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14. ABSTRACT The objective of this project is to fully document the effects of acoustic impulses on the middle ear and on middle-ear muscle contractions (MEMCs). This project will provide critical information on the middle ear musculature states during warned and unwarned exposures to acoustic impulses. This information is necessary in the development of new (or revising existing) damage risk criteria (DRCs) and health hazard assessment methods for exposure to high-level acoustic impulses such as experienced by users of military and civilian law enforcement weapon systems, civilian recreational hunting and shooting, and industrial high-level impulsive noises (impacts and impulses).					
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Introduction:

The objective of this project is to fully document the effects of acoustic impulses on the middle ear and on middle-ear muscle contractions (MEMCs). This project will provide critical information on the state of the middle ear muscles during unwarned and warned exposures to acoustic impulses, which are described as reflexive MEMCs (rMEMCs) and early MEMCs (eMEMC), respectively. An rMEMC is an involuntary response to an elicitor, such as the acoustic impulse. Proponents of a protective eMEMC speculate that it will always occur if a hazardous sound is anticipated, which implies that the response must be acquired through some form of learning. Further, these proponents also advise that a protective eMEMC should be assumed to be active if an individual pulls the trigger on a weapon or if the impulse is immediately preceded by a warning signal¹.

The central question of this research is whether either type of MEMC is pervasive (i.e., determined with 95% confidence that at least 95% of persons exhibit the response). This information is necessary to inform damage risk criteria (DRCs) and health hazard assessment methods for exposure to high-level acoustic impulses such as experienced by users of military and civilian law enforcement weapon systems, civilian recreational hunting and shooting, and industrial high-level impulsive noises (impacts and impulses).

Keywords:

Noise exposure; hearing loss, noise-induced; impulsive noise; reflex; conditioned response; middle ear; damage-risk criteria; health hazard evaluation

ACCOMPLISHMENTS:

What were the major goals of the project?

The major goals of the project as stated in the approved SOW are:

1. Determine the prevalence of acoustic reflexes among young people with H-1 hearing status as per Army Regulation 40-501, Table 7-1.
2. Determine whether reflexive MEMCs are pervasive for multiple acoustic and non-acoustic stimuli.
3. Determine whether conditioned MEMCs are pervasive, in either laboratory or field settings, and if so, identify differences between reflexive and conditioned MEMCs.

What was accomplished under these goals?

Task 1: Determine the prevalence of acoustic reflexes among young people with H-1 hearing status as per Army Regulation 40-501, Table 7-1.

Major activities

This task involved the development of algorithms for identifying acoustic reflexes (ARs), which are a type of rMEMC optimized for clinical purposes, based on middle ear admittance as a function of time. Admittance was estimated using a 0.226 kHz tone at 1 and 2 kHz in each ear separately. Data from the U.S. National Health and Nutrition Examination Survey (NHANES) between 1999 and 2012 were used. The NHANES is an ongoing national study returning estimates of the health of the noninstitutionalized U.S. population. The analyzed dataset consisted of approximately 60,000 AR traces from 15,106 persons included in the NHANES sample.

Two detection algorithms were developed. The frequentist algorithm indicated whether the values in the AR traces shortly after the onset of the tonal elicitor represented a significant deviation from baseline acoustic admittance. The Bayesian/Kalman algorithm was used to estimate the underlying state of acoustic admittance as a function of time, and the maximum correlation between the Kalman-filtered traces and prototypical AR trace shapes was determined. Using the Bayesian/Kalman algorithm, the AR was determined to be present when the maximum correlation was greater than 0.82 – a value that best matched consensus judgements of a panel of three investigators that an AR was present. Complex

¹ Fedele PD, Binseel MS, Kalb JT, Price GR (2013). Using the Auditory Hazard Assessment Algorithm for Humans (AHA AH) With Hearing Protection Software, Release MIL-STD-1474E (ARL-TR-6748). Aberdeen Proving Ground, MD: Army Research Laboratory.

sample binary logistic regression, was used to identify factors in the U.S. population related to the presence of an AR. Additional details regarding the analyses of ARs in NHANES can be found in Flamme et al. (2017). A confirmatory study using different methods and a diagnostic middle ear analyzer was presented in McGregor et al. (2018).

Significant results

There was no identifiable subpopulation in the noninstitutionalized U.S. population wherein the prevalence of ARs was found to be pervasive. Increased rates of ARs were identified in a subset of 3132 NHANES participants between the ages of 18 and 30 and having H-1 hearing status, but AR prevalence was not pervasive even in this group. Multivariable logistic regression analyses indicated that men were less likely to exhibit ARs than women, as were younger people and those with better hearing sensitivity. It was noteworthy that poorer hearing sensitivity at frequencies remote to the AR elicitor frequency were significantly related to the detection of ARs.

Table 1. Prevalence of bilateral acoustic reflexes, by participant group and detection approach. Data presented in Flamme et al. (2016).

