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**TITLE:** Functional Impairment in Service Members with Normal Audiometric Thresholds

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Fort Detrick, Maryland 21702-5012

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**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

**AND ADDRESS(ES)**
Henry M. Jackson Foundation, for the Adv. of Mil. Med.
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Bethesda, MD 20817

**8. PERFORMING ORGANIZATION REPORT NUMBER**

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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

| **16. SECURITY CLASSIFICATION OF: Unclassified** | | | **17. LIMITATION OF ABSTRACT** | **18. NUMBER OF PAGES** | **19a. NAME OF RESPONSIBLE PERSON** |
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## 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. This 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 April 2022, which will extend this work for an additional twelve months through 14 June 2023.

- **Specific Aim 1 Accomplishments:**

- University of Texas- Dallas (UTD)
    - IRB protocol to reflect COVID restrictions was approved.
    - Weekly meetings between UTD and WRNMMC continued throughout the period of performance.
    - Programming of the Tabsint protocol for data collection was completed.
    - Pilot data collection is underway.
- Quantico
    - A report of noise samples collected in July 2019 was submitted to the Commander of the Marine Corps Installations National Capital Region.
    - MIT Lincoln Labs publication/presentation regarding the utility of the new mNoise impulse noise dosimeter has been accepted for presentation at the Annual International Conference of the IEEE Engineering in Medicine and Biology Society. 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).
  - In September Dr. Schurman traveled to Quantico to provide the IH department with mNoise devices. Dr. Schurman trained Matt Young and Oscar Adams on how to use the devices and how to upload the subsequent data. Mr. Young and Mr. Adams are both industrial hygienists and they have expressed interest in using the mNoise devices to characterize all noise exposures experienced by Marines training at Quantico. Walter Reed will support their noise collection efforts. The new POC at the Quantico IH department is Debora Rivera. She has been responsive and instrumental in moving this effort forward. Multiple additional meetings have occurred between Dr. Schurman and Ms. Rivera.
  - On 5 OCT Dr. Schurman traveled to Quantico to assist with the mNoise dosimeter set up on the rifle range. This data collection was intended to be a pilot session to ensure everything is working well with the equipment and data upload.

  - 2 DEC Meeting: This meeting included members of the Quantico IH team (Oscar Adams, Matthew Young, and Debora Rivera), Navy Portsmouth IH team (Revonna Sanders), Walter Reed (Jaclyn Schurman), and Marine Safety Officers (Rufus Godwin). The purpose of this meeting was to discuss the importance of measuring the noise exposure at all weapon ranges at TBS. Mr. Godwin provided multiple documents to the Quantico IH team, including The Marine Corps Occupational Safety and Health Program Manual, Marine Corps Order 6260.3A (requiring all commands to preserve the hearing readiness of Marines), and the Marine Corps Safety Management System. These documents outline the importance of capturing the noise levels of weapon systems in order to provide all Marines with the proper hearing protection. In addition, Mr. Godwin empowered the Quantico IH department to use these documents in order to justify the collection of noise exposure data and to highlight that these activities are public health initiatives and should not be considered research.

  - Dr. Schurman traveled to Quantico for noise exposure data collected on 16 JUN at Quantico. Noise exposure collected at the M777 range and the Mortar range. Exposure results below.

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

**IEEE EMBC conference paper:** Walter Reed team members have been collaborating with MIT Lincoln Labs to write a conference paper that will be submitted to the IEEE EMBC conference. The paper details the design of a body-worn noise dosimeter (mNoise) that processes both impulse and continuous noise ranging in level from 40dBA185dBP (i.e. a quiet whisper to a shoulder-fired rocket). mNoise data collected at Quantico is shown in Figure 1. mNoise device 010 captured 240 rounds of AR-15, 10 rounds of 9mm handgun and 1 round of 12 ga shotgun. mNoise device 003 captured 300 rounds of AR-15 and 100 rounds of 12 ga shotgun.

