Celebrating our 20th anniversary

VA RR&D

NCRAR

National Center for Rehabilitative Auditory Research

2017 Annual Update

VA

U.S. Department of Veterans Affairs

Veterans Health Administration

VA Portland Health Care System

National Center for Rehabilitative Auditory Research

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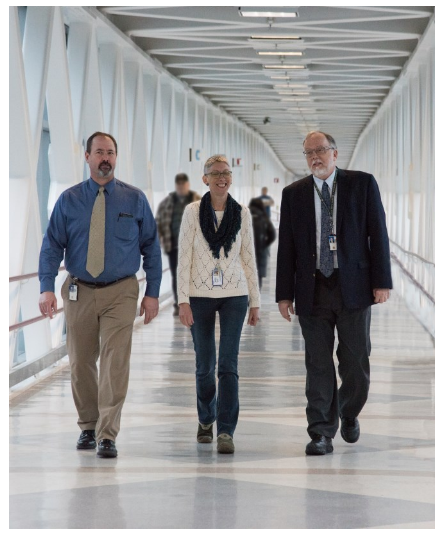
A Word from the NCRAR Director

Dr. M. Patrick Feeney

Welcome to the first NCRAR annual update. We will use this vehicle to communicate comprehensive annual progress at the Center. I will start by highlighting awards and honors in the past year. Our very own Dr. James Henry received the *2017 James Jerger Award for Research in Audiology* “awarded to an individual for research contributions in the field of audiology/hearing science, whose work has had major impacts on the field and/or practice of audiology.” This award honors a research career that Jim has dedicated to those suffering with tinnitus. The Frederick V. Hunt Postdoctoral Research Fellowship from the Acoustical Society of America was awarded to Anna Diedesch, Au.D., Ph.D. who was mentored on by Dr. Frederick (Erick) Gallun. Anna’s research involved sound localization performance for hearing-impaired individuals and hearing aid users. Anna is now an Assistant Professor of Audiology at Western Washington University. Dr. Gaby Saunders, Associate Director of the NCRAR, was given an Honorary Appointment with the University of Nottingham, School of Medicine. Additionally, Gaby and her research team received the 2017 Ear and Hearing Editors’ Award for the publication ‘A Randomized control trial: Supplementing hearing aid use with Listening and Communication Enhancement (LACE) Auditory Training’ [Saunders et al., (2016). *Ear and Hearing*, 37(4), 381-396].



NCRAR Administration (l-r): Patrick Helt, Deputy Director/ Administrative Officer; Dr. Gaby Saunders, Associate Director; Dr. Patrick Feeney, Center Director.

There were a number of significant projects related to the Center’s work in ototoxicity monitoring this year. To highlight just one, in collaboration with the DoD Hearing Center of Excellence, several NCRAR staff members serve on a national *Working Group on Otoxicity*. This year Dr. Dawn Konrad-Martin spearheaded a review of U.S. national audiology guidelines in relation to “real world” ototoxicity monitoring programs and identified successful monitoring strategies, gaps and barriers. The results were published in ‘Applying U.S. national guidelines for ototoxicity monitoring in adult patients: Perspectives on patient populations, service gaps, barriers and solutions’ (Konrad-Martin et al., 2017).

Dr. Gallun, in collaboration with Dr. Michelle Molis, Dr. Aaron Seitz of the University of California, Riverside Brain Game Center, and Dr. David Eddins of the University South Florida of have developed two applications available for free on the iTunes App Store. The first, Spatial Release, is an iPad-based version of a test of the use of binaural cues, and *Listen: An Auditory Training Experience*, is a game that uses auditory stimuli to increase listener sensitivity to spectrotemporal modulations and differences in spatial location. Both apps are currently being examined for usability and effectiveness in laboratories across the world. A recent related publication is ‘Validating a rapid, automated test of spatial release from masking’ (Jakien et al., 2017).

The NCRAR held a very successful Biennial Conference on October 4-6 titled *"Translating Tinnitus Research Findings into Clinical Practice."* Gaby Saunders was Conference Chair, Dr. Sarah Theodoroff served as Program Chair, and Christine Kaelin served as Conference Coordinator. See page 34 for more about the conference.

A number of new initiatives were funded this past year including:

Effects of Military Noise Exposure on Auditory Function in Service Members and Recently Discharged Veterans
PI: Henry. DoD, 4/2017-3/2021

Using electrophysiology to complement speech understanding-in-noise measures
PI: Billings. VA Merit, 2/2017-1/2021

A new approach to diagnosing hyperacusis in tinnitus patients
PI: Theodoroff American Tinnitus Association, 7/2017-6/2019

VA Office of Academic Affiliations (OAA) Advanced fellowship in polytrauma/traumatic brain injury rehab - research program
Fellow: Koerner; Mentors: Gallun and Billings, 7/2017-9/2019

OAA associated health professions Au.D. externship program Joint program with VAPORHCS Audiology and Speech Pathology Service
PI/Program Directors: Saunders and Hamilton-Sutherland, 10/2017-9/2018

Please enjoy this inaugural version of the NCRAR Annual Update. In it you will find descriptions of current research projects implemented by each of our investigators. Take a look at our website, or contact me or the PI if you want additional information on any of our projects.

NCRAR Staff Photo January 2018

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NCRAR's mission is to improve the quality of life of Veterans and others with hearing and balance problems through clinical research, technology development, and education that leads to better patient care.

Dr. Stephen Fausti Reflects on NCRAR's History

In honor of NCRAR's 20th anniversary this year, we are sharing some reflections from NCRAR's founder and first Director, Dr. Stephen (Steve) Fausti. Steve founded the NCRAR back in 1997, when the opportunity arose to apply for VA RR&D center funding. Steve retired in 2010, after dedicating 39 years to VA and holding the distinction of being one of the longest continuously-funded VA investigators.

Steve's inspiration for founding the NCRAR was to build an auditory research center that had the capacity to attract and cultivate auditory researchers at all stages in their career – from students to senior scientists. This model remains in place today. His plan for the Center was simple: hire staff with diverse yet complementary expertise so that the whole could become greater than the sum of its parts. Following this plan, the NCRAR has been on the cutting edge of auditory rehabilitation research since its inception in the areas of early identification of ototoxic-induced hearing loss, tinnitus evaluation and treatment, central auditory processing disorders associated with traumatic brain injury and/or blast exposure, effects of diabetes and multiple sclerosis on auditory function, hearing loss prevention, health behavior change, and many others. Steve attributes the success of the Center to being in the *right* place at the *right* time with the *right* vision and ideas. "The Center's success would not have been possible without the support of VA RR&D, though NCRAR held up its side of the bargain by being remarkably productive through the years."

Steve says his most memorable NCRAR moment was during the 2006 ribbon cutting ceremony for the completed NCRAR facility because it represented the embodiment of his vision, work and perseverance in creating the NCRAR environment, and because he believed that having a consolidated, standalone and highly visible facility for the Center would promote community and collaboration. His proudest moments, on the other hand, were seeing his staff be successful as scientists, knowing that he had contributed to their success. Going forward, Steve's hope is that the Center continues to grow and remains a premier translational research facility and a magnet for international collaborators who generate quality research with clinical application to auditory rehabilitation. In this way he hopes it can achieve its goal of *"alleviating communicative disorders that result from auditory system impairments in Veterans as well as the general public."*

The guiding principle for creating the Center was to establish and nurture an environment with "one stop shopping" in which each individual feels valued, supported and fulfills a key role – because no single function is more important than another. One of his favorite sayings is "Every successful organization is built with finders, minders, binders and grinders."

To summarize these sentiments in a few of Steve's words "If you build it they will come, and I love it when a plan comes together." And indeed it has.

