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Tinnitus and Trauma

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Tinnitus and Trauma

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Trauma and Tinnitus

Annual Meeting of the American Speech-Language-Hearing Association
November 12, 2015

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The contents of this presentation do not represent the views of the Department of Veterans Affairs or the United States Government.
Trauma and Tinnitus

1. Physical and psychological trauma and stress: traumatic brain injury, posttraumatic stress “disorder” and their association with tinnitus
2. Traumatic memory consolidation and tinnitus
3. Cognitive-Behavioral Therapy and Pharmacological agents
4. Data from a large VA tinnitus clinic
5. Two audiologist-friendly strategies: Hearing Aids and Self-Efficacy
Traumatic Brain Injury (TBI)

- Traumatic Brain Injury: Association with psychological conditions (Brain Injury Assoc. of America)
  - Approx. 6% of Americans suffer significant depression at some point in their lives
  - Nearly ten times that number experience at least one episode of severe depression while recovering from a traumatic head injury
  - Because psychological health and tinnitus severity are often closely related, the increased risk of psychological disorder following trauma increases the likelihood of a patient developing severe tinnitus
# TBI-related Emergency Dept. Visits

<table>
<thead>
<tr>
<th>Age</th>
<th>Motor Vehicle Traffic</th>
<th>Falls</th>
<th>Assault</th>
<th>Struck by/Against</th>
<th>All Other Causes</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–4</td>
<td>14,655</td>
<td>250,413</td>
<td>1,513</td>
<td>53,761</td>
<td>13,222</td>
<td>10,225</td>
<td>343,789</td>
</tr>
<tr>
<td>5–14</td>
<td>18,110</td>
<td>101,790</td>
<td>16,612</td>
<td>101,112</td>
<td>31,355</td>
<td>20,763</td>
<td>289,742</td>
</tr>
<tr>
<td>15–24</td>
<td>76,602</td>
<td>77,951</td>
<td>81,822</td>
<td>71,031</td>
<td>34,486</td>
<td>22,722</td>
<td>364,614</td>
</tr>
<tr>
<td>25–44</td>
<td>75,122</td>
<td>80,867</td>
<td>75,527</td>
<td>49,505</td>
<td>36,933</td>
<td>22,855</td>
<td>340,809</td>
</tr>
<tr>
<td>45–64</td>
<td>46,923</td>
<td>95,824</td>
<td>28,206</td>
<td>36,925</td>
<td>15,843</td>
<td>18,804</td>
<td>242,525</td>
</tr>
<tr>
<td>≥ 65</td>
<td>10,359</td>
<td>174,544</td>
<td>4,068</td>
<td>12,815</td>
<td>6,285</td>
<td>5,216</td>
<td>213,287</td>
</tr>
<tr>
<td>Total</td>
<td>241,771</td>
<td>781,389</td>
<td>207,748</td>
<td>325,149</td>
<td>138,124</td>
<td>100,585</td>
<td>1,794,766</td>
</tr>
</tbody>
</table>

Source: National Hospital Ambulatory Medical Care Survey — United States, 2001–2010 (Emergency Department Visits; Avg./yr.)
## TBI-related Emergency Dept. Visits: Rate by age group per 100,000 Americans

<table>
<thead>
<tr>
<th>Age</th>
<th>0–4 yr</th>
<th>5–14 yr</th>
<th>15–24 yr</th>
<th>25–44 yr</th>
<th>45–64 yr</th>
<th>65+ yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2</td>
<td>1112.6</td>
<td>498.8</td>
<td>576.9</td>
<td>388.3</td>
<td>164.8</td>
<td>373.1</td>
</tr>
<tr>
<td>2003-4</td>
<td>1272.3</td>
<td>529.8</td>
<td>827.5</td>
<td>320.3</td>
<td>197.3</td>
<td>293.3</td>
</tr>
<tr>
<td>2005-6</td>
<td>1268.3</td>
<td>591.4</td>
<td>648.3</td>
<td>373.0</td>
<td>267.0</td>
<td>485.8</td>
</tr>
<tr>
<td>2007-8</td>
<td>1374.0</td>
<td>590.2</td>
<td>811.3</td>
<td>366.7</td>
<td>307.4</td>
<td>544.7</td>
</tr>
<tr>
<td>2009-10</td>
<td>2193.8</td>
<td>888.7</td>
<td>981.9</td>
<td>470.0</td>
<td>328.2</td>
<td>603.3</td>
</tr>
</tbody>
</table>

Source: National Hospital Ambulatory Medical Care Survey — United States, 2001–2010 (Emergency Department Visits; Avg./yr.)
Traumatic Exposures Associated with Tinnitus and Hearing Loss

- Head Trauma
  - Blasts
  - Blunt Trauma
- Noise exposure from other source (witnessing MVA, for example)
- Acceleration/Deceleration injuries
  - Whiplash
- Other exposures, such as prolonged captivity, lead to psychological injury
At-Risk Populations: Trauma and PTSD

• Civilian
  – Victims of sexual abuse/sex trade
  – Domestic violence
  – Motor vehicle accident survivors
  – If trauma inflicted prior to 10 years of age, victim is more likely to develop PTSD later in life

• Military
  – Combat trauma (either as perpetrator, victim, or observer)
  – Blast survivors (w/ mTBI)
  – Childhood trauma victims

• Victims of Captivity (whether military or civilian)
Audiologic Consequences of Blast Exposure: Myers et al., 2009

- **Outer ear**
  - Burns, amputation of (parts of) pinna, infection from contaminated debris

- **Middle ear (in addition to TM perf)**
  - Ossicular discontinuity/fracture in up to 33% of cases
  - Cholesteatoma resulting from epithelial cells forced through perfed TM (8% of exposures) and may recur

- **Inner ear**
  - Damage both from the blast wave and the ensuing SPL (hearing loss maybe conductive, mixed, or SN)
  - Blast wave produces physical damage to membranes
  - Hearing protection helps but is not always used, up to 75% of exposed pts develop hearing loss, 40% tinnitus
Blast Effects (Hoffer et al., 2009)