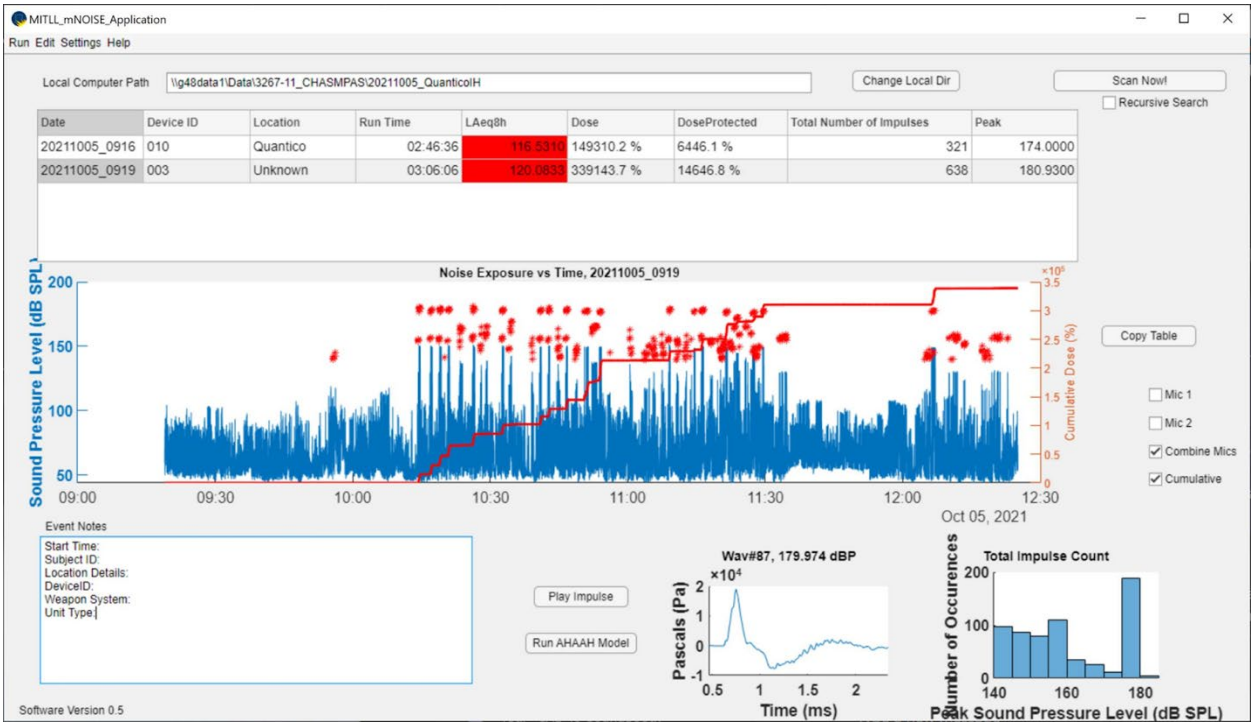


Figure 1. Noise levels collected using the MIT Lincoln Labs mNoise device from the rifle range at Quantico. The x-axis shows the time of the noise exposure and the y-axis is the level of the noise. The red dots indicate peak levels of noise.

**Quantico TBS Collection:** Monitoring was conducted on 16 June 2022. M777 Howitzer training was performed on Range 4 in the morning and in the afternoon training was conducted on Range 7 with M120 Mortars.

Instructors trained multiple groups of students on the firing of the M777 Howitzer (charge one) on Range 4 from approximately 0945-1040. One instructor (responsible for pulling the lanyard) and one student (responsible for loading the weapons system) wore dosimeters during the weapons firing evolution; see Figures 2 and 3 for results and number of rounds fired.

Personnel were observed wearing various types of single hearing protection devices including ear plugs and muffs.