NCRAR Timeline

On the following pages, you will notice a blue line running down the right-hand edge of the page. This line represents a timeline of the history of the NCRAR and highlights important milestones and memorable events that have occurred at the Center over the past 20 years. We've also included some extra photos of the Center, Portland, and the surrounding area.

NCRAR Principal Investigators

Curtis Billings, Ph.D.

I use human electroencephalography, specifically auditory evoked potentials, and behavioral methods to understand the effects of auditory deprivation and stimulation on the brain. I am interested in the neural effects of hearing impairment, aging, hearing aids, and auditory training. As a licensed audiologist, I am particularly interested in improving the diagnosis and treatment of hearing impairment by determining how experience-related changes in the brain facilitate and/or inhibit successful auditory rehabilitation.

A particularly challenging problem in auditory rehabilitation that we are working on is measuring and improving speech understanding in background noise, especially for older individuals and those with impaired auditory systems. Background noise is all around us and most of us find ourselves trying to communicate in noisy environments on a daily basis. Signal-to-noise ratios (SNR) in different everyday listening situations differ greatly as seen in **Figure 1**. A hallmark of perception-in-noise difficulties is the wide variance in performance across individuals, despite similarities in the audiogram or even the presence of audiometric thresholds within the normal range. We recently completed an analysis of over 3.5 million

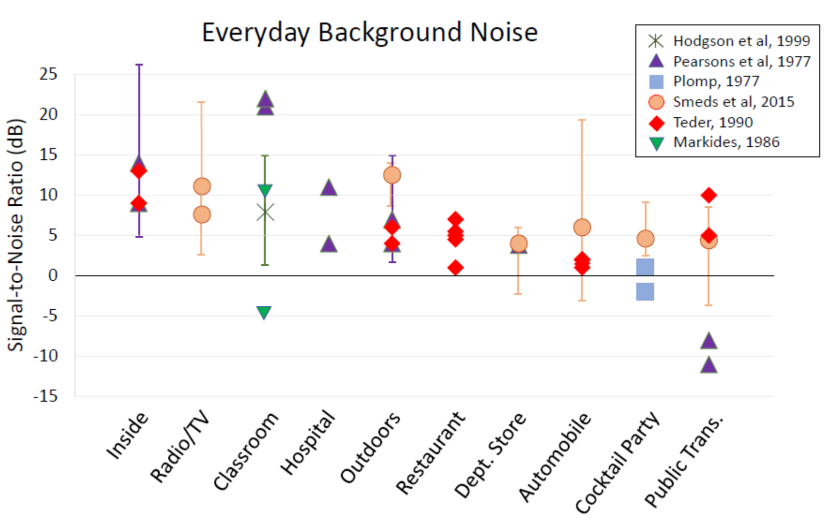
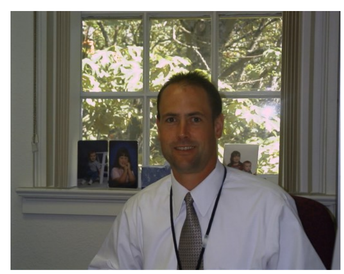


Figure 1. *Background noise is present in many everyday listening situations making communication difficult. Signal-to-noise ratios for a variety of environments generally range from about 0 to 15 dB SNR. Symbols represent means/medians and error bars represent ranges when available (figure modified from Billings & Madsen, in press).*

October 1997: *The NCRAR is established —Wendy Helt, Jim Henry, Dan McDermott, and Susan Griest were there and are still here today.*

August 1998: *Pat Helt joins as NCRAR Administrative Officer*



audiograms tested within the VA system, and determined that 10% of Veterans seen at VA audiology clinics present with normal pure-tone thresholds (Billings, Dillard et al., in press). Presumably, many of these Veterans have hearing complaints, the root cause of which lies beyond the audiogram. A physiological measure of auditory neural coding may help to explain some of this variability and perhaps serve as a substitute for speech-understanding testing in those who cannot be tested reliably.

Figure 2. Brainwaves are recorded using scalp electrodes. These neural measures help to reveal how the brain is encoding speech sounds presented in various levels and types of background noise.

In a current project, we are using various auditory evoked potentials recorded from the scalp of study participants (see **Figure 2**) as well as cognitive measures as predictors of speech understanding in noise. Our hope is that a better understanding of the contributions of bottom-up and top-down processing will allow for improved assessment of those with speech-in-noise difficulties and provide information about the processing capacity of the auditory system. This will allow the clinician to tailor treatment strategies to the specific needs of each individual and to counsel patients more effectively in terms of the expectations they should have and the benefit they should expect as a result of specific treatments.

Work supported by NIH NIDCD DC008764 and DC15240 and by the VA RR&D 5IK2RX000714 and 1I01RX002139

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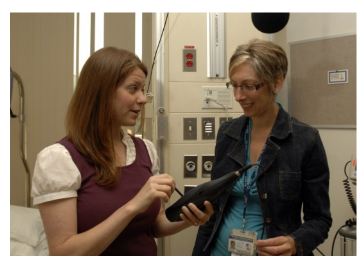
***April 2001:** groundbreaking ceremony for new NCRAR facility*

***July 2001:** Gaby Saunders joins the NCRAR as a PI*



Naomi Bramhall, Au.D., Ph.D.

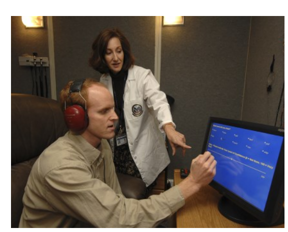
My research focuses on damage to the auditory system that can occur following loud noise exposure, but which is not detected by a standard clinical hearing test. Hair cells, the sensory cells of the cochlea, were previously assumed to be the component of the auditory system most vulnerable to damage from loud noise exposure. However, recent studies in rodents show that some types of noise exposure can damage the synapses between the hair cells and the auditory nerve, even when the hair cells are undamaged. This loss of synapses degrades the quality of the auditory signal sent to the brain. For simple listening tasks, such as detecting tones during a hearing test, this may not be noticeable. However, for more complex tasks, such as understanding speech in a noisy environment, the reduction in information likely has a bigger impact. Clinical hearing tests are insensitive to the loss of cochlear synapses because they are designed to detect hair cell damage. For this reason, synaptic damage has been termed "hidden hearing loss", because it does not show up on a standard hearing test. Until recently, it was not clear whether hidden hearing loss occurred in humans. The predicted perceptual consequences of hidden hearing loss include tinnitus, abnormal sensitivity to loud sounds, and difficulty understanding speech in background noise.

I use the auditory brainstem response (ABR), a non-invasive measure of auditory nerve function, to identify possible cochlear synaptic loss in young Veterans and non-Veterans with clinically normal hearing. Animal models of hidden hearing loss have shown a strong correlation between the amplitude of wave I of the ABR and synaptic number. I recently found lower ABR wave I amplitudes among Veterans with a history of significant loud noise exposure and non-Veterans who reported using a firearm compared to non-Veterans with minimal noise exposure. In addition, I showed that the perception of tinnitus was associated with a reduction in ABR wave I amplitude (**Figure 1**, following page). This suggests that there may be a high prevalence of hidden hearing loss among Veterans and non-Veteran firearm users and that this auditory deficit may lead to some forms of tinnitus. I am currently conducting further research to determine the best means of diagnosing hidden hearing loss in the audiology clinic, particularly in individuals who have a combination of hair cell loss and synaptic damage. The ability to diagnose hidden hearing loss will help us understand how synaptic loss affects auditory perception, an important first step in developing treatments for this type of auditory damage.

