AWARD NUMBER: W81XWH-15-1-0490

TITLE: “Diagnosing Contributions of Sensory and Cognitive Deficits to Hearing Dysfunction in Blast-Exposed/TBI Service Members”

PRINCIPAL INVESTIGATOR: Dr. Barbara Shinn-Cunningham

CONTRACTING ORGANIZATION: Trustees of Boston University
Boston, MA 02215-1703

REPORT DATE: Oct 2019

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE	**2. REPORT TYPE**	**3. DATES COVERED**
Oct 2019	Annual	**09/15/2018 - 09/14/2019**

4. TITLE AND SUBTITLE

Diagnosing Contributions of Sensory and Cognitive Deficits to Hearing Dysfunction in Blast-Exposed/TBI Service Members

5a. CONTRACT NUMBER

5b. GRANT NUMBER
W81XWH-15-1-0490

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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Boston, MA 02215-1703

8. PERFORMING ORGANIZATION REPORT

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT ***brief (~200 word) unclassified summary of most significant finding during the research period***
Year 4 of the project was a continuation of Year 3's goals of increasing the number of study participants for the blast exposed group. At the conclusion of Year 4 we have consented 130 (88 male) potential study candidates, of which 93 (57 male) were eligible for full participation. As of the writing of this report, we currently have 76 subjects (59 controls and 17 blast exposed) who have participated in the auditory (ASA) and visual (VSA) selective attention/frequency following response tasks. Preliminary results show all subjects perform well in the ASA and VSA tasks. Audiological results (high-frequency thresholds and DPOAEs) show evidence of sub-clinical hearing loss and cochlear dysfunction in the blast-exposed. Although there is some evidence to suggest delayed cognitive processing speed in blast subjects, the results suggest compromised auditory peripheral processing is primarily responsible for reported problems with speech comprehension in noisy and crowded environments in blast exposed military service members.

15. SUBJECT TERMS
Subject recruitment, inclusion criteria change, control group data collection complete, blast-exposed group recruitment challenges, preliminary data analysis

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
					USAMRMC
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
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1. Introduction

Blast-exposed Service Members (SMs) returning from recent conflicts in Afghanistan and Iraq pose a new and challenging problem for the audiological community—many have normal to near-normal hearing thresholds, but have difficulty understanding speech amidst competing sounds. Many of these SMs may have a Central Auditory Processing Disorder (CAPD) or cognitive deficits, but this is seldom assessed clinically. Exposure to blast likely plays a role in hearing dysfunction and has been linked to cognitive dysfunction with and without a confirmed diagnosis of traumatic brain injury. Two independent factors may play a role in understanding CAPD, one related to supra-threshold auditory coding fidelity and the other to cortical control, both of which can be adversely affected by exposure to blast. The goals of this study are to use objective electrophysiological tests to quantify specific sensory and cognitive deficits contributing to CAPD, to determine how these are related to blast exposure, and to develop a clinically useful test battery to quantify each of these deficits.

2. Keywords

Blast exposure, Central Auditory Processing Disorder (CAPD), traumatic brain injury (TBI), hearing loss, cochlear neuropathy, electroencephalography (EEG), frequency following response (FFR), auditory brainstem response (ABR)

3. Accomplishments

What were the major goals of the project?

As with Year 3 of the project, the primary focus of Year 4 was to increase the subject recruitment and participation numbers of the blast-exposed subject group. Although we have met our recruitment targets for the non-blast control group, we are still shy of our target for the blast exposed group.

In addition to our recruitment efforts, compilation and analysis of data collected from the behavioral, electrophysiological, and neurocognitive tests continued this year. These efforts have yielded preliminary results that will be described later in this report.

What was accomplished under these goals?

SOW Major Task 4b: Data collection of control group complete

As of the writing of this report 81 participants (63 controls, 18 blast exposed) have completed both the Behavioral (BTS) and Electrophysiological Test Sessions (ETS) yielding between 71 to 76 complete and usable datasets depending on the type of electrophysiological test (see SOW Task 5a below).

We have applied for and have received a one year no-cost extension to continue recruiting blast-exposed study candidates.

SOW Major Task 4: Participant recruitment and evaluations

Amendment to Y3 Annual Report:

The numbers we provided in last year's Y3 Annual Technical Report accidentally reflected the total number of subjects from two additional research sites, which are peripherally associated with this current project, but should not have been included in the subject counts. The numbers presented below are an accurate representation of subject participation at WRNMMC.

- Total number of subjects consented = 130 (88 male, 42 female)
- Total number of eligible subjects = 93
    - Controls = 70 (34 male, 36 female)
    - Blast-Exposed = 14 male
    - Blast-Exposed (BU only) = 9 male
- Study withdrawals = 8
    - Controls = 6 (3 male, 3 female)
    - Blast-Exposed = 2 male

SOW Major Task 5: Analyze and Disseminate Data

5a: Monitor data collection rates and data quality: summarized below

Number of subjects who completed the Electrophysiological Test Session (ETS) = 81

- Controls = 63 (34 male, 29 female)
- Blast-Exposed = 18 male

Breakdown summary of the completed datasets from the Electrophysiological Test Session (ETS)

- Auditory Selective Attention (ASA) = 72(56 controls, 16 blast-exposed) Tests N6, N7
    - Usable data (55 controls, 16 blast-exposed)
- Visual Selective Attention (VSA) = 71 (55 controls, 16 blast-exposed) Tests N9, N10
    - Usable data (55 controls, 16 blast-exposed)
- Frequency-Following Response (FFR) = 76 (59 controls, 17 blast-exposed) Test N8
    - Usable data (58 controls, 17 blast-exposed)

For electrophysiological data, it is not unusual to exclude datasets due to the presence of excessive noise artifact during the recording session. The "Usable data" category summarizes the number of quality datasets used in the analysis of the individual electrophysiological tests.

5b: Analyze research data

Research audiologist, Dr. Kimberly Jenkins, research communications scientist, Dr. Jennifer Myers, and research engineer Scott Bressler have continued work on integrating the numerous datasets produced from the behavioral, electrophysiological, and neurocognitive test sessions. With the departure of Dr. Jenkins, this collaboration is continuing with a new research audiologist, Dr. Rebecca Lewis. Along with Co-PIs Drs. Barbara Shinn-Cunningham and Ken Grant, the team is in constant discussions as to how best to analyze and interpret the study findings.