	Prevalence %	95% confidence interval limits	
		Low	High
All (unweighted N = 15,106)			
Either	74.6	73.2	75.9
Frequentist	68.3	66.7	69.9
Bayesian/Kalman	58.5	57.1	59.9
Both	52.3	50.7	54.0
Ages 18–30 (unweighted N = 3280)			
Either	85.3	82.9	87.4
Frequentist	81.5	78.8	83.9
Bayesian/Kalman	72.2	69.7	74.6
Both	68.4	65.9	70.9
Ages 18–30, H-1 (unweighted N = 3132)			
Either	86.9	84.8	88.7
Frequentist	83.4	81.1	85.5
Bayesian/Kalman	73.8	71.6	76.0
Both	70.4	68.0	72.6

The implications of Task 1 outcomes are that ARs cannot be expected to be pervasive among military recruits or other Service members.

Other achievements:

Nothing to report.

Task 2: Determine whether reflexive MEMCs are pervasive for multiple acoustic and non-acoustic stimuli.

AND

Task 3: Determine whether MEMCs can be classically conditioned with 95 % certainty in 95 % of people, either in laboratory or field settings, and if so, identify any differences between reflexive and conditioned MEMCs.

Major activities

The major activities for Tasks 2 and 3 for the project included the development of a method for detecting rMEMCs and eMEMCs for internally- and externally-controlled elicitors. A further challenge involved the integration of the signals used to elicit and detect MEMCs in a synchronous, multichannel data acquisition system integrating surface electromyography (EMG) measures of key muscle groups, force and pressure sensors, and control of visual stimuli presented to participants.

Data collection was conducted at three sites: a university research laboratory; the U.S. Army Aeromedical Research Laboratory; and at an outdoor military firing range at Ft. Rucker, AL. Participants included adults with normal hearing, and rMEMC and eMEMC assessments were conducted only with participants exhibiting clinical ARs.

The likelihood of person-level tendencies to exhibit rMEMCs was evaluated for 9 brief acoustic elicitors, 3 levels of voluntary closure effort of the eye ipsilateral to the monitored ear, and to pneumotactile stimulation at four locations on the face (nares and temple, ipsilateral and contralateral to the monitored ear). Acoustic elicitors included 100 ms tones presented at octave intervals from 0.5 through 8 kHz, a 100 ms white noise, and gunshot impulses from quasi-free field recordings of three firearms (0.22 long rifle caliber, 5.56 x 45 mm, and 0.50 caliber BMG) measured at the shooter's ear location. All acoustic elicitors were presented at a 100 dB field-equivalent A-weighted sound exposure level, which corresponded to peak levels between 113- and 121-dB SPL, depending on the spectral content of the signal. Participants were instructed to close the eye ipsilateral to the monitored ear using an effort level that matched a visual analog scale on a large display monitor directly in front of their seated position. Three eye close effort levels were used, maximum (100 % on the visual analog scale), tight (80% on the visual analog scale), and light (30% on the visual analog scale) closure effort, and activity of orbicularis oculi, a primary eye closure muscle, was monitored continuously using EMG. The pneumotactile stimulus was a 200 ms puff (12 kPa peak pressure) of medical-grade nitrogen gas delivered in a random pattern to 4 different locations on the face.

To date, none of the DRCs invoking a protective eMEMC have specified the process by which the eMEMC is expected to develop. As a safeguard against overlooking a potent means of demonstrating an eMEMC, the potential for pervasive eMEMC was evaluated along a continuum of realism ranging from laboratory-based conditioning studies to the discharge of military M4 carbine rifles with live ammunition. Participants in this project were administered only one eMEMC task, which occurred prior to administering rMEMC tasks in study visits including both project components. A related project wherein participants were administered multiple eMEMC tasks was also conducted (Tasko, Flamme & Deiters, 2017²).

In the tasks involving the development of a conditioned response, the unconditioned stimulus (UCS) was the white noise stimulus used in the rMEMC tasks described above. Attempts to elicit eMEMCs through response conditioning included conditioning stimuli (CS) delivered by visual and auditory sensory systems. The effect of the participant's attention to the auditory CS was also examined, with one group of participants instructed to press a response button if the conditioning stimulus was heard. This is labeled the attended auditory (AA) eMEMC task. In order to assess the likelihood of passively developing a conditioned eMEMC, an unattended auditory (UA) task was also included. In this task, the acoustic signal from the AA task was delivered to a group of participants engaged in a visual tracking task similar to a video game. The tracking task involved using a yoke-mounted toy gun with an attached inertial measurement unit (IMU) to track a randomly moving target on a large video screen directly in front of the participant. The CS for the attended visual (AV) task was the transition of the type and color of a geometric image displayed on the same large video screen. The CS was a large blue oval, and the screen displayed a yellow rectangle at other times during the AV task. The luminance and total screen area occupied by the images was identical.

