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14. ABSTRACT

Military service is more hazardous to hearing than almost any other occupation, and both the line and medical components of the Department of Defense (DoD) have a responsibility to protect Service Members from the harmful effects of noise exposure. Despite the best efforts of a comprehensive DoD-wide hearing conservation program, hearing loss and tinnitus continue to be the most frequent permanent injuries in the military; nearly 30% of service members experience a permanent threshold shift and just over 30% report tinnitus. These problems propagate to our veteran population, resulting in almost 1.5 million veterans receiving compensation for hearing loss and tinnitus. Of further concern is the increasing incidence of Service Members reporting hearing difficulty and/or tinnitus in the presence of normal hearing. These factors could have a significant impact on readiness and resilience in the Active-Duty population.

The goal of this research effort is to advance our understanding of the etiology and implications of noise- and blast-related hearing damage in our Active-Duty population with normal or near-normal audiograms, and obtain normative data for tests that could be used to efficiently assess these problems in DoD Audiology Clinics. This will be accomplished by three studies. The first study will be a direct evaluation of the relationship between objectively measured noise dosimetry and subjective noise surveys. This data will be used to improve the ability to obtain reliable self-reports of noise exposure. In the second study, auditory tests that are sensitive to objective differences in performance among Service Members with normal or near-normal thresholds and varying levels of noise and blast exposure will be identified, to establish normative data in those tests that will facilitate their direct transition to clinical use. Finally, auditory and functional tests that are sensitive to differences in performance among Service Members with normal or near-normal thresholds and various levels of bothersome and non-bothersome tinnitus will be identified, and normative data will be established to facilitate direct transition to clinical use.

15. SUBJECT TERMS

NONE LISTED

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TABLE OF CONTENTS

INTRODUCTION:

The line and medical components of the Department of Defense (DoD) have a responsibility to protect Service Members from the harmful effects of noise exposure. Despite the best efforts of a comprehensive DoD-wide hearing conservation program, hearing loss and tinnitus continue to be the most frequent permanent injuries in the military; nearly 30% of Service members experience a permanent threshold shift and just over 30% report tinnitus. This study will address the current lack of knowledge regarding actual versus self-reported noise exposure and the functional impact of noise- and blast-exposure in Service members with normal hearing. This study will also address the lack of knowledge regarding the prevalence and incidence of tinnitus in military Service members as a function of noise- and blast-exposure, as well as the functional impact of tinnitus. The overarching goal of this effort is to better understand the relationship between noise exposure, blast exposure, tinnitus, and subjective and objective measures of hearing impairment in the military population with normal hearing thresholds. We believe the only way to make inferences about the complex interactions between these different factors is to collect data from a large number of volunteer participants from both military and civilian populations. These data will help us both 1) determine which standardized tests are most likely to be sensitive to the effects of blast and noise exposure; and 2) establish normative data on these standardized tests and transition the tests to the clinic for validation on individuals with clinical complaints of hearing difficulty or tinnitus.

2. KEYWORDS:

Provide a brief list of keywords (limit to 20 words).

Tinnitus, hidden hearing loss, hearing impairment, noise/blast exposure

3. ACCOMPLISHMENTS:

What were the major goals of the project?

- **Specific Aim 1:** Evaluate and Optimize Subjective Metrics for Assessing Noise History
    - **Major Task 1:** Improve our ability to obtain reliable self-reports of noise exposure by directly evaluating the relationship between objectively measured noise dosimetry and subjective noise surveys.
        - Subtask1: Submit documents for local IRB review. Local IRBs include Walter Reed and the University of Texas, Dallas.
        - Subtask 2: Design and develop infrastructure to implement objective and subjective noise measurements.
        - Sub task 3: Collect data
- **Specific Aim 2**: Evaluate the influence that noise and blast exposure have on the performance and subjective hearing handicap of listeners with normal hearing thresholds.
    - **Major Task 2:** Identify auditory tests that are sensitive to objective differences in performance among Service Members with normal or near-normal thresholds and

varying levels of noise and blast exposure and establish normative data in those tests that will facilitate their direct transition to clinical use.
    - Subtask1: Collect data at Walter Reed and at the University of Texas, Dallas (UTD) audiology clinic.
    - Subtask2: Analyze and begin to publish results from Aim 1.
    - Subtask 3: Begin developing infrastructure and collecting pilot data for major task 3.

- **Specific Aim 3**: Evaluate the non-bothersome and bothersome tinnitus in Service members
    - **Major Task 3:** Identify auditory and functional tests that are sensitive to differences in performance among Service Members with normal or near-normal thresholds and various levels of bothersome and non-bothersome tinnitus and establish normative data in those tests that will facilitate their direct transition to clinical use.
        - Subtask 1: Collect data at Walter Reed
        - Subtask 2: Analyze and begin to publish from Aim 2
        - Subtask 3: Analyze and publish data from Aim 3

What was accomplished under these goals?

A no cost extension was approved in May 2023, which will extend this work for an additional twelve months through 14 June 2024.

- **Specific Aim 1 Accomplishments:**

- University of Texas- Dallas (UTD)
    - IRB protocol to reflect COVID restrictions was approved.
    - Regular meetings between UTD and WRNMMC continued throughout the period of performance.
    - Full data collection is underway.
- Quantico
    - Results of the efforts for this aim were presented at the National Hearing Conservation Association Conferences on 11 Feb 2023. See the significant results section for details.

    - Multiple meetings occurred between Walter Reed, The Navy & Marine Corps Public Health Center- Industrial Hygiene (IH) Department (POC: Revonna Sanders) and the Quantico IH department (POC: Debora Rivera).
        - The Walter Reed Team met with Rufus Godwin (Marine Safety Officer) to discuss the implications of the noise exposures collected at Quantico.

- Noise exposure data was collected on 7 JUL 2022 and 9 NOV 2022 at Quantico. Noise exposures collected included a M240B and a .50 cal machine gun. Exposure results below. Data collection efforts at Quantico have included three of the seven planned scenarios. Two of our IH POCs at Quantico have left which slowed down our ability to continue data collection at Quantico. We are optimistic that we will be able to complete data collection with the provision of the second no cost extension allowing data collection to continue through June 2024.

- **Significant Results Aim 1 (Subjective Noise Exposure):**

Quantico TBS Collection: Monitoring was conducted on 7 July 2022 and 9 NOV 2022. On July 7, 2022, the mNOISE devices were placed on one instructor and one student. The training exercise took place in Range 7 and consisted of firing a M240B and a .50 cal machine gun. Students were provided with 50 rounds per weapon to fire. The position safety officer (PSO) was at the firing line while the students completed their rounds. The exercise began with the firing of the M240B machine gun at approximately 0818 hours until training for that weapon was complete. The next exercise consisted of firing with the M2 .50 caliber machine gun which started at approximately 1232 hours. Both instructor and the student were wearing single hearing protection of the flange and foam type with NRR of approximately 27 and 33 respectively. Total rounds fired for the day were calculated at approximately 1500. PSOs conduct these training exercises up to five times a month or 12 days per month for six to hours a day.

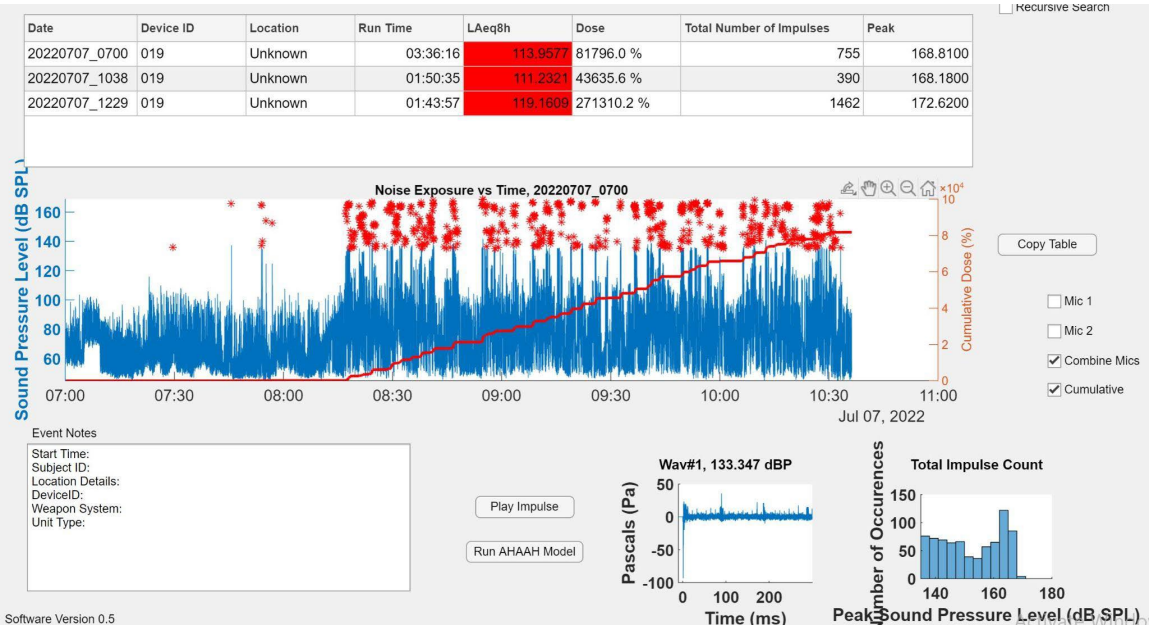

Figure 1: Instructor firing a M240B and a .50 cal machine gun.