• Blast exposure
  • Tinnitus observed immediately in 33% of patients, and 43% within one month post exposure

• Blast-related mTBI
  • 70% report tinnitus w/in 72 hours post blast
  • Rate of tinnitus reports decreases over time, however the authors report that tinnitus prevalence>h. loss
  • Attribute sub-clinical (sub-audiogram) changes to localized peripheral damage to metabolic and vascular disruptions
• **Acceleration/Deceleration injuries**
  - Whiplash
  - Associated with somatic tinnitus regardless of hearing loss; tinnitus that can be modulated with jaw, neck, or other body movements

• **Kreuzer et al., 2012**
  - Review of traumatic exposures associated w/ tinnitus
  - Effects of whiplash, head trauma, noise trauma
  - 1,627 patients with tinnitus, 1,382 (85%) indicated tinnitus had a specific “onset related event”
  - 241 (17% of those) indicated traumatic event
  - 146 reported noise trauma, 44 whiplash, 28 head trauma, or combinations of the three
Traumatic Brain Injury: Association with psychological conditions

- Time Course and sequelae (Deployment Health Clinical Center)
  - Symptoms may appear immediately after the injury or appear days or weeks later
  - Up to 80% display mild symptoms that subside within 3-6 mos. following trauma
    - In moderate/severe TBI, amnesia may preclude intrusive memories
  - 10-25% of all trauma patients develop longer-term symptoms of varying severity
    - Somatic/sensory (headache, tinnitus, insomnia, etc.)
    - cognitive (memory, attention and concentration difficulties)
    - emotional/behavioral (irritability, depression, anxiety)
Traumatic Exposures: Summary

- Blast exposure may produce widespread cortical/cerebellar damage due to penetrating and/or blunt trauma and substantial inner ear and conductive system damage.
- Blast-exposed patients more likely than non-exposed individuals to develop psychological injury or disorder.
- In addition to head trauma, psychological injury (i.e., PTSD) may also result from captivity, physical, and psychological abuse.
- Therefore, expect that victims of head trauma, in spite of other more urgent health care and psych needs, may also experience severe tinnitus.
- Paula Myers and others advocate for audiologist on the polytrauma team to support management.
mTBI and PTSD Co-occur in military and civilian populations (Carlson, 2009; VA HSR&D analysis)
Beyond Blasts/TBI: Persons affected/100,000 (www.ptsd.va.gov)
PTSD Changes People and Character

• Judith Herman (1997) quotes a victim (in this case, of captivity):

  – “All those norms of human behavior which are inculcated in one from the cradle are subjected to deliberate and systematic destruction. You will have to strain all your inner resources to remember that there is...another reality...Only by maximum exertion of will is it possible to retain one’s former, normal scale of values.” (Trauma and Recovery; p. 77-78)

  – The more pronounced and longer in duration the captivity/trauma, the more likely one loses the struggle to retain their sense of value, or their character
PTSD: Perpetrator, Victim, Witness

• Jonathan Shay (1994) comments on the perpetrator of trauma experiencing PTSD:
  – Violation of “what is right” or social/moral order (whether in families or the military) “inflicts manifold injuries” on the victim
  – Cites narratives from veterans who report firing at the enemy only to find they were civilians; orders were to increase body count
  – As in a family abuse situation, violation of a moral order affects the most vulnerable most profoundly (children/foot soldiers)

• Consider also Lifton’s interviews w/ Nazi Doctors
• Witnesses to My Lai massacre
Posttraumatic Stress Disorder

• Origins of the PTSD diagnosis (see Herman, 1997 for review, examples, definitions, etc.)
  – PTSD first appears in the DSM-III (1986) as distinct from “gross stress reaction” which did not consider the durability of the symptoms
  – Long-term trauma or captivity increases severity and number of symptoms; Herman has proposed terming such cases “complex PTSD” (ie., POWs, concentration camp survivors, domestic abuse victims)
  – Shay urges us to consider PTSD an invisible wound, an injury, as opposed to a psychological condition that can be managed pharmacologically
    • “We don’t say that someone with a broken arm has ‘broken arm disorder.’”
PTSD effects on mental state

• With regard to CNS and auditory function:
  – Produces a ‘baseline change in CNS activity’ (Herman, 1997) measured using EEG
  – Provokes sensation of chronic hypervigilance and hyperawareness of one’s surroundings
  – Affects sleep, concentration, digestion, emotional state
  – Resulting exaggerated startle response causes stress, exacerbates tinnitus loudness (i.e., reactive tinnitus), raises anxiety level, contributes to visual, olfactory, and auditory hypersensitivity
PTSD: Behavioral Diagnostic Markers

• As defined in the Diagnostic and Statistical Manual of the APA (DSM-V; 2013), the criteria for a diagnosis of PTSD include:
  A: Exposure to traumatic stressor
  B: Re-experiencing symptoms (flashbacks; acknowledges considerations for at-risk children)
  Avoidance and numbing symptoms split in new version:
  C: Focuses on avoidance behaviors
  D: Cognitive distortions and mood changes related to trauma and its reminders
  E: Symptoms of increased arousal
  F: Duration > one month
  G: Significant distress or impairment of functioning
PTSD: Behavioral Diagnostic Markers

- The DSM-IV (2013 revision) manual further specifies the symptoms of increased arousal – patients must demonstrate 2 of the following:
  - Sleep Disorder (difficulty going to sleep and/or staying asleep)
  - Irritability or outbursts of anger
  - Difficulty concentrating
  - Hypervigilance (anxiety, stress)
  - Exaggerated startle response (sound tolerance problems)
PTSD in Primary Care

- PTSD Primary Care Questionnaire (Prins et al, 1999); patients screened w/ following questions:

In your life, have you had any experiences that were so frightening, horrible, or upsetting that, in the past month, you…..

1. Have had nightmares about it or thought about it when you did not want to?
2. Tried hard not to think about it or went out of your way to avoid situations that reminded you of it?
3. Were constantly on guard, watchful, or easily startled?
4. Felt numb or detached from others, activities, or your surroundings?

