	**Phase**		**Pearson’s Chi-Square Significance *p* values *(Bold if α > .05)***
	Training	**Subsequent**	
Malodor Exposure Training	22 (39.3%)	15 (26.8%)	.203
No Malodor Exposure Training	3 (5.9%)	18 (35.3%)	**.000**
Control	9 (15%)	9 (15%)	1.000

For the within group alternative hypotheses of interest, the null hypotheses of equivalence between phases for the Malodor Exposure Training group could not be rejected. The inference is that simulation of a burned flesh malodor during training does NOT reduce the number of subjects experiencing stress, as measured in terms of SCRs, on the same complex task in a latter exposure to that malodor. SCR analysis also revealed nine individuals (15%) in the Control group for both phases reported a change in odor and experienced an SCR when no burnt flesh malodor was introduced. Additionally, three participants in the No Malodor Exposure Training group also reported a change in odor and experienced an SCR when no burnt flesh malodor was introduced. For experimental purposes, these Control and No Malodor Exposure Training odor change reports are false positives and possibly due to transient odors introduced by the ambient air blown into the tent by unscented ScentAir machines.

Table 4 shows significance levels for between group, within phase SCR comparisons.

TABLE 4. Pearson's Chi-Square significance for between group, within phase comparison of the number of participants exhibiting one or more SCRs.

Phase / Conditions Compared	Training Phase *p* values	Subsequent phase *p* values
Malodor Exposure Training (A) vs No Malodor Exposure Training (B)	.000 A > B	.341 A=B
Malodor Exposure Training (A) vs Control (C)	.003 A > C	**.003** **A > C**
No Malodor Exposure Training (B) vs Control (C)	.002 C > B	.002 B > C

In terms of the between group alternative hypotheses of training interest, the anticipated drop in stress between the Malodor Exposure Training and No Malodor Exposure Training groups did NOT occur. Rather equivalence could NOT be rejected. Further, the anticipated equivalence between Malodor Exposure Training and control did NOT occur. Rather Malodor Exposure Training subjects still reported malodors at significantly higher levels than Control subject, despite the false positives observed in Control. One unanticipated anomaly did occur. Specifically, during the training phase the number of participants reporting a change in odor and experiencing a SCR in the Control group was statistically greater than the number of participants reporting a change in odor and experiencing SCR. Since neither group experienced a burnt flesh malodor, the number of false positives should not be statistically different.

Escape/Avoidance Behavior Hypothesis

No participant left the experiment early. For the follow-on experimentation question, five or fewer individuals per condition said they would not participate. Subsequent analysis indicated no statistical difference between conditions, thus there was no support for Malodor Exposure Training experience reducing escape/avoidance behavior in a subsequent phase experience.

Evidence of Olfactory Adaptation

The anticipated decrease in perceived intensity from training phase to subsequent phase for the Malodor Exposure Training condition was not met at a significant level nor were the between the anticipated group differences achieved. In contrast, the anticipated increase in detection time from treatment phase to response phase for those experiencing the Malodor Exposure Training condition was met at a statistically significant level. However, though the time differences were statistically different, the actual difference of 19 seconds increase (Md = 27 sec to Md = 46 sec) may have little or no operational meaning for a 10-minute medical evacuation procedure exam or even a two and half minute real world medical evacuation procedure.

DISCUSSION

The findings above indicate that adding a simulated malodor to live field training, by itself without additional sensory experience, does not make a statistically measurable contribution to improving performance, decreasing stress, or decreasing escape/avoidance in USMA cadets exposed to the same level of malodor in a subsequent battlefield exposure. Further, for the physiology of olfactory adaptation, cadets did experience a statistically significant time delay in the detection of the malodor, but the 19 second delay is problematic as to any meaningful operational significance.

The results above have some agreement and contrasts with previous literature.

First, improvement of complex task performance for all conditions from an initial phase to a subsequent phase is similar to findings by Vazquez and Proctor (under review).