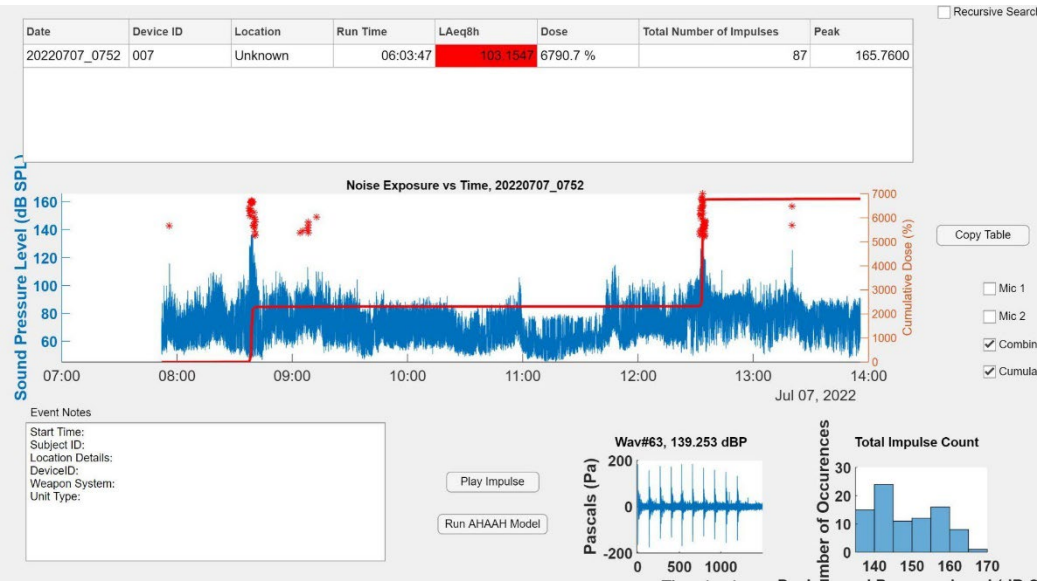

Figure 2: Student firing 50 rounds of a M240B and a .50 cal machine gun.

On November 9, 2022, the mNOISE devices were placed on one instructor exposed to a C4 demolition. The personal noise dosimetry monitoring results seen in Figure 3 indicate that equivalent continuous noise for an eight hour time weighted average (TWA) were at the action level but below the occupational exposure limit (OEL) of 85 dB. The action level indicates the level at which additional requirements, such as exposure monitoring and medical surveillance apply. The peak (dBP) levels for both the EOD techs were above the OEL of 140 dBP for that iteration.

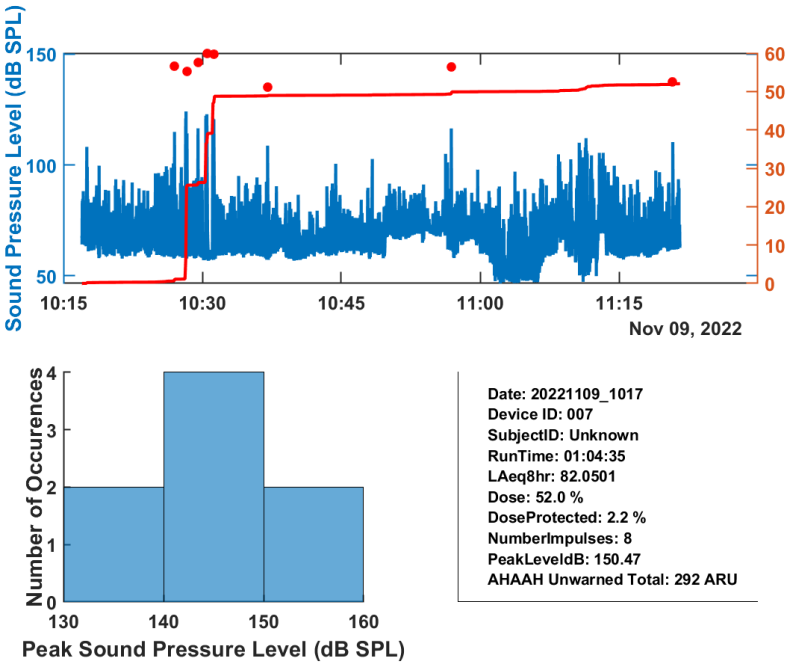

Figure 3: Instructor exposure to C4 demolition down range.

Developing and validating subjective noise surveys

We compared two methods for evaluating history of continuous noise exposure on more than 3,000 service members. The first was a written question that asked how often they were exposed to noise that was loud enough to require a raised voice to communicate three feet away. The second was a question that played a sample of 85 dB noise and asked how often they were exposed to noise at or above that level. The results could have important implications for hearing conservation. For example, participants reported a higher frequency of exposure for the noise sample question, suggesting that noise levels must be higher than 85 dB before individuals feel a raised voice is required for communication (**Figure 4**). In addition, individuals that reported

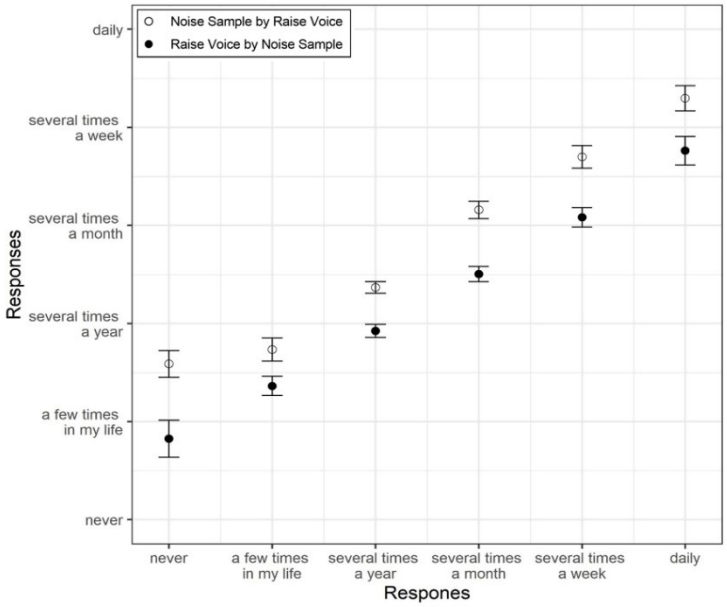

Figure 4. The open circles represent how frequently people who never had to raise their voice said they heard a sound as loud as the noise sample. If the open and closed circles were overlapping then the frequency of responses would be the same for both questions. However, the frequency is higher for the open circles suggesting that people more often said they were exposure to the 85 dB sample compared to the raise your voice question and this continues for the whole response range

increased difficulty hearing also reported having to raise their voice more often than individuals that reported less difficulty hearing (**Figure 5**). It is often difficult to validate noise exposure surveys because there is no "gold-standard" or clinically valid questionnaire. Therefore, the validity of a noise exposure survey is typically validated based on the ability to separate subgroups of individuals, such as individuals with hearing loss versus no hearing loss or individuals complaints or hearing difficulty versus no difficulty. Both the voice question and the noise sample question were capable of separating groups based on hearing loss and hearing complaints (**Table 1 and 2**). These questions could be a clinically feasible approach to document noise exposure history and indicate that subjective hearing difficulty should be taken into consideration when capturing noise exposure history.