Positive responses on 3 items “strongly” suggests need for complete evaluation
PTSD: Diagnostic Tests

• Mississippi Scale for Combat-Related PTSD (Keane et al., 1988); standardized on 2200 vets
  • 35-item questionnaire (also a 39-item version, but the Quillen VAMC section uses the former)
  • 1-5 points for responses
  • 107-point cut-off is recommended for Dx

12. I wonder why I am still alive when others died in the military.

   1  2  3  4  5
   Never Rarely Sometimes Frequently Very Frequently

28. I feel there are certain things that I did in the military that I can never tell anyone because no one would ever understand.

   1  2  3  4  5
   Not at all True Slightly True Somewhat True True Very True
PTSD: Diagnostic Tests

- Mississippi Scale for Combat-Related PTSD
- Additional items reflecting degree of distress

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. When I think of things I did in the military I wish I were dead</td>
<td>1. Never True</td>
</tr>
<tr>
<td></td>
<td>2. Rarely True</td>
</tr>
<tr>
<td></td>
<td>3. Sometimes True</td>
</tr>
<tr>
<td></td>
<td>4. Frequently True</td>
</tr>
<tr>
<td></td>
<td>5. Very Frequently True</td>
</tr>
<tr>
<td>26. Nobody understands how I feel, not even my family.</td>
<td>1. Not at all True</td>
</tr>
<tr>
<td></td>
<td>2. Rarely True</td>
</tr>
<tr>
<td></td>
<td>3. Somewhat True</td>
</tr>
<tr>
<td></td>
<td>4. Very True</td>
</tr>
<tr>
<td></td>
<td>5. Extremely True</td>
</tr>
<tr>
<td>5. The people who know me best are afraid of me.</td>
<td>1. Never True</td>
</tr>
<tr>
<td></td>
<td>2. Rarely True</td>
</tr>
<tr>
<td></td>
<td>3. Sometimes True</td>
</tr>
<tr>
<td></td>
<td>4. Frequently True</td>
</tr>
<tr>
<td></td>
<td>5. Very Frequently True</td>
</tr>
</tbody>
</table>
PTSD: Diagnostic Tests

- Mississippi Scale for Combat-Related PTSD
- Examples of relevance for tinnitus clinic

<table>
<thead>
<tr>
<th>20. I have trouble concentrating on tasks.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never True</td>
<td>Rarely True</td>
<td>Sometimes True</td>
<td>Frequently True</td>
<td>Very Frequently True</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>24. I fall asleep easily at night.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
<td>Frequently</td>
<td>Very Frequently</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>25. Unexpected noises make me jump.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never True</td>
<td>Rarely True</td>
<td>Sometimes True</td>
<td>Frequently True</td>
<td>Very Frequently True</td>
<td></td>
</tr>
</tbody>
</table>

Note: “positive worded” item scores are reversed
PTSD: Diagnostic Tests – the PTSD CheckList: Civilian version (PCL-C)

- Avoid *activities* or *situations* because they *remind you* of a stressful experience from the past?
- Trouble *remembering important parts* of a stressful experience from the past?
- Feeling emotionally numb or being unable to have loving feelings for those close to you?
- Feeling as if your future will somehow be cut short?
- Repeated, disturbing *memories, thoughts, or images* of a stressful experience from the past?
- Repeated, disturbing dreams of a stressful experience from the past?
Most people who experience a traumatic event will not develop PTSD. However, individuals are more likely to develop PTSD if they:

- Experienced trauma during childhood
- Were seriously injured during the event
- Traumatic event was long-lasting or very severe
- Felt helpless during the trauma and were not able to help oneself or a loved one
- Had a severe reaction during the event, such as crying, shaking, vomiting, or feeling apart from surroundings, consistent with a dissociative experience (i.e., patient reports seeming to leave or hover over body, watching the event transpire)
Models of Trauma: Dissociation and PTSD

- Trauma often leads to dissociative states
  - Freud and Janet commented re: high prevalence of dissociation (multiple personalities) among trauma survivors
  - Dissociative states and related symptoms are linked to sensory disruptions and inaccurate processing
- Narrowing of attention (on tinnitus?)
  - Trauma victims “fixate faster and longer on unusual or highly informative objects.”
  - Tinnitus (an informative object?) associated with the trauma, perhaps due to its onset, could contribute to, or be affected by, related memories, arousal states, or incoherence of sensory integration (i.e., pts expressing they cannot trust their senses)
Experience and Neural Plasticity

• Judith Herman (1997): “Repeated trauma in adult life erodes the structure of the personality already formed, but repeated trauma in childhood forms and deforms the personality. For hundreds of years, observers have described these phenomena with both fascination and horror.”

• William James (1890): “An impression may be so exciting emotionally as almost to leave a scar upon the cerebral tissues.”

• Aage Møller (2010): “Activation of neural plasticity can be purposeful and beneficial, or it can be purposeful, but not beneficial”
Stress/PTSD Mechanisms: Cortisol

• Cortisol: levels elevated by stress, and may remain chronically high after event’s conclusion
  – Produced in adrenal glands and contributes to chronic hyperarousal through long-lasting, elevated noradrenergic levels (akin to chronically high levels of adrenalin even when not needed)
  – Decreases immune system function (as short-term survival is the priority during cortisol release)
  – Increases blood sugar level and blood pressure
  – Decreases muscle mass; impairs sleep; decreases bone density; produces transient infertility
  – May produce “adrenal fatigue,” associated w/ other chronic health problems
Stress/PTSD Mechanisms: Cortisol Physiologic Effects

• Primary control over cortisol levels is mediated by pituitary gland and the hypothalamus; stimulation provided to adrenal cortex for cortisol production
  – The stress-provoked hyperactivity of the Hypothalamus-Pituitary-Adrenal (HPA) axis is well-documented in trauma victims (Schnurr & Janikowski, 1999)
• Reduces serotonin levels in the brain
  – Consider the beneficial effects of SSRIs in trauma pts
• Sleep deprivation and caffeine increase cortisol levels
  – Consider individuals charged with keeping long hours who are exposed to, or witness the consequences of, traumatic events (EMTs, ER workers, first responders)
PTSD Mechanisms: Cortisol and Memory

• In concert w/ adrenalin, cortisol contributes to memory storage of brief emotional events (so-called flash-bulb memories)
  – Perhaps cementing in memory threatening environments or people to be avoided in the future, or sensory inputs linked to the event (ie., tinnitus)

• Chronic elevated levels of cortisol damage cells in the hippocampus
  – Decreased volume has been recorded in hippocampus of soldiers returning from combat deployments
  – Learning impairments (specifically w/ regard to coping strategies)
  – Deficiencies in memory retrieval
Experience and Neural Plasticity

- Judith Herman (1997): “Repeated trauma in adult life erodes the structure of the personality already formed, but repeated trauma in childhood forms and deforms the personality. For hundreds of years, observers have described these phenomena with both fascination and horror.”