November 2001: *Inaugural NCRAR Hearing Tonight public lecture*

October 2002: *NCRAR Center Grant renewed*

April 2003: *Dawn Konrad-Martin joins the NCRAR as a PI*



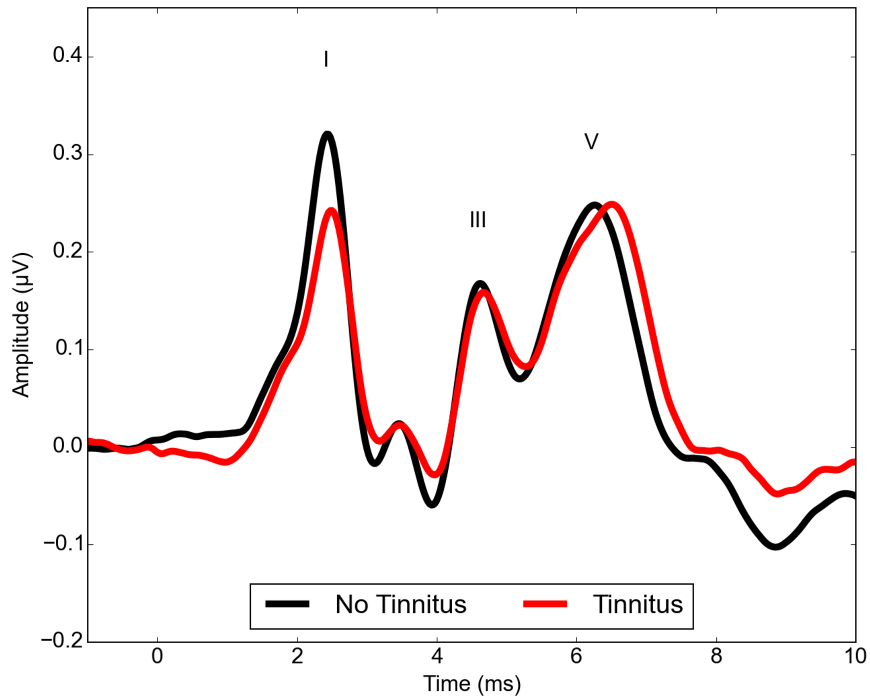


Figure 1. *Mean ABR waveforms by tinnitus group. Grand mean ABR waveforms for a 110 dB p-pe SPL 4 kHz toneburst are plotted for participants with and without tinnitus. The group with tinnitus shows a reduction in wave I amplitude compared to the no tinnitus group.*

Two students contributed to work in the lab this year. Rachel Etzler, an audiology graduate student, joined the lab this summer as part of the NIH T-35 training program. She helped analyze envelope-following response data from study participants with and without a history of loud noise exposure and presented her results at the 2018 American Auditory Society. Chris Niemczak began his Au.D. externship with us in July 2017. In addition to helping test subjects on a large battery of physiological measures, Chris is analyzing data from auditory evoked potentials collected from study participants.

Work supported by VA RR&D awards C1484-M and C9230-C (to NCRAR).

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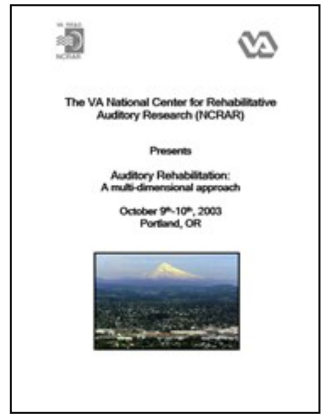
October 2003: *1st Biennial NCRAR Conference—Auditory Rehabilitation: A Multi-dimensional Approach*


The VA National Center for Rehabilitative Auditory Research (NCRAR)

Presents

Auditory Rehabilitation:
A multi-dimensional approach

October 9th-10th, 2003
Portland, OR

April 2004: *Dr. Fausti receives the Paul B. Magnuson Award for outstanding achievement in rehabilitation research and development from VA RR&D*

Michelle Cameron, M.D., P.T.

My research focuses on optimizing mobility in people with multiple sclerosis (MS). MS is the most common disabling neurologic disease of young adults. It affects over 900,000 people in the United States, over 2.5 million people worldwide, and 16,000 Veterans, approximately 6,000 of whom are service-connected for MS.

MS impairs cognition, muscle strength, muscle tone, sensation, coordination, balance and gait, all of which are associated with mobility impairment and falls. Up to 70% of people with MS fall at least once in a 6-month period, with around 50% falling multiple times. The long-term goal of my research is to optimize mobility, and thereby independence and quality of life, in people with MS. I am taking a range of approaches to achieve this goal. First, I am working on determining the epidemiology and mechanisms underlying falls and imbalance in people with MS. Second, I am evaluating a range of rehabilitation interventions for fall prevention in people with MS. And, finally, I am working with engineers to optimize automated detection of mobility metrics and falls in people with MS. This work will not only contribute to improving the lives of people living with MS but will also contribute to improving the lives of people living with other conditions, such as stroke, orthopedic injury, traumatic brain injury, and Parkinson's disease, associated with impaired mobility.

Figure 1. *Subject participating in ADSTEP .*

This year I completed a pilot study evaluating a multicomponent walking aid program, ADSTEP, that includes device selection, fitting and training (**Figure 1**). I found that this program helped prevent falls and altered functional brain connectivity as detected by functional MRI, while also showing moderate to strong trends for increasing walking time and reducing sitting time (**Figure 2**, following page). I have applied for Merit Review funding to evaluate the impact of this training program on falls and objectively measured physical activity through a full scale two-site randomized controlled trial.

September 2005: *2nd Biennial NCRAR Conference—The Aging Auditory System: Considerations for Rehabilitation*

October 2005: *Marjorie Leek joins NCRAR as a PI and Deputy Director of Research*

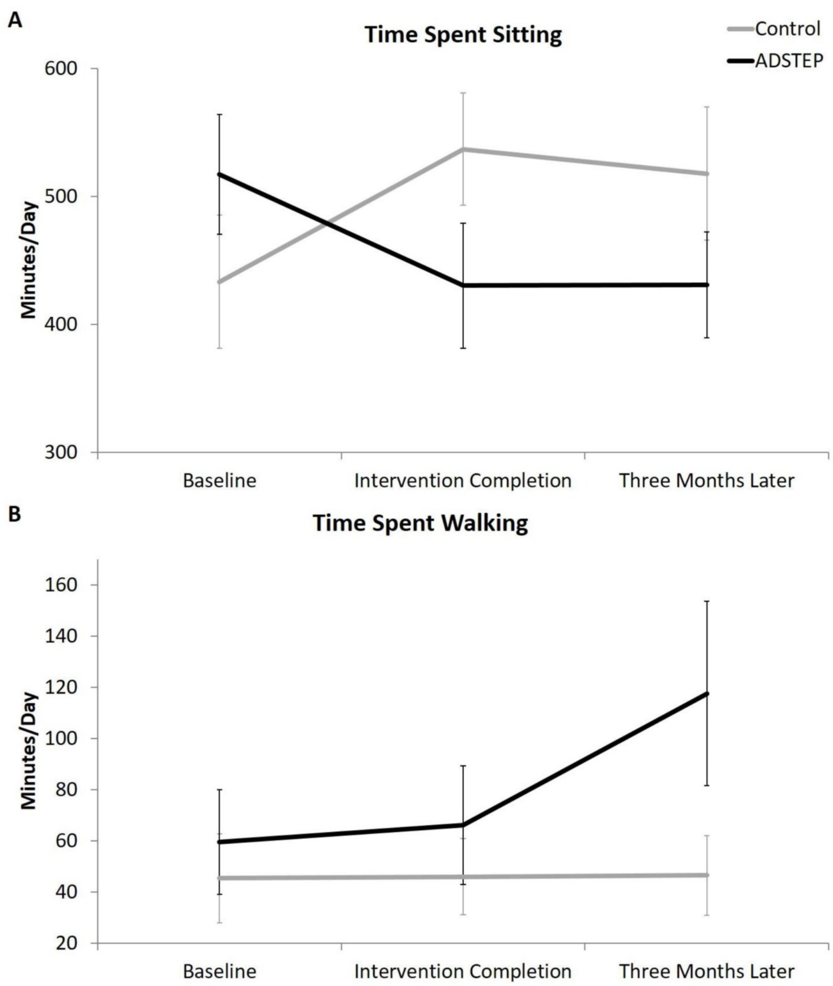


Figure 2. A: ADSTEP was associated with greater decrease in time spent sitting than control. B: ADSTEP was associated with greater increase in time spent walking than control.