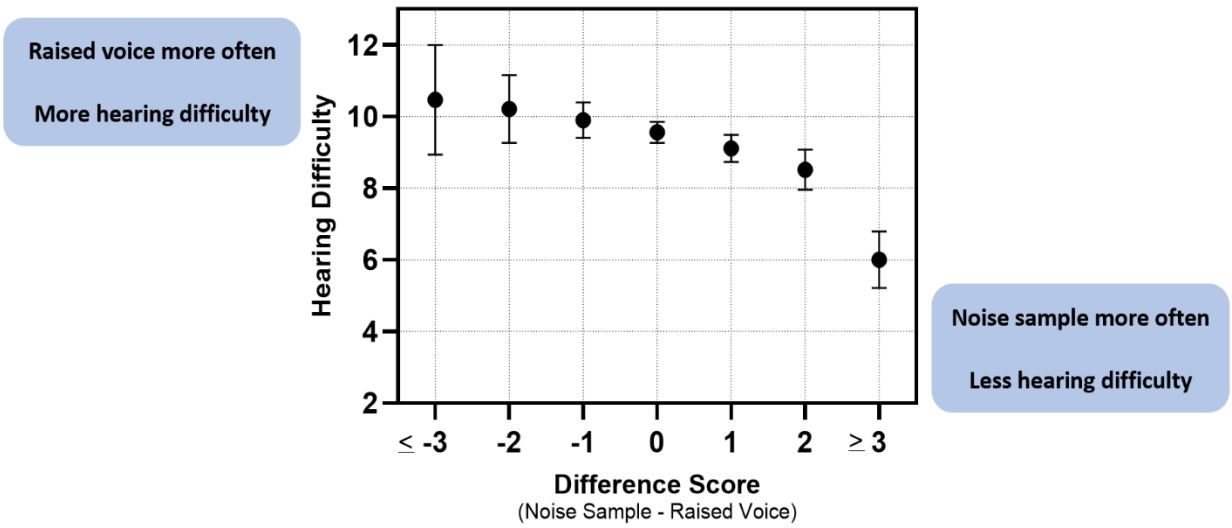

Figure 5. Individuals reporting more hearing difficulty also reported raising their voice more often than being in situations at least as loud as the noise sample. It is possible that people with hearing complaints need a higher signal to noise ratio to understand speech, therefore they need to start raising their voice at a lower noise level.

Table 1. Raise voice and noise sample questions were compared with the Lifetime Exposure to Noise and Solvents Questionnaire (LENS-Q) regarding the prevalence of hearing loss within the tertiles of noise exposure groups. For example, the LENS-Q column indicates that 10% of individuals in the lowest tertile had high frequency hearing loss and 35% of individuals in the highest tertile had high frequency hearing loss. The odds ratio row shows the difference in hearing loss (i.e. pure tone threshold > 20 dB HL) between the lowest and highest tertile groups. An odds ratio above one typically indicates a significant difference between tertiles.

	LENS-Q	Raise Voice	Noise Sample
Noise Tertile	High Hz PTA	High Hz PTA	High Hz PTA
Lowest	10%	6%	7%
High	35%	10%	13%
Odds Ratio	3.5	1.6	1.8

Table 2. Raise voice and noise sample questions were compared with the Lifetime Exposure to Noise and Solvents Questionnaire (LENS-Q) regarding the prevalence subjective hearing complaints within the tertiles of noise exposure groups. For example, the LENS-Q column indicates that 14% of individuals in the lowest tertile had hearing complaints based on responses to the Hearing Handicap Inventory for Adults (HHIA) and 38% of individuals in the highest

tertile had reported hearing difficulty. The odds ratio row shows the difference in subjective hearing complaints on the HHIA and the Tinnitus Hearing Survey (THS) between the lowest and highest tertile groups. An odds ratio above one typically indicates a significant difference between tertiles.

	LENS-Q	Raise Voice	Noise Sample
Noise Tertile	HHIA	THS - Hearing	THS - Hearing
Lowest	14%	4%	4%
High	38%	15%	13%
Odds Ratio	2.71	3.75	3.25

Specific Aim 2 Accomplishments:

- Continuing review approved in Fall 2022.
- Data collection continued through this performance period, with data collection completed at WRNMMC and continuing at UT Dallas. See below for result details.
- Results from Aim 2 have been disseminated at multiple meetings and publications. See the publication section for publication details.

- **Significant Results Aim 2:**

These data were collected under MRMC IRB Protocol Log No. M-10386; HRPO Log No. A-20639.

The goal of Aim 2 is to identify auditory tests that are sensitive to objective differences in performance among SMs with normal or near-normal thresholds and varying levels of noise and blast exposure, and establish normative data for those tests, that will facilitate the direct transition to clinical use.

Establishing normative data: Tinnitus and Hearing Survey

In this year we have established normative data for the Tinnitus and Hearing Survey (THS), using a large sample of United States service members. Normative data allows a patient's THS results to be compared to the population rather than being only self-referential. In total, 22,583 SMs completed the THS-Hearing (THS-H) subscale and 5410 SMs completed the THS-Tinnitus (THS-T) subscale.

The THS questionnaire was rescaled from the original 5 points (THS_{16}) to 11 points (THS_{40}) to be comparable with other measures of hearing difficulty. Age, gender and degree of hearing loss were taken into consideration when determining a normative cutoff for the THS-H.

Degree of hearing loss was categorized by hearing profiles, outlined by the US Army Regulation 40-502. Age, gender, degree of hearing loss, and tinnitus severity were taken into consideration when determining a normative cutoff for the THS-T.

For the THS-H, age and gender had very small effect sizes on performance, however, THS-H performance was dependent on hearing profile. A cutoff value of 26 was determined to identify abnormality in performance. The THS-T was relatively insensitive to age, gender, and hearing profile, however, the severity of tinnitus, indicated by bothersomeness, substantially impacted THS-T performance. A receiver operating characteristic (ROC) curve was used to determine a cutoff of 9 on the THS-T as being highly sensitive to detect bothersome tinnitus. The THS is a viable tool for identifying patients with substantial hearing or tinnitus complaints. The cutoff scores of 26 (THS-H) and 9 (THS-T) provide a clinical reference point to guide referrals to audiology.

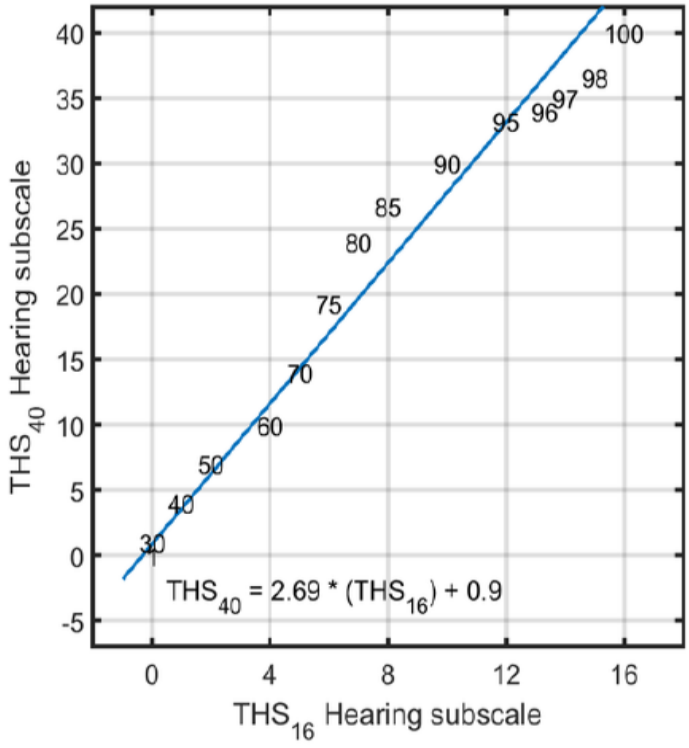

Figure 6. Scatterplot of THS_{16} responses against THS_{40} responses on the hearing subscale of the THS. Every 5th point is labeled with the percentile rank. The function used to convert between the 5pt and 11pt scale is printed on the bottom of the figure.

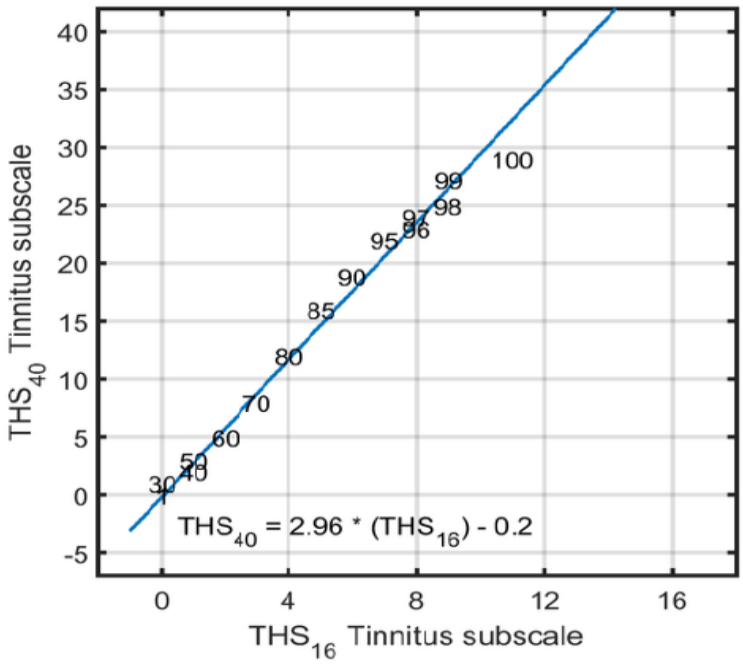

Figure 7. Scatterplot of THS_{16} responses against THS_{40} responses on the tinnitus subscale of the THS. Every 5th point is labeled with the percentile rank. The function used to convert between the 5pt and 11pt scale is printed on the bottom of the figure.