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Stress/PTSD: Neural Mechanisms

• Animal models of fear conditioning and acute stress support subsequent human brain imaging results
• Three major brain structures are implicated:
  • The amygdala, activated by fear and stress, triggers powerful emotions that compel action and attention
  • The hippocampus, important for memory and conditioning but which is damaged, and whose function impaired by chronically high arousal states
  • The prefrontal cortex (PFC), which should, under normal conditions, exert inhibitory control over the amygdala
PTSD Mechanisms: Thalamus

- Interactions with limbic system and cortical structures
  - Uncontrollable stress activates the amygdala
  - Central nucleus of the amygdala facilitates the relay of sensory information to cortical and limbic structures (Clugnet & LeDoux, 1990)
  - Central noradrenergic systems (which could be primed by prior trauma) also activated by uncontrollable stress and facilitate thalamic output
  - However, the thalamic output’s fidelity may be reduced when stimulation is associated with the stressor; the output produces perceptual interference rather than enhancement of the sensory transmission (Krystal et al., 1997)
  - Such interference or distortions may contribute to sensory gating disturbances (LeDoux and Farb, 1991)
Functional Neuroanatomy of Trauma Spectrum Disorders

Medial Prefrontal Cortex
Inc. Anterior Cingulate
Planning, execution, extinction of fear response

Thalamus
Sensory Gateway; coordinates brain’s stress response

Sensory inputs

Posterior Cingulate, Parietal & Motor Cortex
Visual-spatial processing and threat assessment: Comparison of environment to that of prior trauma

Amygdala
Emotional Valence

Hippocampus: Memory

Cerebellum

Adapted from Bremner, 2002
Experience and Neural Plasticity

Traumatic events that produce auditory insult raise the probability that individuals will develop tinnitus, but does the process by which traumatic/emotional memories are formed increase the likelihood that a victim develops and maintains distressing and handicapping tinnitus that persists beyond the temporal boundaries of the traumatic event?
Experience and Neural Plasticity

• William James (1890): “An impression may be so exciting emotionally as almost to leave a scar upon the cerebral tissues.”

• Judith Herman (1997): “Repeated trauma in adult life erodes the structure of the personality already formed, but repeated trauma in childhood forms and deforms the personality. For hundreds of years, observers have described these phenomena with both fascination and horror.”

• Aage Møller (2010): “Activation of neural plasticity can be purposeful and beneficial, or it can be purposeful, but not beneficial”
Effects of traumatic stress

Diamond et al suggest that traumatic exposures generate a “strong emotional learning experience” with associated activation of short-term plasticity and ultimately long-term potentiation in the amygdala and hippocampus.

Trauma-provoked activation of the two systems (amygdala and hippocampus) may produce memories that are incomplete – fragments may be described in detail but the event’s entirety defies ability to recall.

The traumatic memory or so-called long-lasting flashbulb memory produces powerful emotions.

Patients may report tinnitus that is associated with such memories, perhaps enhancing its effect on attention, and performance of complex tasks requiring divided attention (previously-mentioned “narrowing of attention?”).
PTSD Mechanisms: Memory

“Disorganization in the trauma memory, indexed by gaps in recall and difficulty in producing a coherent narrative, is typical of normal trauma memories and has been described by many PTSD researchers.” – Brewin, 2001

Diamond et al., provide a model that illustrates the mechanisms through which “disorganization” may occur
Initial response to traumatic stressor includes increases in stress hormones as well as acetylcholine, dopamine, and changes in GABA receptor binding. Hippocampal mechanisms of memory storage are rapidly engaged, rather than suppressed, by an arousing and stressful experience. This contributes to declarative memory of the event. Release of glucocorticoids (wh/ include cortisol) enhances LTP. This time period can be thought of as a form of (emotional) priming for consolidation of trauma-associated learning and memory.
Within minutes of the exposure’s onset, NMDA receptor sensitivity saturates, decreases, and ongoing stimulation reduces hippocampal LTP despite continued activation of the amygdala. “The greater the interference with the continuity of hippocampal processing during the trauma, the more likely verbally accessible memory representations are to be impoverished.” – Brewin, 2001 p. 384
Amygdala eventually displays inhibitory phase, allowing for further consolidation of “snatches” of declarative, and traumatic/emotional elements of memory. Memory may include events co-occurring with the trauma (ie., the “warning signal” as described by Ehlers et al). Suggest we consider the possibility that tinnitus may be (an element of) this warning signal.
Pre-frontal cortex is exclusively inhibited by stress (unlike hippocampus and amygdala). “Recovery from its suppression of functioning would depend on the nature and intensity of the stressor, interacting with the ability of the individual to cope with the experience.” - Diamond et al. Add’l elements of the model supported by Bremner and others who have shown that in cases of severe trauma, the PFC may not recover its ability to suppress the activity of lower brain areas, such as the amygdala.
Johnathan Shay: Achilles in Vietnam

• Shay (1994): “When the body is tortured or its boundaries are violated, or it is otherwise assaulted by starvation, sleep deprivation, cold, or drugs under which escape is impossible, the body reacts with fear and rage, and the mind undergoes a distinctive kind of deep learning. After the danger and violation have passed, the deep learning persists as PTSD symptoms and damage to the best (and most highly valued) character as understood within the culture.” p. 208
Tinnitus, PTSD, and “Deep Learning:” Provoking the Fear Response (Brewin, 2001)