Secondly, from the perspective of stress, the 32% decrease in Malodor Exposure Training condition SCRs compared to the 500% increase in No Malodor Exposure Training condition SCRs was quite remarkable on the face, but NOT statistically significant in terms of between group within phase comparison. This leads to a question: If perceived malodor intensity is a greater indicator of stress, might a suprathreshold concentration (Dalton, 2000) during the training phase have altered the subsequent phase SCRs even more?

Two additional factors – experimental temperature and difference in temperature between conditions - could have served to confound the EDA data. Recently, MacNeill and Bradley (2016) reported an influence between clinical polygraph EDA readings and temperature (10°C, 22°C, and 34°C) with 22°C being optimal and 10°C least effective. For our outdoor Malodor Exposure Training and No Malodor Exposure Training conditions, Weather Underground reported a mean temperature of 13°C. Furthermore, post hoc correlation analysis indicates a significant positive correlation ($p <= .000$, Spearman's rho coefficient = .334) between percent EDA change and experimental temperature for these two conditions. Thus, the progressive effects of the outside cold may have had a stronger impact on EDA measurements for the Malodor Exposure Training and No Malodor Exposure Training conditions than the malodor training itself. Further, for the Control condition, where no EDA change was observed between phases, most of the runs were inside, due to test facility limitations, at the preferred 22°C (approximately).

The fact that nine Control condition participants reported a change in odor when no malodor was introduced is not easily explainable. However, analyzing the odors these participants claimed to detect reveals a large percentage smelled odors similar to burning meat, indicating conflating of malodors from ambient cooking odors, the odor machines, the boxes holding the odor machines and canister, or the hoses may have been contaminated from earlier use in an odor condition, although care was taken to attempt to preclude this possibility. The second highest odor detected related to musty building, which would be expected given that the tents were in an old building with limited airflow.

The observed 8% cadet escape behavior, evenly distributed across conditions, contrasts sharply with escape behavior noted in Asmus and Bell (1999), where as many as 26% of the male participants opt out of a (notional) follow-on experiment.

Indeed, the performance, stress and escape behavior results may indicate an underlying uniqueness of the USMA cadet population demographics. Specifically, (Parsons et al., 2009) found for heart rate, a potential indicator of stress, USMA cadets showed significantly lower heart rates than peers at a state university in a low-immersion (PC monitor and headphones) scenario. Though there were no Signiant differences during a high-immersion (head-mounted visual display) scenario, the study suggests USMA cadets may be less prone to exhibit stress under certain conditions than others. Further, a conditioned response requires a specific learning experience or experiences to occur that changes one or more of those behaviors despite environmental distractions such as a malodor (Wyrwicka, 2000; Zidda et al., 2018). USMA cadet training prior to the experiment abounds with experiences that may condition the cadets to "filter key information from these (combat) sights, sounds, and smells" (Cameron, 1997, p. 11). Szivak and Kraemer (2015) refer to an individual's ability to handle stress as "hardiness" (p. S36), and one way to increasing hardiness is repeated exposure to stressors, or "stress inoculation" (p. S36).

From the perspective of the physiology of olfactory responses, the results indicate some level of "traditional" olfactory adaptation. Findings are not inconsistent with past literature. Specifically, Cain (1974) and Steinmetz, Pryor, and Stone (1970) both indicate a longer training period is necessary to reduce the olfactory system perceived intensity than to increase detection threshold. U. Berglund (1974) indicates the olfactory system's ability to perceive intensity recovers exponentially with the stronger concentrations completely recovered within 10 to 12 minutes after initial training, while the olfactory system ability to perceived intensity to the weakest concentration recovered linearly within another five minutes. Pryor, Steinmetz, and Stone (1970) indicate recovery of detection threshold occurs even faster, with approximately 90% of the recovery occurring within one minute except for the highest concentration. In this experiment, times were not recorded for the period between the two phases, since the pilot study indicated the inter-phase time period was short enough to allow for adaptation.

POTENTIAL USE CASE

Given the mixed results, and referring back to previous research into olfactory desensitization, we offer the following use case as way to incorporate simulated malodors into an existing training regimen. It is assumed scenario-based simulation-enhanced training (e.g., "lane training") follows a period of classroom instruction; it is in this lane-training we recommend simulated odors be applied.

