Animal Model of Blast Induced Tinnitus; transitioning from continuous noise to blast induced ear injury

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Introduction

• Continuous noise and blast exposure are a major source of hearing loss and tinnitus

• Blast exposures from improvised explosive devices have become more common in military personnel serving in Iraq and Afghanistan

•Both hearing loss and tinnitus are now top veteran disability claims with compensation costs exceeding $1 billion

Rationale

•The pattern of hearing loss from blasts can be more severe than that observed from continuous noise or noise from small arms fire

• Efforts at finding effective treatments have been limited by a lack of well developed animal models for blast induced tinnitus

Approach

• Adult rats were exposed to either continuous noise (126 dB SPL, NBN, 1h) or repeated unilateral blasts (3-6; ~187-192 dB pSPL)

•Rats were assessed for hearing loss using dPOAE and behavioral evidence of tinnitus 15-30 days post trauma using a modified gap prepulse inhibition of the acoustic startle (GPIAS)

Blast Wave Generator

• A custom blast wave generator was constructed from standard PVC piping rated at 250 PSI and covered with a metal shield.

•The generator was sealed at one end with a threaded PVC cap and the other end with custom fabricated multilayered aluminum diaphragms.

•A solenoid driven arrow was housed inside the tube and used to pierce the diaphragm at the desired pressure

•Using house air, blasts of 186-192 dB pSPL could be reliably produced (measured with a dedicated high-pressure probe)

Apparatus for Blast

•Blast tube with subject placed at opening of tube. Rats anesthetized during blasts (187-192 dB pSPL)

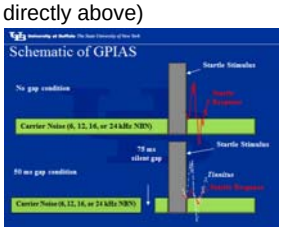
•Blast probe under platform for measurement

Conventional Unilateral Noise Exposure

•Unilateral Noise Exposure (left ear, 1h, 126 dB SPL NBN, centered at 16 kHz

GPIAS Tinnitus Assessment

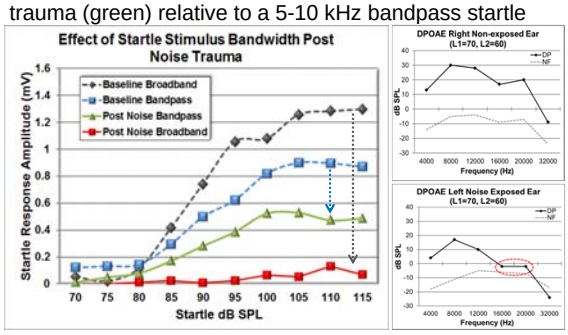
- Rat in GPIAS chamber (speaker directly above)



- Carrier noise without gap triggers large startle response (top)
- Presence of gap (below) attenuates startle response, tinnitus interferes with perception of gap leading to reduced inhibition of response

Results and Conclusions

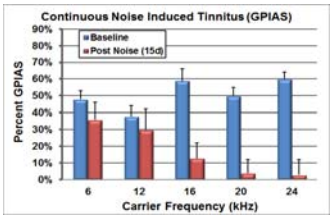
Experiment 1: The efficacy of the conventional broadband startle stimulus (grey) in eliciting a robust startle response was evaluated post unilateral noise trauma (green) relative to a 5-10 kHz bandpass startle



•Broadband noise is ineffective at producing a reliable robust startle, post *unilateral* noise trauma.

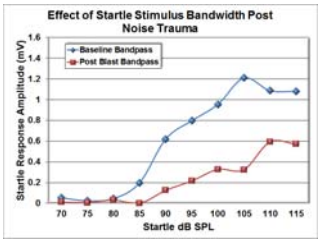
•Hearing loss in the high frequencies confirmed by distortion product otoacoustic emissions (DPOAE, shown on right panel) in the exposed ear likely results in reduced loudness perception of the broadband startle stimulus

Tinnitus

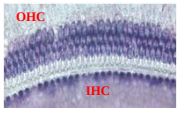


Unilateral noise trauma (126 dB SPL) resulted in tinnitus at the frequency of the hearing loss and above, consistent with human results (*note other ear is normal and can hear real sounds under the GPIAS paradigm*)

Experiment 2: The effects of unilateral blast trauma were evaluated on the raw startle amplitude and for evidence of tinnitus under GPIAS



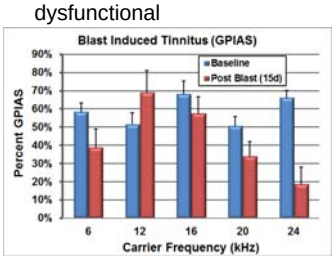
Control Ear



Blasted Ear

•Unilateral blast trauma further reduces the startle amplitude, results consistent with the continuous noise exposure data

•Blast trauma resulted in massive cochlear damage with nearly all outer hair cells (OHC) destroyed or dysfunctional



•Unilateral blast shows evidence of high frequency tinnitus in the 20-24 kHz region (left)

• However, only a subset of animals can be tested due to poorer startle reflex

Summary

Blast Trauma

•We developed an effective and low cost blast generator that can produce simulated blasts (187-192 dB pSPL)

•Physiological, behavioral, and anatomical data support the presence of blast induced hearing loss

•Exposure to our blasts results in widespread damage across large regions of the cochlea and evidence of tinnitus

Tinnitus

•A modified startle reflex paradigm can be used to study the effects of tinnitus in only a subset of animals exposed to blast

•Carrier bandwidth and startle bandwidth are critical in studying noise or blast induced tinnitus

•Traditional broadband acoustic stimuli can become ineffective after significant hearing loss even to just one ear

•We propose the use of a lower frequency (bandpass noise 5-10 kHz) stimulus to evoke a startle after either continuous noise or blast

•After either continuous noise or blasts, subjects develop high-frequency tinnitus, results consistent with human results and our previous data.

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•Tinnitus Research Initiative

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