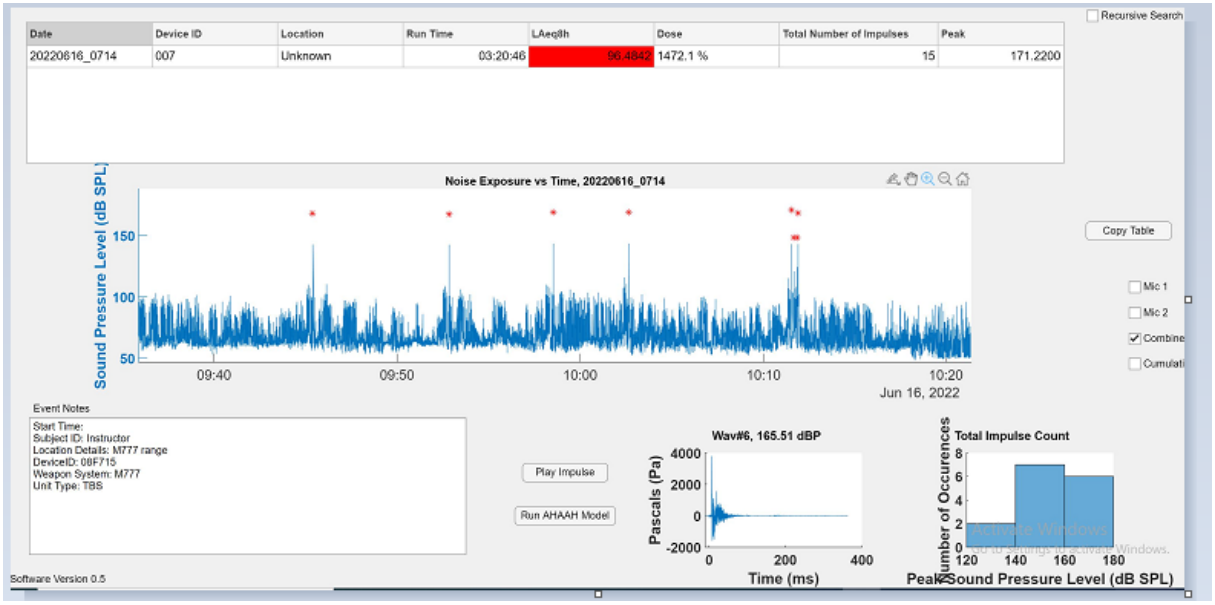


Figure 2: Results M777 Howitzer Firing Instructor

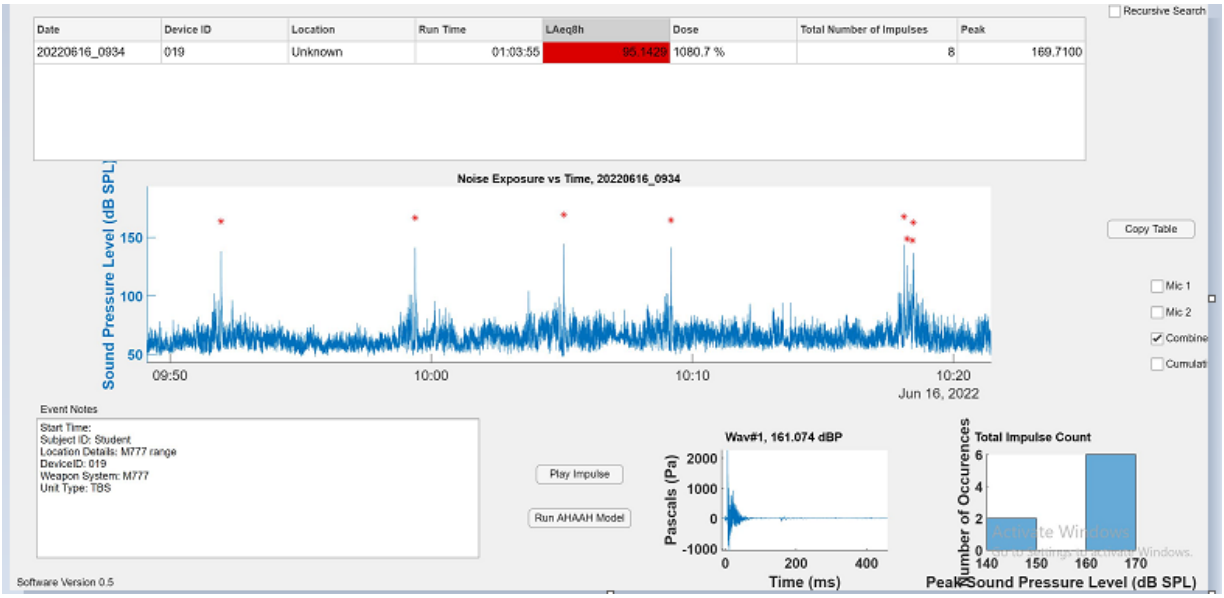


Figure 3: Results M777 Howitzer Firing Student

Instructors provided demonstration and training on the M120 Mortar weapons fire (charge one). This evolution took place on Range 7 at MCQB from approximately 1215-1315. Six instructors were placed on the firing line and three instructors were approximately 15 feet

away manning the Firing Direction Center. Students were standing near the Firing direction center. One instructor serving on the firing line as AGunner and one instructor positioned at the Firing Direction Center wore dosimeters during the weapons firing evolution; see Figures 4 and 5 for results and number of rounds fired. Personnel were observed wearing various types of single hearing protection devices including ear plugs and muffs.


Figure 4. Results M120 Mortar Firing Instructor (Gunner)


Figure 5. Results M120 Mortar Firing Instructor (Fire Direction Center)

Debora Rivera, an industrial hygienist from the NMRTC Quantico Industrial Hygiene Program Office (IHPO), performed noise sampling with impulse noise dosimeters developed by the Massachusetts Institute of Technology Lincoln Laboratory (MITLL). Dosimeters were worn

by one student and three instructors, with microphones clipped to the shoulder during the SWM FEX weapons firing activities described above. Jaclyn Schurman, an audiologist from Walter Reed National Military Medical Center (WRNMMC) and Revonna Sanders, an industrial hygienist from the Navy and Marine Corps Public Health Center (NMCPHC), were also in attendance for information gathering, training on the mNoise dosimeters. Ms. Rivera will use the data collected to advise/make recommendations to these commands regarding when they require single and double hearing protection for the various weapons firing evolutions. mNoise Dosimeters will continue to be used for the collection of data on large weapons systems