The lack of a specified process for developing an eMEMC in DRC suggests the possibility that regular firearm users will have developed eMEMCs during their prior exposure history. To evaluate the potential pervasiveness of eMEMCs developed this way, a progression of eMEMC tasks was administered. Participants engaged in these tasks were either off-duty military Service members or civilians who regularly fired small firearms (defined as discharging at least 10 rounds in the 30 days prior to enrolling in the study). The least realistic task was the simulated trigger (ST) task, which involved tracking the target (as with the UA task, above) and pulling the trigger on the toy gun when the cursor was near the target icon. The dry fire (DF) task was similar to ST, except that the participant operated a yoke-mounted disabled .410 shotgun with a single-action trigger. The DF condition was expected to be slightly more realistic than ST due to the appearance, mass, and trigger mechanism. Study staff recharged the single-action trigger. The Shooter-Spotter (SH, SP) tasks involved the use of a simulated military M4 carbine designed for use with the Engagement Skills Trainer system (EST2000, Cubic Corporation, San Diego, CA). In the SP task, the participant was seated in an indoor air rifle range, with attention directed at a group of targets downrange while a member of the study

² Tasko, S. M., Flamme, G. A., & Deiters, K. K. (2017). *Assessment of the Response of the Middle Ear Muscle Contraction to Stimuli in Attended and Distracted Unattended Conditions*. (Final report for CDC/NIOSH Contract # 200-2015-M-63121).

staff operated the simulated carbine. In the SH task, the participant directed attention downrange and triggered the simulated M4. A member of the study staff recharged the simulated carbine between trigger pulls.

The live fire task was conducted with off-duty Service members on an outdoor military rifle range. During the eMEMC detection interval two participants assumed a prone position in neighboring firing lanes. Each participant was issued an unloaded M4 carbine and magazines. The occluding acoustic probe assembly used to monitor for eMEMC was inserted into the ear opposite the shoulder against which the M4 rested. An occluding earphone for delivering instructions was inserted into the other ear, and both ears were covered with large-volume earmuff/hearing protector. Each magazine was loaded with M855 5.56 x 45 mm NATO ball ammunition. Participant instructions included loading and charging the weapon and preparing to fire upon a designated target silhouette on a standard M16 25-meter target. Target identification and firing instructions were given to the left and right shooter at different times, making it possible to identify eMEMC under live fire active (LA) and waiting (LW) conditions. Each participant discharged a minimum of 12 and a maximum of 15 rounds, with the larger number of discharges included only if the investigators identified problems with data acquisition during a 3-discharge series (e.g., misfire, failed M4 safety release). The AA, UA, AV, ST, DF, SP, and LA tasks provide a warning signal or involve trigger operation and therefore emulate a warned exposure. The SP and LW tasks emulate unwarned conditions.

Additional details on procedures related to Tasks 2 and 3 can be found in Deiters, et al. (2019), Tasko et al. (2020), Flamme et al. (2020), and prior progress reports.

Significant results

Pervasive rMEMCs were not observed for any elicitor (Figure 1). The eye close elicitor at maximum effort approached pervasiveness, and in general, the non-acoustic elicitor conditions were more likely to produce rMEMC than the acoustic elicitors. Among acoustic elicitors, the 1 kHz and white noise elicitors were most likely to elicit rMEMC. Recorded gunshots from the two weapons used in the military (i.e., 5.56 mm and 0.50 caliber BMG) elicit a tendency toward rMEMC in fewer than 40% of participants.

The proportions presented in Figure 1 represent person-level tendencies toward exhibiting rMEMC across multiple trials. These proportions represent an overestimate of the proportions of responses to single trial presentations of a stimulus, which is the level of analysis of interest to DRCs. For example, the median proportion of acoustically-elicited rMEMC at the trial level was 0.20 (white noise elicitor) or less. This proportion must be contrasted with the conjecture of 100 % rMEMC that is embedded within any DRC invoking rMEMCs as a protective factor. Note also that these results relate only to the proportions of rMEMCs detected. These proportions were sufficiently low that there was no need to compare the magnitude of rMEMC against implementations within DRC models.