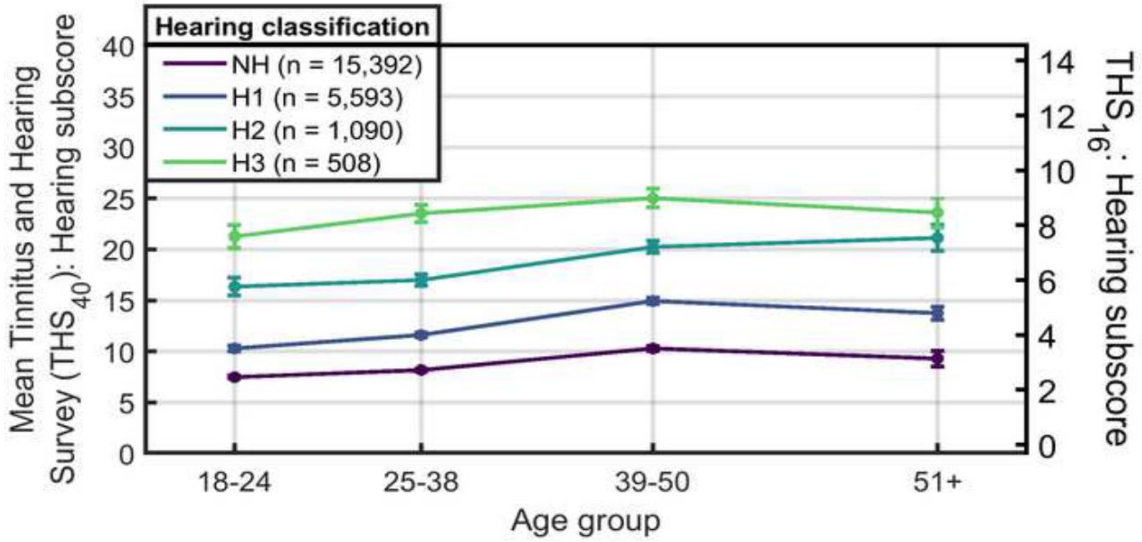

Figure 8. Mean THS-H scores as a function of age with each line showing a different hearing profile.

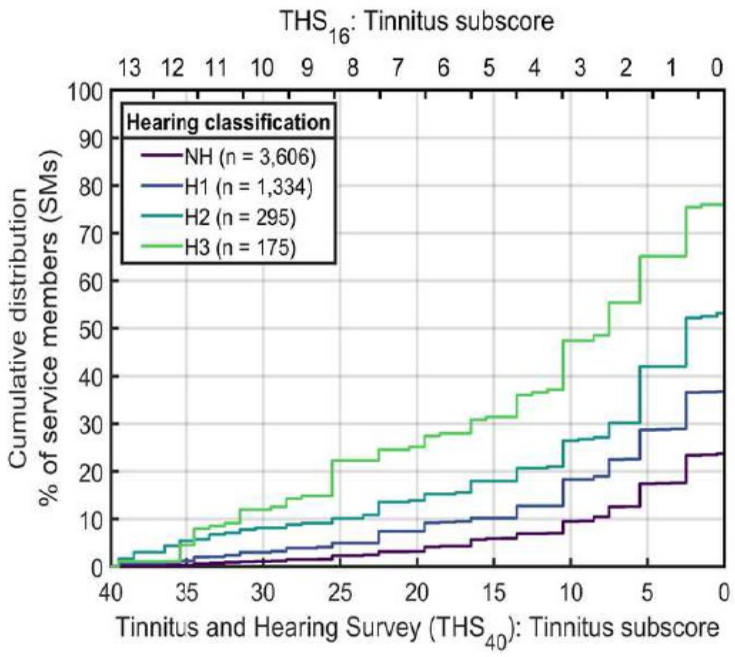

Figure 9. Cumulative distribution of THS-H scores by age bracket for listeners with normal hearing.

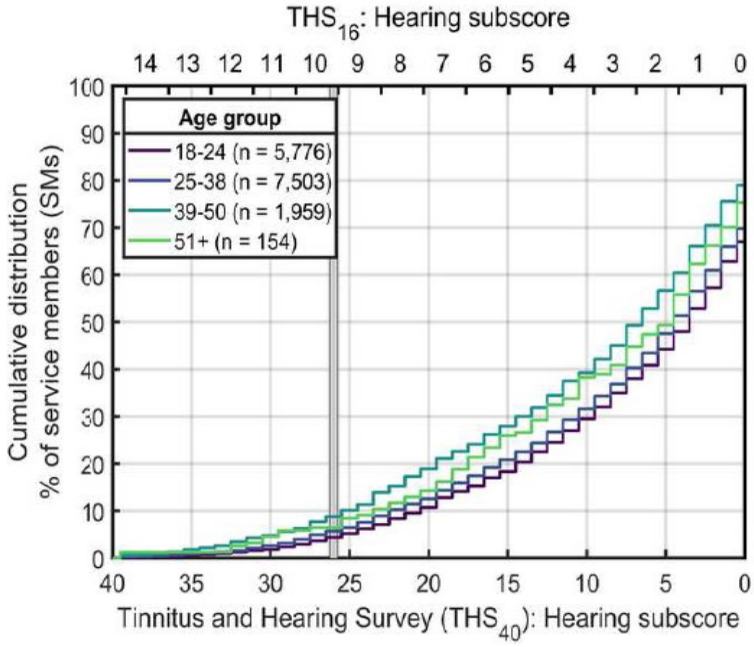

Figure 10. Cumulative distribution of scores on the THS-T by hearing profile.

The development and results of these normative data ranges were presented at a poster at the American Auditory Society in March 2023; a manuscript is in development to be submitted to a

peer reviewed journal in the next quarter. Figure 11 below displays the poster presented at the American Auditory Society conference.

