



The Potential Impacts of Acute and Chronic Blast Exposure on Warfighter Performance in Combat Environments

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Non-Disclosure



Douglas Brungart has no conflicts to report



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1 Walter Reed National Military Medical Center

2 Pookela Solutions, LLC

3 Defense Centers for Public Health - Aberdeen

4 Henry M. Jackson Foundation, Inc.



Repetitive Blast Exposure and Hearing



Hearing health is essential for operational readiness and overall quality of life

Many studies have shown blast causes acute and chronic hearing difficulties...
but the operational impacts of these blast related effects are not clear

Here we examine the link between operational performance and blast exposure



Methodology



Data were collected in DOW hearing conservation clinics

Individuals who completed DOEHRS-HC testing were asked to participate

Those who volunteered completed questionnaires and functional hearing tests

Results were combined with hearing thresholds for inclusion in data set



Blast Ordnance and Occupational Exposure Measure (BOOM)



Blast exposure survey developed for clinical use by NiCoE (Sours Rhodes et al., 2023)

Asks about exposure levels for 8 blast-related categories

Each has 5 different selections related to number of exposures

We score on a scale from 8 (no blast) to 40 (maximum blast)



Blast Ordnance and Occupational Exposure Measure (BOOM)

Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Small explosives e.g., grenades, flash bangs, landmines, claymores

None

1 - 10

11 - 100

100 - 500

500+

*For the purpose of this survey, "exposure" is defined as:
Any incident where you physically felt the overpressure wave whether the blast was the result of an incoming enemy fire or a charge or weapon system that you fired or were near to.

Help

Submit

Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Shoulder-fired weapons e.g., RPG, LAW, SMAW, Dragon, GUSTAV, AT4, Javelin, grenade launcher

None

1 - 10

11 - 100

100 - 500

500+

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Any incident where you physically felt the overpressure wave whether the blast was the result of an incoming enemy fire or a charge or weapon system that you fired or were near to.

Help

Submit

Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Large artillery, missile weapons systems, and vehicle-mounted large arms e.g., Howitzer, M120, TOW, multiple rocket launcher, airdrop (danger close)

None

1 - 10

11 - 100

100 - 500

500+

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Any incident where you physically felt the overpressure wave whether the blast was the result of an incoming enemy fire or a charge or weapon system that you fired or were near to.

Help

Submit

Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Explosive breaching

None

1 - 10

11 - 100

100 - 500

500+

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Any incident where you physically felt the overpressure wave whether the blast was the result of an incoming enemy fire or a charge or weapon system that you fired or were near to.

Help

Submit



Blast Ordnance and Occupational Exposure Measure (BOOM)



Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Explosive ordnance disposal or blast related demolition

None

1 - 10

11 - 100

100 - 500

500+

*For the purpose of this survey, "exposure" is defined as:
Any incident when you physically felt the overpressure wave whether the blast was the result of an exploding enemy fire or a charge or support system that you fired or were near to.

Help

Submit

Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Improvised Explosive Devices (IEDs)

None

1 - 10

11 - 100

100 - 500

500+

*For the purpose of this survey, "exposure" is defined as:
Any incident when you physically felt the overpressure wave whether the blast was the result of an exploding enemy fire or a charge or support system that you fired or were near to.

Help

Submit

Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Mortars

None

1 - 10

11 - 100

100 - 500

500+

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Any incident when you physically felt the overpressure wave whether the blast was the result of an exploding enemy fire or a charge or support system that you fired or were near to.

Help

Submit

Blast Ordnance and Occupational Expos...

Select the approximate range of lifetime blast exposures* for:

Large caliber firearms (50 caliber or larger, e.g. M2 machine gun, SASR).

None

1 - 10

11 - 100

100 - 500

500+

*For the purpose of this survey, "exposure" is defined as:
Any incident when you physically felt the overpressure wave whether the blast was the result of an exploding enemy fire or a charge or support system that you fired or were near to.

Help

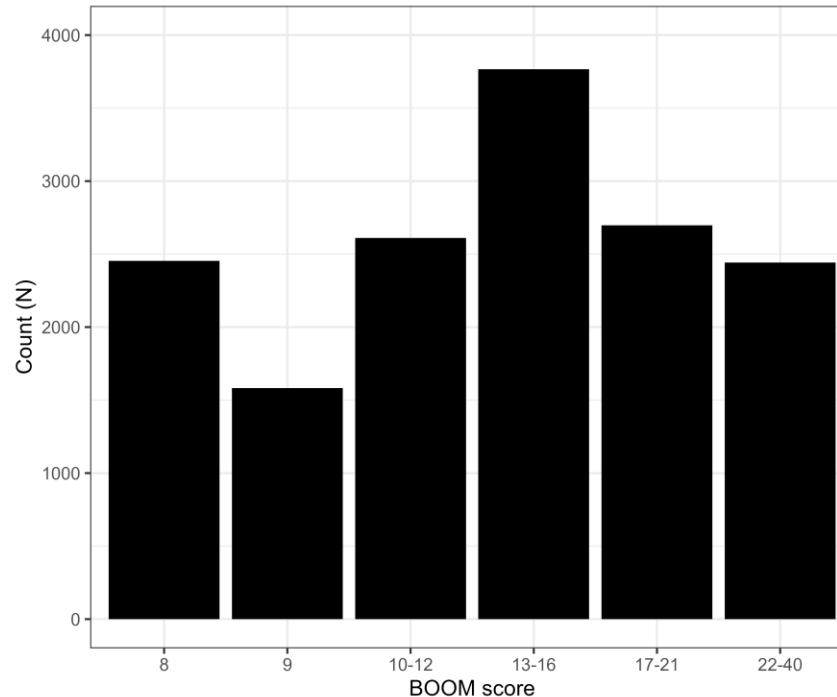
Submit



Distribution of BOOM scores across SMs

BOOM Data collected on
15110 SMs across DOW

BOOM scores divided into
5 bins with roughly
equal numbers of SMs



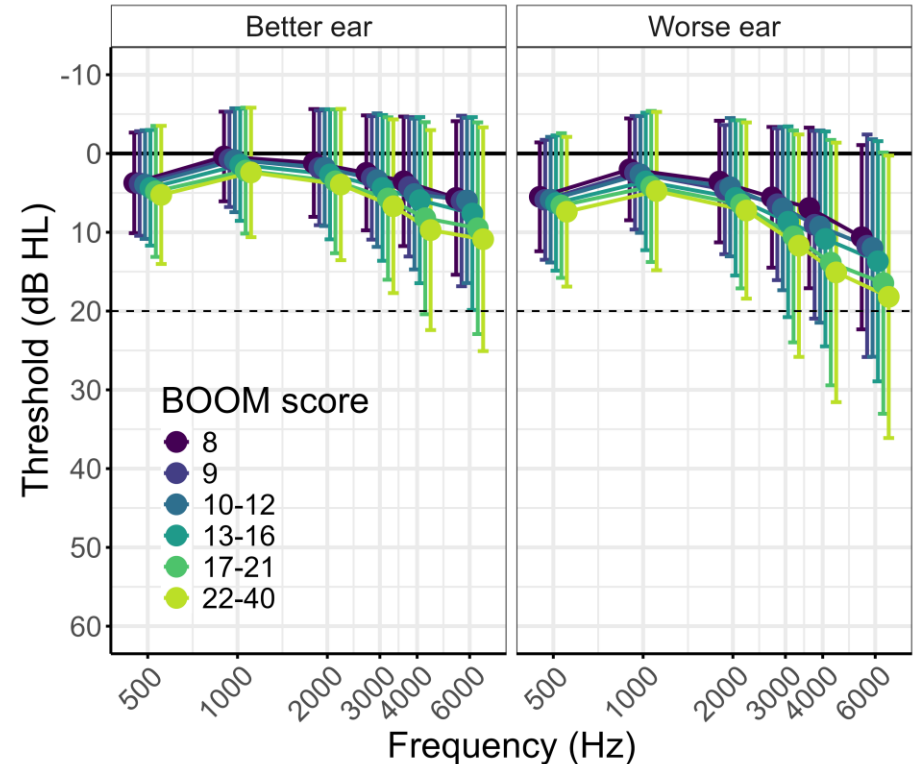


Effect of BOOM score on Audiogram



There was very little change
in audiometric thresholds
as a function of BOOM score