and other equipment as requested by the Marines. Ms. Rivera will conduct additional noise dosimetry at MCBQ on 7 July 2022. Weapons firing will include the M50. Dr. Schurman from WRNMMC will be emailed the files for analysis; she will distribute the results to NMRTC Quantico IHPO and NMCPHC Contact, Revonna Sanders.

- **Specific Aim 2 Accomplishments:**
  - Continuing review approved in Fall 2021.
  - Data collection continued through this performance period. See below for result details.
  - Results from Aim 2 have yielded multiple publications. See the publication section for publication details.

- **Significant Results Aim 2:**

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

A new procedure for measuring binaural detection was developed and pilot data was collected during this quarter. Previously we had been measuring binaural detection with a yes/no procedure in which subjects hear a single sound and need to indicate if they heard a tone in the noise. The new procedure is based on an oddball paradigm where the subject hears three short bursts of noise and one of these bursts contains a tone in addition to the noise while the other two do not. The task of the subject is to report which of the three sounds was different. Oddball type paradigms have better statistical properties than yes/no procedures. More importantly, oddball paradigms can be used with stimuli for which it is difficult, if not impossible, to describe the difference the subjects are listening for. The top panel of Fig. 6 shows the probability of a correct response as a function of the signal-to-noise ratio (SNR) for a group of subjects that completed a Yes/No procedure and a different group of subjects that completed the oddball procedure. Chance performance in the oddball procedure is 0.33. The bottom panel shows the minimum SNR needed to reliably detect the signal (i.e., threshold). The differences in threshold likely reflect that the signals were of shorter duration in the oddball procedure.