- Two forms of memory are implicated in traumatic exposures
  - Verbally Accessible Memory (VAM) is associated with declarative memory and a narrative that facilitates contextualizing the trauma within the person’s autobiographical knowledge base
  - Situationally Accessible Memory (SAM) does not verbally encode events, rather it captures sensory/visuospatial information and the body’s response to the remembered scene
- Consider the relative contributions of amygdala (SAM circuit) and the hippocampus (VAM circuit)
  - A patient’s failure to create accurate VAM will impair adjustment
  - Traumatic memories may be focused more on the emotional and body response to the event rather than an accurate image of the event’s details
  - When triggered by similar environments or stimuli, the pt may not be able to employ “self-talk” to control responses; a pt. who can modify SAM into VAM, through analysis or counseling, may gain control over their responses over time
Tinnitus, PTSD, and “Deep Learning:” Provoking the Fear Response (Brewin, 2001)

- Responses to perceived threat may be difficult to control or suppress (Vets avoiding war movies; trauma victims avoiding empty streets, crowded spaces, parks, etc.)
  - This would be related to the SAM system and not under conscious control of the patient
  - If a sensory scene or environment resembles the scene of trauma, and if tinnitus is a part of that scene, then its presence may serve as a potential trigger long after the event’s conclusion
  - Provokes flashbulb memories and associated physical responses

- Verbalizing elements of the traumatic experience can allow the victim to reframe or recontextualize an understanding of the experience as well as their response to similar environments; but such reframing is less likely in cases of hippocampal impairment
  - Analogous to the “talking cure” promoted by psychoanalysis
  - Facilitates learning new coping strategies for challenging environments
Functional Neuroanatomy of Trauma Spectrum Disorders

Posterior Cingulate, Parietal & Motor Cortex
*Visual-spatial processing and threat assessment*

Medial Prefrontal Cortex
Inc. Anterior Cingulate
*Planning, execution, extinction of fear response*

Amygdala
*Emotional Valence (SAM)*

Thalamus
*Sensory Gateway; coordinates brain’s stress response*

Hippocampus:
*Declarative Memory (VAM)*

Cerebellum

Adapted from Bremner, 2002
Profile of Patients with Tinnitus and Co-Morbid Psychological Injury/Disorder

• Clinical findings support mutual reinforcement:
  • McKenna (2004), Coles (1995), Baguley (2011), not to mention centuries-old medical literature
  • Of our first 800 patients, 276 (or 35%) are enrolled concurrently in one or more PTSD clinics (many have PTSD in addition to other psych-specific service connections)
  • An additional 254 patients seen in mental health clinics for anxiety/depression/panic disorders w/out PTSD
  • Symptoms that indicated need for psych referral relate to onset of tinnitus, reactive tinnitus, presence of hyperacusis, and exacerbating conditions (also nightmares, hypervigilance, exaggerated startle response)
Why Consider Traumatic Associations with Tinnitus in the audiology clinic?

- What we learn in the clinic from patients with tinnitus and psychological disorder
  - Greater tinnitus handicap as indicated on questionnaire responses
  - Patients have lower levels of confidence in ability to manage condition, poorer coping ability and lower self-efficacy, than patients whose tinnitus is not complicated by psychological injury
  - Patients frequently misinterpret or misjudge physical characteristics of environmental events
    - Hyperacusis may be a blatant form of the effect
    - Exaggerated startle responses
  - All of this can occur, and affect tinnitus, regardless of hearing loss
Perceived Tinnitus Handicap, and Relation to Auditory Sensitivity

![Graph showing the relationship between Pure-Tone Average (0.5, 1, 2 kHz) and Tinnitus Handicap Inventory Score (0-100). The graph compares Tinnitus alone to Tinnitus with PTSD, showing mean scores and distributions.](image-url)

- **Tinnitus**
- **Tinnitus & PTSD**
- **Tinnitus Mean**
- **Tinn & PTSD Mean**

Graph legend:
- ○ Tinnitus
- ■ Tinnitus & PTSD
- ● Tinnitus Mean
- □ Tinn & PTSD Mean
Patient Ratings of Tinnitus/Hearing Symptoms

![Graph showing patient ratings of tinnitus/hearing symptoms]

- **TINNITUS ONLY**
- **TINNITUS + PSYCH**
- **TINNITUS + PTSD**

Fagelson & Smith, submitted
Profile of Patients with Tinnitus and Co-Morbid Psychological Injury/Disorder

• Clinical findings – Tinnitus-related symptoms that distinguish stressed patients:
  • Onset of tinnitus (2x more likely to experience sudden onset)
  • Reactive tinnitus (3x more likely to experience tinnitus that is exacerbated by exposure to other sounds)
  • Presence and severity of hyperacusis
  • Other exacerbating events, such as nightmares, hypervigilance, exaggerated startle response
Reported Onset of Tinnitus (N=500; T=329; PT=171)

Fagelson, (2007). The Association between tinnitus and PTSD; AJA.
Tinnitus-Related Disturbances

Fagelson, (2007). The Association between tinnitus and PTSD; AJA.
Prevalence of ‘reactive’ tinnitus

<table>
<thead>
<tr>
<th>Does tinnitus get louder in response to other sounds?</th>
<th>Proportion of Patients (N=520)</th>
</tr>
</thead>
<tbody>
<tr>
<td>THI: Mild tinnitus (N=167)</td>
<td>18%</td>
</tr>
<tr>
<td>THI: Moderate tinnitus (N=198)</td>
<td>31%</td>
</tr>
<tr>
<td>THI: Severe tinnitus (N=155)</td>
<td>68%</td>
</tr>
<tr>
<td>Of the pts above w/ MH connection:</td>
<td></td>
</tr>
<tr>
<td>Pts. with psych. condition (N=206)</td>
<td>62%</td>
</tr>
<tr>
<td>Pts. with PTSD (N=173)</td>
<td>91%</td>
</tr>
</tbody>
</table>
Patient Ratings of Tinnitus Loudness and Sound Tolerance