Effects of blast exposure are not
captured by hearing conservation





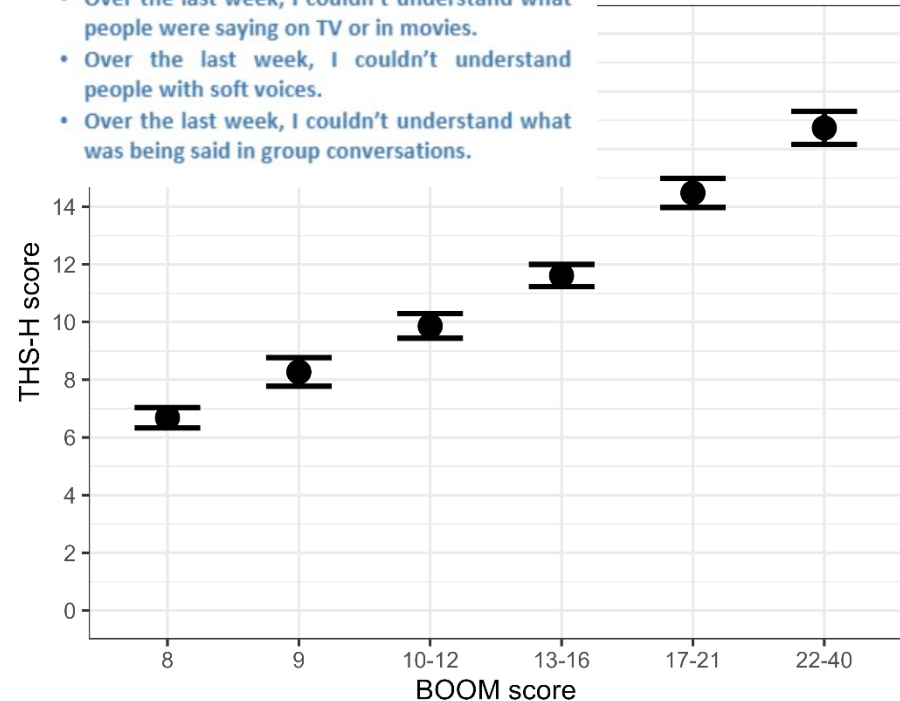
Effect of BOOM score on Hearing Complaint

THS-H measures “everyday” hearing difficulties

Hearing difficulties increased systematically with BOOM score

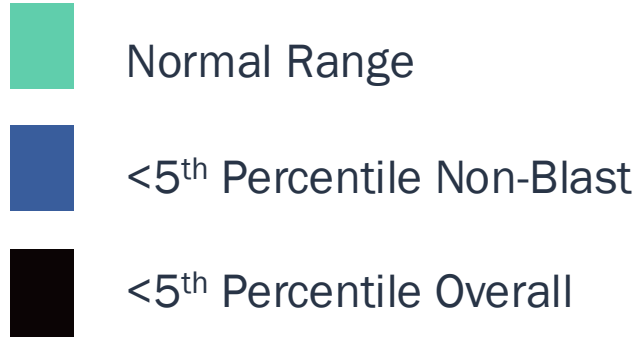


- Over the last week, I couldn't understand what others were saying in noisy or crowded places.
- Over the last week, I couldn't understand what people were saying on TV or in movies.
- Over the last week, I couldn't understand people with soft voices.
- Over the last week, I couldn't understand what was being said in group conversations.



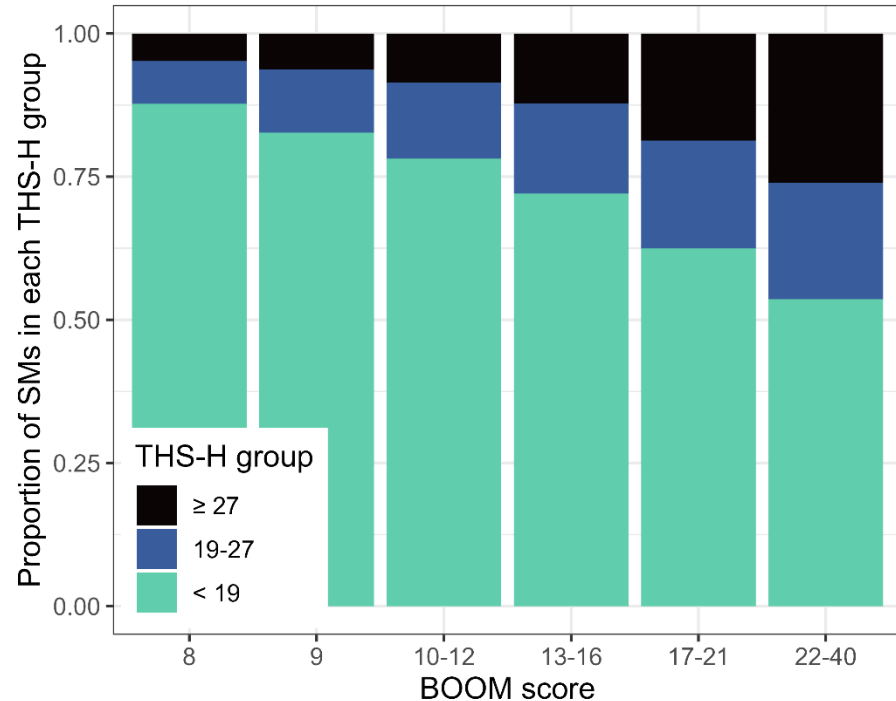


Effect of BOOM on Hearing Aid Candidacy



THS-H Score >27 indicates probable benefit from low-gain hearing aids

Hearing aid candidacy increased from 5% to 30% with BOOM score





Tone-in-Noise Detection Conditions

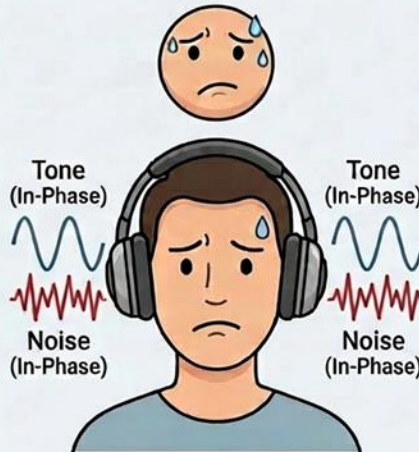
BINAURAL HEARING: TONE IN QUIET AND NOISE CONDITIONS

PANEL 1: TONE IN QUIET
(IN-PHASE)



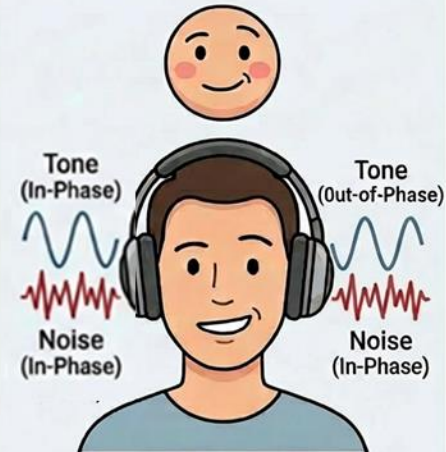
Tone is identical in both ears.
Easy to detect.

PANEL 2: TONE IN NOISE
(N0S0)



Tone and noise are identical
in both ears. Difficult to
detect tone.

PANEL 3: TONE IN NOISE
(N0S π)

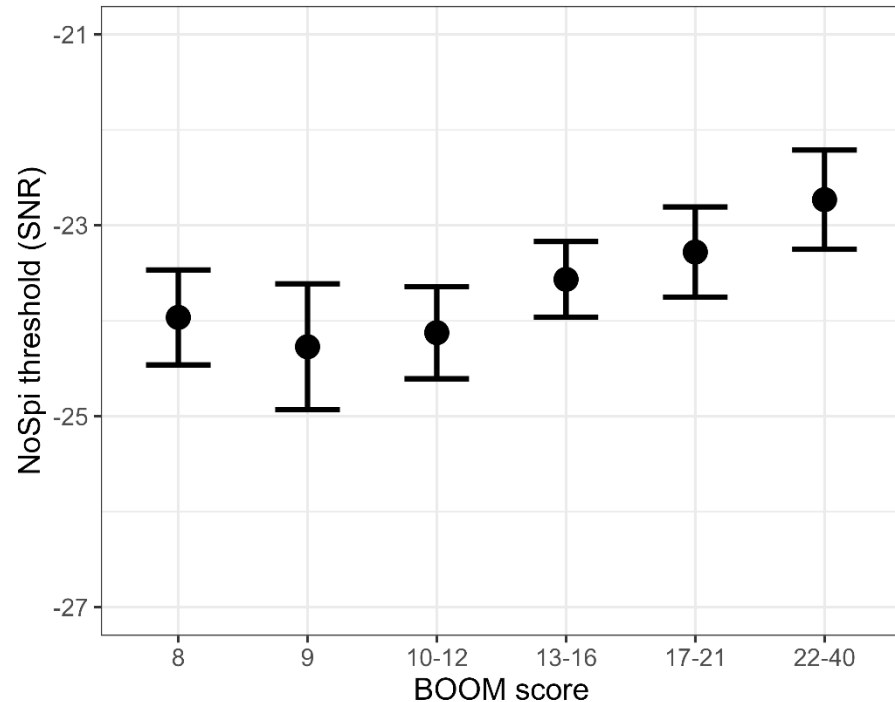


Noise is identical, but tone is
out-of-phase. Easier to detect
tone than in Panel 2.