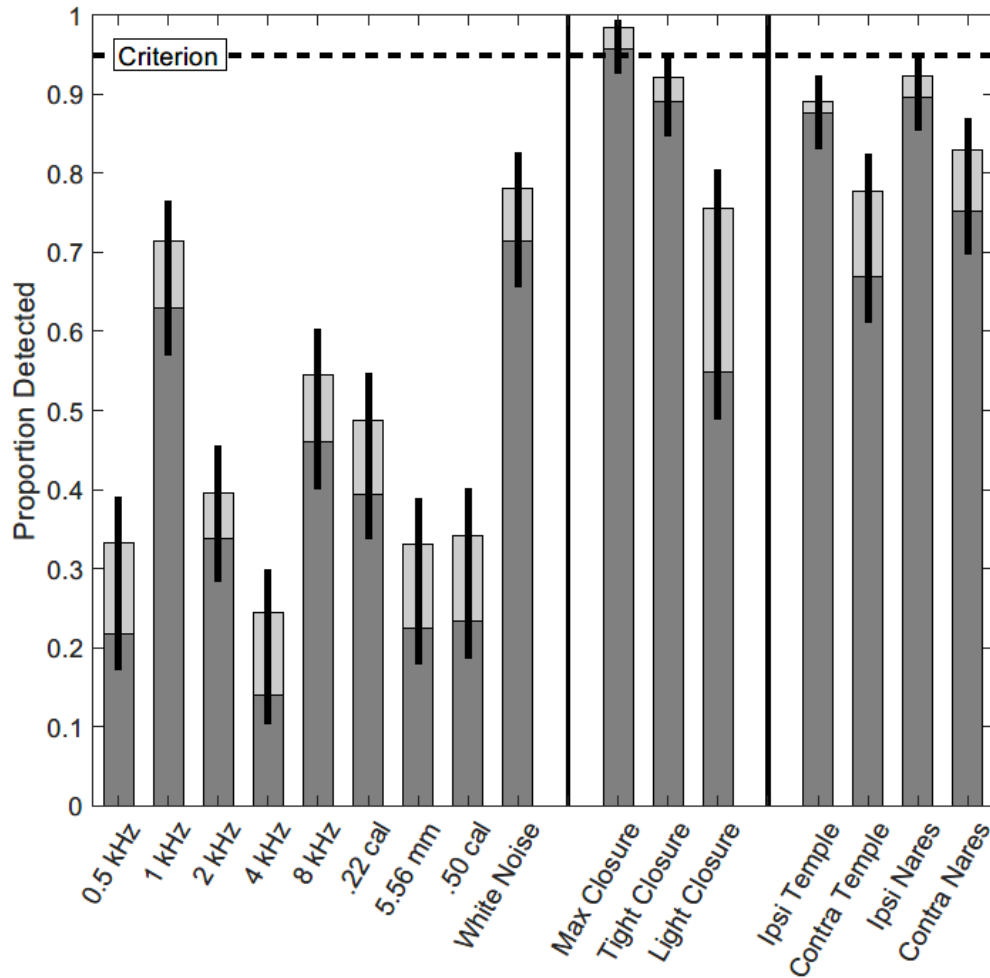


Figure 1. Key results for all rMEMC elicitors included in the project.

None of the 9 eMEMC tasks yielded evidence that eMEMCs were pervasive (Table 1). At best, it is possible to be 95% confident that at least 51% of people would exhibit a tendency toward an eMEMC in the AA task. This percentage is far lower than the criterion of 95% confidence that at least 95% of exposed persons would exhibit an eMEMC. The level of response for the AA tasks did not generalize to the tasks that shared either attention (AV) or CS sensory mode (UA). In these tasks, one cannot be 95% confident that more than 0% of exposed persons will exhibit an eMEMC. Taken together, the results of the AA, AV, and UA tasks and Tasko et al. (2017) indicate that the development of a conditioned eMEMC relies heavily on both attention and the use of an auditory CS. The rapid extinction of conditioned responses of this type (Yonovitz, 1976) suggests that the conditioned eMEMC perishes rapidly, which does not suggest that the conditioned eMEMC has substantial utility in military training or operations.

The tasks relying on development of the eMEMC by unspecified processes returned decreased percentages of participants with eMEMCs as the realism increased. None of these tasks approached the proportions of participants with eMEMCs necessary to justify inclusion as a protective factor in DRCs. The LA task was perhaps the most important eMEMC task in this project, and data collection on this study component was halted because data from additional participants would have had no impact on the conclusion drawn from this task. In order to support a declaration that eMEMCs are pervasive in the LA task, eMEMCs would need to be observed on 488 consecutive participants. Even if resources were available to support this work, the probability of this outcome was vanishingly small ($p < 1 \times 10^{-16}$).

Table 2. Results from eMEMC tasks. Judgments made independently by 3 raters. Evidence of a pervasive eMEMC would be indicated by a lower limit of the 90% confidence interval greater than or equal to 95 %. The final column represents the numbers of consecutive participants exhibiting eMEMCs that would be required to meet the pervasiveness criterion, starting with the observed proportion. These results provide neither support for eMEMC as a protective factor nor an indication that pervasiveness would be identified if additional participants were evaluated.