Fagelson, (2007). The Association between tinnitus and PTSD; AJA.
## Sounds Triggering Physical Discomfort

<table>
<thead>
<tr>
<th>Offending Sound</th>
<th>Proportion of Patients Reporting (N=166)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impulse</td>
<td>84%</td>
</tr>
<tr>
<td>Impulse (&quot;worse when unexpected?&quot;)</td>
<td>100%</td>
</tr>
<tr>
<td>Children Shouting (&quot;Carrying on&quot;)</td>
<td>72%</td>
</tr>
<tr>
<td>Metallic &quot;scraping&quot; sounds</td>
<td>69%</td>
</tr>
<tr>
<td>Sirens</td>
<td>67%</td>
</tr>
<tr>
<td>Machinery</td>
<td>56%</td>
</tr>
<tr>
<td>Helicopters/Airplanes</td>
<td>53%</td>
</tr>
</tbody>
</table>
What’s Worse? Tolerating Moderately-Loud, Routinely-Experienced Everyday Sounds, or Your Tinnitus?

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>% Reporting HA&gt;T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinnitus</td>
<td>18%</td>
</tr>
<tr>
<td>Tinnitus + Psych. (Depression, Anxiety, OCD, Panic Attacks)</td>
<td>31%</td>
</tr>
<tr>
<td>Tinnitus + PTSD</td>
<td>62%</td>
</tr>
</tbody>
</table>
Tinnitus Provoking Heightened Fear Response in Trauma Victims

• Sensory events trigger powerful physical responses
• The sensory events (including tinnitus) can be misinterpreted by the perceiver, ultimately processed as if threatening even if innocuous
• May create arousal consistent with survival instincts or with the sense of threat (deafness, tumor, insanity, etc.)
• May produce tinnitus that demands attention in a manner consistent with the weapon used in an assault
  • The attention it demands ensures it will interfere with routine tasks, concentration, sleep, etc.
PTSD Effects: Thalamus

Frontal cortex:
- Generates
- prioritization
- plan for attention
- and working memory

Cingulate:
- Involved in
- prioritizing or shifting
- attention

Amygdala:
- Modulates the
- generation of emotional
- states

Hippocampus:
- Encodes
- long-term declarative
- memory

Thalamus:
- Modulates the fidelity of sensory processing

Sensory input

Direct and indirect feedback from cortical and limbic structures

Tinnitus Response Orientation to tinn.

Input from systems modulating arousal: locus ceruleus (norepinephrine), raphe nucleus (serotonin), reticular nuclei (acetylcholine)

Krystal et al., 1997
Targeting the Response to Tinnitus: Opportunities for AUDs

A = Event
(Awareness of Tinnitus)

↓

Self-Efficacy Training
B = Cognitions
(Thoughts)

Counseling re: Mechanisms

Cognitive-Behavioral Therapy

Hearing Aids

↓

C = Emotional State
(Depression, Anger, Anxiety)
Cognitive-Behavioral Therapy

- Objective:
  - Focus on maintaining accurate thoughts re: tinnitus, traumatic experiences and their effects
  - Modification (or increased accuracy) of thoughts can produce a change in behaviors
  - Change in behaviors can result in reduction of tinnitus handicap as patient discovers and employs new strategies to cope with and overcome challenging situations
  - Using more positive and productive behaviors may improve quality of life
Tinnitus

Event(s) → Traumatic Associations → Increasing distress and arousal

Catastrophic recognitions → Emotional Response

Thoughts About Event(s)

Cause of tinnitus (traumatic episode) → Tinnitus

Adapted from Hinton et al., 2006 (J. of Traumatic Stress)
Tinnitus (and PTSD): Counseling & Educating the Patient

• Cognitive behavioral therapy (CBT)
  • Teaches patient ways of thinking and reacting to the events that trigger trauma-related symptoms
  • The counseling, dialogue, and/or group interactions should improve pt. understanding
    • Following Brewin’s model, CBT may facilitate transferring SAM to VAM, thereby facilitating pt. adjustment and recovery
  • Goal is to bring the powerful symptoms under control
  • Use of rational thinking, or conscious knowledge of events and tinnitus to improve sense of control
  • Patients with PTSD challenged by chronic-stress-related changes to cortical and limbic system structures that should only be activated during stressful or threatening events
Counseling & Educating the Patient

• CBT is the most widely reported (and successful) veteran PTSD treatment
  • Effective in 60-80% of reported cases
• Also Recommended by Sweetow (1986), Henry & Wilson (2001), Cima et al. (2011) for managing severe tinnitus (several elements also used in TRT)
  • Patient reframes experience by internalizing different definitions/lexicon of the tinnitus/trauma (cognitive restructuring: again…SAM VAM?)
  • Modifies behavior so that the factors associated with stress/tinnitus exacerbation are managed more effectively
Example: Patient who withdraws from activities due to belief that tinnitus ruins all social interactions by impairing communication, resulting in the patient feeling inadequate

- Patient may also have aversion to crowds due to sense of insecurity, or feeling unsafe
- If communication is the problem, strategies, hearing aids, rehab may be employed
- If negative beliefs re: perceptions or intentions of strangers is the problem, such thoughts can be examined with family members and support group
- Education re: tinnitus and hearing loss may confirm for pt. that the problems experienced are to be expected in the presence of background noise
- Intentions of others may remain a problem, but patient can benefit from improved ‘internal dialogue’ and rational approaches to social situations
Tinnitus

Cause of tinnitus (traumatic episode)

Event(s)

Tinnitus

(Illusory) Thoughts About Event(s)

“I can’t hear well enough to communicate

Emotional Response

Anger, frustration, avoidance, insecurity

“Tinnitus causes me to feel unsafe and insecure, and I can’t function in crowds” or “I’ll never sleep well again”
Cognitive-Behavioral Therapy