5d: Work with data core and dissemination of findings

Research Audiologist, Dr. Kimberly Jenkins presented a poster at the 46th Annual Scientific and Technology Meeting of the American Audiological Society (AAS) in Scottsdale, AZ, entitled "Electrophysiological Responses in Blast and Non-Blast Exposed Military Service Members." Poster authors: Kimberly A. Jenkins, AuD, Jennifer R. Myers, PhD, Alessandro Presacco, PhD, and Ken W. Grant, PhD. 28-Feb-2019 to 02-Mar-2019.

Research Engineer, Scott Bressler presented a poster during the Topics in Physiological and Psychoacoustics (2aPPb) session at the 177th Meeting of the Acoustical Society of America in Louisville, KY, entitled "Blast Exposure in the Military and Its Effects on

Sensory and Cognitive Processing." Poster authors: Scott Bressler, Kimberly Jenkins, Jennifer Myers, Ken Grant, and Barbara Shinn-Cunningham. 14-May-2019.

SOW Major Task 6: Oversight and administration of the project

Research Engineer, Scott Bressler, and Research Audiologist, Dr. Kimberly Jenkins were in frequent contact with each other regarding the progress of subject recruitment and data collection. This same level of oversight continues with Dr. Jenkin's replacement, Dr. Rebecca Lewis.

To this end, Mr. Bressler made two trips to WRNMMC to discuss data collection and analysis with to Research Audiologists, Dr. Kimberly Jenkins and Dr. Rebecca Lewis, and Research Communications Scientist, Dr. Jennifer Myers. These trips have also provided Mr. Bressler with valuable face time with the team at Walter Reed to discuss recent results and data analysis strategies.

Summary of Mr. Bressler's trips to WRNMMC:

- 04-Jun-2019 to 06-Jun-2019
    - EEG data analysis and review
- 19-Aug-2019 to 23-Aug-2019
    - EEG data analysis and review

6b: Submit quarterly reports for CDMRP submission
All three quarterly technical reports were submitted.

6f: Develop scripts for analyzing results
Mr. Bressler continues to develop new and refine existing MATLAB data analysis scripts for summarizing individual and group data. Group summarized data can be generated and updated as subjects complete the required measures from the Electrophysiological Test Sessions (ETS).

SOW Major Task 2: Hiring and Training of Research Audiologist

2a: Advertise and interview for Research Audiologist
The last quarter of this project year saw the departure of Research Audiologist, Dr. Kimberly Jenkins and the hiring of her replacement Dr. Rebecca Lewis.

2b: Train Research Audiologist
2c: Audiologist hired and trained
Research Engineer, Scott Bressler, and Dr. Lewis have been in frequent contact both over phone and email, as well as in person during one of Mr. Bressler's trips. Training in EEG techniques and data processing continues to this day.

What opportunities for training and professional development has the project provided?

The EEG setup at WRNMMC continues to provide Drs. Jenkins and Myers opportunities to refine their EEG data collection techniques. Additionally, Dr. Jenkins has also become more experienced scripting in MATLAB and has started performing her own data analysis in parallel with Mr. Bressler's.

Mr. Bressler continues to receive exposure to translational research in a clinical setting. His interactions with Dr. Grant and his lab continue to broaden his knowledge in auditory neuroscience, audiology, and psychoacoustics. Mr. Bressler has also taken it upon himself to learn linear regression modeling techniques to help determine which of the multiple test measures might be significant predictors of problems with speech comprehension in noisy environments, Aim 3 of this project (To develop a clinically useful test batter to diagnose and isolate sensory and cognitive deficits that can produce hearing dysfunction in Service Members with H1 profile).

How were the results disseminated to communities of interest?

Dr. Jenkins presented a poster at the 46th Annual Scientific and Technology Meeting of the American Audiological Society held in Scottsdale, AZ between 28-Feb-2019 and 02-Mar-2019.

"Electrophysiological Responses in Blast and Non-Blast Exposed Military Service Members." Poster authors: Kimberly A. Jenkins, AuD, Jennifer R. Myers, PhD, Alessandro Presacco, PhD, and Ken W. Grant, PhD

Research Engineer, Scott Bressler presented a poster during the Topics in Physiological and Psychoacoustics (2aPPb) session at the 177th Meeting of the Acoustical Society of America in Louisville, KY. 14-May-2019

"Blast Exposure in the Military and Its Effects on Sensory and Cognitive Processing." Poster authors: Scott Bressler, Kimberly Jenkins, Jennifer Myers, Ken Grant, and Barbara Shinn-Cunningham

What do you plan to do during the next reporting period to accomplish the goals?

Our primary goal for the fifth year of the project is to meet our target number of blast exposed study participants. We currently have two promising sources of potential new study candidates.

- Our partnership with the Center for Neuroscience and Regenerative Medicine (CNRM) was formalized this project year, and we are now receiving referrals of blast-exposed service members on a fairly regular basis. It is important to note that many of these new referrals are more severely affected by blast, and as a result, often are not study eligible. We have, however, been able to enroll several new study candidates from this new source of potential subjects at a rate faster than we have been able to obtain in the past. We will continue our relationship with the CNRM in the fifth year of this project and are optimistic that it will help us reach our target number of blast exposed subjects.
- Although no longer directly associated with this project, Dr. Kimberly Jenkins has agreed to continue to help with blast-exposed subject referrals in her new position as clinical audiologist at Walter Reed. Dr. Jenkins continues to work closely with Dr. Myers and newly hired research audiologist, Dr. Lewis, to increase subject enrollment.
-

4. Impact

What as the impact on the development of the principal discipline(s) of the project?

Results suggest that even for subjects classified as having normal to near-normal hearing, exposure to blast can negatively impact cochlear function as indicated in poorer audiometric thresholds and DPOAEs. This reduction in cochlear function in the blast-exposed subjects

appears to be consistent with self-reported complications with hearing in everyday settings as measured by an abbreviated 6-question version of the Speech, Spatial, Qualities Questionnaire (Gatehouse and Noble, 2004).

Tests of the auditory periphery (pure tone audiometric thresholds, DPOAEs, and to some extent the frequency following response) are showing consistent differences between control subjects with no history of blast exposure and high functioning hearing as determined by the 6-question SSQ survey and our auditory screening measures of time-compressed speech and binaural integration, blast-exposed subjects who report lower levels of functional hearing (blast +), and blast-exposed subjects who report relatively higher levels of function hearing (blast -).