Effect of BOOM on Tone-in-Noise Detection

BOOM scores also lead to systematic increase in Tone-in-Noise thresholds



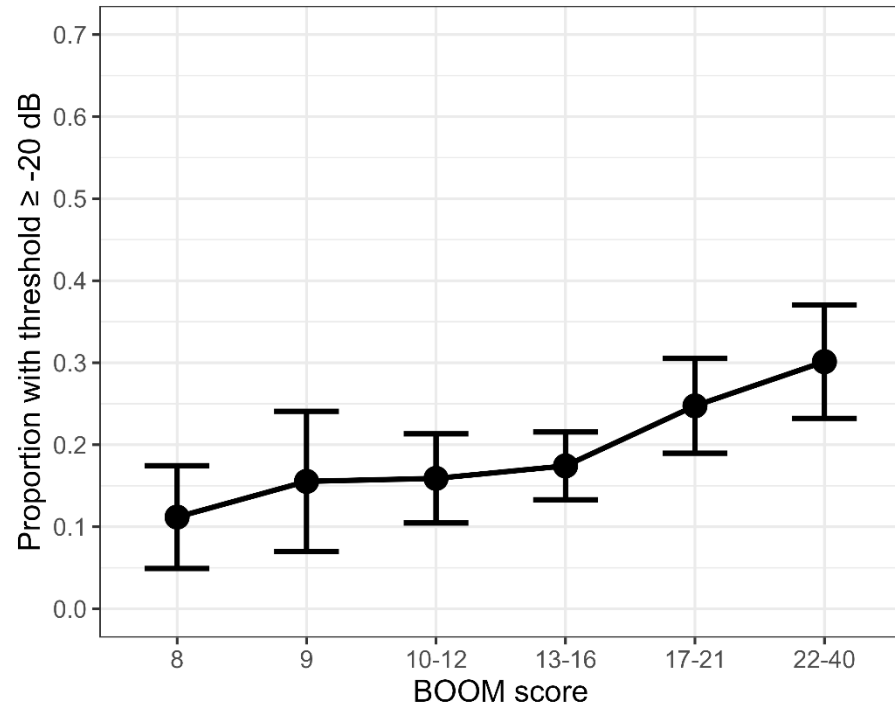


Effect of BOOM on % Abnormal NoS π scores



This increase is particularly noticeable in terms of percentage of abnormal NoS π scores...

Percentage with threshold ≥ -20 dB *triples* with increasing BOOM score





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Blast Exposure Clearly Causes Hearing Difficulties in Everyday Listening Environments



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But is there an Operational Impact?



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How is Operational Performance Measured?



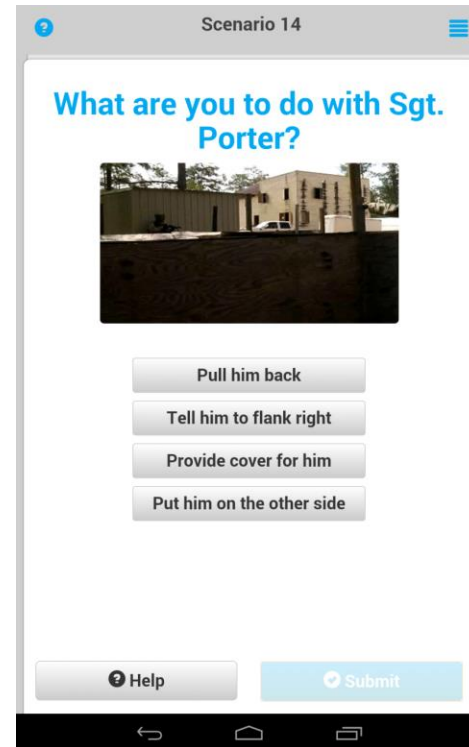
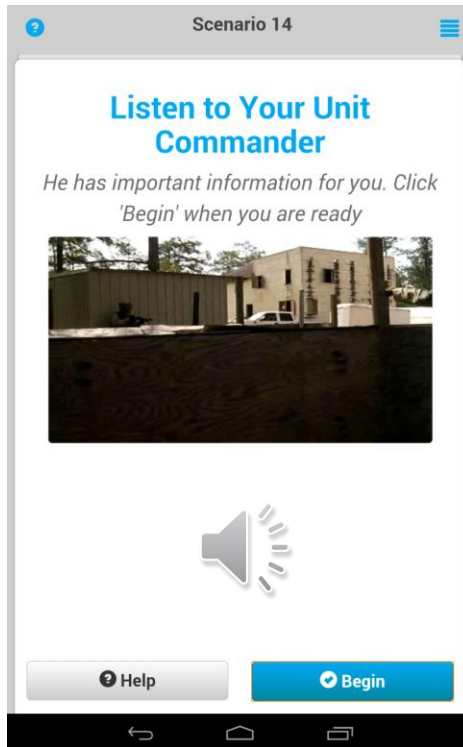
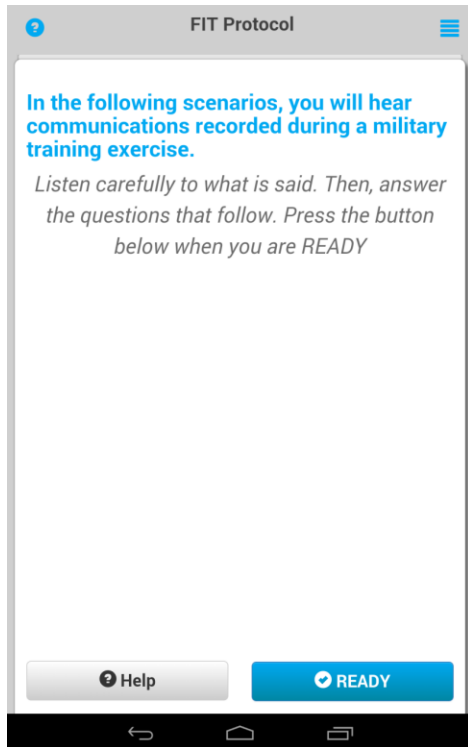
Binaural recording device attached to after-action camera at JRTC, Ft. Polk
Used to capture realistic calibrated recordings of critical combat communications





UNCLASSIFIED

Recordings Turned Into Multiple-Choice Questions About Real-World Operational Scenarios



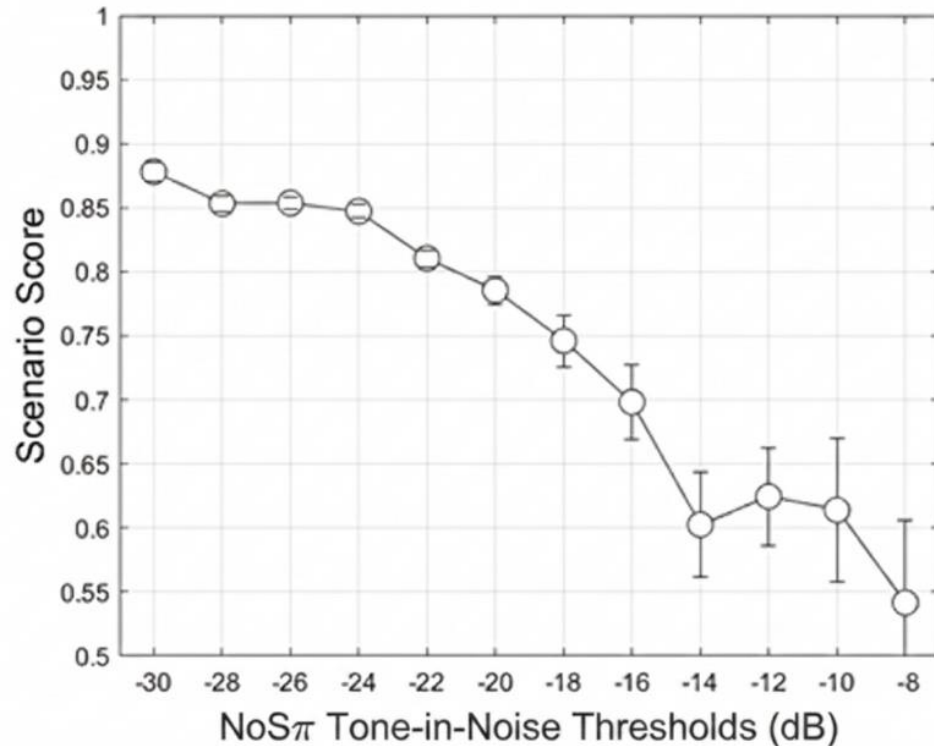
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Performance on Operational Scenarios is Highly Correlated with NoS π Tone-in-Noise Performance



