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

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# REPORT DOCUMENTATION PAGE

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<b>14. ABSTRACT</b> <p>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.</p> <p>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.</p>					
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## 1. 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:

The 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.

### What were the major goals of the project?

- **(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.
    - Subtask1: Submit documents for local IRB review. Local IRBs include Walter Reed and University of Texas, Dallas.
    - Subtask 2: Design and develop infrastructure to implement objective and subjective noise measurements.

- Sub task 3: Collect data
- **(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: 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.
- **(Year 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?

- Specific Aim 1 Accomplishments:
  - Subtask1: IRB and HRPO approval have been received for Aim 1 protocols at WRNMMC and UTD.
    - September 2020
      - Letters from the Commanding General and Commanding Officer at the Basic School at Quantico were received, which outline the support for our group to conduct the proposed study outlined in the IRB protocol.
    - March 2020
      - HRPO approval was received.
      - Administrative approval was received from the research review committee at Quantico. These items were pending since September 2019.

- Dr. Schurman, the point of contact on this grant, was on maternity leave from November 2019 to March 2020. Therefore, efforts to follow-up with HRPO and the Quantico administrative review committee between November 2019 and March 2020 did not occur, which led to the delay in approvals for both documents.
  - HRPO approval received for the IRB protocol at UTD.
- Subtask 2:
  - There is a working demo for the subjective noise exposure protocol and pilot data is currently being collected. The engineering team will be implementing changes to the protocol in the next quarter.
- Subtask3:
  - **Objective noise exposure portion of Aim 1:**The noise levels for each weapon/range are either known or were being collected as part of a Public Health Project. The Navy & Marine Corps Public Health Center- Industrial Hygiene (IH) Department were tasked with measuring the known noise exposure levels for all ranges at Quantico and our team have been assisting in data collection. Our team has traveled to Quantico to collect noise exposure data on the rifle range, grenade range and .50 caliber machine gun. The noise levels from these ranges were analyzed in August 2020. Please see the significant results for Aim 2 below.
  - In Fall 2019 Ned Berg, the IH lead of this project, reported that he is longer able to continue supporting this effort. However, the mandate states that collaborators can also take noise measurements. We plan to work with the local audiologist and IH department at Quantico to make noise exposure measurements under this mandate. Additional noise measurements have not been attempted due to Dr. Schurman's maternity leave from November 2019 to March 2020 and then COVID-19. Due to COVID-19 all research was put on hold from March 2020 to June 2020 at Quantico.
  - **Subjective Noise exposure portion of Aim 1:** Due to Dr. Schurman's maternity leave, the delay in HRPO and administrative approvals at Quantico, data collection could not be completed in Fall of 2019. Pilot testing is currently underway for the subjective noise exposure protocol.
  - Data collection at Quantico for the subjective portion of Aim 1 will be implemented in Fall 2020. Data collection for the subjective protocol cannot occur prior to Fall 2020 because service members will be asked to quantify their noise exposures over the entire course of training. Therefore, data collection must occur at the end of the six-month training course, which will take place in November or December 2020.
  - The IRB approved protocol for Aim 2 includes a relevant subjective noise questionnaire regarding previous noise history,

which will directly support the goals of Aim 1. Please see the significant results section for Aim 1.

- Subtask 3: University of Texas, Dallas: Data collection at the UTD was scheduled to begin during Year 2 Quarters 3 and 4. However, data collection has been on hold due to COVID-19. The approved IRB protocol at UTD proposed that students would attend concerts and measure their noise exposures. Then, one week later the students would be tested at the UTD clinic to assess their subjective noise exposure history and objectively measure any changes in hearing that occurred due to the loud noise exposure event. Due to the current closure of large venues, we propose to amend the UTD protocol. The teams at WRNMMC and UTD have been attending weekly meetings to discuss options for protocol amendments and we believe that we will still be able to meet the goals of this grant. Amendments to the UTD protocol are not expected to change the direction of this project.

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

One of the goals of Aim 1 was to evaluate the difference between purely subjective noise questionnaires that are based on exposures to verbally-described noise environments and objective noise questionnaires where the listener is given a calibrated noise "sample" to use as a comparison point for their noise history.