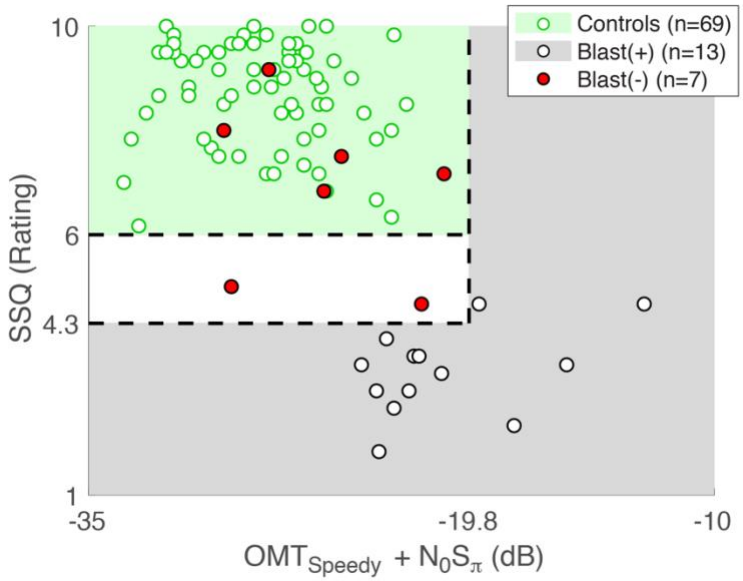


Figure 1: Subject group assignment based on two-factor inclusion criteria: the average of the 6-question SSQ survey (y-axis) and the combined detection thresholds of a modified version of the Oldenberg Matrix speech-in-noise Test (OMTSpeedy) and the N0Sπ detection threshold of a standard masking level difference test. Shaded green areas delineate cutoff parameters for inclusion into the control group. Shaded gray areas delineate inclusion criteria for blast+ subjects. Blast- subjects (red) are any blast exposed subjects who fall outside of the gray blast+ inclusion criteria area.

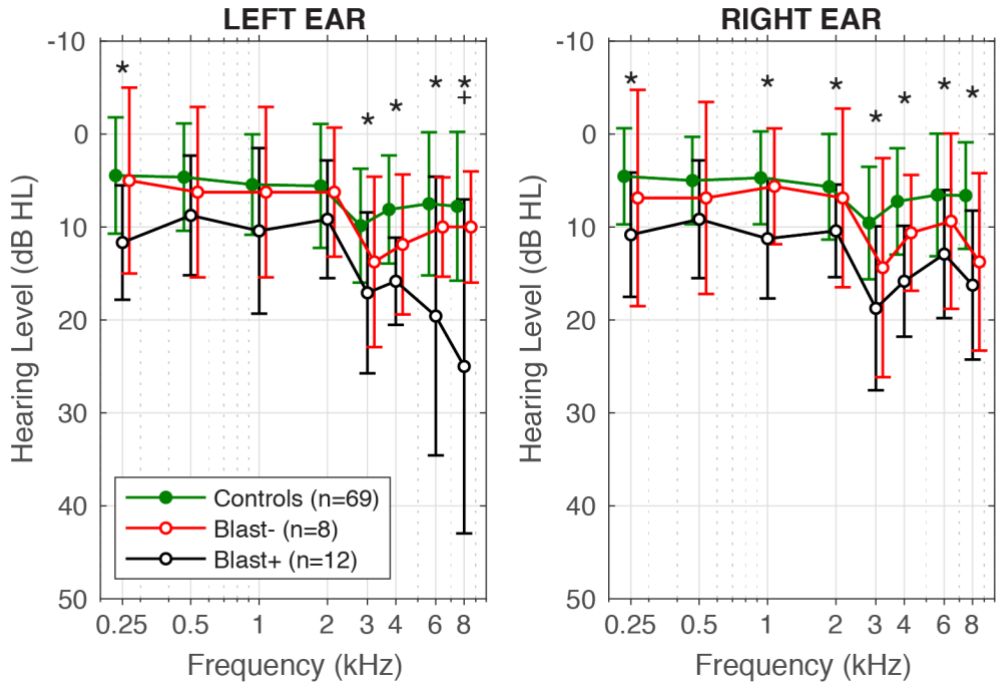


Figure 2: Pure tone air conduction thresholds comparing non-blast controls (green), blast-exposed subjects with good functional hearing (red), and blast-exposed subjects with poor functional hearing (blast +: black). Asterisks (*) denotes significant differences between controls and blast+ subjects. Plus sign (+) denotes significant differences between blast+ and blast- subjects. Non-parametric Wilcoxon rank sum comparisons were adjusted for multiple comparisons using the Benjamini-Hochberg correction.