• Components that may be included in CBT course:
  – Group sessions: coping strategies, others’ narratives
  – Interprofessional team approach
    • Include ENT, clinical psychology, physical therapy, social work, nutrition, neurology, other?
  – Mindfullness training
    • Teaching patient to focus attention in purposeful and willful manner
    • Practice different forms of imaging, relaxation exercises, meditation, yoga; all intended to sharpen the patient’s ability to shift attention
    • May also produce durable changes in neural activity associated with stress and relaxation
    • Shown to improve management of chronic pain, stress, and other hyperactive neural activity similar to tinnitus
Drug Therapy

• Drugs shown to be beneficial for trauma survivors in many cases provide tinnitus relief
  – SSRIs and serotonergic antidepressants
    • Sertraline, paroxetine, fluoxetine, trazadone (esp. for sleep)
    • May counteract elevated cortisol levels
    • Reduces symptoms associated with intrusive recollections, avoidance/numbing, and hyperarousal
    • Promote relaxation, sleep, and facilitate higher activity level
  – Benzodiazepenes – not frontline tx for PTSD
    • Reduce anxiety, but not re-experiencing or avoidance symptoms
    • Alprazolam (xanax), clonazepam (clonapin)
    • Foster relaxation, sleep, but may produce withdrawal problems (see the Ashton manual for management strategies)
  – Tri-cyclic Antidepressants
    • Imipramine, amitriptyline, desipramine
    • Reduce intrusive recollections, flashbacks
    • Anti-anxiety facilitates relaxation and stress reduction
Self-Efficacy Theory

• Belief, or *domain-specific* confidence, individuals have in their abilities (or a specific skills) to accomplish, develop, and/or maintain a certain behavior, including health behaviors (Bandura, 1986, 1997)
  – self-efficacy can be high in one domain, low in another

• Different from a general self-confidence or self-esteem

• Investigated as a way to improve patients’ sense of control
Why Is Self-Efficacy Important?

• Patients with high self-efficacy beliefs for skills needed to manage a health condition have been associated with:
  – Increased compliance with treatment/management recommendations
  – Improved subjective and objective outcomes
  – Higher health-related quality of life
  – Persevere in face of difficulty
  – Put forth greater effort in managing condition
Motivation for the Self-Efficacy for Tinnitus Management Questionnaire (SETMQ)

• In the context of existing questionnaires
  – Many functional and emotional items consistent across different intake forms, self-assessments of handicap
  – Sleep, communication/hearing, emotional response to tinnitus, concentration ability (i.e., Tyler, 2006)

• Common patient complaints
  – Lack control over the sensation (on THI, more than 85% of our patients endorse that specific item)
  – Lack understanding of its source and relation to hearing loss
  – Self-image affected, ability to function questioned; some patients question the accuracy of their senses
Sample SETMQ Items
(Smith & Fagelson, 2008)

1. I can communicate with more than one person at a time despite hearing my tinnitus.

   How certain are you that you can do this right now? (circle one %)

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

   Cannot do          Moderately certain             I am certain
   this at all                   I can do this                I can do this

6. I can control feelings of being afraid when I hear my tinnitus.

   How certain are you that you can do this right now? (circle one %)

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

   Cannot do          Moderately certain             I am certain
   this at all                   I can do this                I can do this
Self-Efficacy for Tinnitus Management Questionnaire Results

![Graph showing self-efficacy levels for different categories of tinnitus]

- TINNITUS ONLY
- TINNITUS + PSYCH
- TINNITUS + PTSD

Fagelson & Smith, submitted
Counseling Considerations: Self-efficacy

• Use of Self-efficacy scaling
  – “The confidence individuals have in their capabilities to perform courses of action needed to manage their tinnitus successfully.” (Smith & Fagelson, 2011)
  – Questions pt. regarding specific activities that challenge coping with and management of tinnitus
  – Although self-efficacy may be high in one area (ie., the pt. believed his tinnitus did not influence his ability to concentrate or communicate one on one with someone), it may be low in another (ie., tinnitus affected quality of sleep and ability to converse with groups of people).
  – Targeting the activities for which the pt. is less certain of success fosters specific management strategy discussion
Use of Aids and Sound Generators

• Sound generator for bedside use (new smartphone apps may reduce need to order specific device)
  – Recommend running device throughout night
  – Set at comfortable level (total masking not the objective)

• Hearing aid selection: Searchfield (2005)
  – Open fit
  – Program for communication situations (set to typical target gain values for preferred prescriptive methods)
  – Program for tinnitus specified for use in quiet situations when tinnitus would be most noticeable
Hearing aid selection with use of ‘tinnitus program:’
Searchfield (2005)

<table>
<thead>
<tr>
<th>Hearing Aid Feature</th>
<th>Standard Program</th>
<th>Tinnitus Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microphone</td>
<td>Directional</td>
<td>Omnidirectional</td>
</tr>
<tr>
<td>Prescriptive Formula</td>
<td>NAL-NL1 or other preference</td>
<td>DSL[i/o]</td>
</tr>
<tr>
<td>Noise Reduction</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>Compression</td>
<td>Low compression ratio if possible, prioritize naturalness and audibility</td>
<td>Low kneepoint, high compression ratio; prioritize use of LF env. sounds</td>
</tr>
<tr>
<td>Output</td>
<td>Must take care in all fittings, for all programs, to ensure patient loudness tolerances are addressed.</td>
<td></td>
</tr>
</tbody>
</table>
Hearing Aids for the Trauma Patient

• Hearing aids
  • Facilitate monitoring environment (currently conducting student project investigating benefits of fittings for patients with PTSD)
  • Make some social situations easier to manage
    • Communication in aversive settings might improve
  • Pt. less often surprised by sudden unexpected sounds; perhaps fewer misinterpretations of events
  • Establishing acceptable output levels the most important consideration
Hearing Aids Ameliorate Tinnitus Distress?