As part of our ongoing data collection efforts, we collected data on 602 service members in an "objective" noise question where listeners were given the following instruction:

*Listen to this sample of a loud noise. Think about how often you are exposed to noises that are at least as loud as this sample. If you were wearing hearing protection, then make your judgment based on the level of the noise underneath the ear plugs and ear muffs.*

*How often have you been exposed to noises at least as loud as the sample?*

- a. Never*
- b. Several times per year*
- c. Several times per month*
- d. Several times per week*
- e. Daily*

Listeners were then presented with a 3 second sample of noise (approximately pink) at 85 dBA SPL. The same group of listeners also completed a purely subjective question on noise exposure, based on the frequency they were exposed to noise loud enough to require a raised voice in order to communicate at 3 feet:

*How often are you exposed to continuous noise that is so loud you need to raise your voice to be heard by a person sitting 3 feet away?*

- a. Never
- b. < Once per year
- c. Once per year
- d. Several times per year
- e. Several times per month
- f. Several times per week
- g. Daily

This question draws from a common rule of thumb in hearing conservation (the 2-3 foot rule) that states "When a sound level meter is not available, you should use the 2-to-3 foot rule: Stand about an arm's length away from your coworker: If you have to raise your voice to be heard 2-3 feet away, you should assume that the sound level is at or above 85 dBA."

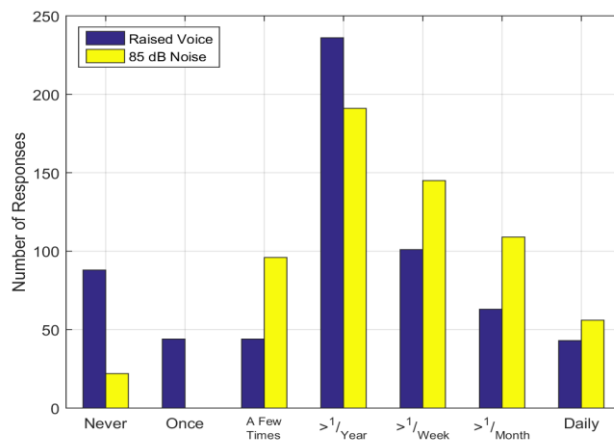


Figure 1a: Histogram of responses in two versions of questionnaire

Figure 1a shows a histogram of the responses for each version of the question. (Note that the "once in my lifetime" response was not present in the 85-dB noise version of the survey). The result shows that, in general, there was a tendency to choose a higher exposure level for the 85-dB version of the questionnaire. In particular, it is clear that there were many more cases where individuals selected a very low exposure level (less than once per year) for the "raised-voice" version of the question than the 85-dB version of the question.

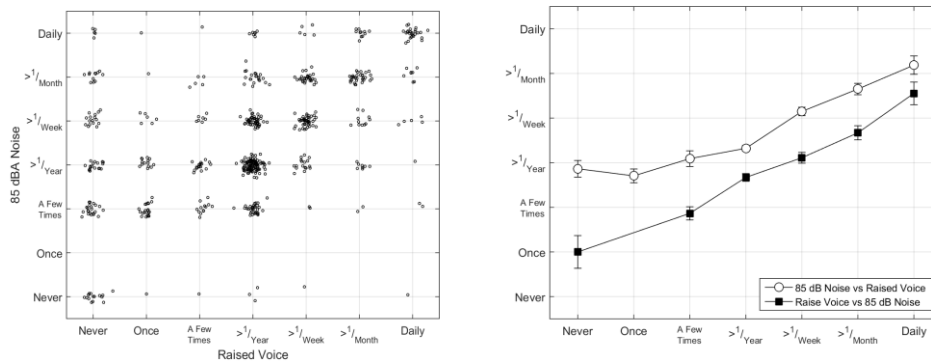


Figure 2a: Scatter plot (left) and marginal means of responses on two questionnaires

The left panel of Figure 2a shows a scatter plot of responses on the raised voice and 85-dB noise versions of the question. Although the responses were significantly correlated, this correlation was relatively modest ( $r=0.48$ ). The right panel of Figure 2a shows the marginal means of the distribution. Thus the closed squares show the raised voice response as a function of the 85-dB noise response, and the open circles show the 85-dB noise response as a function of the raised voice response. This graph shows that there was a consistent bias for individuals to respond with a higher frequency on the Noise question than the Raised Voice question, especially when the overall exposure rates were low.

An analysis of the experimental parameters that were correlated with the *difference* between the two responses revealed that the overall hearing complaint score (from the Tinnitus and Hearing Survey) was significantly lower in individual who indicated that they had been exposed to 85 dB noise more often than they have been exposed to noise that required a raised voice. This trend is shown in Figure 3a.