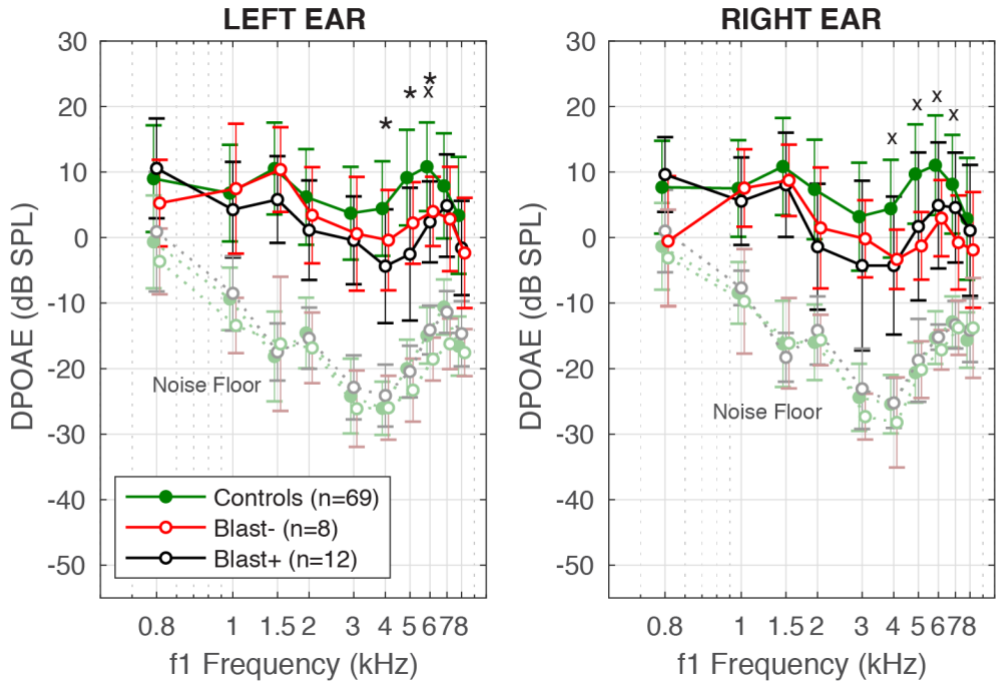


Figure 3: Distortion product otoacoustic emissions (DPOAEs) with appropriate noise floor estimates (lighter colored plot lines) for controls (green), blast- (red), and blast+ (black) subjects. Asterisks (*) denote statistically significant differences between controls and blast+ subjects. X's denote significant differences between controls and blast- subjects. Non-parametric Wilcoxon rank sum comparisons were adjusted for multiple comparisons using the Benjamini-Hochberg correction.

We will continue to monitor these outcomes as we collect more data from new blast-exposed study participants.

For both the Auditory (ASA) and Visual Selective Attention (VSA) tasks, behavioral and electrophysiological measures continue to show no significant differences between control and blast-exposed groups. With the relaxation of the inclusion criteria for the blast group, we have enrolled Service Members whose hearing has been less affected by blast exposure as determined by their audiometric threshold data and scores on the SSQ and hearing screeners. Our plan is to investigate individual differences across the different test measures and how they may or may not relate to blast exposure history. Findings from this analysis will be written up for consideration for publication in an appropriate peer-reviewed journal and will be included as a chapter in Mr. Bressler's doctoral dissertation.

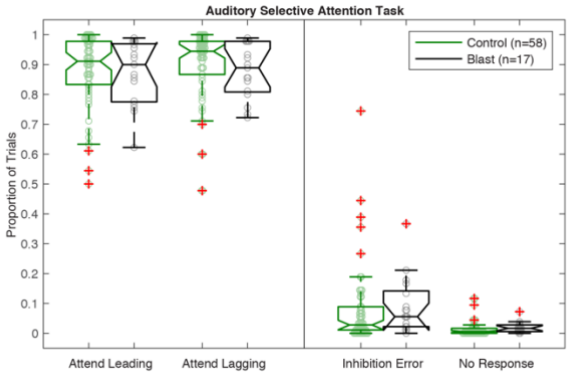


Figure 4: Behavioral results for the Auditory Selective Attention (ASA) task.

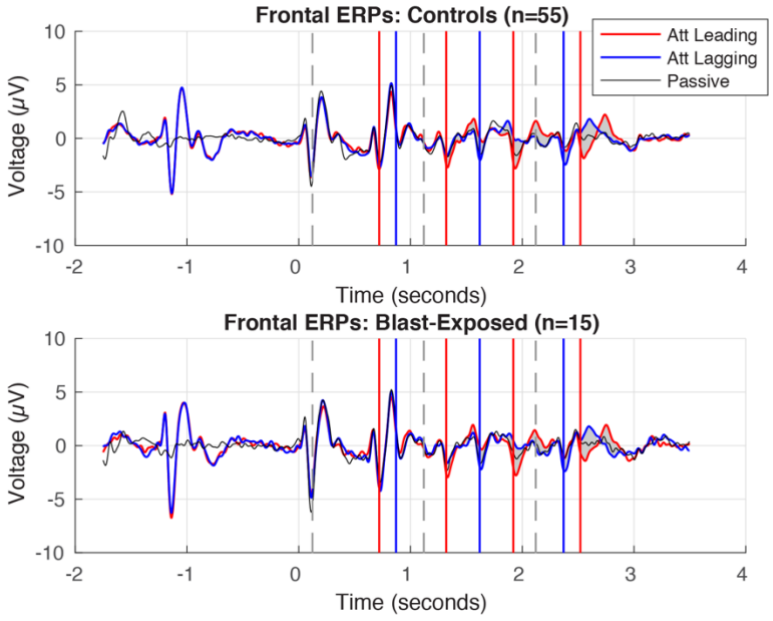


Figure 5: Auditory evoked responses from the average of five frontal EEG channels for controls (top) and blast-exposed (bottom) subjects. Gray shaded areas highlight statistically signficant differences between attend leading (red) and attend lagging (blue) conditions.

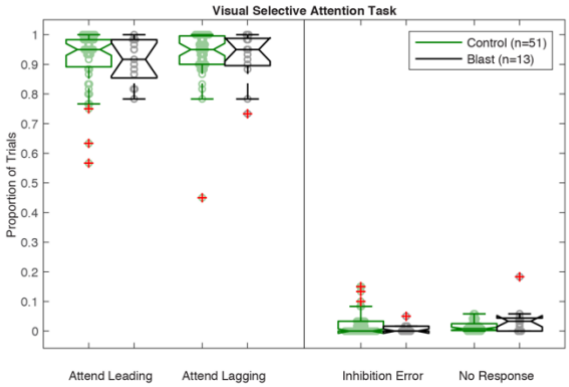


Figure 6: Behavioral results for the Visual Selective Attention (VSA) task

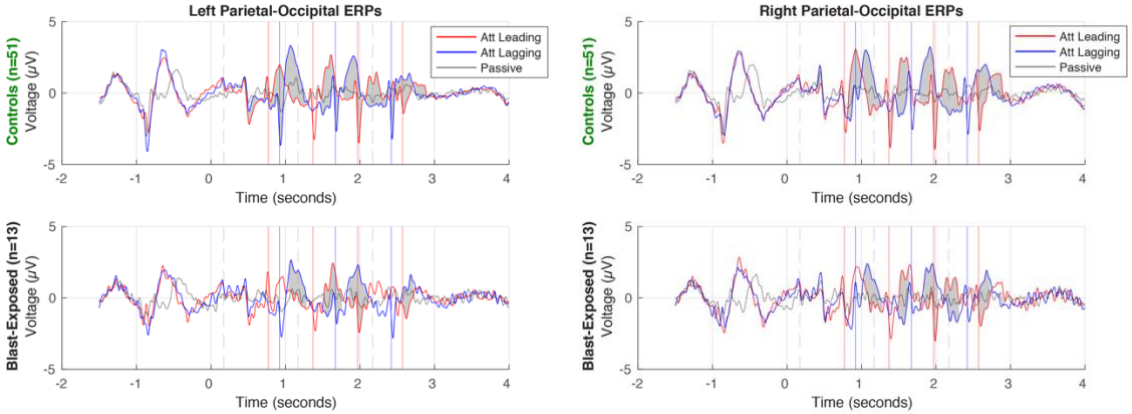


Figure 7: Visual evoked responses from left and right hemispheric parietal-occipital electrodes.