Task	Percent of participants with a tendency toward eMEMC, majority judgment	Lower limit of 90% confidence interval	Upper limit of 90% confidence interval	# of consecutive eMEMC responses required to achieve pervasiveness criterion
AV	15	0	27	953
AA	80	51	86	569
UA	5	0	12	1400
ST	66	7	93	176
DF	66	18	89	200
SH	4	0	8	1252
SP	11	0	21	1252
LA	5	2	23	488
LW	11	0	30	536

Collectively, the results across Tasks 1 through 3 present an unequivocal rejection of the speculation that MEMCs are a dependable protective factor that should be included in DRCs for impulsive noise. This finding poses a problem for all DRCs that invoke a protective rMEMC or eMEMC. This includes one of the two DRCs in a current DoD acquisition standard (MIL-STD-1474E) and all of its predecessors (MIL-STD-1474 through MIL-STD-1474D).

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

Nothing to report.

How were the results disseminated to communities of interest?

Dissemination of the results of this project has led to five manuscripts prepared for peer-reviewed journals, six reports available on DTIC, and 37 presentations at scientific meetings. Details for all dissemination products are presented in the Products section below.

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

Nothing to report.

Impact

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

This project informs the evaluation, selection, and development of DRCs for impulsive noises. The methods developed for this study enable the assessment of MEMCs for a wide range of stimuli. The primacy of non-acoustic elicitors of rMEMCs informs the interpretation of prior studies of the association between impulse exposure and auditory outcomes. We are unaware of any studies that controlled for concomitant facial muscle activity as a mediating factor, and it is plausible that such uncontrolled effects could lead bias the outcomes of those studies.

What was the impact on other disciplines?

The results of the laboratory-based components of this study demonstrate that assessments of middle ear function could be compromised if concomitant muscle activity is not also monitored. This finding has implications for medical diagnostic evaluations and among investigators interested in motor control.

What was the impact on technology transfer?

Nothing to report.

What was the impact on society beyond science and technology?

For decades, the MEMC has been assumed to have a protective role in multiple damage-risk criteria for impulsive sounds. Some damage-risk criteria have presumed that a listener who knows of an imminent impulse will produce eMEMCs via classical conditioning. There is a weak evidentiary basis for a protective role of rMEMCs for brief sounds, and the evidentiary basis for an eMEMC was nearly non-existent prior to this work.

This project has found no support for either rMEMCs or eMEMCs as a form of protection that should be invoked in any damage-risk criterion for impulsive noise. The current project is likely to inform the development and application of damage-risk criteria and health hazard evaluations by policymakers. The consequent improvements in the accuracy of damage risk criteria will benefit warfighters and other personnel exposed to impulsive sounds in the line of their duty and occupation. In addition, these criteria could inform the evaluation of the hazard of impulsive noise for firearm users.

Changes/Problems

Changes in approach and reasons for change

Nothing to report.

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

Nothing to report.

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.

PRODUCTS:

Publications, conference papers, and presentations

Journal publications.

Flamme GA, Deiters KK, Tasko SM, Smith MV, Jones HG, Murphy WJ, Greene NT, Ahroon WA (Prepared for Military Medicine). Middle ear muscle contractions as protection against impulsive noise: Recent studies.

Tasko SM, Deiters KK, Flamme GA, Smith MV, Murphy WJ, Jones HG, Greene NT, Ahroon WA (Submitted to Hearing Research). Effects of eye closure on middle ear muscle contractions.

Deiters KK, Flamme GA, Tasko SM, Murphy WJ, Greene NT, Jones HG, Ahroon WA (2019). Generalizability of clinically-measured acoustic reflexes to brief sounds. *J. Acoust. Soc. Am.*, 146(5) 1-14, DOI: 10.1121/1.5132705.

McGregor KD, Flamme GA, Tasko SM, Deiters KK, Ahroon WA, Themann CL, Murphy WJ (2017). Acoustic reflexes are common but not pervasive: evidence using a diagnostic middle ear analyser. *Int. J. Audiol.*, 57, S42-50. DOI: 10.1080/14992027.2017.1416189.

Flamme GA, Deiters KK, Tasko SM, Ahroon WA (2017). Acoustic reflexes are common but not pervasive: evidence from the National Health and Nutrition Examination Survey, 1999-2012. *Int. J. Audiol.*, 56(S1), 56-62.

Books or other non-periodical, one-time publications.

Flamme GA, Deiters KK, Tasko SM, Smith MV, Jones HG, Murphy WJ, Greene NT, Ahroon WA (under review, 2020). Pervasiveness of early middle ear muscle contractions. (USAARL-TECH-FR-2020-xxx) U.S. Army Aeromedical Research Laboratory, Ft. Rucker, AL.

Tasko SM, Deiters KK, Flamme GA, Smith MV, Murphy WJ, Jones HG, Greene NT, Ahroon WA (2020). Effects of eye closure on middle ear muscle contractions. (USAARL-TECH-FR-2020-044) U.S. Army Aeromedical Research Laboratory, Ft. Rucker, AL.

Deiters KK, Flamme GA, Tasko SM, Murphy WJ, Greene NT, Jones HG, Ahroon WA (2020). Generalizability of clinically-measured acoustic reflexes to brief sounds. (USAARL-JAOA-PV--2020-020) U.S. Army Aeromedical Research Laboratory: Ft. Rucker, AL.