Tone-in-Noise Performance may be a predictor of operational performance in blast-exposed SMs

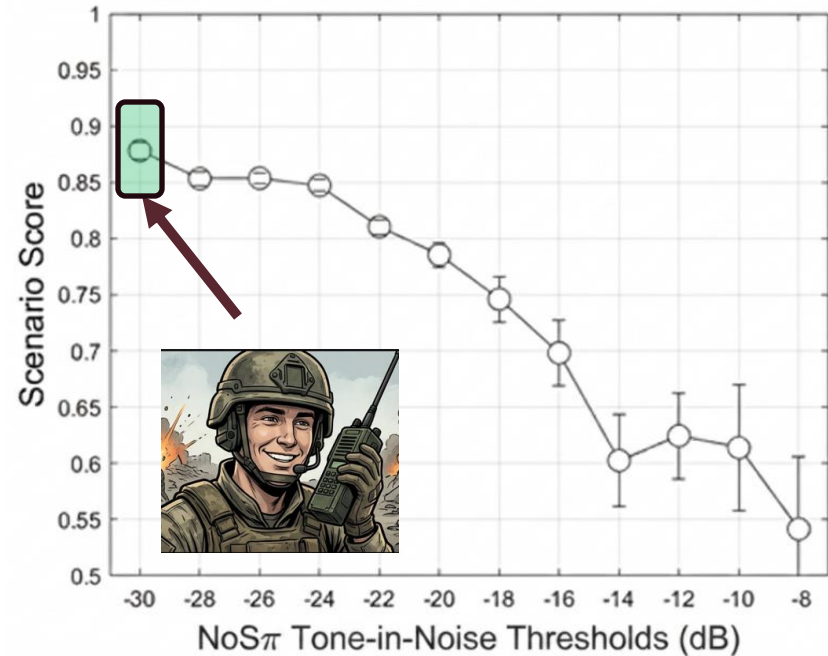




Effect of BOOM on Operational Performance



Individuals with perfect NoS π scores do very well on operational tasks...



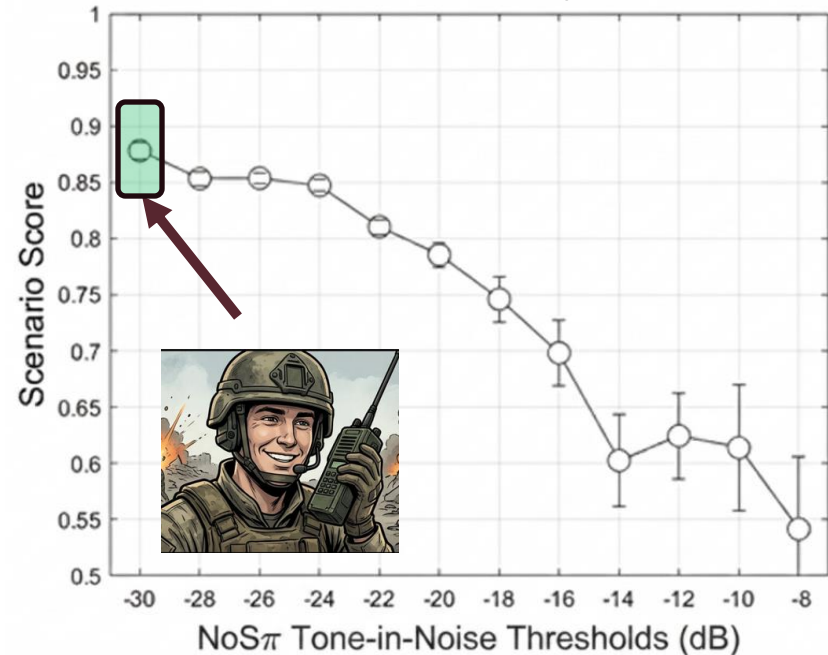
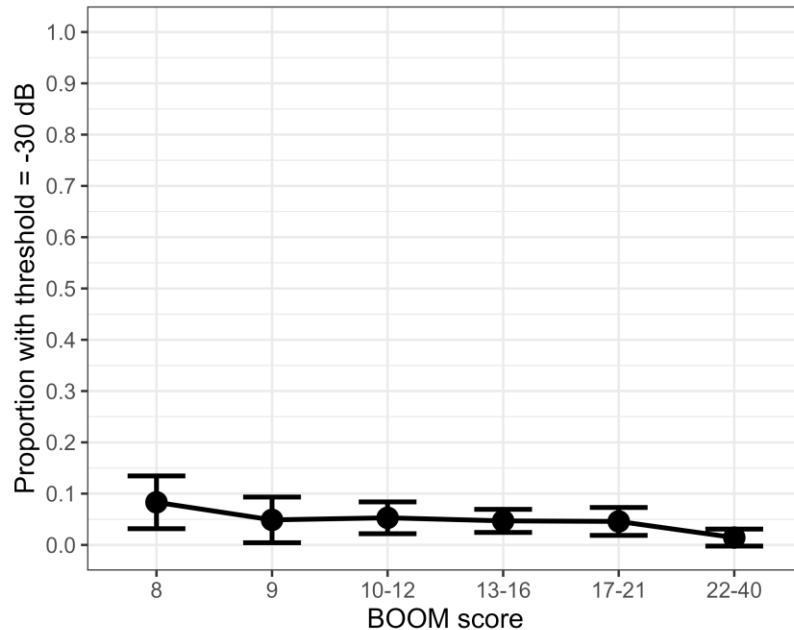


Effect of BOOM on Operational Performance



Individuals with perfect NoS π scores do very well on operational tasks...