What was the impact on other disciplines?

Preliminary analysis of our data seems to be suggesting that current audiological standards for classifying "normal hearing" may be too general. It appears that pure tone thresholds of 15-20 dB HL, while still technically normal, may in fact be affecting a person's ability to communicate in complex listening environments. If confirmed, this may lead to changes in the way sub-clinical hearing loss is categorized and treated at the Walter Reed Audiology and Speech Pathology Clinic as well as the Scientific and Clinical Studies Section. The new American Speech-Language-Hearing Association (ASHA) guidelines define normal hearing as hearing thresholds between -10 to +15 dB HL. While the American Academy of Audiology (AAA) guidelines define normal hearing to be between -10 to 20 dB HL.

What was the impact on technology transfer?

Nothing to report

What was the impact on society beyond science and technology?

Nothing to report

5. Changes/Problems

Changes in approach and reason for change

Nothing to report

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

- As of the writing of this report, research engineer, Scott Bressler, has successfully defended his doctoral thesis. With Co-PI Dr. Shinn-Cunningham's new appointment at Carnegie Mellon and pending shut down of the Auditory Neuroscience Lab at Boston

University, he is currently seeking employment opportunities in the metropolitan Boston area. In the meantime, he will remain on staff and continue to help with the data analysis and training of project staff members at Walter Reed. In anticipation of his departure, we will be taking steps to ensure project data, analysis scripts, and other relevant documents are properly transitioned over to the care of Co-PI Dr. Ken Grant and research audiologist Dr. Lewis. Mr. Bressler has also agreed to assist the project as a contracted hire in the event he locates new employment in the future before the project is completed.

- We have applied for and received a second one-year no-cost extension, which should give us enough time to increase the numbers in the experimental group.
- Despite being in two different locations, Mr. Bressler and Dr. Shinn-Cunningham have been in close communication and have regular weekly video conference calls to review the latest results and overall progress of the project.

Changes that had a significant impact on expenditures

Nothing to report

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

Nothing to report

Significant changes in use or care of human subjects

Nothing to report

Significant changes in use or care of vertebrate animals

Nothing to report

Significant changes in use of biohazards and/or select agents

Nothing to report

6. Products

Publications, conference papers, and presentations

Journal publications

Two to three planned manuscripts are currently being discussed

Books or other non-periodical, one-time publications

Nothing to report

Other publications, conference papers, and presentations

Conference posters:

Kimberly A. Jenkins, AuD, Jennifer R. Myers, PhD, Alessandro Presacco, PhD, and Ken W. Grant, PhD, "Electrophysiological Responses in Blast and Non-Blast Exposed Military Service Members." 46th Annual Scientific and Technology Meeting of the American Audiological Society held in Scottsdale, AZ between 28-Feb-2019 and 02-Mar-2019.

Scott Bressler, Kimberly Jenkins, Jennifer Myers, Ken Grant, and Barbara Shinn-Cunningham, "Blast Exposure in the Military and Its Effects on Sensory and Cognitive Processing." 177th Meeting of the Acoustical Society of America in Louisville, KY. 14-May-2019

Website(s) or other Internet site(s)

Nothing to report

Technologies or techniques

Nothing to report

Inventions, patent applications, and/or licenses

Nothing to report

Other products

Nothing to report

7. Participants and Other Collaborating Organizations

What individuals have worked on the project?

Name:	Prof. Barbara Shinn-Cunningham
Project Role:	Principal Investigator
Research Identifier:	0000-0002-5096-5914
Nearest person month worked:	2.4
Contribution to project:	
Funding support:	

Name:	Dr. Kenneth Grant
Project Role:	Co-Principal Investigator
Research Identifier:	
Nearest person month worked:	1.2
Contribution to project:	
Funding support:	

Name:	Scott Bressler
Project Role:	Research Engineer/Graduate Student
Research Identifier:	
Nearest person month worked:	12
Contribution to project:	Mr. Bressler is responsible for the procurement and installation the research hardware, development of the experimental and data analysis software, and training Research Audiologists, Drs. Jenkins and Lewis, and Research Communications Scientist, Dr. Myers, in EEG data collection and analysis techniques. He has also been instrumental in filing the quarterly technical progress reports.
Funding support:	

Name:	Dr. Kimberly Jenkins
Project Role:	Research Audiologist
Research Identifier:	
Nearest person month worked:	9 (hired 17-Jan-2017)
Contribution to project:	Dr. Jenkins is responsible for subject scheduling, evaluation, data collection, and data archiving. She represents the main point of contact for the study participants and is Mr. Bressler's direct contact for all technical and/or equipment related issues.

Funding support:	

Name:	Dr. Jennifer Myers
Project Role:	Research Communications Scientist
Research Identifier:	
Nearest person month worked:	12 (hired 14-Nov-2016)
Contribution to project:	Dr. Myers is responsible for Phases I & II of the CAPD Prevalence Study to which the BU study is attached. Along with Dr. Jenkins, she is also a main point of contact for the study participants, and a secondary contact for Mr. Bressler on EEG-related hardware, software, and data collection issues.
Funding support:	CAPD Prevalence Study

Name:	Dr. Rebecca Lewis
Project Role:	Research Audiologist
Research Identifier:	
Nearest person month worked:	1
Contribution to project:	Dr. Lewis is the new project research audiologist, a position recently vacated by Dr. Jenkins in June of 2019. She was hired in August 2019
Funding support:	CAPD Prevalence Study

Name:	Tom Heil
Project Role:	Engineer
Research Identifier:	
Nearest person month worked:	0.6
Contribution to project:	Mr. Heil has provided valuable technical support of the EEG hardware and software infrastructure.
Funding support:	CAPD Prevalence Study

Has there been a change in the active or support of the PD/PI(s) or senior key personnel since the last reporting period?

Nothing to report

What other organizations were involved as partners?