Medical first-responder trainees enter an enclosed space where they observe patient simulators with a variety of injuries. In addition to the visual cues, relevant simulated odors have been dispersed prior to trainee entry from multiple machines, thus resulting in a high concentration. After a 10 minute period in which trainees respond as a team to the injuries, they move into additional spaces in one or two member teams. Patient with patient simulators exhibiting injuries and relevant odors (singular and at a lower concentration than the initial space) are dispersed throughout.

By initially being exposed to a higher concentration of malodors, the limited decrease in perceived intensity we saw in our experiment may be overcome. In addition, using patient simulators with injuries that match the malodors may also result in a more realistic outcome.

CONCLUSIONS AND FUTURE RESEARCH

Stevenson (2011) hints to the impact of context on perceived intensity of a malodor. The inference is, rather than the malodor acting in isolation on the psyche of a soldier in combat, the combination of a malodor with other sensory experiences such as related battlefield sights and sounds combine to challenge a soldier's mental toughness. Whether or not malodor combinations or adding photos of burnt bodies or a manikin with burnt moulage would provide more visual context would require future research.

Conditioning should be considered with respect to selection of subjects. As future officers, USMA cadets may be required to perform a medical evacuation order, similar to medics or other soldiers. However, the selection and rigorous conditioning of USMA cadets may introduce physiological or behavioral differences between populations of interest similar to difference observed by Parsons et al. (2009) yielding different results. For malodor training, likely future target populations might include novice medics as well as similarly novice search, rescue, and recovery personnel in initial training.

Without improvement in EDA equipment reliability, subject populations should be sufficient to allow for approximately 15% subject data loss per condition. Further, our Q-Sensor EDA data experienced lower reliability and contained more noise than reported by Vazquez and Proctor (2018) using the Empatica E4 wristband. Feasibility and reliability of current stress-reporting methods (e.g., cortisol, continuous heart-rate monitoring, other EDA technologies) should be considered prior to follow-on research.

Future research should also explore recovery time (Philpott, Wolstenholme, Goodenough, Clark, & Murty, 2008) since field training might have longer periods between odor exposure, thus allowing for olfactory systems to recover. An additional thread for future research should consider additional methods of alleviating harmful effects of malodors. Our research indicates a single, relatively short pre-exposure with consistent concentration is insufficient to produce significant improvements. However, other possible methods exist and should be explored, including resilience and stress inoculation training.

Resilience has been defined as "class of phenomena characterized by good outcomes in spite of serious threats to adaptation or development" (Masten, 2001), "the ability to persist in the face of challenges and to bounce back from adversity" (Reivich, Seligman, & McBride, 2011), and "the process of coping with or overcoming exposure to an adversity of stress" (Meredith et al., 2011). Mindfulness, a method of being aware of physical sensations and the thoughts and emotions which arise from those sensations, has shown positive correlation in civilian community, although more research is needed to determine whether this correlation holds true universally in military populations (Rice et al., 2013).

While mindfulness techniques can be taught to groups of people (Stanley, Schaldach, Kiyonaga, & Jha, 2011), stress inoculation training, or SIT, is individualized and seeks to determine the root of a subject's anxiety (Meichenbaum &

Deffenbacher, 1988). SIT has also been applied primarily as post-trauma treatment rather than pre-trauma training (Foa et al., 1999). Saunders, Driskell, Johnston, and Salas (1996) indicate SIT's primary aim is to reduce anxiety, and someone who has yet to be exposed to a malodor may not have developed an anxiety about that first exposure. Further, Saunders et al. (1996) indicate that anxiety reduction may not be sufficient for improving performance, but, when accompanying traditional training, may result in both improved performance and reduced anxiety.

While a single, 10-minute exposure to simulated burnt flesh did not produce statistically significant results during a second 10-minute exposure to the same simulated malodor, the experiment provide valuable lessons with respect to the use of simulated odors in a field training environment. Among others, these lessons include ensuring the odor is presented in context to the environment and the tasks being performed, any measuring equipment is fully tested prior to data collection, odor intensity during the initial phase is stronger than the subsequent phase, and participants relate more closely to the targeted population.

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