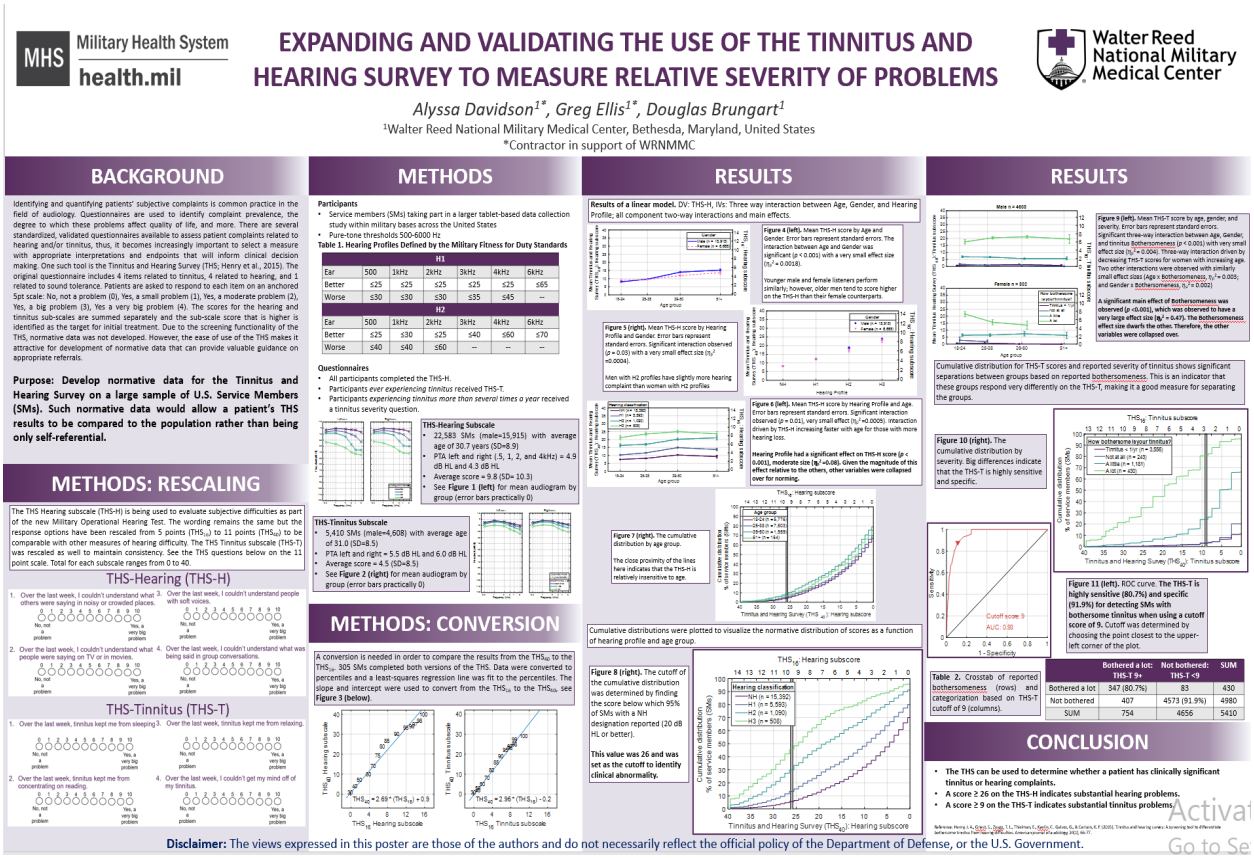

Figure 11. Poster presented at the 50th Annual American Auditory Society Conference, March 2023.

Non-native speech recognition

As part of this aim, we have already made substantial progress developing tests of binaural perception, speech perception, and subjective complaints that are sensitive both to temporary threshold shifts and to blast exposure. We are now also exploring whether a speech-in-noise task that incorporates "non-native" speech materials might provide an additional level of difficulty relative to standard speech materials that might help differentiate performance between blast- and non-blast exposed listeners. As a starting point, we have reviewed the results of a large study that used stimuli recorded from non-native English speakers at a recent NATO exercise. A manuscript describing this study and these data is currently under review with the Journal of Speech Language and Hearing Research.

A total of 1939 participants completed this task, which involved listening to a corpus of native and non-native accented American English Matrix Test sentences. The talkers for this corpus were residents of NATO-member countries, and represented 13 different countries and 11

different native languages. The sentences were mixed in a 4-talker babble masker at signal-to-noise ratios (SNRs) of -4 and -1 dB SNR, mixed in a speech-shaped noise masker at -6 and -9 dB SNR, or presented essentially in quiet (+10 dB SNR). **Figure 12**, below, shows overall recognition levels for the stimuli at each SNR, as measured in participants who indicated that they considered English to be their native language. **Figure 12** also demonstrates a significant effect of talker language in background noise - sentences produced by talkers who were native speakers of English had higher intelligibility than sentences produced by non-native English talkers, when listening in noise.

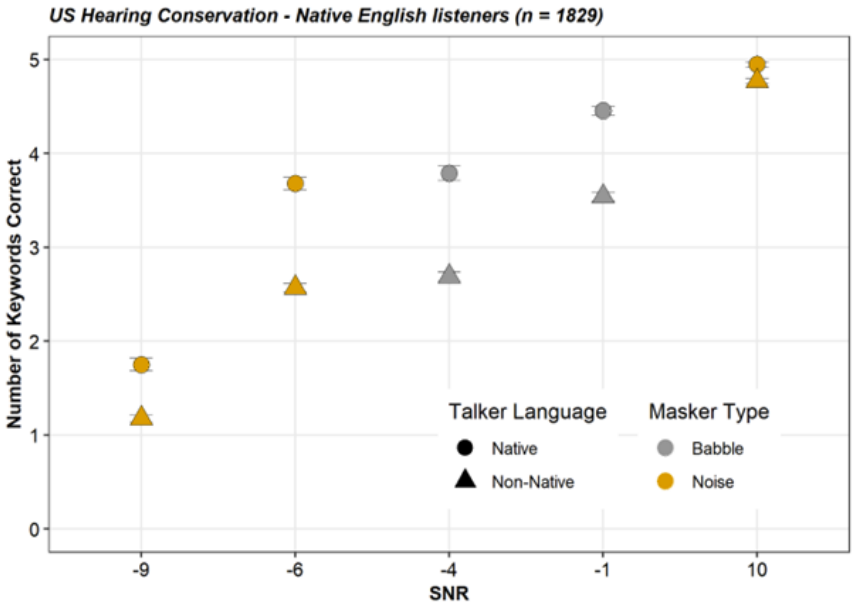

Figure 12. Intelligibility of native-accented and non-native accented English sentences in multi-talker babble (grey symbols) and speech-shaped noise (orange symbols).

One question of interest was whether listeners with hearing impairment would be disproportionately impacted by a non-native English accent when listening to speech in noise. **Figure 13**, shown below, demonstrates an interaction of high frequency hearing sensitivity and talker nativeness. Tor both native and non-natively produced stimuli, recognition of speech was poorer for listeners with worse high frequency hearing thresholds. However, this relationship was stronger for stimuli produced by native talkers as compared to non-native talkers.

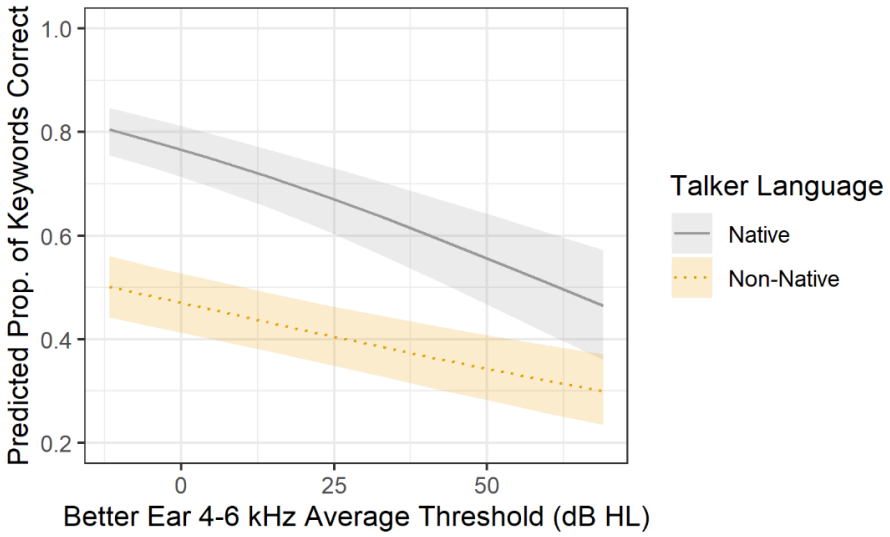

Figure 13. Speech recognition performance as a function of high frequency hearing (average of 4-6 kHz threshold in the better-hearing ear). Shading reflects the 95% confidence interval.

We also observed in this dataset that listeners were sensitive to the talkers' proficiency with spoken English, such that talkers who had higher English proficiency scores produced speech that was more intelligible. This effect was stronger when speech was presented in a multi-talker babble as compared to a speech-shaped noise, as shown in Figure 14.

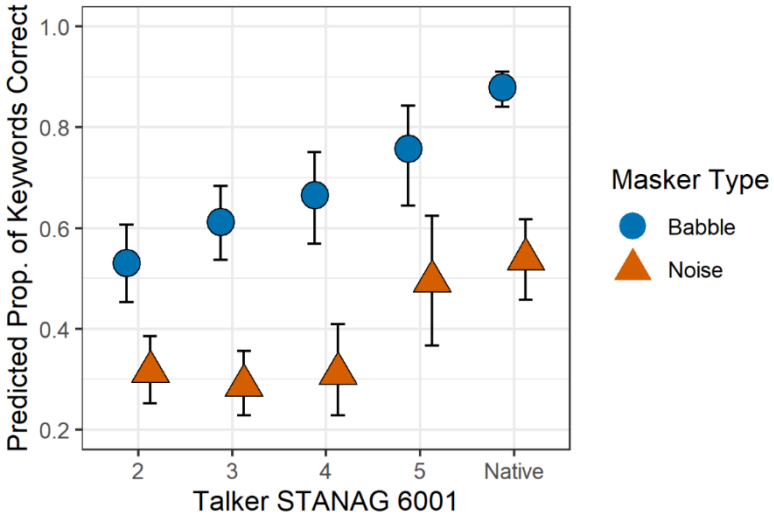

Figure 14. Speech recognition performance as a function of the talkers' spoken English proficiency on the NATO Standard Agreement (STANAG) 6001 scale. Error bars reflect the 95% confidence interval.