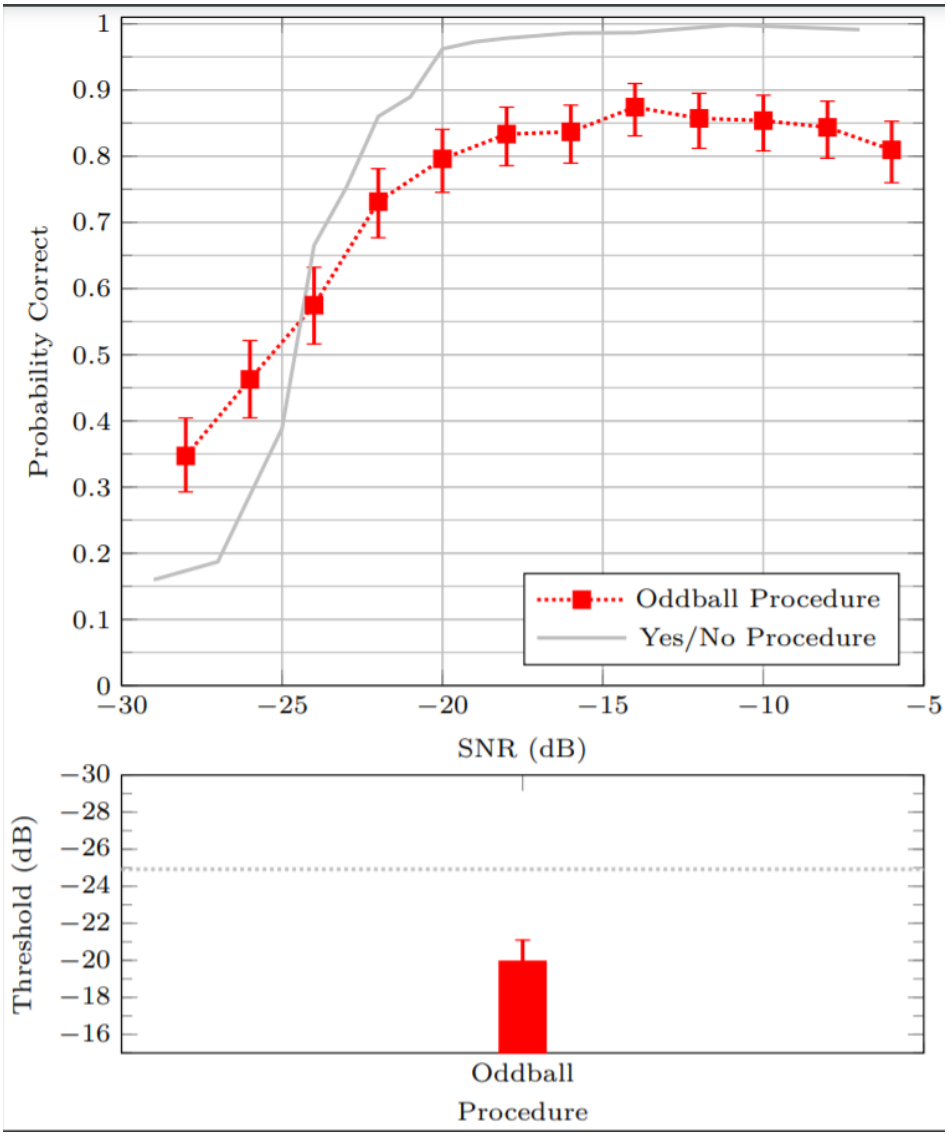


Figure 6. The top panel shows the probability of a correct response as a function of the signal-to-noise ratio (SNR). The bottom panel shows the minimum SNR needed to reliably detect the signal (i.e., threshold).