McGregor KD, Flamme GA, Tasko SM, Deiters KK, Ahroon WA, Themann CL, Murphy WJ (2020). Acoustic reflexes are common but not pervasive: evidence using a diagnostic middle ear analyser (USAARL-JAET-PV--2020-015), U.S. Army Aeromedical Research Laboratory (USAARL): Ft. Rucker, AL.

Flamme GA, Deiters KK, Tasko SM, Ahroon WA (2020). Acoustic reflexes are common but not pervasive: evidence from the National Health and Nutrition Examination Survey, 1999-2012 (USAARL-JAET-PV--2020-003), U.S. Army Aeromedical Research Laboratory (USAARL): Ft. Rucker, AL.

Greene NT, Jones HG, Ahroon WA, Deiters KK, Tasko SM, Flamme GA (2018). Assessment of middle ear function during the acoustic reflex using wideband acoustic reflectance. (USAARL Report No. 2018-22), U.S. Army Aeromedical Research Laboratory (USAARL): Ft. Rucker, AL.

Other publications, conference papers, and presentations.

Smith MV, Jones HG, Greene N, Ahroon WA, Flamme GA, Tasko SM, Deiters KK (2020). Does knowledge of an impending impulse elicit early middle ear muscle contractions? Presentation at the National Hearing Conservation Association 44th Annual Conference. Miramar Beach, Florida, February 2020.

Deiters KK, Tasko SM, Flamme GA, Smith MV, Murphy WJ, Jones HG, Ahroon WA (2020). Distinguishing between middle ear muscle contractions and the eye-blink startle response: A preliminary study. Presentation at the National Hearing Conservation Association 44th Annual Conference. Miramar Beach, Florida, February 2020.

Tasko SM, Flamme GA, Deiters KK, Smith MV, Murphy WJ, Jones HG, Ahroon WA (2020). An approach to identification of middle ear muscle contractions that controls for the effect of incidental motor activity.

Presentation at the National Hearing Conservation Association 44th Annual Conference. Miramar Beach, Florida, February 2020.

Flamme GA, Tasko SM, Deiters KK, Smith MV, Murphy WJ, Jones HG, Akins ER, Greene N, Ahroon WA (2020). Middle ear muscles do not provide dependable protection: Implications for impulsive noise damage risk criteria. Presented at the National Hearing Conservation Association 44th Annual Conference, Miramar Beach, Florida, February 2020.

Jones HG, Akins ER, Milam LS, Tasko SM, Deiters KK, Smith MV, Murphy WJ, Ahroon WA, Flamme GA (2020). Middle-ear muscle contraction measurements reveal no anticipatory activation during live rifle fire. Presented at the Association for Research in Otolaryngology 43rd Annual Mid-Winter Meeting, San Jose, CA, January 2020.

Flamme, GA, Deiters, KK, Tasko, SM, Smith, MV, Murphy, WJ (2019). Hearing protection from middle ear muscle contractions. Presented at the International Symposium on the Effects of Complex Noise Exposure on Hearing, State University of New York at Plattsburgh Valcour Conference Center, Peru, NY, August 2019.

Flamme GA, Tasko SM, Deiters KK, Smith MV, Jones HG, Murphy WJ, Ahroon WA, Greene NT (2019). Laboratory and field studies of middle ear muscle contractions as protection against impulsive noise. Presented at the 4th International Forum on Blast Injury Countermeasures (IFBIC), McLean, VA, May 2019.

Deiters KK, Flamme GA, Tasko SM, Jones HG, Smith MV, Murphy WJ, Ahroon WA, Greene NT (2019). Laboratory and field studies of MEMC in response to impulsive noise. Presented at the National Hearing Conservation Association Annual Convention, Grapevine, TX, February 2019.

Tasko SM, Flamme GA, Deiters KK, Smith MV, Murphy WJ, Jones HG, Ahroon WA, Greene NT (2019). Influence of incidental motor activity on middle ear muscle contractions. Presented at the National Hearing Conservation Association Annual Convention, Grapevine, TX, February 2019.

Jones HG, Tasko SM, Flamme GA, McGregor KD, Smith MV, Deiters KK, Murphy WJ, Greene NT, Ahroon WA (2019). Middle-ear muscle contractions should not be included in damage-risk criteria. Presentation at the 42nd annual mid-winter meeting of the Association for Research in Otolaryngology, Baltimore, MD, February 2019.

Greene NT, Jones HG, Ahroon WA, Deiters KK, Tasko SM, Flamme GA (2018). Assessment of middle ear function during the acoustic reflex using wideband acoustic reflectance (USAARL Report No. 2018-22). U.S. Army Aeromedical Research Laboratory (USAARL): Washington, DC.