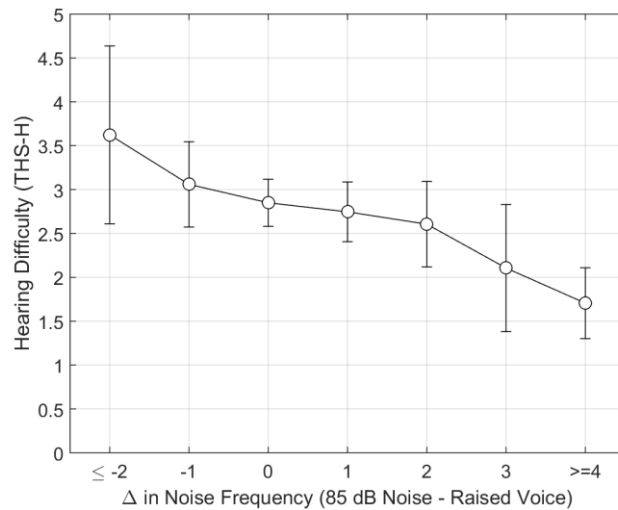


Figure 3a: Hearing handicap as a function of the difference between the 85-dB noise response and the raised voice response. Thus, higher numbers on the x-axis indicate subjects who said they were exposed to the noise sample more frequently than they were exposed to noise that made them raise their voice.

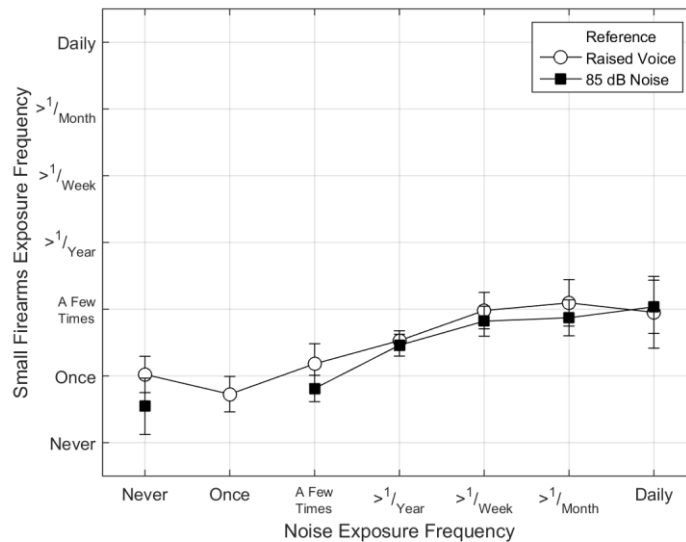


Figure 4a: Scatter plot (left) and marginal means of responses on two questionnaires

However, the differences between the two measures did not systematically bias listener responses on other noise exposure questions. Figure 4a shows the response frequency in a question that asked respondents "How often are you exposed to noise from small-caliber firearms (up to 12.7 mm)". These results show no systematic differences when plotted as a function of the subjective or objective versions of the noise questionnaire.

These results clearly show that there are differences between the noise exposures reported in a purely subjective questionnaire and those reported in a questionnaire based on exposure to a calibrated noise sample. In this instance, the subjective environment was selected to have the same nominal noise level (85 dB) as the objective noise sample. If the raised voice requirement truly corresponds to 85 dBA in the real-world situation, then these results suggest that individuals on subjective measures may underestimate their noise exposure level, because their internal estimation of the subjective event (a noise level requiring a raised voice) is lower than the actual noise level. However, the results here suggest that there may be another confound, in which individuals who have difficulties communicating in noise may perceive the noise levels in their everyday lives to be higher (relative to an objective noise sample baseline) than those who do not have difficulty communicating in noise. This potential confound could be critical in studies, including many recent studies on auditory synaptopathy, that attempt to establish a link between self-reports of lifetime noise exposure and overall hearing difficulties not captured by the audiogram.

Although it is clear that the subjective and objective questionnaires are not consistent, at this point it is difficult to determine which questionnaire might be "correct". This is one of the goals of Aim 1, which will have service members from the basic school and students from the University of Texas rate the relative noise exposures from known events with calibrated noise exposure levels.