Very few individuals with high BOOM scores reach this level of performance

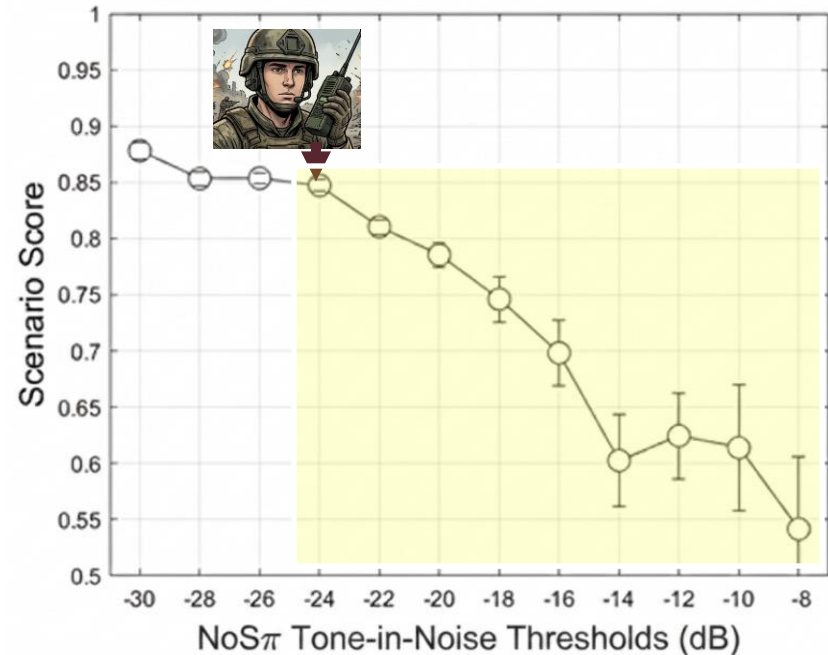




Effect of BOOM on Operational Performance



Individuals with NoS π scores ≥ -24 dB start to have difficulties



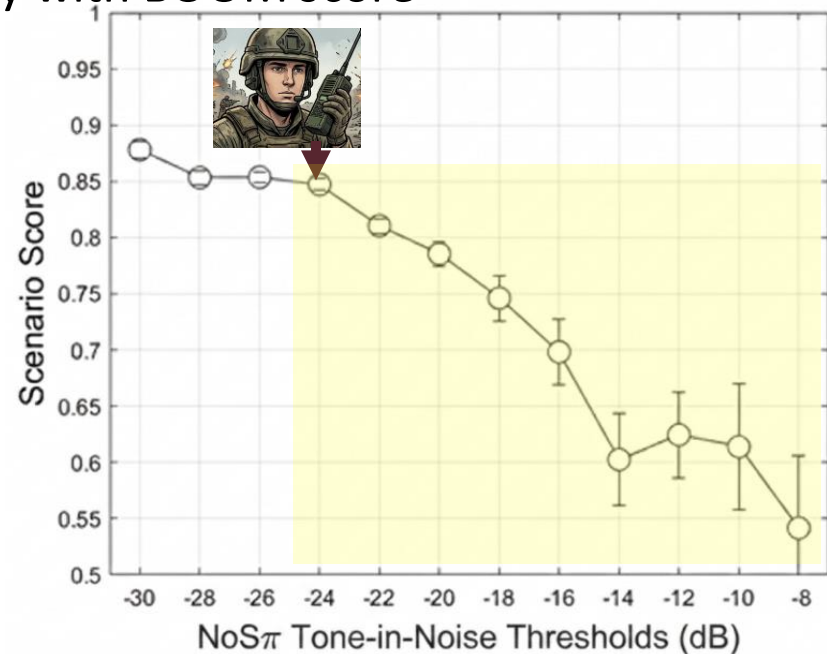
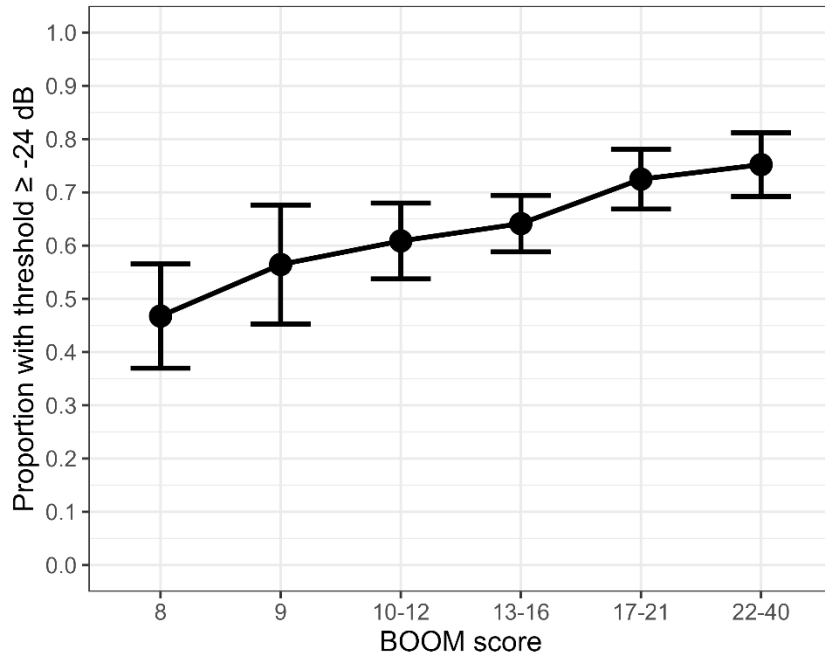


Effect of BOOM on Operational Performance



Individuals with NoS π scores ≥ -24 dB start to have difficulties

This population increases systematically with BOOM score

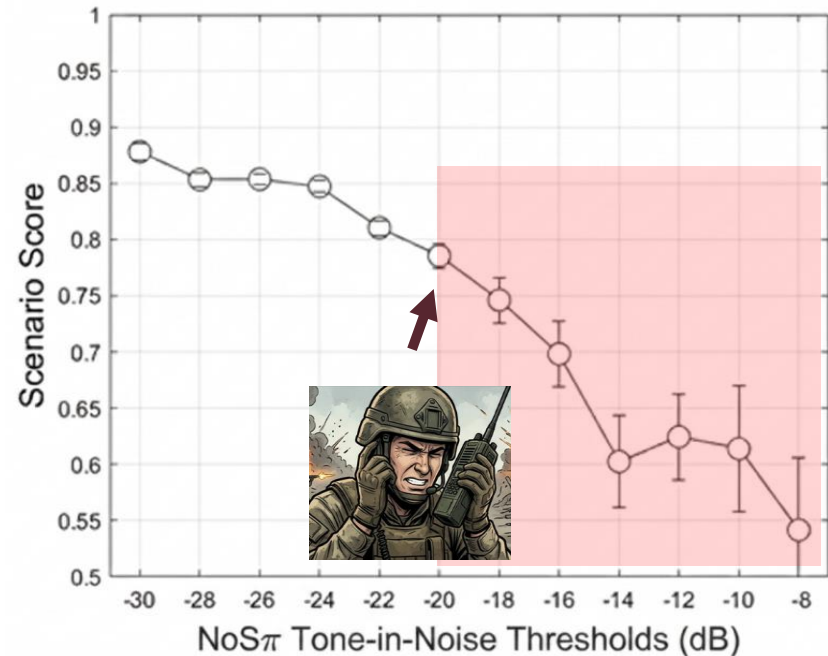




Effect of BOOM on Operational Performance



Individuals with NoS π scores ≥ -20 dB have noticeable difficulty on scenarios

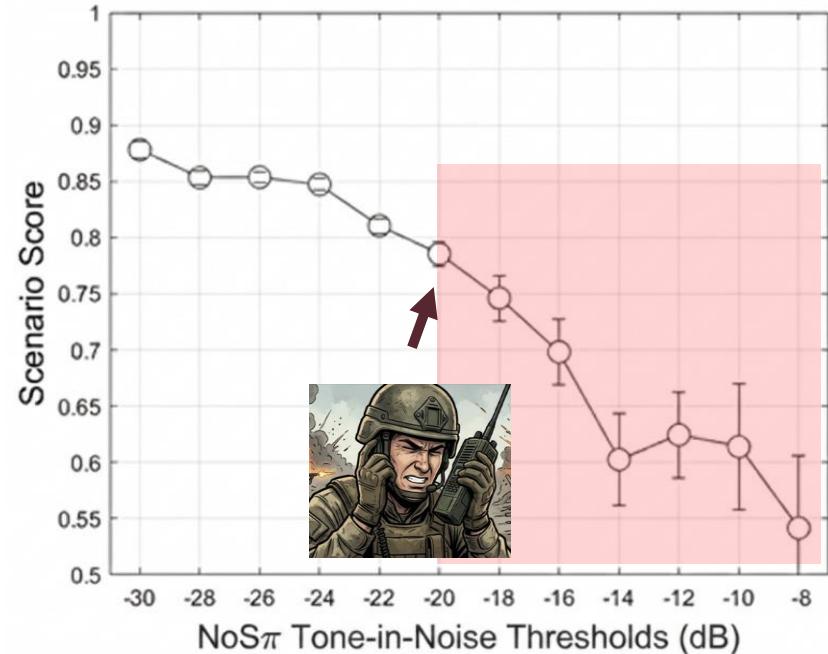
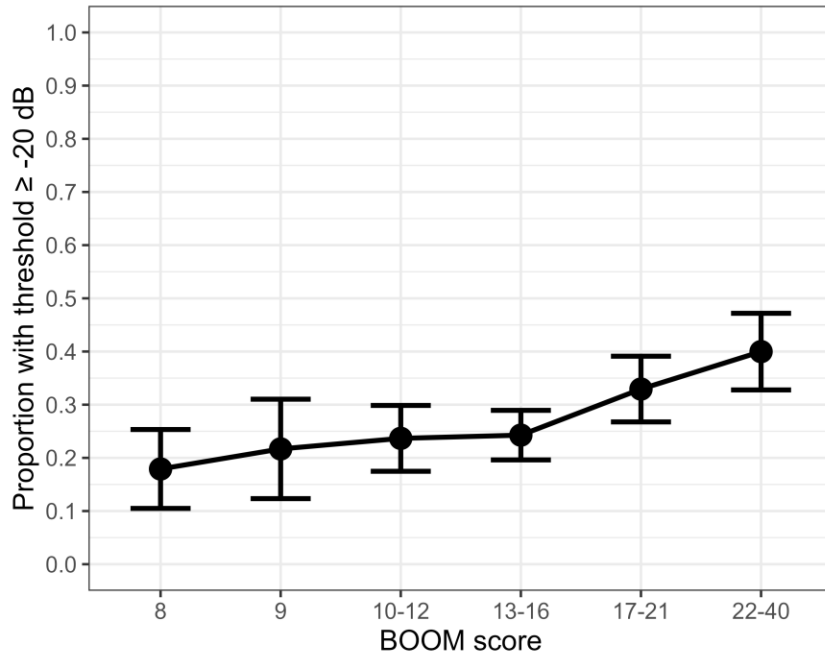




Effect of BOOM on Operational Performance



Individuals with NoS π scores ≥ -20 dB have noticeable difficulty on scenarios
This population more than doubles in population with high BOOM scores





What About Acute Effects?