Flamme GA, Tasko SM, Deiters KK, Smith MV, Murphy WJ, Jones HG, Ahroon WA (2018). Dependability of conditioned middle ear muscle contractions. Presented at the U.S. Office of Naval Research Noise-Induced Hearing Loss Program Review, Portland, OR, August 2018.

Flamme GA, Ahroon WA, Tasko SM, Deiters KK, Murphy WJ, Jones HG, Greene NT (2018). Effects of acoustic impulses on the Middle Ear. Presented at the USAMRMC In-Progress Review meeting, Ft. Detrick, MD, July 2018.

Flamme GA, Tasko SM, Deiters KK, Murphy WJ, Jones HG, Ahroon WA, Greene NT (2018). Anticipatory middle ear muscle contractions in damage-risk criteria. Presented at the Acoustical Society of America Spring Meeting, Minneapolis, MN, May 2018.

Tasko ST, Flamme GA, Deiters KK, Ahroon WA, McGregor KD, Smith MV, Murphy WJ, Greene NT, Jones HG (2018). Can middle ear muscle contractions provide dependable protection from impulse noise?

Presented at the 3rd Japan-US Technical Information Exchange Forum on Blast Injury (JUFBI), Tokyo, Japan, May 2018.

Flamme GA, Tasko SM, Deiters KK, Greene NT, Murphy WJ, Jones HG, Ahroon WA (2018). Middle ear muscle contractions as hearing protection? Presented at the Annual Collaborative Auditory Vestibular Research Network (CAVRN), Dayton, OH, April 2018.

Flamme GA, Tasko SM, Deiters KK, Greene NT, Murphy WJ, Jones HG, Ahroon WA (2018) Laboratory Conditioning of Middle Ear Muscle Contractions. Presented at the National Hearing Conservation Association Annual Meeting, Orlando, FL, February 2018.

Tasko SM, Flamme GA, Deiters KK, Smith MV, Murphy WJ, Jones HG, Greene NT, Ahroon WA (2018). Concomitant head/neck muscle activity and middle ear muscle contractions. Poster presented at the National Hearing Conservation Association Annual Convention, Orlando, FL, February 2018.

Smith MV, Tasko SM, Flamme GA, Deiters KK, Murphy WJ, Jones HG, Greene NT, Ahroon WA (2018). Middle ear muscle activity associated with mastication. Poster presented at the National Hearing Conservation Association Annual Convention, Orlando, FL, February 2018.

Flamme GA, Tasko SM, Deiters KK, Greene NT, Murphy WJ, Jones HG, Ahroon WA (2018). Middle ear muscle contractions are not dependable hearing protection. Presented at the American Auditory Society Annual Conference, Scottsdale, AZ, February 2018.

Deiters KK, Flamme GA, Tasko SM, Murphy WJ, Greene NT, Jones HG, Ahroon WA (2018). Generalizability of clinically-measured acoustic reflexes to brief sounds. Presented at the National Hearing Conservation Association Annual Convention, Scottsdale, AZ, February 2018.

Green NT, Jones HG, Flamme GA, Tasko SM, Deiters KK, Ahroon WA (2018). A method of detecting frequency dependence in middle ear muscle contractions during task engagement. Poster presented at the Association for Research in Otolaryngology (ARO) 41st Annual MidWinter Meeting, San Diego, CA, February 2018.

Greene NT, Jones HG, Flamme GA, Tasko SM, Deiters KK, and Ahroon WA (2017). Acoustic and non-acoustic elicitors of middle ear muscle contractions in military and civilian populations. Presented at the Military Health Science and Research Symposium, Kissimmee, FL, August 2017.

Jones HG, Greene NT, Ahroon WA, (2017). Preliminary results: Classical conditioning of the MEMC during the acoustic reflex. 2017 Military Health Science and Research Symposium, Kissimmee FL, August 2017.

Jones HG, Greene NT, Ahroon WA. Experimental testing whether the acoustic reflex can be warned. Presented at the Collaborative Auditory Vestibular Research Network (CAVRN) Meeting, San Antonio, TX, June 2017.

Smith MV, Tasko SM, Flamme GA, Deiters KK (2017) Identification of Masseter Muscle Activity during Chewing through an Automated Algorithm. Presented at the Mid-East Honors Association Annual Conference, May 2017.

Flamme GA, Tasko SM, Deiters KK, Greene NT, Ahroon WA, (2017). Reflexive and anticipatory middle ear muscle contractions for impulsive sounds. Presented at the Aerospace Medical Association's 88th Annual Scientific Meeting, Denver, CO, April 2017.

McGregor KD, Flamme, GA, Tasko SM, Deiters, KK (2017). Pervasiveness of acoustic reflexes among people tested using a diagnostic middle ear analyzer. Presented at the National Hearing Conservation Association Annual Conference, San Antonio TX, February 2017.