### **Significant Results (Objective Noise Exposure Measurements):**

Noise levels were collected as part of the Navy mandate to measure the noise exposures of all weapons at Quantico. Noise exposures were collected using the MIT LL shoulder worn dosimeter. Noise levels were collected at the M16 Rifle range, Grenade range, and M249 range. Figure 5 shows the noise levels documented at the M16 Rifle range and Figure 6 shows the noise levels from the Grenade and M249 range. These noise level results will be further analyzed in conjunction with the service member's subjective assessment of relative loudness. Service members will be asked to rank-order the relative noise hazard they believe each environment would pose to their hearing if they were exposed to it with or without hearing protection. We will be able to directly compare the true noise levels of each weapon to the subjective assessment. We anticipate most listeners will be able to identify relative loudness of different events with much better than chance accuracy.

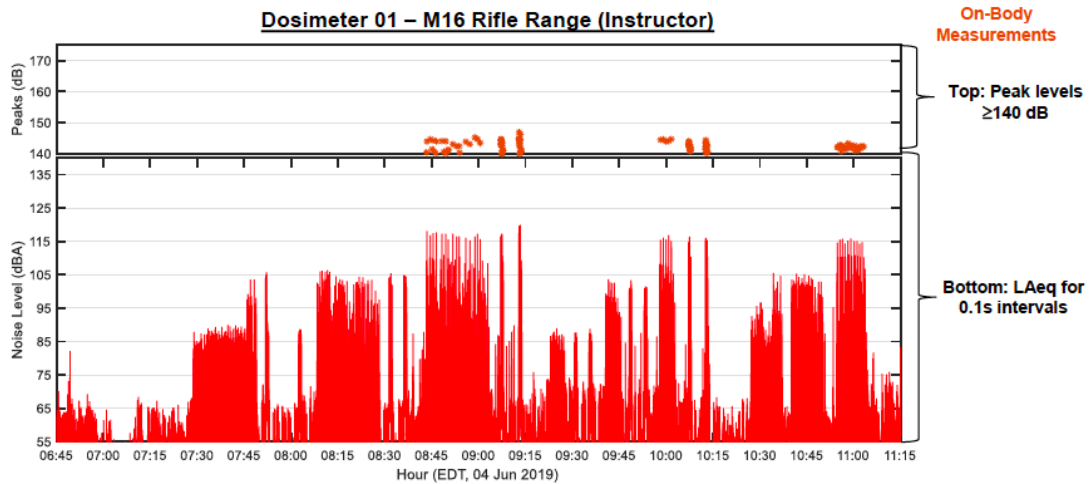


Figure 5: Noise levels from the M16 Rifle range. The x-axis shows the time of the noise exposure and the y-axis is the level of the noise. The red dots indicate peak levels of noise.

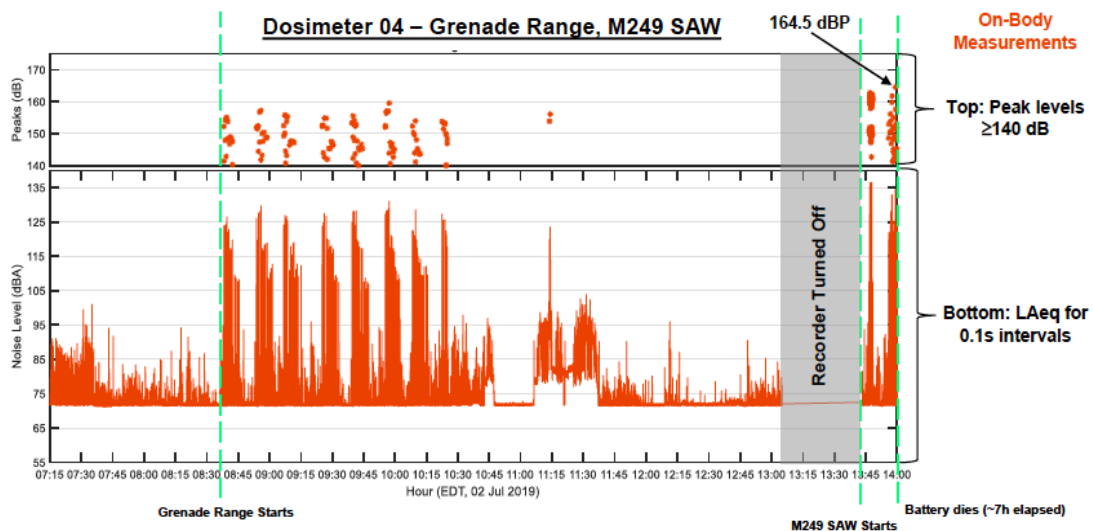


Figure 6: Noise levels from the Grenade and M249 ranges. The x-axis shows the time of the noise exposure and the y-axis is the level of the noise. The red dots indicate peak levels of noise.