I am also currently conducting a full-scale, single-site randomized controlled trial of a comprehensive 8-week education and exercise MS fall prevention program, Free From Falls, that includes optimizing an automated body-worn fall detection device. We have thus far enrolled 73 of the projected 94 subjects for this study.

Work supported by VA RR&D 5I21RX001918-02

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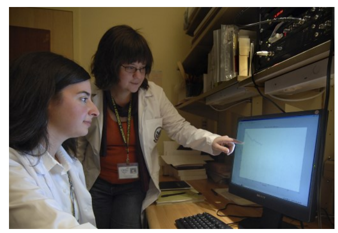
***February 2006:** Michelle Molis joins the NCRAR as a PI*



***May 2006:** The current NCRAR facility opens and staff start moving in*

Kathleen Carlson, Ph.D.

The goal of my research program is to inform the development of services that work to prevent Veterans' injuries and enhance reintegration, participation, and quality of life among Veterans who have incurred injuries related to their military service. Much of my research focuses on Veterans with traumatic brain injury (TBI) and its common comorbidities (tinnitus, hearing loss, post-traumatic stress disorder, pain, etc.). In 2017, several projects on TBI and tinnitus took center stage.

Dr. James Henry and I worked on a VA-sponsored project focused on tinnitus rehabilitation needs and interests among Veterans with and without a history of TBI. This study will help us develop materials and strategies for making sure that effective tinnitus services are available across the VA. This 2-year mixed-methods project involves a survey of a random sample of Veterans with tinnitus with and without TBI. An in-depth follow-up phone interview will be conducted with a smaller group of survey respondents. In 2017, we developed and pilot tested a survey instrument that covers the key topics important to the project. We also received pilot feedback from a Veteran steering committee with whom our team closely works. Finally, we designed a 14-page survey booklet (**Figure 1**) along with a matching online survey, so that our random sample of Veterans has the option of completing the survey in either format. We will roll-out the survey later this year.

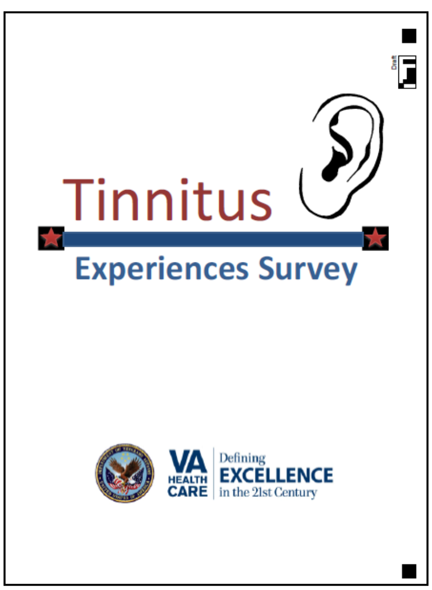


Figure 1. Cover of the Tinnitus Experiences Survey.

As part of this project, we have also analyzed VA healthcare data for Veterans who have been diagnosed with tinnitus, comparing their healthcare utilization and comorbid diagnoses to Veterans without tinnitus diagnoses. We found that 13% of all Veterans who used VA healthcare between 2011 and 2016 had been diagnosed at least once with tinnitus; 4% had been diagnosed more than once. When comparing Veterans with tinnitus diagnoses to those without, we found that tinnitus was associated with greater VA healthcare utilization and greater likelihood of comorbid mental health, behavioral health, and pain

November 2006: *Erick Gallun joins the NCRAR as a PI*

January 2007: *1st seminar in NCRAR Seminar series*

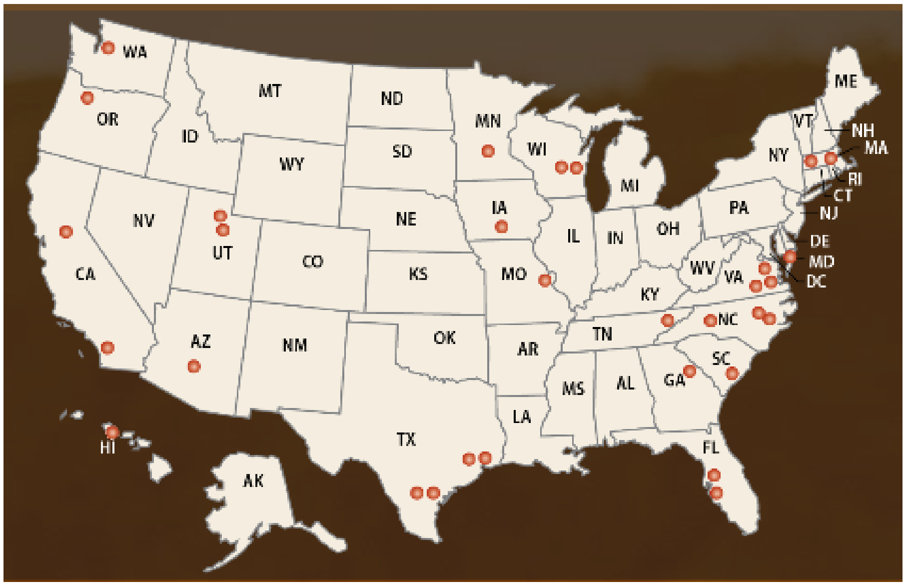


Figure 2. Enrollment sites for VA/DoD-funded CENC research (Source: cenc.rti.org)

diagnoses. The findings from this work suggest a need for coordinated audiology and mental healthcare services for Veterans in the VA system of care who have bothersome tinnitus.

Dr. Henry and I also collaborate as site PIs for the VA-Department of Defense (DoD) Chronic Effects of Neurotrauma Consortium (CENC) study examining the long-term effects of concussion/mild TBI (mTBI). We are focusing on the associations between mTBI, neurodegeneration, cognitive decline (e.g., dementia), and auditory outcomes of mTBI. In the last year, we started enrolling subjects at the Portland site, and finished the year with 53 enrollees who will be followed over their lifetimes. Portland participants joined nearly 1,200 other enrolled Veterans from CENC sites all around the country (**Figure 2**). Veterans who enroll undergo an initial full day of testing to determine their TBI history along with assessment of the prevalence, type, and intensity of symptoms that might be related to mTBI. We will then assess function annually to track any declines.

Work supported by DoD W81XWH-13-2-0095, VA HSR&D PPO-13-123, VA RR&D C2216-P, and VA CSR&DSPLF-001-13F

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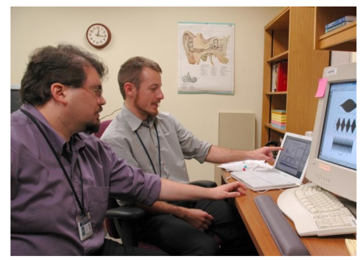
June 2007: *NIH T-35 grant awarded*



July 2007: *NCRAR Au.D. Extern program begins*

September 2007: *3rd Biennial NCRAR Conference—Hearing Therapies for the Future*

Patrick Feeney, Ph.D.

