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Military Trauma and its Influence on Loudness Perception

The sensory mislabelling of environmental events is one of the more pronounced disruptions associated with posttraumatic stress disorder (PTSD) [1]. Mislabelling, in this context, results from an erroneous or exaggerated neural representation of a sound, sight, tactile sensation, or smell producing a perception that does not correspond accurately to the magnitude of the related stimulus. The exaggerated perception may trigger in the patient with PTSD a state of hyperarousal that produces profound negative reactions and ultimately contributes to avoidance behaviours. The resulting sensations of pain and anguish experienced by the affected individual may upset their most valued relationships, drive family members apart, and produce in the sufferer a sense of despair or self-loathing. In order to facilitate a patient's ability to manage hyperacoustic responses, and to understand the physiologic mechanisms of sensory mislabelling, it is essential for clinicians to address the contributions of psychological distress to the auditory experience. A management plan that incorporates interdisciplinary teams of professionals stands the best chance of improving the coping skills of individuals thus affected.

It is often the case that veterans who experience hyperacusis have hearing loss and tinnitus; what sets the patient with PTSD apart is an increased likelihood that they will rate sound tolerance problems as more severe than tinnitus and hearing loss. Patients report that they avoid certain social and occupational situations due to

sound-triggered pain and discomfort when in the presence of everyday sounds that do not bother their colleagues, friends, or family. Table 1 summarises findings from the last 500 patients observed at a Veterans' Affairs clinic in the US with respect to the rating of sound tolerance problems compared to pure-tone sensitivity and ratings of hearing loss and tinnitus. It is clear that the veterans with PTSD experience the loudness of environmental sounds in a substantially different way from patients with similar absolute threshold, and similar ratings of tinnitus loudness. Patients with PTSD are also three times more likely to state that exposure to loud sounds exacerbates tinnitus loudness than members of the other groups [2]. The difference extends to comparisons of patients with tinnitus and psychological disorder (that is, anxiety, depression, or panic attacks) other than PTSD (Figure 1). To what do we attribute the apparent mislabelling of sound that affects patients with PTSD to a greater degree than patients without PTSD?

The DSM-IV [3] specifies the symptoms that must be present to endorse a PTSD diagnosis as including, 1) exposure to traumatic stressor, 2) re-experiencing symptoms (flashbacks), 3) avoidance and numbing symptoms, 4) hyperarousal, 5) duration of symptoms > one month, and 6) significant distress or impairment of functioning. The symptoms associated with hyperarousal are consistent with patients' complaints regarding the experience of excessive loudness associated with moderate sound levels. When confronted

Figure 1: Patient ratings of tinnitus loudness and degree of sound tolerance problems experienced during routine activities. Ratings are based on verbal response and a 0-10 scale.

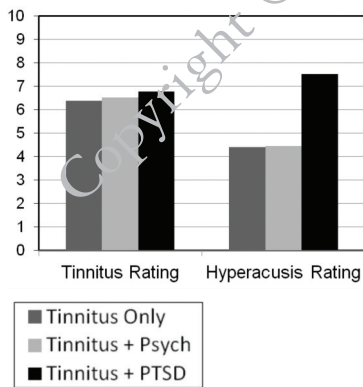


Table 1. Patient group information regarding tinnitus, hyperacusis, and hearing loss. Ratings are based on verbal response and a 1-10 scale.

Patients with:	Tinnitus Only		Tinnitus + Psych Dx		Tinnitus +PTSD	
	Mean	SD	Mean	SD	Mean	SD
PTA (better ear)	33.8	7.6	33.2	8.1	34.4	7.7
PTA (worse ear)	38.1	8.8	38.8	9.2	38.3	8.9
Hyperacusis Rating (1-10)	4.40	3.4	4.46	2.8	7.51	2.7
Tinnitus Loudness Rating (1-10)	6.37	2.5	6.51	2.1	6.78	2.2
Hearing Loss Rating (1-10)	5.13	2.5	5.28	2.7	6.10	2.7

by the perception of excessive loudness, patients respond as though they are in danger, they maintain an alert state that is disproportionate to the stimulus magnitude.

Hyperarousal is recognised as a condition in which patients experience reduced pain tolerance, anxiety, exaggerated startle responses, insomnia, and heightened sympathetic nervous system activation. If we consider an exaggerated neural response as an element of PTSD-related hyperarousal, then it is reasonable to think of hyperacusis as a sound-based analogue of reduced pain tolerance. Patients who experience startle responses that compel withdrawing from social situations illustrate the power of the sensory mislabelling. Clearly, the individual with PTSD who experiences an episode of hyperacusis perceives something that is not present in the environment, and their reaction, although perhaps appropriate at some time in the past when a similar sound signified danger, would not be appropriate in their present circumstance.