- Specific Aim 2 Accomplishments:
  - Subtask 1: Data collected to date is being used to create an alternative test for binaural processing which may provide improved early detection of functional impairment. However, data collection is currently on hold due to COVID-19. Pilot testing on staff members in our research section at WRNMMC has been ongoing in order to continue with test development. Please see significant results below. Data collection for Aim 2 at UTD has also been on hold due to COVID-19. IRB amendments are currently

underway to mitigate the constraints now in place due to COVID-19. Please see section 5 (Changes/Problems) of this report for the proposed changes to the protocol.

- Subtask2: Data analysis for Aim 1 has begun, please see the significant results from Aim 1 above.
- Subtask 3: IRB protocol has been submitted and approved for Aim 3. Please see Aim 3 accomplishments below.

### Significant Results Aim 2:

Towards the goal of finding a more sensitive test for binaural function than the “Wilson” clinical test for Masking Level Difference that was used in the preliminary studies, we previously developed a new “oddball” task. Analysis of the data collected using the initial implementation of the oddball task suggested that there were some instruction or training issues with the task, which we have now addressed. Data was collected using a modified version of the task that includes a brief training exercise and screening test before the oddball task, as well as instructions that were revised based on feedback and suggestions from the technicians who had first-hand experience answering questions about the task from the participants. Inspection of the trial-by-trial performance of participants who completed the oddball task after these changes were implemented (shown in Figure 7) indicates that these changes successfully reduced the number of participants whose data are consistent with confusion about the task. Additional analysis of SNR thresholds from participants who completed this updated implementation of oddball task are moderately correlated with thresholds estimated using the Wilson test, as shown in Figure 8. This relationship suggests that the oddball task is successfully capturing information about listeners’ binaural sensitivity while eliminating the response bias that can affect the Wilson test.

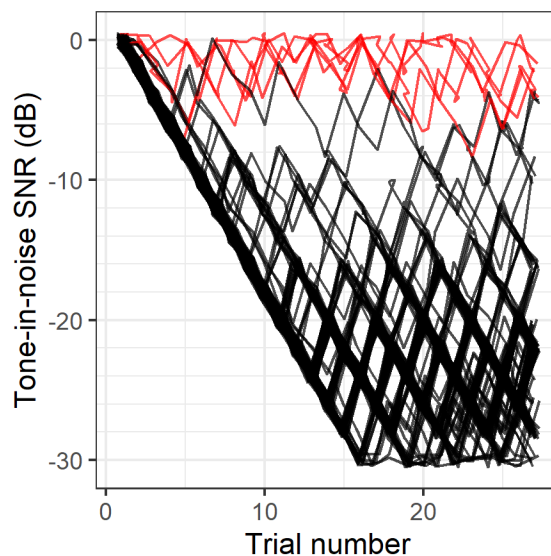


Figure 7: Plotting the trial-by-trial performance of participants who completed the training and screening task prior to the oddball task indicates that almost all participants showed an orderly and expected response pattern starting from the first trial. The absence of any participants (shown as individual lines) whose data show inconsistencies in responses between the first several trials and the last several trials suggests that there were no participants who at first failed to understand the task but at some point mid-test came to understand the task. Instead, almost all participants show the expected pattern of participants consistently responding correctly when the test SNR is well above their threshold. A small number of remaining participants appeared to choose not to apply themselves to the task despite completing the training and screening task beforehand (data for these participants is shown in red and is consistent with random guessing).