Nothing to report

8. Special Reporting Requirements

Collaborative awards

Quad charts

Diagnosing contributions of sensory and cognitive deficits to hearing dysfunction in blast-exposed / mTBI Service Members

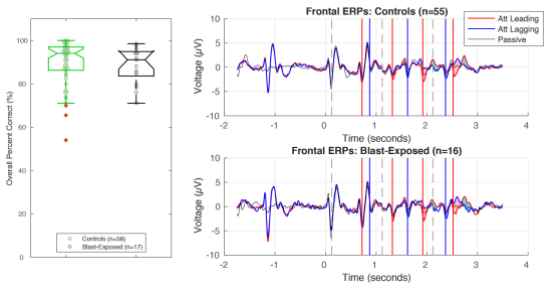
PI: Barbara G. Shinn-Cunningham **Org:** Boston University (sub: Walter Reed Nat. Mil. Med. Cent.) **Award Amount:** $1,500,000

Study/Product Aim(s)

- Understand why roughly 40% of blast-exposed Service Members returning from Iraq or Afghanistan (~15% of all personnel) experience difficulty understanding speech in noisy environments, despite having normal to near-normal hearing thresholds. These individuals are often misdiagnosed as having no hearing deficit, and are thus offered no treatment plan.
- Develop an efficient battery of tests appropriate for clinical use to diagnose patterns of hearing dysfunction in individual Service Members.

Approach

We will recruit Service Members with varying degrees of blast exposure. Using both behavioral measures and physiological biomarkers, we will quantify 1) supra-thredshold coding fidelity (likely related to noise and possibly blast exposure), and 2) cognitive / executive function (likely related to blast exposure). We will quantify the relationships amongst communication deficits, blast exposure history, sensory hearing fidelity, and cognitive / cortical control deficits. We will develop a clinically appropriate test battery to diagnose and tease apart contributions of sensory and cognitive deficits to hearing dysfunction in individual Service Members.



Preliminary results from the Auditory Selective Attention (ASA) task suggest no apparent deficit in executive control in either the behavioral or cortical measures even in blast-exposed subjects with normal to near-normal audiometric thresholds.

Timeline and Cost

Activities CY	16	17	18
Prepare for data collection			
Recruit and test ~50 subjects			
Model key relationships in results			
Develop efficient diagnostic battery			
Estimated Budget ($K)	**$537**	**$475**	**$488**

Updated: (15 Mar 2019)

Goals/Milestones

CY16 Goals – Setup and study initialization
- 🗓 Hire and train research audiologist at WRNMMC
- 🗓 Collect data on ~16 subjects (full set on ~12)
- 🗓 Present preliminary results and solicit feedback

CY17 Goals – Data collection and dissemination
- 🗓 Collect data on ~36 subjects (full set on ~27)
- ☐ Develop statistical model of key factors leading to hearing dysfunction
- 🗓 Present results and solicit feedback

CY18 Goals – Wrap up and dissemination
- 🗓 Finish data collection on ~18 subjects (full set on ~11)
- ☐ Finalize statistical analysis and modeling
- ☐ Develop efficient test battery for individualized diagnosis of specific sensory and cognitive deficits contributing to auditory dysfunction

Budget Expenditure to Date

Cumulative Expenditure: $1,409,205

Remaining Budget: $68,739

9. Appendices

Conference Presentations

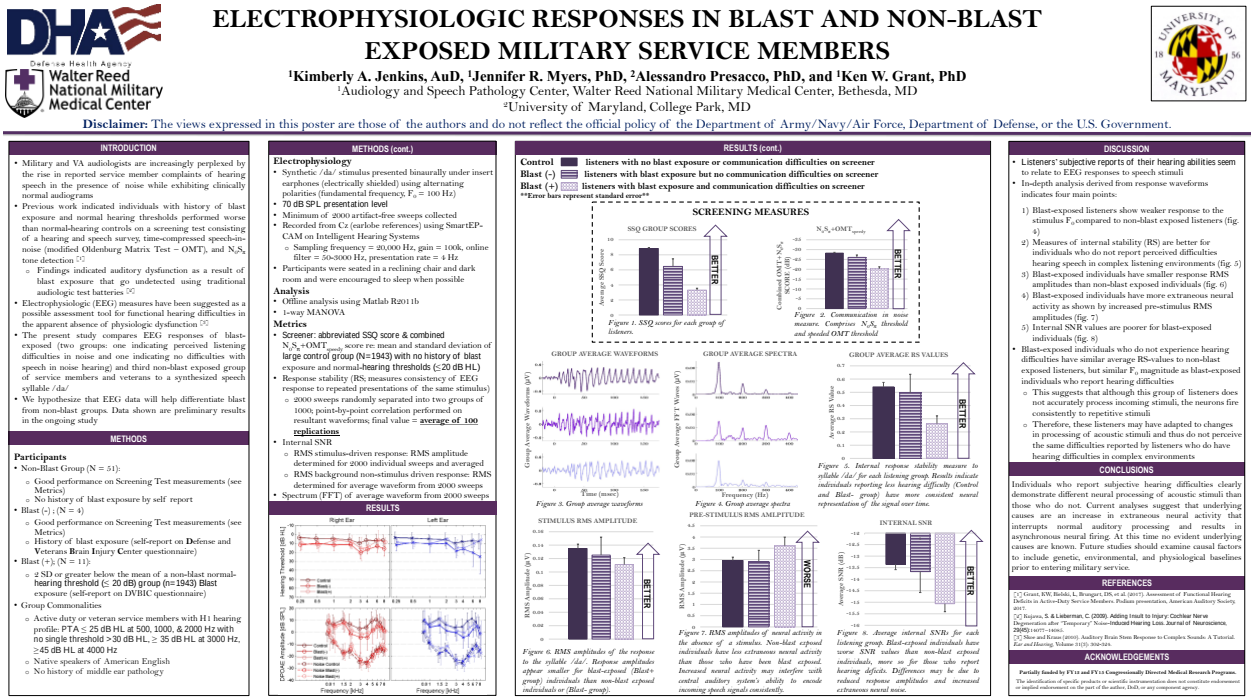
Abstract

Electrophysiologic (EEG) Responses in Blast and Non-Blast Exposed Military Service Members

Kimberly A. Jenkins, AuD; Jennifer Myers, PhD; Ken Grant, PhD, Walter Reed National Military Medical Center, Bethesda, MD