<table>
<thead>
<tr>
<th>Do hearing aids reduce the amount of tinnitus distress?</th>
<th>Proportion of “Yes” Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild tinnitus (N=83)</td>
<td>58%</td>
</tr>
<tr>
<td>Moderate tinnitus (N=162)</td>
<td>53%</td>
</tr>
<tr>
<td>Severe tinnitus (N=89)</td>
<td>59%</td>
</tr>
<tr>
<td>Pts. with psych. condition (N=134)</td>
<td>32%</td>
</tr>
<tr>
<td>Pts. with PTSD (N=118)</td>
<td>55%</td>
</tr>
</tbody>
</table>
Summary

• High prevalence of PTSD among civilian and veteran populations has implications for audiologists, their tests, and interpretation of pt. history and complaints (age(s) trauma experienced a major factor)
• Trauma-induced hyperarousal causes mislabeling of sensory information, central to PTSD and hyperacusis
• Intrusive memories may be triggered by sensory inputs, including tinnitus, particularly those associated w/ trauma (unexpected impulse sounds, etc.)
Summary

• Priorities of audiologic intervention for trauma patients
  – Intent is to improve pt’s response to tinnitus
  – Identify strategies that address specific functional impairments experienced by patient (ie., sleep, communication)
  – Hearing aids a far more effective intervention (due to their flexibility) than in the past, with or without combination masking circuitry; promote sense of security in environment
  – Support pt’s ability to distinguish tinnitus effects from the effects of other conditions or injuries that exacerbate it
  – Work w/ psychologists, or other professionals to ensure that all mental and physical health needs are being addressed
Considerations for Audiologists

- Arousal symptoms to watch for:
  - Irritability (by own report): Indicates excessive physiological activation (sound-provoked tinnitus exacerbation)
  - Exaggerated Startle: A heightened sense of “being on guard”
  - May want door to booth open, certain lighting, unknown people (ie., supervisees) out
  - Priority must be to create an environment in which the patient feels safe, and can share impressions freely
PTSD Changes People and Character

• Herman (1997):
  – “Traumatized people suffer damage to the basic structures of the self. They lose their trust in themselves, in other people, and in God. The identity they have formed prior to the trauma is irrevocably destroyed.”
  – However: “…creating a protected space where survivors can speak their truth is an act of liberation. They remind us that bearing witness, even within the confines of that sanctuary, is an act of solidarity.”

• Shay (1994):
  – “The painful paradox is that fighting for one’s country can render one unfit to be its citizen.”
4 great references:
1. Jonathan Shay – Achilles in Vietnam (Scribner)
2. Judith Herman – Trauma and Recovery (Basic Books)
3. Jonathan Shay – Odysseus in America (Scribner)
Patient Background

• 53 yr. old male: Audiologic case info (2001):
  – Communication difficulties; particularly in challenging listening conditions
  – Longstanding (since 1968) tinnitus
  – Pain in his ears and facial muscle weakness that seems to be getting worse over time

• Results:

<table>
<thead>
<tr>
<th></th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001 R</td>
<td>20</td>
<td>25</td>
<td>35</td>
<td>45</td>
<td>40</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>2001 L</td>
<td>15</td>
<td>20</td>
<td>30</td>
<td>35</td>
<td>45</td>
<td>55</td>
<td>55</td>
</tr>
</tbody>
</table>

• No middle ear problems, reliability good, word recognition scores in quiet >80%
Case Study: Trauma Victim

• Military trauma, however it is clearly not the typical case, and relates to events that might also affect a civilian

• Tinnitus Case History (53 yr. old male; initial contact 2001):
  – Tinnitus sound: High-pitched tone
  – Sudden onset following noise trauma on the firing range (1968)
  – Reached current level at onset
  – Reactive tinnitus exacerbated by unexpected impulse sounds
  – Sound tolerance problems, both when aided and unaided, complains aids have “never worked right”
Case Studies: Trauma Victim

- Additional Medical History
  - Dxed with PTSD in the 1990s (charted info supports presence of chronic stress, anger, pain, sleep disturbance, depression, anxiety)
  - VIIth nerve surgery on right side years before due to “weakness and pain” (eventually bilateral)
  - Psych intervention recently initiated; including meds for sleep and pain
  - “Never been out of Greene county” except for time overseas in the service
Management Plan: Initial contact

• Sound generator to facilitate sleep
  – Different devices and sounds demonstrated for the pt.
  – Pt. counseled on use of device
    • Do not set at uncomfortable level (‘arms race’ between device and tinnitus if total masking sought)
    • Do not use timer
  – Counsel re: mechanisms of tinnitus and hearing loss
  – Confirm pt. is continuing psych. care in order to continue educational sessions
Case Study

- Brief chronology:
- 9/24/01 – initial contact, case hx, tinnitus tests, sound generator discussed and ordered
- 10/26/01 – pt. reports sound generator very helpful for sleep; counseling re: mechanisms and reactions
- 12/27/01 – sleep continues to improve, understanding of the tinnitus mechanism also helpful (reduces stress); THI repeated
- 2/25/02 – hearing worse following 2nd VIIth N. surgery; tinnitus less bothersome than first contact, but worse since surgery
- 3/21/02 – counseled re: hearing aids with maskers; impression taken, aids ordered
- 5/13/02 – hearing aids and maskers fitted, helpful immediately
- 7/25/02 – Substantial improvement noted w/ hearing aids; tinnitus testing repeated
Dates during which tinnitus measurements were made

<table>
<thead>
<tr>
<th></th>
<th>9/24/01</th>
<th>12/27/01</th>
<th>7/25/02</th>
</tr>
</thead>
<tbody>
<tr>
<td>T match</td>
<td>8kHz @ 62 &amp; 67 dB HL (AD &amp; AS)</td>
<td></td>
<td>8kHz @ 60 &amp; 62 dB HL (AD &amp; AS)</td>
</tr>
<tr>
<td>WN MML</td>
<td>50 dB AD</td>
<td>50 dB AD</td>
<td>50 dB AD</td>
</tr>
<tr>
<td></td>
<td>52 dB AS</td>
<td></td>
<td>50 dB AS</td>
</tr>
<tr>
<td>LDL</td>
<td>80-90 dB HL</td>
<td>90-95 dB HL</td>
<td></td>
</tr>
<tr>
<td>THI</td>
<td>50</td>
<td>42</td>
<td>4</td>
</tr>
</tbody>
</table>