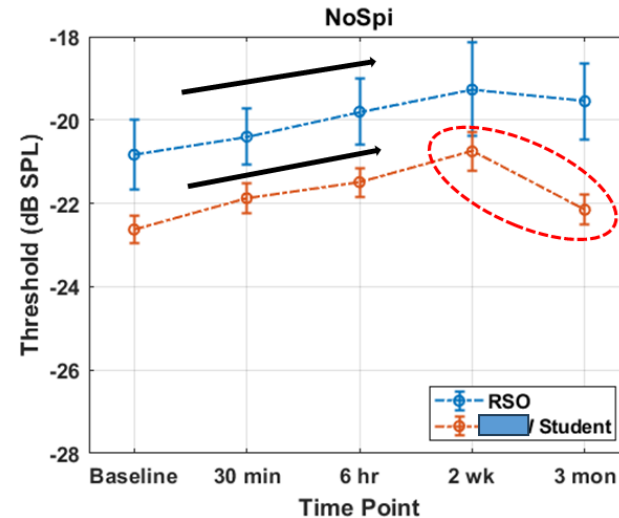
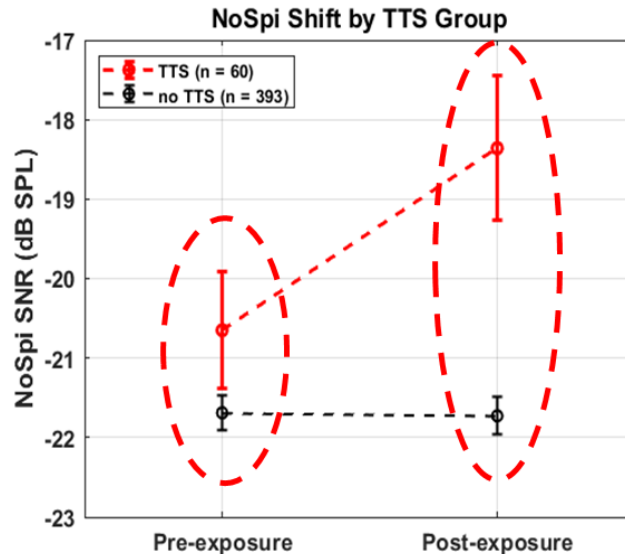




Acute Hearing Damage Degrades No π



A major concern is that individuals who are blast exposed have *acute* No π shifts. These occur both immediately after a TTS and slowly over sustained training.

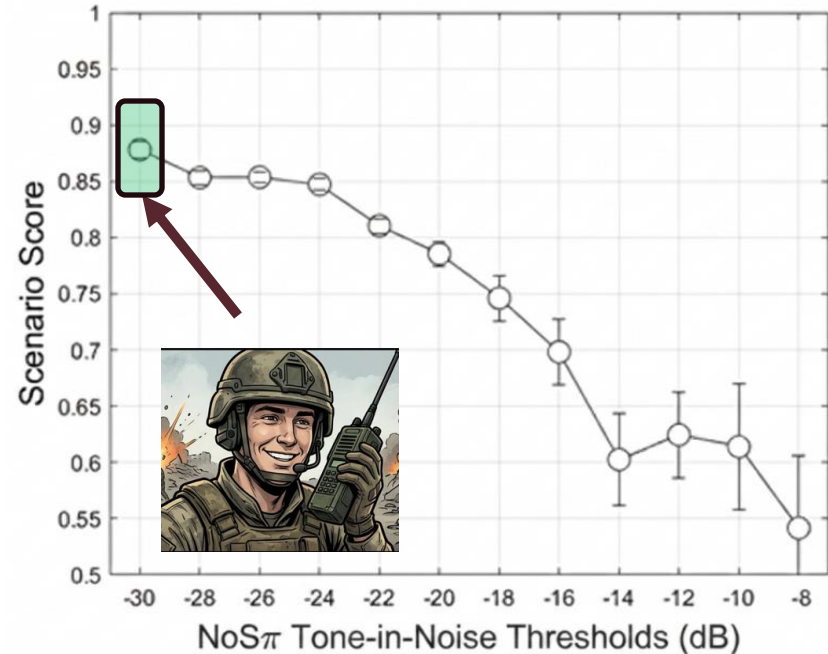




Operational Challenges after Acute Exposure



Individuals with perfect NoS π scores do very well on operational tasks...
These perfect scores would be completely eliminated after 4 dB shift

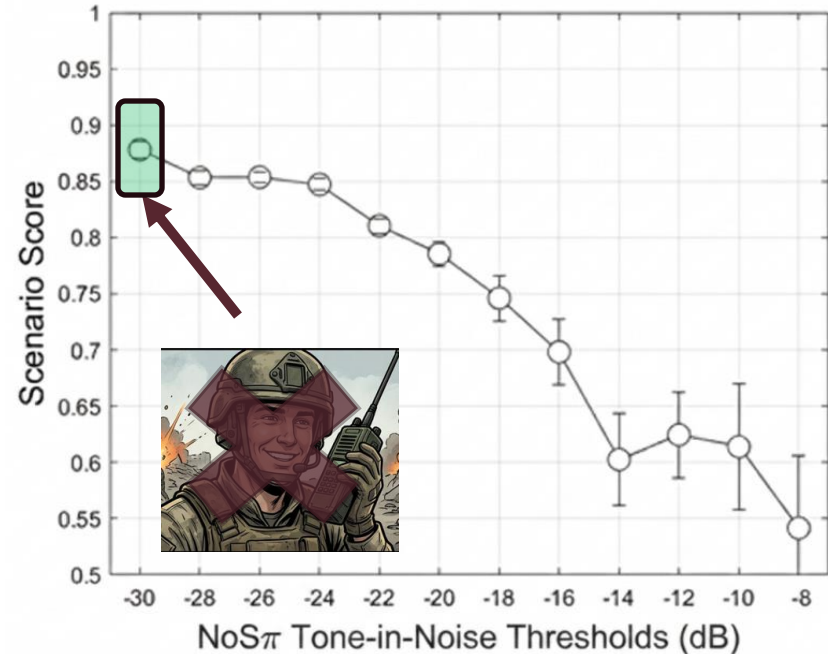
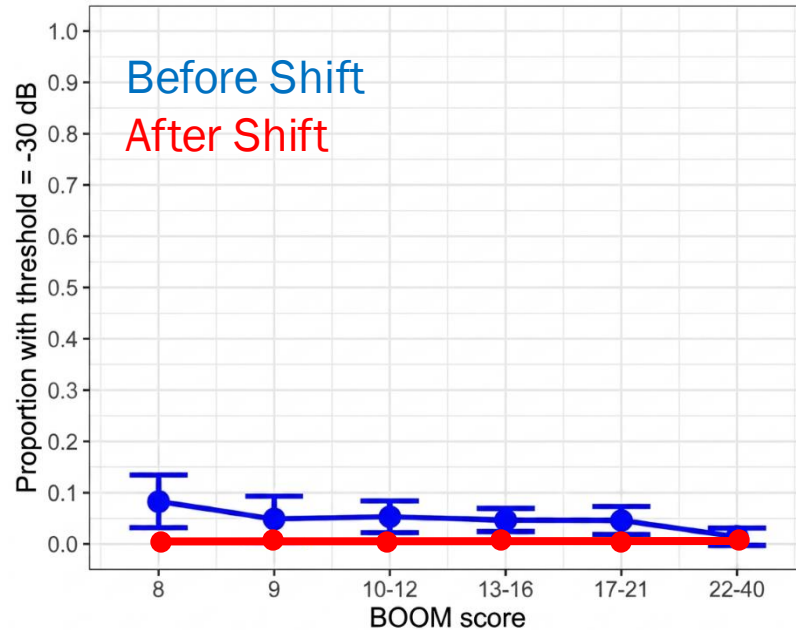