My primary research interest is in the assessment of auditory function to improve the diagnosis, monitoring and screening of hearing loss. I collaborated with Dr. Douglas Keefe (Boys Town National Research Hospital) in the first use of wideband reflectance to measure the acoustic stapedius reflex (ASR) in 1999. That study eventually led to methods for detection of the ASR threshold, which is the basis for current wideband ASR tests recently developed with Drs. Keefe and Lisa Hunter (Cincinnati Children's Hospital).

One focus of our work this year was reporting on our longitudinal study funded by NIH NIDCD: Wideband Clinical Diagnosis and Monitoring of Middle-Ear and Cochlear Function (Feeney, Hunter and Keefe, PIs). In that study we conducted longitudinal monitoring of patients with cystic fibrosis (CF) being treated with ototoxic antibiotics such as tobramycin for lung infections. We used transient-evoked otoacoustic emissions and distortion product otoacoustic emissions extending to 8000 Hz and found them to be useful for evaluating ototoxic changes in auditory function. These physiological measures of auditory function can be used when patients are unable to perform behavioral hearing tests due to illness. Ototoxic hearing loss starts in the highest frequencies and progresses to lower frequencies. **Figure 1** shows exemplary hearing threshold data from one patient with CF who had a progressive ototoxic hearing loss. The patient routinely received IV-aminoglycosides and had a high frequency hearing loss on her first evaluation for the study (**Figure 1**, visit 1). She had a decline in high-frequency hearing from baseline on visits 2 and 3, with a reduction in distortion product otoacoustic emission signal-to-noise ratio (SNR) at 8 kHz on visit 3 consistent with the audiogram. In future studies we plan to use transient evoked

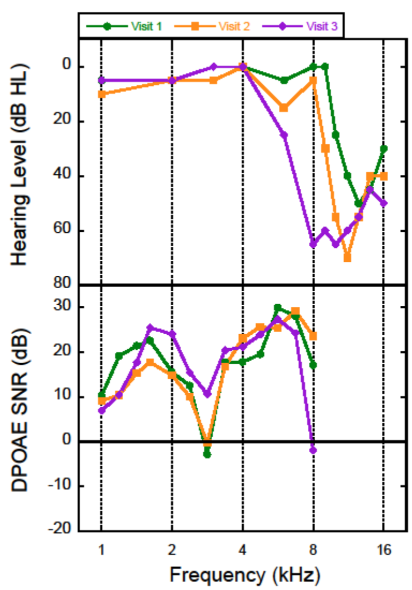
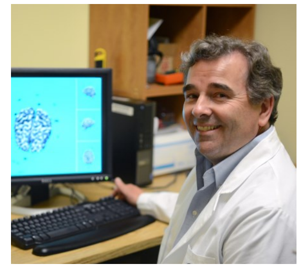


Figure 1. Puretone audiogram (top panel) and distortion product otoacoustic emission (DPOAE) signal-to-noise (SNR) for a patient with progressive sensorineural hearing loss on three test visits.

September 2007: Bob Folmer joins the NCRAR as a PI



October 2007: NCRAR Center Grant Renewed otoacoustic emissions that extend in frequency to 14 kHz to provide an earlier indication of ototoxic hearing loss that progresses from high to low frequencies. Wideband reflectance measures obtained as part of this study were useful in separating changes observed in transient otoacoustic emissions caused by middle ear versus inner ear dysfunction.

Our lab is also currently involved in data collection with Dr. Kim Schairer, Mountain Home VA, on a VA Merit Review study, Comprehensive Wide Bandwidth Test Battery of Auditory Function in Veterans, which uses a wideband test battery (wideband tympanometry, wideband acoustic reflex thresholds and otoacoustic emissions) to assess auditory function of Veterans.

Figure 2. *Demonstration of subject taking the automated digits-in-noise hearing screening on a touchscreen kiosk.*

This year we also continued data collection for an NIH-funded study to compare the extent to which three different automated adult hearing screening methods motivate patients to seek an audiological evaluation within 6 months of failing a hearing screening. As further described by Dr. Folmer (see Page 16), subjects screened their own hearing using a touch-screen kiosk (**Figure 2**). The three different screening methods used were: an automated audiogram, a pure tone fixed-level screener at four frequencies, and a digits-in-noise test. Data collection for this study is almost complete.

Work supported by NIH NIDCD DC011769 and DC010202 and VA RR&D RX001268

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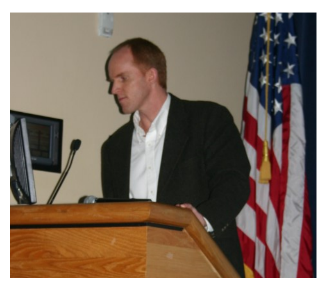
2008 NCRAR Staff Photo

August 2008: *Curtis Billings joins the NCRAR as a PI*



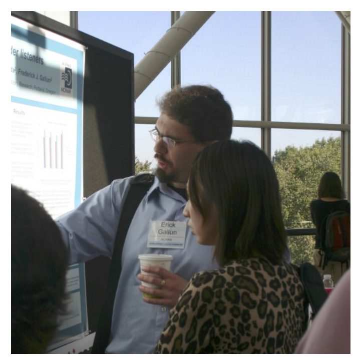
Robert Folmer, Ph.D.

In collaboration with Dr. Patrick Feeney (see Page 14) and our colleagues at Indiana University, we developed and tested a hearing screening program that is self-administered via personal computer. The hearing screener is a digits-in-noise (DIN) test that consists of sequences of three spoken digits presented at varying signal-to-noise ratios (SNRs). Participants entered each three-digit sequence they heard using an on-screen keypad. This computer version of the DIN test demonstrated excellent sensitivity and specificity for our sample of 40 participants. Therefore, this test should be very useful for adult hearing screening and could be made available to large numbers of people via the internet. Detailed results of this study are in Folmer, Vachhani, McMillan et al. (2017).

Our research group also completed and published results of a study that assessed auditory processing abilities of patients with Parkinson's Disease (PD). Since PD primarily affects older people, a majority of PD patients have age-related hearing loss (HL) that will worsen over time. The goal of this study was to assess peripheral and central auditory functions in a population of PD patients and compare the results with a group of age-matched healthy control subjects. Assessments included questionnaires, neuropsychological tests, audiometric testing, and a battery of central auditory processing tests. Both study groups exhibited patterns of sensorineural hearing loss (slightly worse in the PD group) which were typical for their age and severe enough to contribute to difficulties in communication for many participants. Compared to the control group, PD patients reported greater difficulty in hearing words people are speaking. Although 27 PD patients (77%) were good candidates for amplification, only 7 (26%) of these hearing aid candidates used the devices. Because it is important for PD patients to optimize communication with their family members, caregivers, friends, and clinicians, it is vital to identify and remediate auditory dysfunction in this population as early as possible. Detailed results of this study are in Folmer, Vachhani, Theodoroff et al. (2017).

NCRAR is one of several sites the U.S. and Canada that participated in a clinical trial of the Portable Neuromodulation Stimulator (PoNS™) device for patients who have problems with balance or gait associated with mild-to-moderate traumatic brain injury (TBI). The PoNS™ device (**Figure 1**, following page) delivered a pattern of mild electrical stimulation to the patient's tongue while he/she participated in a five-week physical therapy training program. The central hypothesis of the clinical trial is that PoNS™

October 2009: *4th Biennial NCRAR Conference—The Ear-Brain System: Approaches to the Study and Treatment of Hearing Loss*



January 2010: *NCRAR Open House*

will enhance the improvement in balance and gait exhibited by study participants post-training by stimulating cranial nerves, the cerebellum, and higher brain regions. Data collection for the study is complete; results are being analyzed and will be submitted for FDA approval. PoNS™ technology was originally developed by the Tactile Communication and Neurorehabilitation Laboratory at the University of Wisconsin. PoNS™ is now manufactured by a company called Helius Medical Technologies.