Additional data on oddball task: Data have been collected on 545 participants with this oddball task with both a 500 Hz tonal signal and a 125 Hz tonal signal transposed to 4 kHz to preserve envelope fluctuations critical for binaural detection. Consistent with published measurements and theory of binaural detection, performance was tested over different ranges of signal-to-noise ratios (SNRs) for the 500 Hz and 4 kHz signals. Based on previous studies, we hypothesize that performance with a 4 kHz signal will be less susceptible to gross changes in audiometric threshold and more sensitive to slight elevations in clinically normal thresholds than performance with a 500 Hz signal.

Figure 7 shows the results of the interim analysis of the data which have currently been collected. The left panel of Fig. 7 shows the probability of a correct response as a function of the

SNR with a 500 Hz signal while the right panel is for a 4 kHz signal. The three lines in each panel correspond to participants whose audiometric hearing thresholds are better than 7.5 dB HL, between 7.5 and 25 dB HL, and greater than 25 dB HL. For both signal frequencies, as the hearing threshold increases performance decreases. The difference between the groups with a 500 Hz signal appears to be systematic such that the group with the best hearing thresholds have the best performance and the group with the worst hearing thresholds have the worst performance. With the 4 kHz signal, performance for the group with thresholds between 7.5 and 25 dB HL appear similar to the group with thresholds greater than 25 dB HL while participants with thresholds better than 7.5 dB HL perform better than the other two groups.

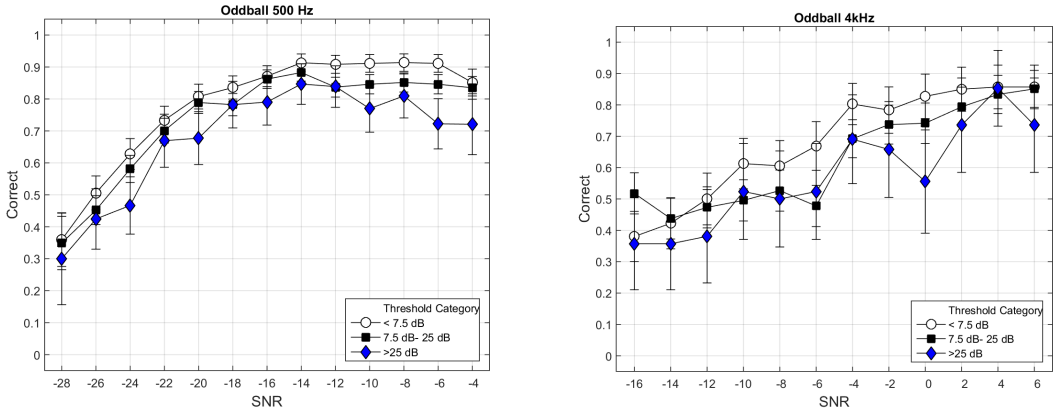


Figure 7. The probability of a correct response in the oddball masking level difference with a 500 Hz signal (left panel) and a 4 kHz signal (right panel).

One significant limitation of the oddball procedure is that performance for normal-hearing listeners never reached 100% even at the highest SNR values tested, in contrast to the Wilson version of the 500 Hz detection task, where listeners always correctly identified the presence of the 500 Hz tone in 100% of the trials at SNRs greater than -20 dB. Based on this result, we became concerned that, if the 4 kHz stimulus had greater sensitivity to hearing loss and blast exposure than the 500 Hz stimulus, this result might be obscured by the inability of some listeners to properly understand the test. To address this problem, we developed a version of the Yes/No task that used 4 kHz transposed tone stimuli (at an appropriate SNR range) rather than the original 500 Hz stimuli.