In this fiscal year, findings from this sub-study have been presented at the 8th Workshop on Battlefield Acoustics and the 51st meeting of the American Auditory Society. In addition, Dr. Rebecca Bieber has briefed leadership at the Henry M Jackson Foundation regarding this line of work, and a manuscript detailing these findings is currently under review at the Journal of

Speech Language and Hearing Research. A copy of the poster presented at the American Auditory Society is displayed in **Figure 15** below.

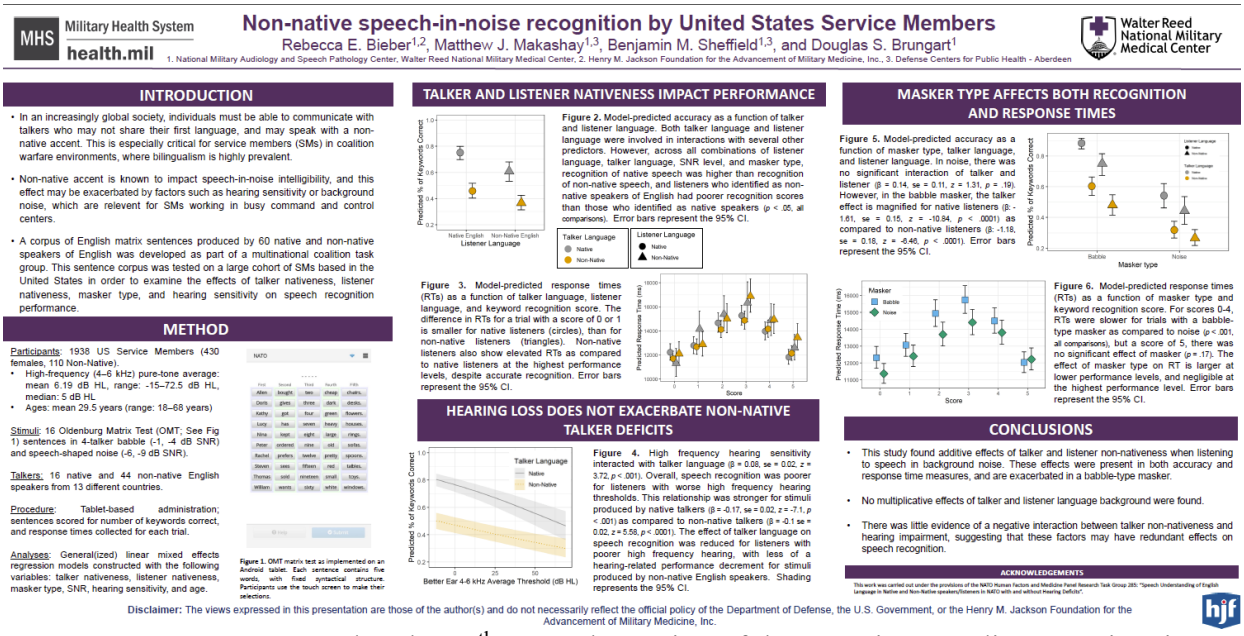

Figure 15. Poster presented at the 50th Annual Meeting of the American Auditory Society in March 2023.

- **Specific Aim 3 Accomplishments:**
    - Final adjustments were made to the tablet data collection protocols and data collection was initiated early during this annual period. To date over 600 participants have been tested, with collection primarily occurring in the Hearing Conservation clinic. Both data collection and data analysis are ongoing.
    - Dr. LaGuinn Sherlock gave a presentation at the World Congress of the Society for Brain Mapping and Therapeutics on 19 FEB, 2023.
- **Significant Results Aim 3**:

The goal of Aim 3 is to identify functional tests that are sensitive to differences in performance among SMs with normal or near-normal thresholds and various levels of bothersome and non-bothersome tinnitus. and establish normative data on those tests that will facilitate the direct transition to clinical use.

To date, data has been collected from 605 participants in Hearing Conservation and 2 participants from the Audiology and Speech Pathology Center. The majority of data analysis to date has centered on the results from the: 1) Flanker task; 2) Letter Location Test; and 3) fixed level frequency test. Factors that are expected to affect performance on the Flanker task and the

Letter Location Test are included in the data modeling, including sleep, anxiety, depression, subjective hearing difficulty, history of head injury and medications for cold/flu symptoms, allergies, anxiety and depression.

Most of the participants to date respond negatively to perceiving tinnitus. About one quarter of the participants indicate they perceive tinnitus and less than 1% respond "not sure." Participants also were asked about reacting to tinnitus (i.e., being bothered). Just over half were not bothered by tinnitus, half indicated being bothered a little or indicated being bothered a lot by tinnitus. Participants were grouped according to their score on the Tinnitus and Functional Index. Those with scores of: 1) less than 25% were categorized as low TFI; 2) between 25 and 50% were categorized as mid TFI; and 3) greater than 50% were categorized as high TFI.

Results from the extended high-frequency threshold testing, shown in **Figure 16**, revealed that those in the high TFI group had a significantly lower frequency threshold than those in the other groups (i.e., poorer extended high-frequency hearing).

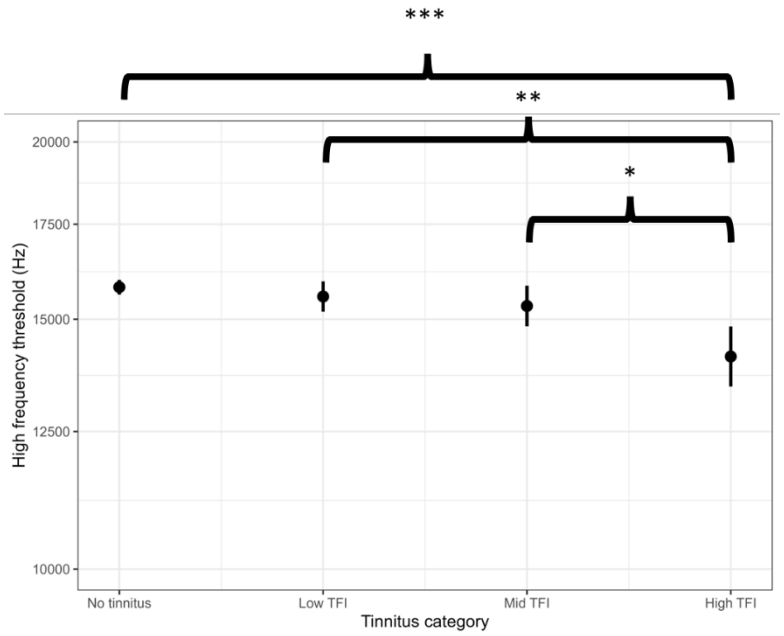

Figure 16. High frequency threshold as a function of tinnitus category. "*" indicates significance at $p < 0.05$, "**" indicates significance at $p < 0.01$, and "***" indicates significance at $p < 0.001$. Only neighboring tinnitus categories are compared.

In **Figure 17**, we examined scores on the Hearing and Tinnitus subscales of the Tinnitus and Hearing Survey. the high TFI group reports more subjective hearing difficulty than the other three groups. On both subscales, we found significant differences between those in the High TFI category as compared to the other categories. The high TFI group reports more subjective hearing difficulty than the other three groups (hearing subscale, panel A), and TFI scores increase as perception of bother increases from "not at all" to "a lot" (tinnitus subscale; panel B). **Figure 18** shows that TFI scores increase as perception of bother increases from "not at all" to "a lot."

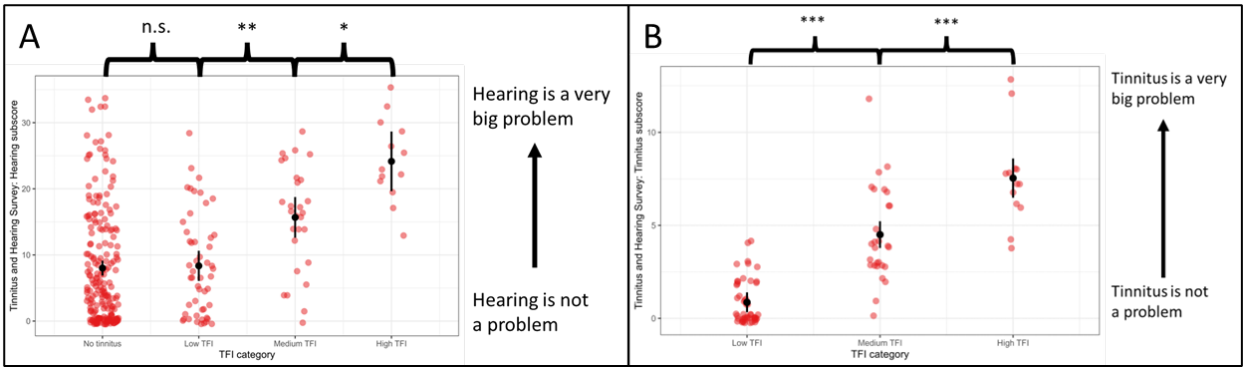

Figure 17. Scores on the Hearing (panel A) and Tinnitus (panel B) subscales of the Tinnitus and Hearing Survey. Each point represents one individual. "*" indicates significance at $p < 0.05$, "**" indicates significance at $p < 0.01$, and "***" indicates significance at $p < 0.001$. Only neighboring tinnitus categories are compared.