Alessandro Presacco, PhD, University of Maryland, College Park, MD

Over the past decade military and VA audiologists have been perplexed by rises in service member complaints of difficulty hearing speech in the presence of background noise while exhibiting clinically normal audiograms. Previous work found that many listeners with normal to near-normal hearing thresholds exposed to blasts performed worse on a simple hearing screening test consisting of a six- question hearing and speech survey, time-compressed speech-in-noise, and N_0S_π tone detection. This indicates blast exposure in humans may cause auditory dysfunction undetected by traditional diagnostic hearing tests. Electrophysiologic measures are currently being utilized to investigate auditory processing in blast- and non-blast exposed military personnel with normal-hearing thresholds. The stimulus consisted of a synthetic speech syllable (/da/). Comparisons of overall response amplitudes indicated decreased signal-to-internal noise ratio (SNR) in blast-exposed individuals. Detailed analyses revealed decreased stimulus response amplitudes and increased pre-stimulus response amplitudes in test subjects. Further, a measure of stimulus-driven response stability was poorer in blast-exposed individuals compared to controls. This suggests blast exposure causes increased extraneous neural activity that increases internal noise, reduces SNR, and impedes the auditory system's phase-locking ability. These changes in physiologic response properties observed through EEG recordings may help explain behavioral and subjective complaints in blast-exposed individuals.



ELECTROPHYSIOLOGIC RESPONSES IN BLAST AND NON-BLAST EXPOSED MILITARY SERVICE MEMBERS

[1]Kimberly A. Jenkins, AuD, [1]Jennifer R. Myers, PhD, [2]Alessandro Presacco, PhD, and [1]Ken W. Grant, PhD

[1]Audiology and Speech Pathology Center, Walter Reed National Military Medical Center, Bethesda, MD

[2]University of Maryland, College Park, MD

Disclaimer: The views expressed in this poster are those of the authors and do not reflect the official policy of the Department of Army/Navy/Air Force, Department of Defense, or the U.S. Government.

INTRODUCTION

- Military and VA audiologists are increasingly perplexed by the rise in reported service member complaints of hearing speech in the presence of noise while exhibiting clinically normal audiograms
- Previous work indicated individuals with history of blast exposure and normal hearing thresholds performed worse than normal-hearing controls on a screening test consisting of a hearing and speech survey, time-compressed speech-in-noise (modified Oldenburg Matrix Test – OMT), and N_0S_π tone detection [5]
  - Findings indicated auditory dysfunction as a result of blast exposure that go undetected using traditional audiologic test batteries [5]
- Electrophysiologic (EEG) measures have been suggested as a possible assessment tool for functional hearing difficulties in the apparent absence of physiologic dysfunction [5]
- The present study compares EEG responses of blast-exposed (two groups: one indicating perceived listening difficulties in noise and one indicating no difficulties with speech in noise hearing) and third non-blast exposed group of service members and veterans to a synthesized speech syllable /da/
- We hypothesize that EEG data will help differentiate blast from non-blast groups. Data shown are preliminary results in the ongoing study

METHODS

Participants

- Non-Blast Group (N = 51):
  - Good performance on Screening Test measurements (see Metrics)
  - No history of blast exposure by self report
- Blast (-) : (N = 4)
  - Good performance on Screening Test measurements (see Metrics)
  - History of blast exposure (self-report on **D**efense and **V**eterans **B**rain **I**njury **C**enter questionnaire)
- Blast (+): (N = 11):
  - ≥ SD or greater below the mean of a non-blast normal-hearing threshold (≤ 20 dB) group (n=1943) Blast exposure (self-report on DVBIC questionnaire)
- Group Commonalities
  - Active duty or veteran service members with H1 hearing profile: PTA ≤ 25 dB HL at 500, 1000, & 2000 Hz with no single threshold > 30 dB HL, ≥ 35 dB HL at 3000 Hz, ≥45 dB HL at 4000 Hz
  - Native speakers of American English
  - No history of middle ear pathology

METHODS (cont.)

Electrophysiology

- Synthetic /da/ stimulus presented binaurally under insert earphones (electrically shielded) using alternating polarities (fundamental frequency, F_0 = 100 Hz)
- 70 dB SPL presentation level
- Minimum of 2000 artifact-free sweeps collected
- Recorded from Cz (earlobe references) using SmartEP-CAM on Intelligent Hearing Systems
  - Sampling frequency = 20,000 Hz, gain = 100k, online filter = 50-3000 Hz, presentation rate = 4 Hz
- Participants were seated in a reclining chair and dark room and were encouraged to sleep when possible

Analysis

- Offline analysis using Matlab R2011b
- 1-way MANOVA

Metrics

- Screener: abbreviated SSQ score & combined N_0S_π+OMT$_{speedy}$ score re: mean and standard deviation of large control group (N=1943) with no history of blast exposure and normal-hearing thresholds (≤20 dB HL)
- Response stability (RS; measures consistency of EEG response to repeated presentations of the same stimulus)
  - 2000 sweeps randomly separated into two groups of 1000; point-by-point correlation performed on resultant waveforms; final value = **average of 100 replications**
- Internal SNR
  - RMS stimulus-driven response: RMS amplitude determined for 2000 individual sweeps and averaged
  - RMS background non-stimulus driven response: RMS determined for average waveform from 2000 sweeps
- Spectrum (FFT) of average waveform from 2000 sweeps

RESULTS

RESULTS (cont.)

Control listeners with no blast exposure or communication difficulties on screener
Blast (-) listeners with blast exposure but no communication difficulties on screener
Blast (+) listeners with blast exposure and communication difficulties on screener
Error bars represent standard error

Figure 1. SSQ scores for each group of listeners.

Figure 2. Communication in noise measure. Comprises N_0S_π threshold and speeded OMT threshold

Figure 3. Group average waveforms

Figure 4. Group average spectra

Figure 5. Internal response stability measure to syllable /da/ for each listening group. Results indicate individuals reporting less hearing difficulty (Control and Blast- group) have more consistent neural representation of the signal over time.

Figure 6. RMS amplitudes of the response to the syllable /da/. Response amplitudes appear smaller for blast-exposed (Blast+ group) individuals than non-blast exposed individuals or (Blast- group).

Figure 7. RMS amplitudes of neural activity in the absence of a stimulus. Non-blast exposed individuals have less extraneous neural activity than those who have been blast exposed. Increased neural activity may interfere with central auditory system's ability to encode incoming speech signals consistently.

Figure 8. Average internal SNRs for each listening group. Blast-exposed individuals have worse SNR values than non-blast exposed individuals, more so for those who report hearing deficits. Differences may be due to reduced response amplitudes and increased extraneous neural noise.