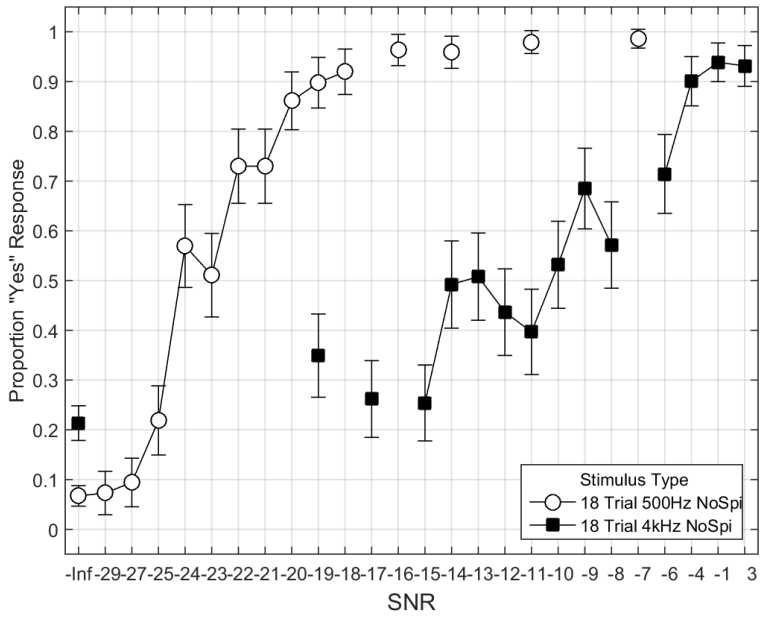


Figure 8. Psychometric curves for "yes/no" procedure with 500 Hz and 4 kHz tone stimuli, collected on 143 service members.

Figure 8 shows psychometric curves for these two versions of the "yes/no" test. Listeners do successfully identify the presence of the tone nearly 100% of the time for the first three trials, and the 4 kHz test shows a systematic slope in "yes" responses with respect to the SNR ratio. However, the percentage of yes detections in the 4 kHz stimulus never drops below 25%, and the false alarm rate of 20% is 3 times higher than for the 500 Hz stimuli. We interpret this to mean that some listeners had difficulty learning to identify the 4 kHz stimulus. Overall scores on the 4 kHz were also substantially less correlated with overall hearing complaint on the tinnitus and hearing survey (r=-.17 vs r=-.43) and less correlated with self-reported temporary hearing shifts after noise exposure (r=-.03 vs r=-.19). Based on these results, we believe that the 18-trial 500 Hz version of the NoSpi test may be the best test for evaluating performance in noise-exposed service members with normal or near-normal hearing.

- **Specific Aim 3 Accomplishments:**
    - Subject recruitment for a test involving the cognitive tests (flanker task and letter location task) was initiated during this performance period and data collection is in progress. Issues were encountered with the responsiveness of the tablet screen for response time, so an external USB number pad was added to improve responsiveness. Seven participants have been tested.

- Exploratory data analysis is being performed to determine if speech-in-noise and other functional test data collected in conjunction with this study is correlated with bothersome tinnitus.

- **Significant Results Aim 3**:

Figure 9 shows speech-in-noise performance on a matrix sentence test for 1944 SMs who participated as part of their annual hearing test. The sentences used for the matrix test were collected from either native English speakers (black squares) or non-native English speakers (open circles) as part of a NATO HFM project. The data have been plotted as a function of the degree of tinnitus bothersomeness the SMs reported as part of their hearing conservation test. The data are limited to individuals who had hearing thresholds of 20 dB or better in their better ear at 4 kHz. While preliminary, this data suggests that bothersome tinnitus interfered with performance on this task both in terms of correct word identification and response time.