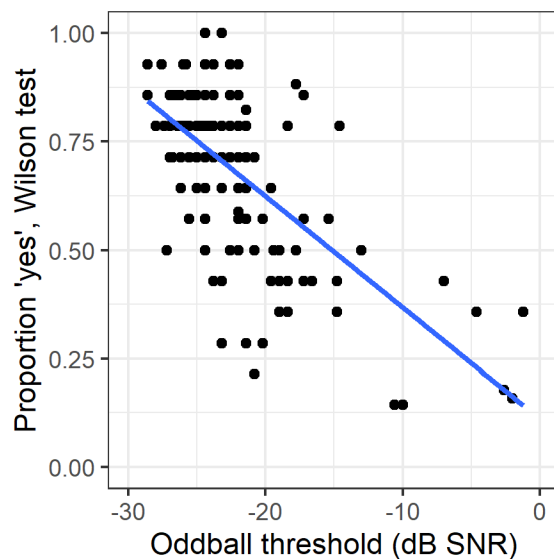


Figure 8: The relationship between tone-in-noise thresholds estimated using the Wilson test and thresholds estimated using the oddball task with revised instructions is moderate, indicating that the revised oddball task results in similar information about the participant's auditory processing abilities. The oddball task has the advantage of eliminating the contribution of listener bias in the estimation of tone-in-noise threshold that is inherent in the Wilson test due to it being a single-interval, yes/no task. Among participants with normal hearing, oddball thresholds will be compared between individuals with and without subjective hearing complaints as well as self-reported estimates of noise and blast exposures and related temporary threshold shifts.

The results above demonstrate the “oddball” task version of the Masking Level Difference (MLD) appears to be a sensitive objective measure that correlates with subjective hearing complaints in individuals without hearing loss. This task is thought to depend upon the fidelity of the fine-timing information conveyed by

lower-level auditory neurons, especially in the binaural system. Although the most common test frequency used in the literature for assessing the MLD is 500 Hz, we speculated that this may not be the test-frequency that best corresponds to early detection of functional impairment. This is because it may be possible for fine-timing information to be preserved at slower firing rates (corresponding with lower tone frequencies in the MLD task) but disrupted at faster firing rates (i.e., higher frequencies).

Accordingly, we speculated that the MLD at 1500 Hz will be more sensitive to functional impairment than the MLD at 500 Hz. We assessed this hypothesis by asking participants to complete the MLD oddball task at two different tone frequencies, 500 and 1500 Hz. Figure 1 shows the distribution of MLDs measured at these frequencies for the same group of listeners. MLDs are generally smaller at the higher test frequency, which is consistent with the hypothesis. In addition, preliminary modeling indicates that the MLD at 1500 Hz has at least as much potential, if not more so, to predict subjective hearing complaints as the MLD at 500 Hz.

Our hypothesis that using a higher test frequency may reveal functional impairment is not contradicted by the data, but the data do suggest that there may be issues with the approach of using a single test frequency. The MLD at a single, lower test frequency may not capture the earliest signs of functional impairment, but the MLD at a single, higher test frequency may not capture sufficient individual differences if a portion of listeners have an MLD of 0 dB or poorer at the higher test frequency, as seen in Figure 9.

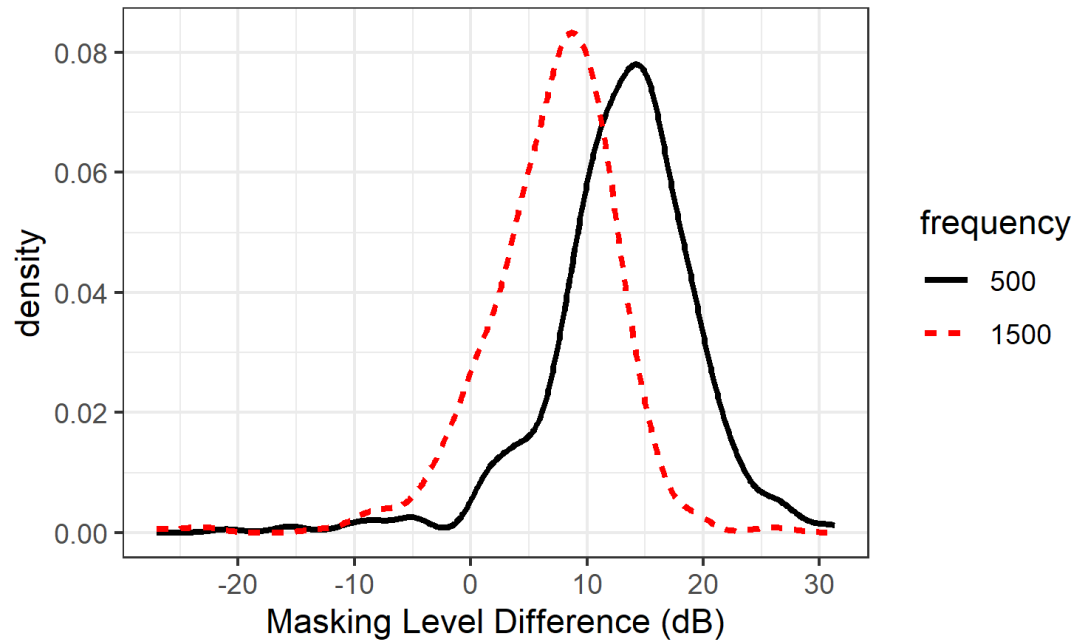


Figure 9: Distributions of Masking Level Differences (MLD) for a tone frequency of 500 Hz (black solid line) and 1500 Hz (red dashed line). MLDs are higher (better) at 500 Hz, and lower (worse) at 1500 Hz.