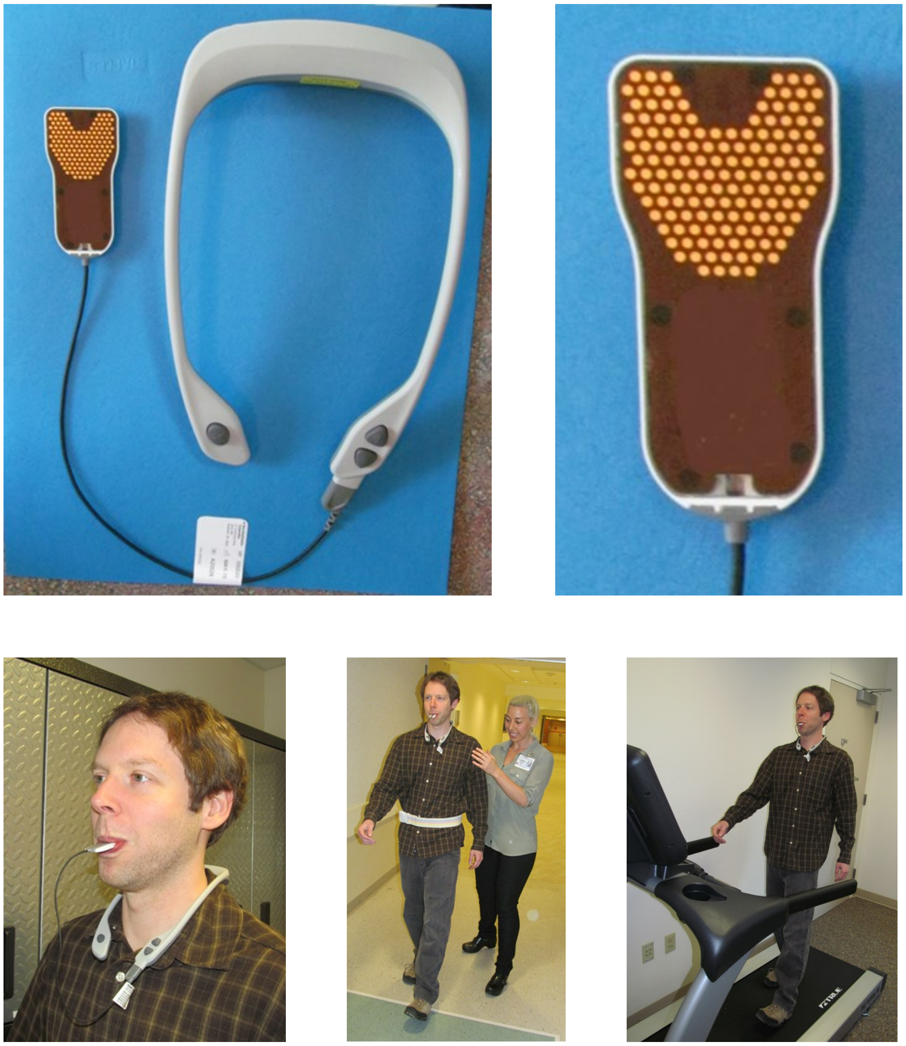


Figure 1. *T he PoNS™ device consists o f a control unit that fits around the neck, plus a mouthpiece that has rows of gold-plated electrodes. The electrodes are placed on top of the tongue and deliver waves of mild stimulation while patients complete physical therapy training exercises.*

Work supported by NIH NIDCD R21 DC011769 01, VA RR&D C8016P, and Helius Medical Technologies

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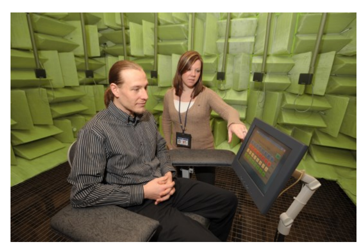
Folmer NCRAR webpage

April 2010: *Dr. Fausti receives Jerger Career Award for Research in Audiology from the American Academy of Audiology*

April 2010: *Michelle Cameron joins NCRAR as a PI*

April 2010: *Anechoic chamber upgraded*



Frederick (Erick) Gallun, Ph.D.

The work in my lab can be summarized by the idea that exposure to high-energy explosions (“blasts”) and aging can both increase the risk of having trouble doing complicated listening tasks even when the ability to do simple auditory detection tasks is preserved. These findings have come out the Gallun Lab’s focus on the ability of listeners to perform complex listening tasks representative of the activities that comprise real world listening behavior.

The work on blast exposure has continued in 2017 through projects involving Dr. Melissa Papesh, Dr. Tess Koerner, Dr. Sheila Pratt (Pittsburgh VA) and Dr. Lindsey Jorgensen (Sioux Falls VA), among many others who work tirelessly to collect and analyze the data from this important population. The work on aging involves multiple collaborators as well, including one NIH-funded project (described below) involving Dr. Aaron Seitz (UC Riverside), Dr. Michelle Molis and Dr. David Eddins (University of South Florida) and one on hearing aid processing headed by Dr. Pamela Souza (Northwestern University) and involving Dr. Richard Wright (University of Washington).

All of these projects are tied together by the attempt to assess the ability to do complex auditory tasks such as separating multiple sound sources using the various auditory cues available, and/or by assessing the ability to make judgments about the spatial, temporal, and spectral information contained in complex sounds. Our participants range in age from 18 to 89 and have hearing that varies from very good to moderately poor. Some of our participants have been near explosions during their military career, or have suffered blows to the head. Some of them have no complaints about their ability to hear and understand speech, while others find listening in noisy environments to be very difficult. Our goal is to do a better job of understanding the problems these people have and what we can do about it. We are also working to find out why some of these people appear to benefit from

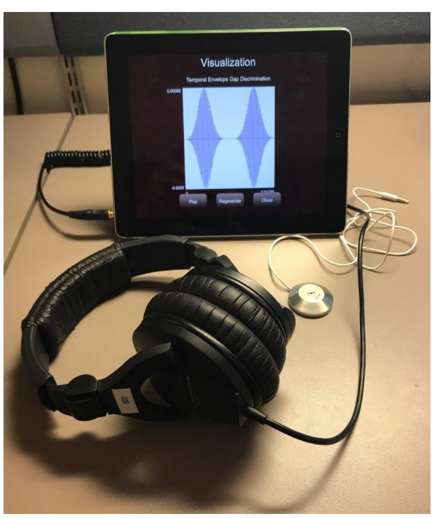
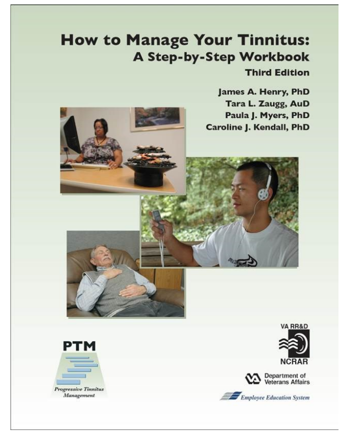


Figure 1. Portable Automated Rapid Testing (PART) equipment and user interface.

2010: Progressive Tinnitus Management (PTM) handbook distributed to VA audiologists



***November 2010:** Dr. Fausti retires*

***November 2010:** Dr. Leek serves as interim Center Director* wearing hearing aids even though their basic ability to detect tones appears normal.