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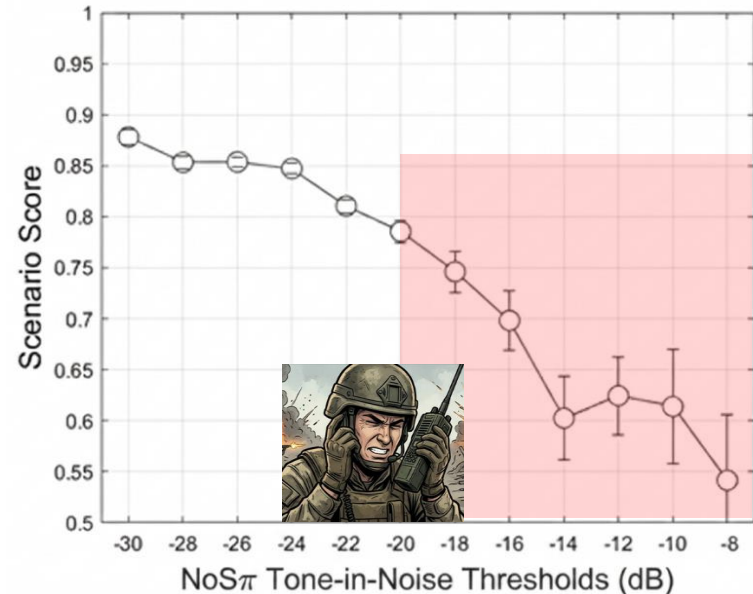




Operational Challenges after Acute Exposure



NoS π scores at or above -20 dB represent potential operational challenges
Proportion roughly doubles with 4 dB shift, reaches 75% of force with high BOOM

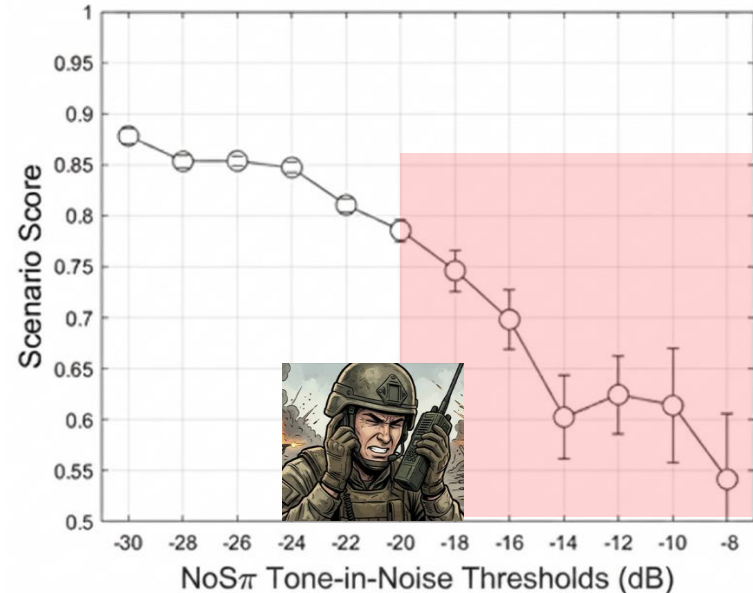
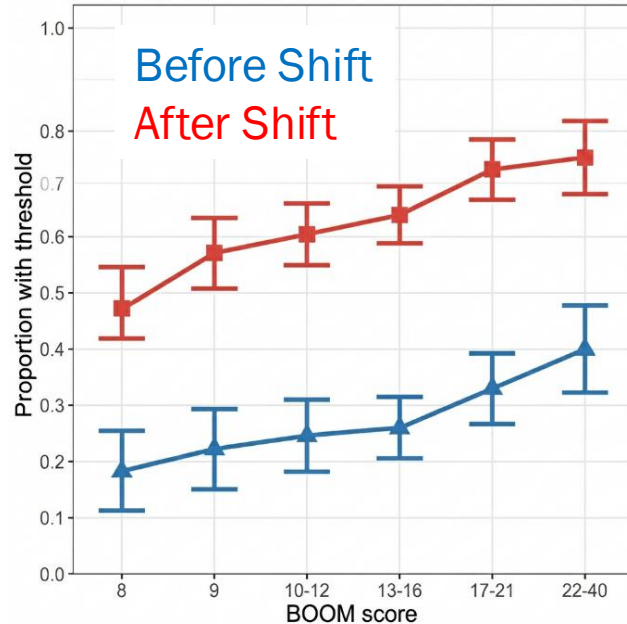




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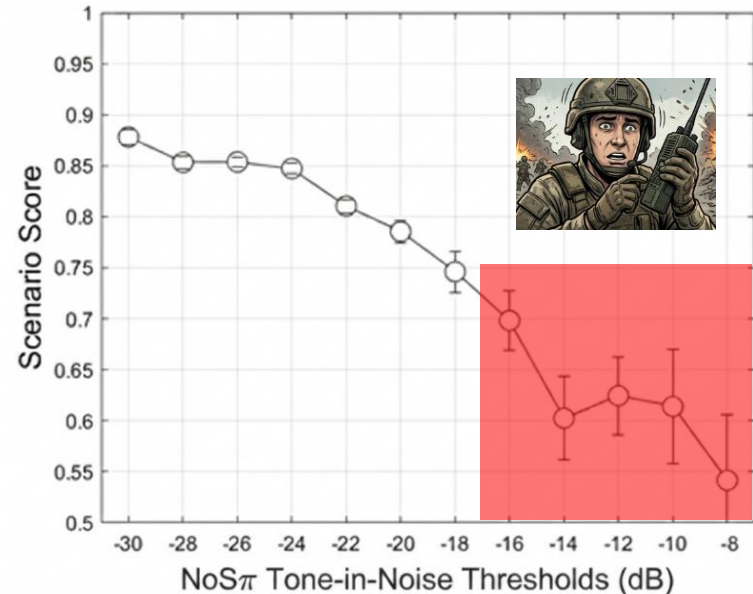




Operational Challenges after Acute Exposure



NoS π scores at or above -16 dB are associated with unacceptable performance
Very rare prior to blast exposure, but could happen with high BOOM + acute blast

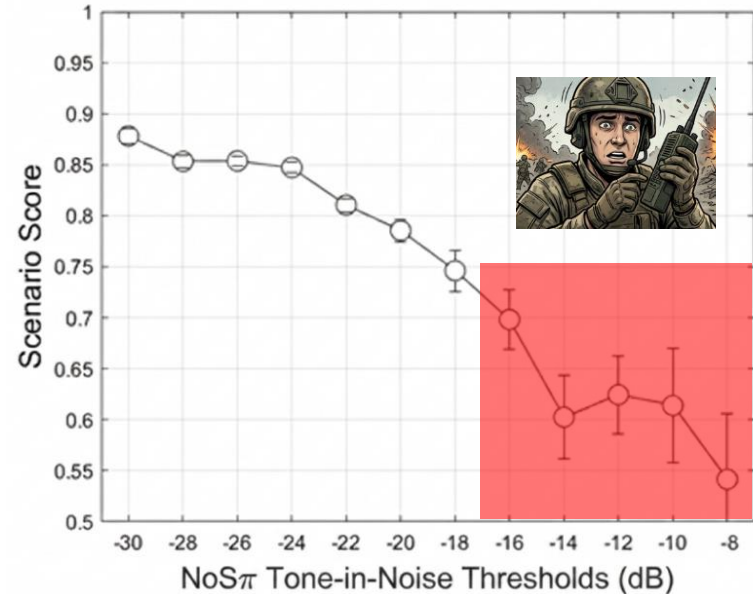
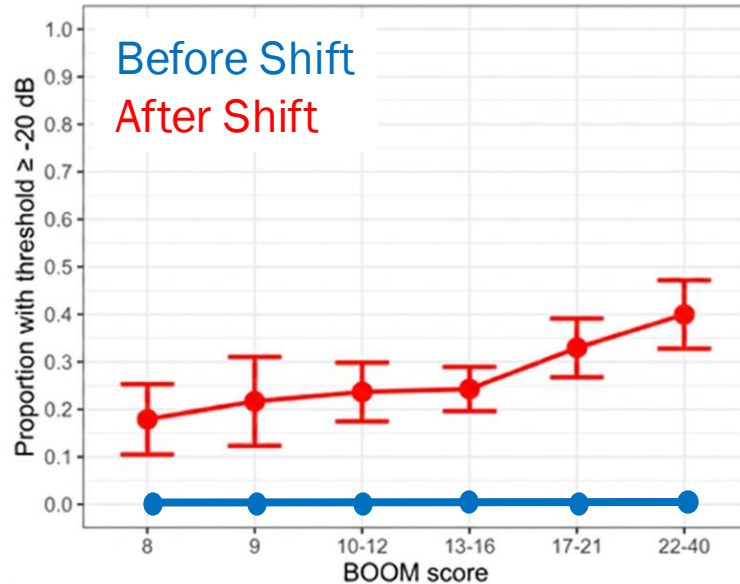




Operational Challenges after Acute Exposure



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Hearing and Drone Warfare: Red Alert!