Data collected using two tone frequencies, 500 and 1500 Hz, suggested that a measurement approach of assessing the MLD at more than a single frequency might improve early detection of functional impairment. This is because it may be possible for fine-timing information to be preserved at slower firing rates (corresponding with lower tone frequencies in the MLD task) but disrupted at faster firing rates (i.e., higher frequencies). Accordingly, a novel testing approach was developed. In the new approach, the highest frequency at which the listener can detect the MLD tone-in-noise stimulus is measured, with the tone at a fixed signal-to-noise ratio relative to the monaural threshold for tone detection. Development of this test and the setting of stimulus parameters was informed in part by distributions of tone detection thresholds measured in previous data collection and also in part by feedback from the technicians responsible for administering the test.

The goal of the new measurement procedure is to capture the listener's overall capacity to capitalize on the binaural phase difference across the range of relevant frequencies, rather than at just one frequency. This will allow us to stratify individuals based upon the highest frequency at which they are able to use the fine-timing information in the lower-level auditory system to detect the tone in the noise. In this approach, individuals with greater functional impairment are expected to require a lower tone frequency to reach equal sensitivity. The hypothesis is that a measure of MLD capacity across multiple frequencies will be a better indicator of functional impairments, and in particular functional

impairments related to speech understanding in noise. One factor in favor of this hypothesis is that the new task is less prone to ceiling- and floor-effects, which limit data interpretability, than the single-frequency MLD task. Another factor is that speech is a broadband stimulus and speech-understanding capacity might be better predicted by a measure that captures sensitivity across a range of frequencies rather than at one single frequency. Data on this new approach will be collected in the upcoming quarters.

- Specific Aim 3 Accomplishments:
  - It should be noted that the majority of the work for Specific Aim 3 was intended to be completed during year 3. However, due to delays in approvals and data collection for Aim 1, our team has been able to make significant progress on the subtasks of Aim 3.
  - Subtask 1:
    - IRB approval for the Aim 3 was approved in November 2019.
    - HRPO approval for Aim 3 was received in March 2020.
    - Programming of the tablet protocol has begun. A Pilot version of Test battery 1 (of 2) has been programmed, and is being compared to programming/data collected from a separate ongoing protocol (NICoE-teria) in order to finalize programming of that test battery. Once completed, Test battery 2 will be programmed and combined with Test battery 1.
  - Subtask 2:
    - Data analysis from Aim 2 has been ongoing throughout this report period. Please see specific Aim 2 accomplishments above for detailed overview of the results.

### **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.
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### **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 from this reporting period have been analyzed internally and have not been disseminated to the communities of interest.

**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.
    - Subtask1: UTD will revise IRB to reflect necessary changes for COVID-19 restrictions.
    - Subtask 2: The tablet protocol will be finalized after the analysis of pilot data and will be ready for use in Fall of 2020.
    - Sub task 3: Quantico: Data will be collected in the Fall of 2020 for the subjective noise exposure goal. Noise exposure levels will be collected pending correspondence with the new safer officer at the Basic School, local audiologist and IH department. UTD: Data collection will begin after the approval of the protocol amendment that is required due to COVID-19 venue restrictions.
- **(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: Continue collecting data.
    - Subtask2: Analyze results from Aim 1.

- Subtask 3: Collect pilot data for Aim 3.
- **(Year 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 data from Aim 2
    - Subtask 3: Analyze data 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.