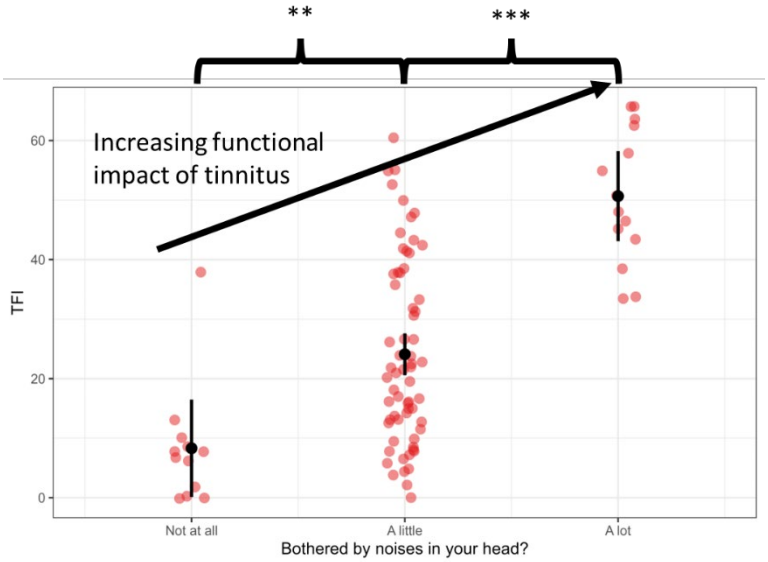

Figure 18. Score on the Tinnitus Functional Index (TFI) questionnaire as a function of bothersomeness rating. Each point represents one individual. "*" indicates significance at $p < 0.05$, "**" indicates significance at $p < 0.01$, and "***" indicates significance at $p < 0.001$. Only neighboring tinnitus categories are compared.

Unlike previous results in a carefully controlled laboratory study, we have found no significant difference in Flanker effect as a function of tinnitus group in the data collected on the tablet. This could be related to the considerable variability in performance in the relatively small population of participants in the high TFI group. We observed a similar outcome for the Letter Location Test in that there was no significant difference in performance between groups.

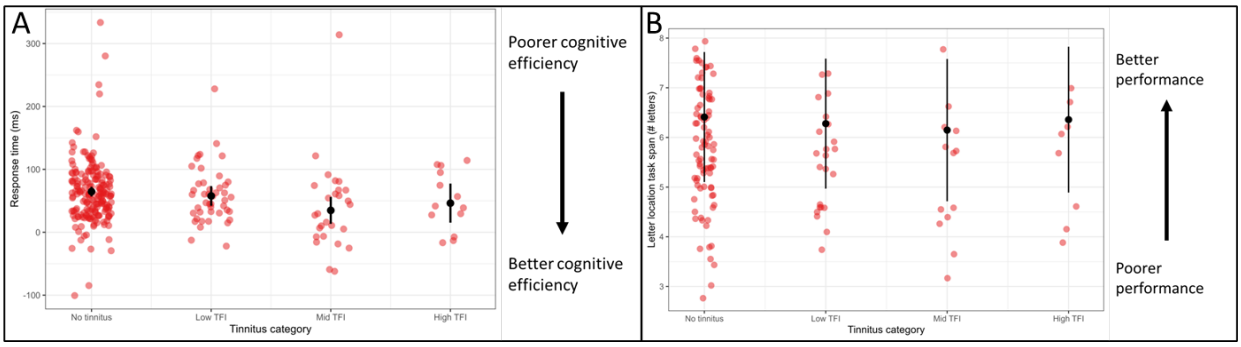

Figure 19. Flanker effect (Panel A) and letter location task scores (panel B) as a function of tinnitus category. Each point represents one individual.

What opportunities for training and professional development has the project provided?
If the project was not intended to provide training and professional development opportunities or there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe opportunities for training and professional development provided to anyone who worked on the project or anyone who was involved in the activities supported by the project. "Training" activities are those in which individuals with advanced professional skills and experience assist others in attaining greater proficiency. Training activities may include, for example, courses or one-on-one work with a mentor. "Professional development" activities result in increased knowledge or skill in one's area of expertise and may include workshops, conferences, seminars, study groups, and individual study. Include participation in conferences, workshops, and seminars not listed under major activities.

Nothing to report.

How were the results disseminated to communities of interest?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how the results were disseminated to communities of interest. Include any outreach activities that were undertaken to reach members of communities who are not usually aware of these project activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Results were disseminated via publications and conference presentations.

What do you plan to do during the next reporting period to accomplish the goals?
If this is the final report, state "Nothing to Report."

Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.

- **(Year 1) Specific Aim 1:** Evaluate and Optimize Subjective Metrics for Assessing Noise History
    - **Major Task 1:** Improve our ability to obtain reliable self-reports of noise exposure by directly evaluating the relationship between objectively measured noise dosimetry and subjective noise surveys.
        - Sub task 3: Continue to collect data at UTD. Continue to collaborate with and support the local Quantico IH department to collect the noise exposure levels for the training exercises at TBS.

- **(Year 2) Specific Aim 2**: Evaluate the influence that noise and blast exposure have on the performance and subjective hearing handicap of listeners with normal hearing thresholds.
    - **Major Task 2:** Identify auditory tests that are sensitive to objective differences in performance among Service Members with normal or near-normal thresholds and varying levels of noise and blast exposure and establish normative data in those tests that will facilitate their direct transition to clinical use.
        - Subtask1: Data collection will continue at UTD.
        - Subtask2: Further analyze and continue to publish and disseminate results.

- **(Year 3) Specific Aim 3**: Evaluate the functional effect of non-bothersome and bothersome tinnitus in Service members
    - **Major Task 3:** Identify auditory and functional tests that are sensitive to differences in performance among Service Members with normal or near-normal thresholds and various levels of bothersome and non-bothersome tinnitus and establish normative data in those tests that will facilitate their direct transition to clinical use.
        - Subtask 1: Complete data collection at Walter Reed
        - Subtask 2: Further analyze and begin to publish from Aim 2
        - Subtask 3: Analyze and publish data from Aim 3

4. IMPACT:

Describe distinctive contributions, major accomplishments, innovations, successes, or any change in practice or behavior that has come about as a result of the project relative to:

What was the impact on the development of the principal discipline(s) of the project?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research in the principal disciplinary field(s) of the project. Summarize using language that an intelligent lay audience can understand (Scientific American style).

The subjective and objective measures of noise exposure developed in Aim 1 could be critical in improving the reliability of the individual noise exposure data in DOEHRS-HC, which could eventually lead to more accurate epidemiological studies of the relationship between noise and hearing impairment in the military. Similarly, the data we collect in Aims 2 and 3 will provide tests that could almost immediately be transitioned to the clinic as diagnostic tools for evaluating patients who have near-normal thresholds, but have subjective complaints about speech-in-noise difficulties and tinnitus. There is now a US Army Public Health Project in place to include the THS-H survey in the annual hearing exams of all SMs, and we are encouraging DoD Audiologists to include the TTS measure, the THS, and an NoSpi measuring in their evaluations of noise exposes SMs and upload them into the Hearing Center of Excellence Enterprise Clinical Audiology Application (ECAA).

What was the impact on other disciplines?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines.

The results we are finding regarding NoSpi perception in blast and noise exposed service members has led to additional measures that appear to confirm the importance of binaural perception in this population. We have now seen evidence of similar effects in the chronic blast-exposed patient population at the National Intrepid Center of Excellence, and we are also finding evidence of short-term changes in binaural perception for noise exposed listeners who are tested pre- and post-exposure in the field.

What was the impact on technology transfer?

Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use, including: transfer of results to entities in government or industry; instances where the research has led to the initiation of a start-up company; or adoption of new practices.

Nothing to Report.

What was the impact on society beyond science and technology?
If there is nothing significant to report during this reporting period, state "Nothing to Report."
Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world on areas such as: improving public knowledge, attitudes, skills, and abilities; changing behavior, practices, decision making,

policies (including regulatory policies), or social actions; or improving social, economic, civic, or environmental conditions.

Nothing to Report.