The conflict in Ukraine is redefining expectations for modern combat

Estimates say 70-90% of all casualties are caused by FPV drones



Hearing and Drone Warfare: Red Alert!

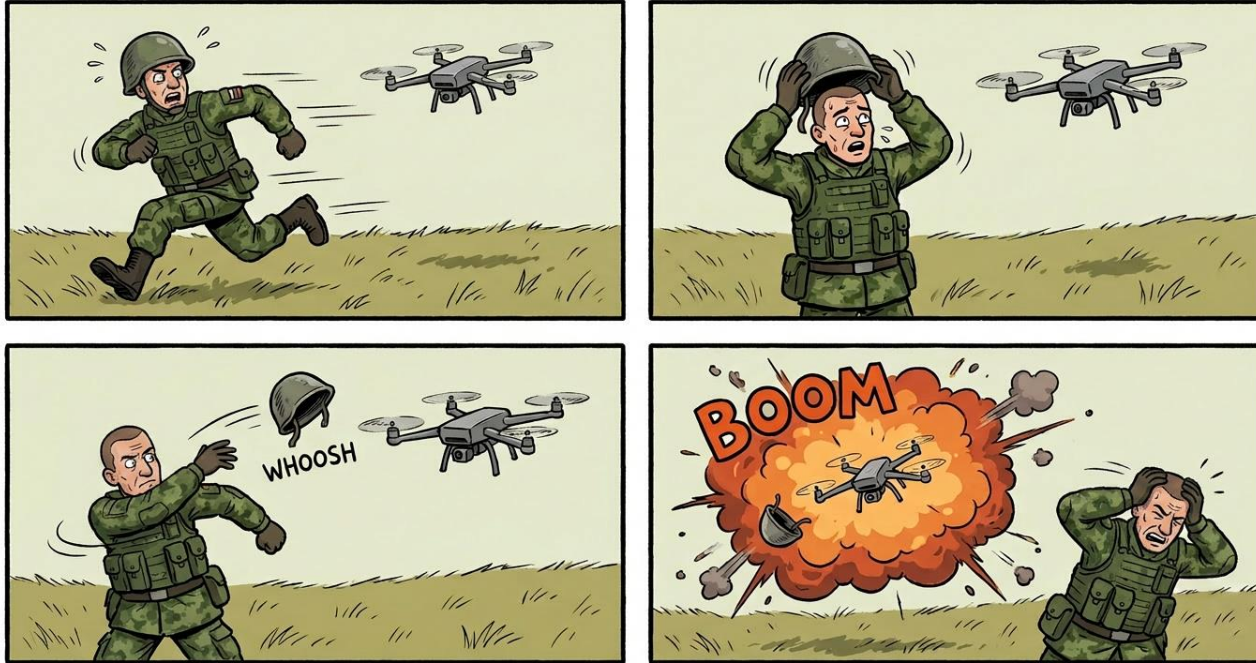
FPV strikes are gruesome, but only 3.6% are fatal....

- Of the FPV drone casualties arriving alive to their facility,
 - 22% had head and neck injuries, despite “military-grade helmets”,
 - 19% lower extremity injuries,
 - **19% their only injury was to the ear, including ear drum rupture, “suggesting hearing protection wasn’t being worn, or was ineffective”,**
 - 14% upper extremity injuries, and
 - 8% had associated burns.

<https://www.crisis-medicine.com/fpv-drone-casualties-in-ukraine/>

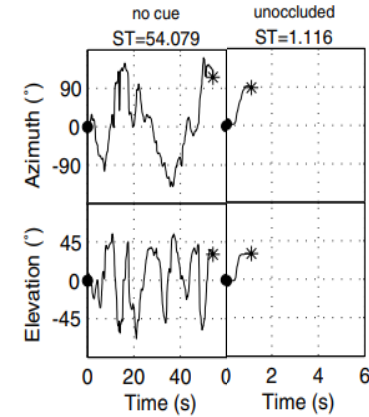


Hearing is Being Used to Detect and Evade





What Happens Next? Soldier Can't Hear or Localize Next Attack





Getting ahead of the curve....



We need to:

- Provide hearing protection solutions for drone ops
- Find best ways to treat acoustic trauma from drones
- Find how to assess impact of acoustic trauma on risk





Conclusions



The BOOM seems to be an efficient clinical tool for capturing blast exposure

BOOM Data collected in large cohorts confirm that blast exposure impairs hearing

- *This hearing impairment is not captured by the audiogram*

Many SMs have BOOM scores indicating potentially impaired operational hearing

Those with mild chronic impairments may experience severe deficits when exposed

More efforts needed to better understand and prevent blast-related hearing damage



Surviving Drone Warfare



“I can’t say enough about cover and concealment, and probably the 2nd thing is.... “



<https://www.youtube.com/watch?v=rMUD4Ux96Jg&t=1225s>, used with permission of Garand Thumb



Hearing and Drone Warfare: Red Alert!



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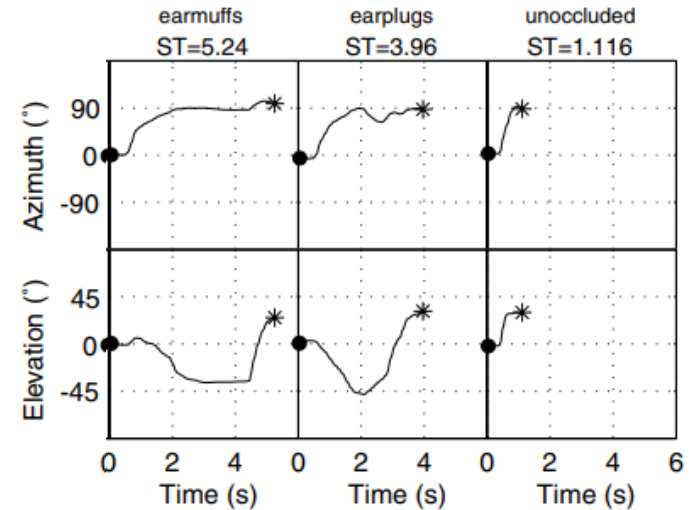
<https://www.crisis-medicine.com/fpv-drone-casualties-in-ukraine/>



Is this a Correct Assessment?



Current hearing protectors do not allow localization in azimuth....
Prior visual search studies show this greatly increases visual search time



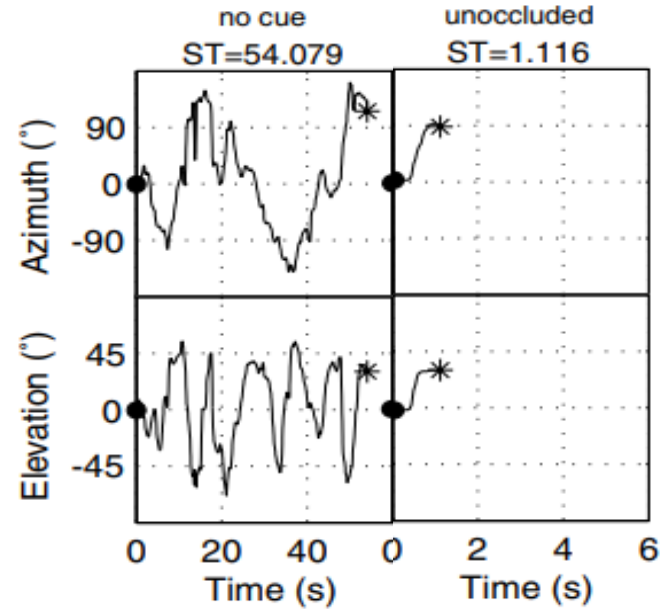


Hearing is Being Used to Detect and Evade





What Happens Next? The Soldier Can't Hear!





Getting ahead of the curve....



We need to find out:

- Relationship between hearing acuity, hearing protection, and drone evasion
- Best ways to treat acoustic trauma from drones
- How to assess impact of acoustic trauma on risk





Questions?