Tasko SM, Flamme GA, Deiters KK, Ahroon, WA, Murphy WJ (2017). Effects of non-acoustic stimuli on middle ear muscle contractions. Presented at the National Hearing Conservation Association Annual Conference, San Antonio TX, February 2017.

Flamme GA, Tasko S, Deiters K, Ahroon WA, Murphy WJ (2016). Middle ear muscle contractions (MEMCs) from non-acoustic elicitors. Presented at the 172nd Acoustical Society of America Annual Meeting, Honolulu, HI, November 2016.

Flamme GA, Tasko SM, Deiters K, Ahroon WA (2016). Prevalence of Acoustic Reflexes in the United States: Implications for Damage-Risk Criteria for Impulsive Noise. Presented at the Japan-US Technical Information Exchange Forum on Blast Injury (JUFBI-2016), Tokyo, Japan, June 2016.

Flamme GA, Tasko SM, Deiters KK, Ahroon WA (2016). Middle Ear Muscle Contraction Assessment for Impulsive Sounds. Presented at the meeting of the American Auditory Society, Scottsdale, AZ, March 2016.

Flamme GA, Deiters KK, Tasko SM, Ahroon WA (2016). Acoustic Reflex Prevalence in the United States. Presented at the Meeting of the American Auditory Society, Scottsdale, AZ, March 2016.

Flamme GA, Tasko SM, Deiters KK, Ahroon WA (2016) Reflexive and anticipatory middle ear muscle contractions for impulsive sounds. Presented at the National Hearing Conservation Association Annual Conference, San Diego, CA, February, 2016.

Flamme GA, Tasko SM, Deiters KK, Ahroon WA (2016) Are acoustic reflexes sufficiently pervasive for inclusion in Damage-Risk Criteria for impulsive noise? Presented at the National Hearing Conservation Association Annual Conference, San Diego, CA, February, 2016.

Stehouwer TJ, Flamme GA, Tasko SM, Ahroon WA, Deiters KK (2016) Measurement of Pupil Contractions in Response to Auditory Stimuli. Presented at the National Hearing Conservation Association Annual Conference, San Diego, CA, February, 2016.

Deiters KK, Flamme GA, Tasko SM, Ahroon WA (2015). Prevalence of acoustic reflexes in the United States. Poster presented at the 170th Meeting of the Acoustical Society of America, Jacksonville, FL, March 2015.

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.

Participants & Other Collaborating Organizations

What individuals have worked on the project?

Name: William A. Ahroon, Ph.D.

Project Role: Principal Investigator (USAARL)
Nearest person month worked: 3 (Calendar)
Contribution to Project: Dr. Ahroon is a Research Psychologist in the Acoustics Branch of the U.S. Army Aeromedical Research Laboratory (USAARL). As the PI for this project, he will be responsible for scientific and programmatic oversight of the project. Specifically, he will guide the protocol through the IRB and other regulatory reviews in implementing the protocol at USAARL, train and supervise research personnel, and facilitate team meetings.

Name: Gregory A. Flamme, Ph.D.
Project Role: Principal Investigator (SASRAC)
Nearest person month worked: 10
Contribution to Project: During year 1, Dr. Flamme's duties are to direct the analyses for the reflexive MEMC study, develop, test, and obtain pilot data for the reflexive and lab-based studies of reflexive and conditioned MEMC. During years 2 through 4, he will work on dissemination of prior results, direct the conduct of the lab-based MEMC studies, and coordinate with USAARL to obtain field study data that are maximally comparable across sites.

Name: Stephen M. Tasko, Ph.D.
Project Role: Co-Investigator (SASRAC)
Nearest person month worked: 3
Contribution to Project: During year 1, Dr. Tasko's duties are to develop, test, obtain pilot data, and prepare analytic routines for the EMG-based measurements obtained in this study. During years 2 and 3, he will manage the EMG-based measurements, perform ongoing quality assurance tasks, and conduct analyses on these data. During year 4, he will conduct analyses on the WMU EMG measures and work on dissemination of study data.

Name: Kristy K. Deiters, Au.D.
Project Role: Co-Investigator (SASRAC)
Nearest person month worked: 3
Contribution to Project: Dr. Deiters will be the project coordinator during all years of the project, focusing on participant recruitment, day-to-day operations, and coordinating efforts between WMU and USAARL. During years 2 through 4, she will also be responsible for data management, quality assurance, descriptive analyses, preparing data sets for inferential analyses, and dissemination.

Name: Heath Jones, Au.D.
Project Role: Co-Investigator (USAARL)
Nearest person month worked: 3
Contribution to Project: Dr. Jones will be involved with participant recruitment and scheduling as the on-site contact for the field testing being conducted at USAARL. He will also be assisting with IRB protocol management, data collection, quality assurance, and dissemination.

Has there been a change in the active other 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.

Special Reporting Requirements

Quad Chart:

Attached.

Appendices

None.