5. CHANGES/PROBLEMS:

The Project Director/Principal Investigator (PD/PI) is reminded that the recipient organization is required to obtain prior written approval from the awarding agency Grants Officer whenever there are significant changes in the project or its direction. If not previously reported in writing, provide the following additional information or state, "Nothing to Report," if applicable:

Changes in approach and reasons for change

Describe any changes in approach during the reporting period and reasons for these changes. Remember that significant changes in objectives and scope require prior approval of the agency.

- An additional no cost extension was approved for this grant which will extend this work for an additional twelve months through 14 June 2023.
- No changes to scope or approach to report for the upcoming performance period.

Actual or anticipated problems or delays and actions or plans to resolve them

Describe problems or delays encountered during the reporting period and actions or plans to resolve them.

1. All Aims: Data collection for all projects was previously put on hold due to COVID-19. We were granted an additional no cost extension, which will enable us to meet the goals of this project.
2. Collection of noise exposure data at Quantico for Aim 1 is dependent on time constraints, availability and motivation of the Quantico IH department.

Changes that had a significant impact on expenditures

Describe changes during the reporting period that may have had a significant impact on expenditures, for example, delays in hiring staff or favorable developments that enable meeting objectives at less cost than anticipated.

Nothing to report.

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Describe significant deviations, unexpected outcomes, or changes in approved protocols for the use or care of human subjects, vertebrate animals, biohazards, and/or select agents during the reporting period. If required, were these changes approved by the applicable institution committee (or equivalent) and reported to the agency? Also specify the applicable Institutional Review Board/Institutional Animal Care and Use Committee approval dates.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals.

N/A

Significant changes in use of biohazards and/or select agents

N/A

6. PRODUCTS:

List any products resulting from the project during the reporting period. If there is nothing to report under a particular item, state "Nothing to Report."

- **Publications, conference papers, and presentations**
  Report only the major publication(s) resulting from the work under this award.

  Journal publications. *List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Davidson, A.**,** Ellis, G., Sherlock, L., Schurman, J., & Brungart, D. (*submitted*). Rapid Assessment of Subjective Hearing Complaints with a Modified Version of the Tinnitus and Hearing Survey. *Trends in Hearing.* Bieber, RE., Makashay, MJ., Sheffield, B., & Brungart, DS. (*submitted*). Intelligibility of native and non-native speech in noise in a large cohort of US Service Members. *Journal of Speech Language and Hearing Research.* Perry, T. T., Brungart, D. S., Myers, J. R., Cord, L. L., & Solomon, N. P. (*accepted*). Prevalence of self-reported voice concerns and associated risk-markers in a nonclinical sample of military service members. *Journal of Speech, Language, and Hearing Research.*

Books or other non-periodical, one-time publications. *Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like. Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (e.g., book, thesis or dissertation); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Nothing to report.

Other publications, conference papers, and presentations. *Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication as noted above. List presentations made during the last year (international, national, local societies, military meetings, etc.). Use an asterisk (*) if presentation produced a manuscript.*

Schurman, J. & Brungart, D. (2023, February). Evaluating noise exposure history with a calibrated noise reference, National Hearing Conservation Association (NHCA), Jacksonville, FL.

Brungart, D. (2023, February). The Myth of Normal Hearing, National Hearing Conservation Association (NHCA), Jacksonville, FL.

Presented by Schurman, J: Brungart, D. (2023, March). Cochlear Synaptopathy in Service Members with self-reported temporary hearing loss. Towson University Symposium. Towson, MD.

Presented by Ellis, G: Brungart, D. & Schurman, J. (2023, March). Cochlear Synaptopathy in Service Members with self-reported temporary hearing loss. American Auditory Society (AAS), Scottsdale, AZ.

Sherlock, Ellis, Schurman, Galloza and Brungart: The Functional Impact of Tinnitus in the Military. Society for Brain Mapping and Therapeutics. Los Angeles, CA. February 19, 2023.

*Davidson, A., Ellis, G., Sherlock, L., Schurman, J. & Brungart, D. (2023, March). Expanding and Validating the Use of the Tinnitus and Hearing Survey to Measure Relative Severity of Auditory Problems. American Auditory Society Conference. Scottsdale, AZ.

*Bieber, RE., Makashay, MJ., Simpson, B., & Brungart, DS. (2023). Non-native speech-in-noise recognition by US Service Members. American Auditory Society Annual Meeting, Scottsdale AZ, March.

Website(s) or other Internet site(s)

List the URL for any Internet site(s) that disseminates the results of the research activities. A short description of each site should be provided. It is not necessary to include the publications already specified above in this section.

Nothing to report.

Technologies or techniques

Identify technologies or techniques that resulted from the research activities. In addition to a description of the technologies or techniques, describe how they will be shared.

Nothing to report.

Inventions, patent applications, and/or licenses

Identify inventions, patent applications with date, and/or licenses that have resulted from the research. State whether an application is provisional or non-provisional and indicate the application number. Submission of this information as part of an interim research performance progress report is not a substitute for any other invention reporting required under the terms and conditions of an award.

Nothing to report.

Other Products

Identify any other reportable outcomes that were developed under this project. Reportable outcomes are defined as a research result that is or relates to a product, scientific advance, or research tool that makes a meaningful contribution toward the understanding, prevention, diagnosis, prognosis, treatment, and/or rehabilitation of a disease, injury or condition, or to improve the quality of life. Examples include: data or databases; biospecimen collections; audio or video products; software; models; educational aids or curricula; instruments or equipment; research material (e.g., Germplasm; cell lines, DNA probes, animal models); clinical interventions; new business creation; and other.

Nothing to report.

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Provide the following information for: (1) PDs/PIs; and (2) each person who has worked at least one person month per year on the project during the reporting period, regardless of the source

of compensation (a person month equals approximately 160 hours of effort). If information is unchanged from a previous submission, provide the name only and indicate "no change."

Name: Douglas Brungart, PhD
Project Role: PI
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Principal Investigator

Name: Jaclyn Schurman AuD PhD
Project Role: Co-I
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Research Audiologist

Name: Colleen LePrell PhD
Project Role: PI at University of Texas, Dallas
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Principal Investigator

Name: LaGuinn Sherlock AuD
Project Role: Co-I
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Research Audiologist

Name: Rebecca Bieber AuD PhD
Project Role: Research Audiologist
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Research Audiologist

Name: Ian Phillips PhD
Project Role: Biomedical Engineer
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Biomedical Engineer

Name: Megan Eitel AuD
Project Role: Research Audiologist
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Research Audiologist

Name: Jacob Lefler
Project Role: Software Engineer
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Software Developer

Name: Roberta Martorana
Project Role: Audiology Technician
Researcher ID: NA
Nearest person month worked: no change
Contribution to Project: Audiology Technician

change has been. Changes may occur, for example, if a previously active grant has closed and/or if a previously pending grant is now active. Annotate this information so it is clear what has changed from the previous submission. Submission of other support information is not necessary for pending changes or for changes in the level of effort for active support reported previously. The awarding agency may require prior written approval if a change in active other support significantly impacts the effort on the project that is the subject of the project report.

Dr. Schurman has left WRNMMC as of May18 2023.

What other organizations were involved as partners?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe partner organizations – academic institutions, other nonprofits, industrial or commercial firms, state or local governments, schools or school systems, or other organizations (foreign or domestic) – that were involved with the project. Partner organizations may have provided financial or in-kind support, supplied facilities or equipment, collaborated in the research, exchanged personnel, or otherwise contributed.
Provide the following information for each partnership:
Organization Name:
Location of Organization: (if foreign location list country)
Partner's contribution to the project (identify one or more)

Financial support;
In-kind support (e.g., partner makes software, computers, equipment, etc., available to project staff);
Facilities (e.g., project staff use the partner's facilities for project activities);
Collaboration (e.g., partner's staff work with project staff on the project);
Personnel exchanges (e.g., project staff and/or partner's staff use each other's facilities, work at each other's site); and
Other.

University of Texas, Dallas (Subaward)
800 W. Campbell Road Richardson, TX 75080
Colleen LePrell, PhD
Collaboration (e.g., partner's staff work with project staff on the project)

8. SPECIAL REPORTING REQUIREMENTS

COLLABORATIVE AWARDS: For collaborative awards, independent reports are required from BOTH the Initiating PI and the Collaborating/Partnering PI. A duplicative report is acceptable; however, tasks shall be clearly marked with the responsible PI and research site. A report shall be submitted to **https://ers.amedd.army.mil** for each unique award.

QUAD CHARTS: If applicable, the Quad Chart (available on https://www.usamraa.army.mil) should be updated and submitted with attachments.

9. APPENDICES:

Attach all appendices that contain information that supplements, clarifies or supports the text. Examples include original copies of journal articles, reprints of manuscripts and abstracts, a curriculum vitae, patent applications, study questionnaires, and surveys, etc.