DISCUSSION

- Listeners' subjective reports of their hearing abilities seem to relate to EEG responses to speech stimuli
- In-depth analysis derived from response waveforms indicates four main points:
  1) Blast-exposed listeners show weaker response to the stimulus F_0 compared to non-blast exposed listeners (fig. 3)
  2) Measures of internal stability (RS) are better for individuals who do not report perceived difficulties hearing speech in complex listening environments (fig. 5)
  3) Blast-exposed individuals have smaller response RMS amplitudes than non-blast exposed individuals (fig. 6)
  4) Blast-exposed individuals have more extraneous neural activity as shown by increased pre-stimulus RMS amplitudes (fig. 7)
  5) Internal SNR values are poorer for blast-exposed individuals (fig. 8)
- Blast-exposed individuals who do not experience hearing difficulties have similar average RS-values to non-blast exposed listeners, but similar F_0 magnitude as blast-exposed individuals who report hearing difficulties
  - This suggests that although this group of listeners does not accurately process incoming stimuli, the neurons fire consistently to repetitive stimuli
  - Therefore, these listeners may have adapted to changes in processing of acoustic stimuli and thus do not perceive the same difficulties reported by listeners who do have hearing difficulties in complex environments

CONCLUSIONS

Individuals who report subjective hearing difficulties clearly demonstrate different neural processing of acoustic stimuli than those who do not. Current analyses suggest that underlying causes are an increase in extraneous neural activity that interrupts normal auditory processing and results in asynchronous neural firing. At this time no evident underlying causes are known. Future studies should examine causal factors to include genetic, environmental, and physiological baselines prior to entering military service.

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ACKNOWLEDGEMENTS

Partially funded by FY12 and FY13 Congressionally Directed Medical Research Programs.

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TITLE: Blast Exposure in the Military and Its Effects on Sensory and Cognitive Auditory Processing

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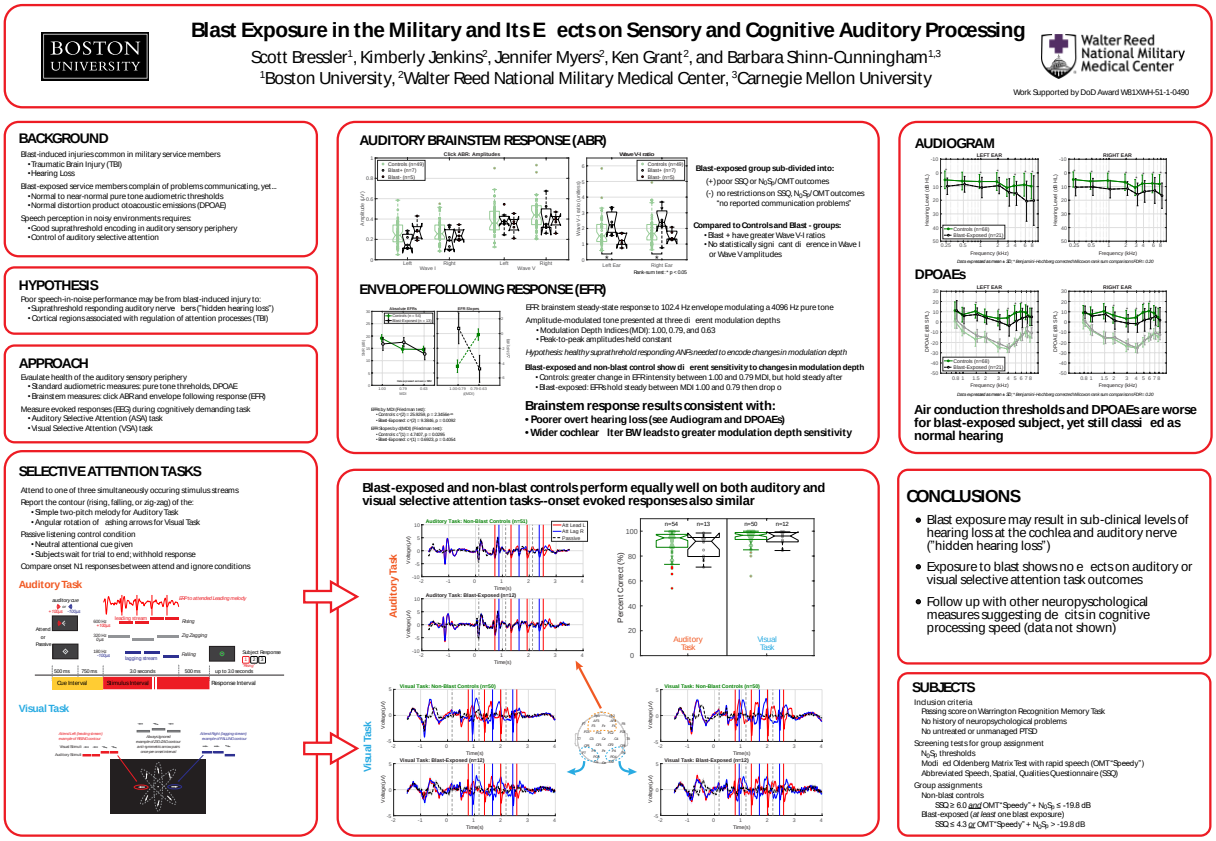
Blast-induced traumatic brain injury (TBI) and hearing loss are the two most common types of injuries sustained by military personnel while serving in the U.S. Global War on Terrorism. Recently several VA audiology clinics have reported active duty service members complaining of having problems communicating in noisy listening environments despite having normal to near-normal pure tone thresholds. In addition to traditional clinical measures, we used electroencephalography (EEG) to determine whether damage to suprathreshold responding auditory nerve fibers in the sensory periphery and/or trauma to cortical regions associated with attention and working memory were responsible for the reported listening complications. In separate auditory and visual selective attention tasks, behavioral and neural measures suggest no evidence of long term neurotrauma affecting normal cognitive function. We found while absolute measures of auditory brainstem encoding varied greatly in all study subjects, comparisons of how the envelope following response (EFR) changes with modulation depth hint at differences between blast and non-blast exposed service members. These findings are consistent with audiometric threshold and distortion product otoacoustic emission data that show subtle differences between groups within clinically defined normal limits. Taken together these results suggest subclinical differences in audiometric measures might explain differences in suprathreshold listening.



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