*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.*

- Data collection for all projects was on hold due to COVID-19. Due to constraints placed on data collection by COVID-19, we plan to request a no cost extension. A no cost extension will be required in order to meet the goals of the study.
- The approach to data collection at UTD must be altered in the event that concerts are not permitted. Please see the proposed adjustments to the UTD protocol below. Importantly, these proposed adjustments are not finalized and discussions are ongoing.
  - **Proposed adjustments to UTD Aim 1:** Participants will engage in typical headphone-based listening in lieu of concert, club, or other loud indoor event attendance as these events are currently not recommended by public health professionals. Temporary changes in hearing including temporary changes in hearing in noise can be measured. Dosimetry will be improved by the use of precise in-ear monitoring. Participants will also rate sound levels before and after music player use. Ratings will be measured over a shorter time period (hours rather than days); a strength of this design is that changes in ratings can be accurately measured in the immediate post music window, assuring that transient effects are not missed.
  - **Proposed adjustments to UTD Aim 2:** This aim can be accomplished using both retrospective analyses and prospective analysis of music player induced functional shifts. Data will be collected after 60 min music player use. As reviewed in Le Prell et al., 2012, number of previous studies employed a model in which subjects were asked to select their own listening level, with significant variability in user-selected listening levels and small sample sizes for any given listening level, and TTS typically measured in only a subset of the subjects (Lee et al. 1985; Pugsley et al., 1993; Hellstrom et al. 1998). Other more recent studies have used sound levels or volume settings as set by the investigator, resulting in more consistent exposures across subjects (Krishnamurti&Grandjean 2003; Bhagat& Davis 2008; Kepler et al. 2010) but no consistent TTS in any participants due to the sound levels selected. Systematic manipulation of music player sound levels by LePrell et al. 2012 revealed significant individual variability from participant to participant even with carefully controlled exposure. For studies on TTS, the failure to induce TTS is a methodological challenge. Here, however, the goal is to assess whether other listening tasks are more sensitive to noise induced deficits and thus the adapted design does not rely on the presence of TTS. We anticipate that a subset of participants tests will have a TTS at the immediate post test time. While recovery of TTS is expected to be completed at the 2-hour test time, hearing in noise may show deficits, based on the data from Grinn et al, 2017 which showed changes in hearing in noise measures at 24 hours post music exposure.

**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 has been put on hold due to COVID-19. Due to constraints placed on data collection by COVID-19, we plan to request a no cost extension. A no cost extension will be required in order to meet the goals of the study
  - a. Data collection will resume as soon as possible for Aim 2 at WRNMMC. However, in order for data collection to resume at UTD the current plan for data collection and IRB protocol will be reevaluated and adjusted. It is anticipated that large venues will be closed for an extended period of time, therefore amendments to the protocol will be made. The proposed amendments will still meet the goals of this grant. Please see section 5 of this report for a review of the proposed protocol changes.
2. Aim 1: "Ace" Ventura, our main contact at the Basic School, is no longer working there. New correspondence will be established with the new safety officer at the Basic School at Quantico. The new safety officer will assist with planning and implementing data collection. In addition, we will work with the local Quantico Audiologist or IH department to continue measuring noise exposures under the Navy & Marine Corps Public Health Center- Industrial Hygiene Department mandate. Responsiveness of the officers at the Basic school has been lacking during the reporting period. Our plan to work with the local audiologist should help improve communication between WRNMMC and Quantico.
3. Due to personal and professional time constraints the contractor for the Industrial Site (Deanna Meinke) has reported that she will no longer be able to implement the protocol outlined in Aim 1. The removal of the industrial site will not impact our ability to answer the specific research questions outlined in Aim 1 of this grant. Data collection at the two additional sites (Quantico and UTD) will be sufficient to meet the goals of this grant.

**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.*

Due to personal and professional time constraints the contractor for the Industrial Site (Deanna Meinke) has reported that she will no longer be able to implement the protocol outlined in Aim 1. Dr. Meinke was budgeted to received \$60,000, which will not longer be allocated for her contracting services.

**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).*

Nothing to report.

**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.*

An abstract was submitted to MHSRS, but that conference has been cancelled due to COVID-19. An abstract was also submitted for the ISL Battlefield Acoustics conference in the fall.

**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: 1

Contribution to Project: Principal Investigator

Name: Jaclyn Schurman, AuD

Project Role: Co-I

Researcher ID: NA

Nearest person month worked: 1

Contribution to Project: Research Audiologist

Name: Colleen LePrell, PhD

Project Role: PI at University of Texas, Dallas

Researcher ID: NA

Nearest person month worked: 1

Contribution to Project: Principal Investigator

Name: La Guinn Sherlock, AuD

Project Role: Co-I

Researcher ID: NA

Nearest person month worked: 1

Contribution to Project: Research Audiologist

**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.*

Due to personal and professional time constraints the contractor for the Industrial Site (Deanna Meinke) has reported that she will no longer be able to implement the protocol outlined in Aim 1.

**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.