Our goal of improving both assessment and rehabilitation is best captured by two of our newest projects. The first is to develop and evaluate Portable Automated Rapid Testing (PART) measures (**Figure 1**, previous page) that are appropriate for expanding the diagnostic capabilities of the clinic and yet require minimal additional time and equipment. This project from the National Institutes of Health (NIH; R01 DC01501) is headed by Drs. Gallun, Eddins, and Seitz. The second new direction is also a collaboration with Dr. Seitz, who is the Director of the UC Riverside Brain Game Center. In 2017, Drs. Seitz and Gallun were awarded

Figure 2. *'Listen: An Auditory Training Experience' user interface.*

an NIH grant to study the effects of auditory training using an engaging game that can be played on the iPad (**Figure 2**). This game seeks to improve sensitivity to those same auditory stimuli that we believe are at the basis of the impairments we see in our participants. By providing an interesting and fun way to become more sensitive to spectral, temporal, and spatial cues, we hope to be able to improve the auditory function of those who play the game that will also lead to improvements in the real-world behaviors with which they struggle and complain that they cannot do. With these portable automated rapid tests, we hope to bring sophisticated auditory testing and training into the clinics and homes where they are needed. To experience the games and evaluations being developed by the UC Riverside Brain Game Center, including *Listen: An Auditory Training Experience*, visit https://bgc.ucr.edu/games/

Work supported by VA RR&D RX 001164 (PI Pratt); NIH R01 DC 015051 (PIs Gallun, Seitz, Eddins); NIH R03 HD 094234 (PI Seitz); NIH R01 DC 006014 (PI Souza); VA RR&D C7751 (PIs Gallun, Leek); NIH R01 DC 011828.

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July 2010: *DoD/VA Joint Incentive Fund (JIF) Hearing education booths are operational and one is installed in the hospital's Specialty Clinic waiting area*

July 2010: *Transcranial Magnetic Stimulation research at the NCRAR*

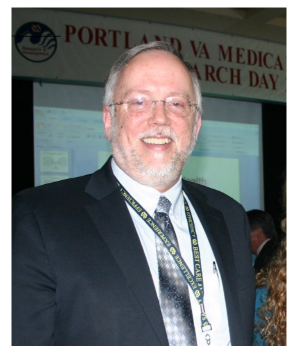
James Henry, Ph.D.

Tinnitus of at least 6 months duration is usually a permanent condition for which there is no cure. Veterans whose tinnitus is bothersome must rely on methods designed to reduce emotional and functional effects of tinnitus. My research is focused on determining whether there is evidence that these methods are effective, and reporting the findings. Such studies are essential for determining the treatment efficacy of devices that are marketed both within and outside of the VA health care system. During the past year, my team has been involved with two randomized controlled trials (RCTs) evaluating specific tinnitus-treatment devices. The first RCT, which we completed early in 2017, evaluated a novel device (Levo system) for acoustic treatment of tinnitus during sleep. The device presents the users with a sound that mimics the sound of the tinnitus with the intent to reduce tinnitus-related distress and/or perceived loudness of tinnitus. We found that both the Levo device and a sham device that presented broadband noise improved reactions to tinnitus more than did standard-of-care treatment (a bedside sound generator). The results are published in Theodoroff et al. (2017). The second RCT is in the enrollment phase. It will determine if the Desyncra sound-based therapy device results in greater reduction in effects of tinnitus compared to cognitive-behavioral therapy (CBT).

In addition to collaborating on the two tinnitus-related projects described by Dr. Carlson (page 12), we are also conducting a longitudinal epidemiology study in collaboration with the Department of Defense Hearing Center of Excellence, San Antonio, Texas. Participants complete comprehensive audiometric testing and 15 questionnaires (18 if they have tinnitus). To date, over 500 Veterans and active Service Members have been enrolled, with a mean age of approximately 33 years. For these samples of study participants, tinnitus has an impact on military Service Members that is comparable to how it affects Veterans who have completed their military service within the previous 2.5 years. For both cohorts, the presence of tinnitus has effects on job performance, concentration, anxiety, depression, and sleep. These data are the first to directly address the question of how tinnitus impacts military Service Members' lives and daily activities.

I am also interested in educating clinicians about tinnitus management. Five years ago, my research group and I developed a comprehensive, 19-module tinnitus training course—Progressive Tinnitus Management (PTM,

April 2011: *Dr. Feeney joins the NCRAR as a PI and as Center Director*



May 2011: *Dr. Saunders becomes NCRAR Associate Director*

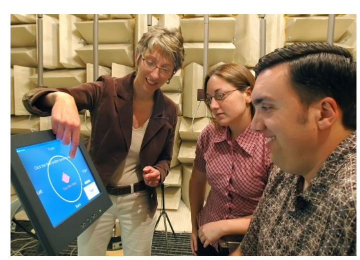


Figure 1)— that has been posted on the VA Talent Management System (TMS). We are in the process of working with outside entities to condense that program into fewer modules. Specifically, we are working with the VA Employee Education System (EES) to develop a 4-module tinnitus training course for VA and DoD clinicians, and with the American Board of Audiology (ABA) on a 7-module training course that will be available to any audiologist, regardless of their affiliation.

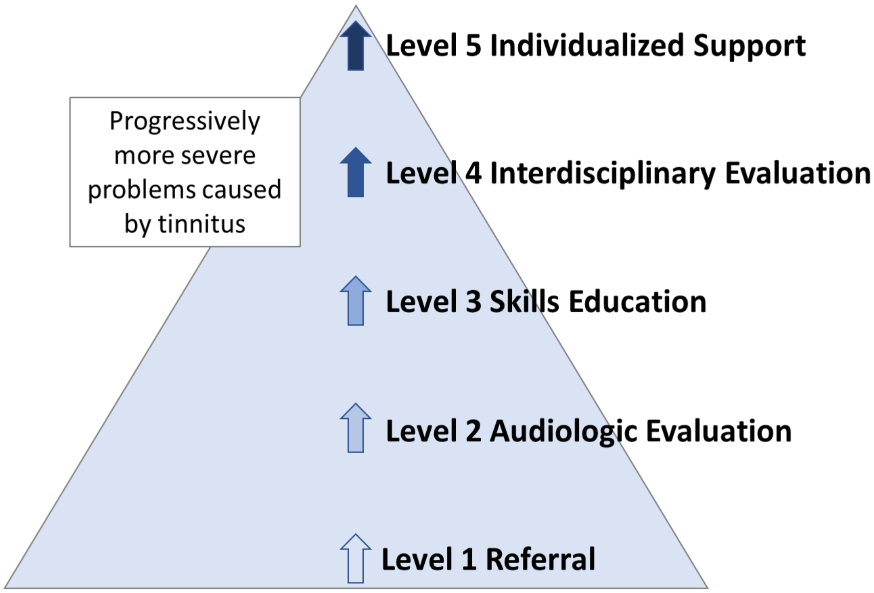


Figure 1. Five levels of progressive tinnitus management (PTM). Each higher level reflects a greater intensity of clinical services, and patients progress only to the level needed.

Work supported by Baker Group LLP (Otoharmonics), 387004/MIRB 3631, (PIs Henry, Theodoroff); Desyncra Tinnitus Limited, PVARF 387005, (PIs Henry, Theodoroff); DoD-CDMRP W81XWH-17-1-0020

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2011 NCRAR Staff Photo

October 2011: *5th Biennial NCRAR Conference—Expanding Our Horizons: Medical Conditions & Audiology*

Dawn Konrad-Martin, Ph.D.

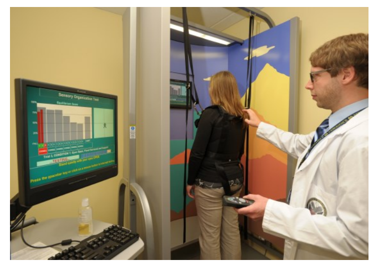
My research interests include determining the pathophysiological changes and functional consequences caused by common forms of acquired hearing loss (from normal aging, diabetes, ototoxicity and noise overexposure). I use non-invasive physiological techniques, including auditory evoked potentials and otoacoustic emissions, to translate findings in animal models to humans, with the goal of improving current clinical assessment and rehabilitation strategies. Below I describe a bit about two of my ongoing studies—one focuses on ototoxicity monitoring; the other focuses on the auditory impacts of diabetes.