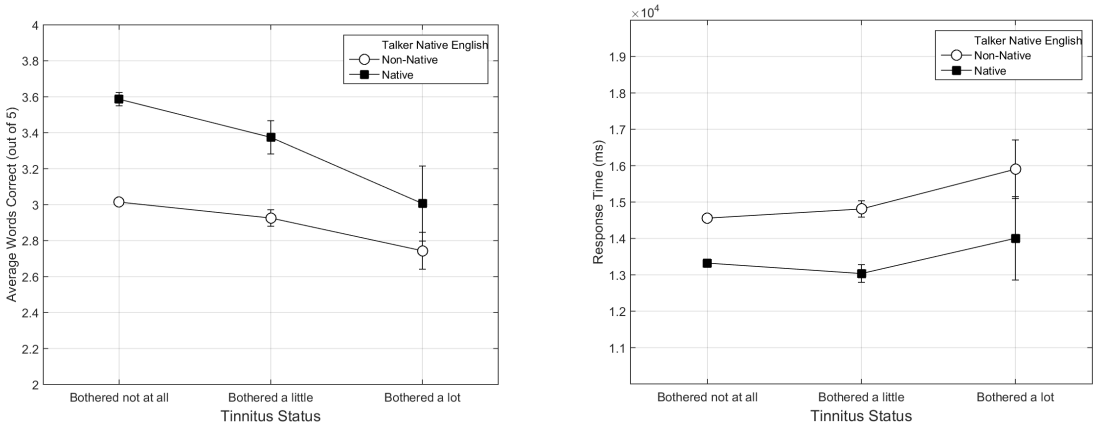


Figure 9. Scores and response times for performance on a matrix test with native and non-native English speech, plotted as a function of how the participant answered on the DOEHRS-HC tinnitus question about how much they were bothered by tinnitus.

**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: Collect data at UTD. 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 Walter Reed and other DoD sites. Data collection will begin at UTD.

        - Subtask2: Further analyze and begin to publish and disseminate results from Aim 1.

- **(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: Collect data 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.

**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.*

- A first time no cost extension was approved for this grant on 19 FEB 2021, which will extend this work for an additional twelve months through 14 June 2022.
- No changes to scope or approach to report for the upcoming performance period.

Nothing to Report.

**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 put on hold due to COVID-19. We were granted a first time 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).*

**Brungart,D., Sheffield,B., Galloza, H., Schurman, J., Russell, S., Barrett, M., Witherell, K., Makashay, M, Heil, T.** (2022) Developing an Evidence-Based Military Auditory Fitness-for-Duty Standard Based on the 80-Word Modified Rhyme Test ($MRT_{80}$) Speech-in-Noise Test. *Ear and Hearing*

**Brungart, D.S., Sherlock, L.P., Kuchinsky, S.E., Perry, T.T., Bieber, R.E., Grant, K.W.,** and **Bernstein, J.G.W**. (2022) Assessment methods for determining small changes in hearing performance over time. *J Acoust Soc Am*. 151, 3866-3885.

**Sherlock**, L.P. and **Brungart**, D.S. (2021). Functional impact of bothersome tinnitus on cognitive test performance. *Int J Audiol*

**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.*

Conference Publication: Smalt, C., Yuan, E., Rodriguez, A., Clavier, O., Audette, W., Brzuska, A., Russell, J., Hecht, Q., Schurman, J., & Brungart, D. Development and Evaluation of a Body-Worn Dosimeter for Continuous and Impulsive Noise. Submitted to IEEE EMBC.

Navy and Marine Corps Public Health Center- Industrial Hygiene report

Brungart, D.S. "Functional Hearing and Communication Deficits (FHCD) in Blast-Exposed Service Members with Normal to Near-Normal Hearing Thresholds," SPIN 2022 Meeting (virtual), 20-21 January 2022.

Brungart, D. S., Kokx-Ryan, M., Russell, S., Schurman, J., Perry, T. T., Benjamin Sheffield, B., Kulinski, D., Holtzman, R, Swann, A., Dirks, C., Grant, K. W., Phatak, S., Kuchinsky, S. E., Chmielenski, K., Horvat, L., & Martorana, R. (submitted) An integrated approach to discovering, diagnosing, and treating auditory injury in the DoD. Abstract submitted to the 2021 MHSRS.

**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
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: La Guinn Sherlock, AuD
Project Role: Co-I

**Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?**
*If there is nothing significant to report during this reporting period, state "Nothing to Report."If the active support has changed for the PD/PI(s) or senior/key personnel, then describe what the 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 was on maternity leave from March to June 2022.

**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.