The concept of hyperarousal and its relation to the fight-or-flight response is attributed, as early as 1915, to Walter Bradford Cannon [4]. The Cannon-Bard theory of emotion centres on the thalamus and its output to cortical regions associated with responses to powerful emotions. Thalamic activity could trigger aversive conditioned responses when, for example, its output is associated consistently with specific events that evoke powerful negative emotions. For the hyperacusis veteran, the response to unexpected impulse sounds is learned; the soldier is trained to recognise the sounds' value as a survival threat. Combat veterans consistently lash out, sometimes violently, at friends and family when startled or when woken suddenly from sleep. For those veterans with experience in combat zones, the responses are difficult to extinguish, they are not easily unlearned. Therefore, while such patients recognise they behave inappropriately, or anti-socially, they are unable to adopt new strategies to cope with arousing environmental conditions.

Bremner and colleagues [5] attributed poor coping strategies among veterans with PTSD to trauma-related changes in neural circuitry, specifically involving the hippocampus, that impaired recalling or learning effective coping strategies. Bremner measured reductions in hippocampal volume among returning combat veterans and related the changes to specific deficits in memory and learning.

Such impairment affected both declarative memory (that is, remembering facts) and non-declarative memory (that is, how to brush one's teeth, or, for our purposes, remembering how to react to an environmental event) [6]. The inability to develop or retain appropriate emotional (and ultimately physical) responses to environmental stimuli was viewed as a direct consequence of hippocampus impairment.

PTSD-related hyperarousal is attributed to a variety of neural and biochemical sources. In addition to hippocampus involvement, chronic excessive cortisol levels associated with prolonged stress such as those experienced by combat veterans or trauma victims contribute to central nervous system irritability and hyperarousal. In this way, the combat experience produces similar effects to those suffered by victims of sexual abuse or captivity.

Judith Herman [7] described victimised women who were known to Freud and other psychoanalysts as experiencing an 'elevated baseline of arousal' in combination with 'an extreme startle response to unexpected stimuli, as well as an intense reaction to specific stimuli associated with the traumatic event' (p. 36). She stated further that trauma victims had difficulty tuning out repetitive stimuli, even if innocuous, as each presentation appeared to be processed as 'a new, dangerous surprise'. It is worth noting here the relatively high prevalence of tinnitus among this population, as tinnitus could be considered a repetitive stimulus generating a similar response. The physiologic consequences for such women mirrored those of veterans who reported feeling 'on patrol' when they have misinterpreted environmental events to a degree that they could not function in routine social situations. Victims of sexual abuse or captivity were long known to exhibit a tendency to startle, withdraw, suffer nightmares, and experience psychosomatic symptoms that were similar to the effects seen in veterans who had survived violent episodes, had perpetrated violence on others, or who had chanced upon horrific scenes of battle recently ended (for example, those soldiers who came upon the village of My Lai after the massacre).

Hyperacusis may be difficult to quantify, however when such patients are asked directly to rate the annoyance and impact on routine life of their sound tolerance problems, the ratings typically exceed those applied by patients to their hearing loss and / or tinnitus. Although the lack of

a well-established hyperacusis assessment clouds the interpretation of patient comments, their reports consistently reveal that they experience enduring discomfort and anxiety. Repeated exposures do not change their experience; as Herman [7] described, it is as if the sensation is new each time it is experienced. Adaptation to such stimuli appears beyond the reach of these veterans.

Mislabelling of stimuli is the result of several factors: training, experience, traumatic memories, and wholesale changes to the baseline activity in the CNS. The aberrant behaviours that result, such as avoidance, irritability, and violent reactions to neutral events, have the potential to rend relationships and upend aspects of daily life that most people take for granted. It is likely that some veterans and military personnel learn to be hyperacusis over time. Their strong physical and emotional responses to sounds that would not bother other people have had substantial ecological value at one time and are reinforced in life-threatening situations. It is the misfortune of such individuals that a plethora of environmental sounds resemble the sounds of war enough so that they trigger extremely disturbing thoughts, memories and actions. The scope of these disruptions warrants the collaboration of professionals devoted to ameliorating their severity. As Shay [8] points out, it may be that to serve one's nation renders the veteran unfit to be its citizen. It is our privilege to help individuals enjoy the benefits that should accrue to their time in the military service.

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