The goal of my ototoxicity monitoring research is to increase the clinical provision, uptake and value of ototoxicity monitoring (OM) in order to optimize quality of life for patients who are receiving ototoxic drug therapies as part of cancer treatment. This year we worked on three aspects of OM. First, we are part way through a randomized clinical trial in which use of our automated OM system is contrasted with usual care. Those randomized to the automated OM received hearing testing chairside on the oncology unit. All patients in this group were willing and able to take an automated hearing test prior to each cisplatin treatment. In contrast, only 50% of Veterans randomized to usual care received any form of OM during their treatment with cisplatin. Typically, this OM occurred at a single timepoint, and therefore could not inform chemotherapy treatment aimed at optimizing patient survival while preserving auditory function. Thus, our preliminary data indicate that the use of chairside automated testing improves patient access to and acceptance of hearing healthcare during chemotherapeutic treatment (Konrad-Martin et al. 2017a). Unfortunately, regardless of group, only 10% of chemotherapy patient participants attempted to correct ototoxic damage through getting a hearing aid or hearing aid adjustment up to one year following treatment.

Using data captured in the clinical trial, we developed a model of ototoxicity in head and neck cancer patients receiving chemoradiation with large, bolus vs. lower, weekly doses of cisplatin. The weekly dosing lowered the risk of ototoxicity by about half compared with bolus dosing among young patients with good pre-treatment hearing. This model shows how cisplatin ototoxicity incidence differs depending on specific features of the patient (age, pre-treatment hearing) and their chemotherapy treatment (cisplatin and radiation dose). Additionally, model results could be obtained for individual patients to tailor pre-treatment counseling regarding

March 2012: *Kathleen Carlson joins the NCRAR as a PI*

July 2012: NCRAR *balance lab equipment installed*



October 2012: *NCRAR Center Grant renewed* expected chemotherapy-related hearing loss. Finally, we worked with OHSU and NCRAR engineers to complete our fully digital audiometer with high-frequency hearing testing capability and digital signal processing to allow distortion-product otoacoustic emission (DPOAE) testing (Brungart et al. 2017). We will use this system to experiment with development of automated DPOAE features that could be incorporated into OM testing in the future. Toward this end, we collaborated with Kristy Knight at OHSU/Doernbecher to characterize normal variability in DPOAEs over the long time periods reflective of chemotherapy regimens for a variety of childhood ages (Konrad-Martin et al. 2017b).

The goal of my diabetes research is to characterize longitudinal changes in auditory function among Veterans with and without diabetes mellitus (DM) using tests that target peripheral-, central-auditory and cognitive stages of processing. Working with Drs. Erick Gallun and Michelle Molis, we found that both hearing loss and aging reduced an individual's ability to understand rapid speech, and that hearing loss was greater among those with DM. Even after adjusting for DM-related hearing loss, DM limited the ability to use binaural cues to understand speech that is spatially separated from noise (**Figure 1**). These deficits would be expected to cause real-world communication problems.

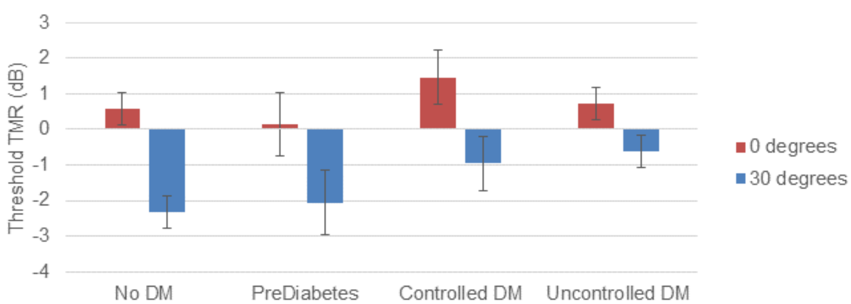


Figure 1. Understanding of target sentences that are co-located (red) versus separated (blue) relative to the spatial location of competing maskers are shown for control participants [no DM] and three groups of participants who varied in their DM severity [Prediabetes, Controlled DM, Uncontrolled DM]. For the co-located condition, target and masker sentences were presented at 0 degrees azimuth; for the spatially separated condition, the target sentence was presented at 0 degrees azimuth and the masking sentences at ± 30 degrees azimuth. All groups needed the target level to be higher than the masker level to achieve criterion performance in the collocated condition, resulting in a positive target to masker ratio (TMR). In the spatially separated condition, participants without DM or with pre-DM could understand target sentences that were more than 2 dB lower than the maskers; however, people with DM showed significantly less benefit from the spatial separation.

Work supported by VA RR&D C0239R and C7455R

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December 2012: *Melissa Papesh becomes an NCRAR PI*

January 2013: *NCRAR Open House*

June 2013: *NIH T-35 grant renewed*

Michelle Molis, Ph.D.

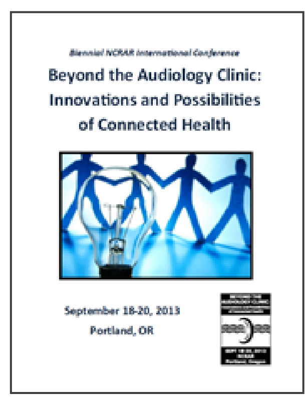
My general research approach is to apply psychophysical methodologies to the study of speech recognition in order to examine the speech perception difficulties experienced by individuals with impaired hearing capabilities. The emphases of my current research are the contribution of dynamic spectral change to the speech understanding of listeners with hearing impairment, and the change of auditory temporal processing ability across the lifespan.

Speech is an inherently dynamic signal. The loss of peripheral auditory sensitivity, precise temporal processing, and frequency selectivity associated with hearing loss will disrupt the perception of spectral change. As a result, the reduction or elimination of dynamic spectral cues may impair speech understanding for hearing-impaired listeners, especially in adverse listening conditions. Recent work in the lab has addressed the ability of listeners with and without hearing impairment to detect dynamic frequency changes in tonal stimuli and in simple speech-like stimuli. Generally, results suggest that thresholds for frequency glide detection depend on the complexity of the stimuli—frequency change is more difficult to detect in more spectrally-complex signals for all listeners. However, it remains to be determined to what degree this result is influenced by bottom-up acoustic processing or top-down phonetic factors. In conjunction with these auditory behavioral studies, I am also collaborating with Dr. Curtis Billings to record electrophysiologic responses to these same dynamic signals. We wish to know if and how the fidelity and morphology of neural responses recorded from the brainstem relate to listeners' behavioral auditory thresholds. To aid with this collaboration, two postdoctoral research fellows, Will Bologna, Au.D., Ph.D. and Ramesh Muralimanohar, Ph.D. have joined the lab this year.

The work carried out the lab also addresses auditory temporal processing across the lifespan. Impaired auditory temporal processing has been implicated as a major factor limiting speech understanding in older, hearing-impaired listeners. However, measures of temporal processing also vary among younger listeners and for listeners with thresholds in the normal range or with sub-clinical hearing losses. Previous research has demonstrated that temporally-distorted stimuli, such as artificially-speeded and reverberant speech, can be used to evaluate speech understanding relative to age, speed of processing, and working memory capacity. This year, audiology graduate student Emily Wilson participated

July 2013: *VA OAA funding for joint NCRAR-clinic Au.D. externships*

September 2013: *6th Biennial Conference: Beyond the Audiology Clinic: Innovations and Possibilities of Connected Health*



in the lab as part of the NIH T-35 program. We investigated the effects of time-compression and reverberation on digit identification by younger and older listeners with auditory thresholds within normal limits. In the absence of time-compression, reverberant stimuli were highly intelligible for both younger and older adults, suggesting that that normal hearing sensitivity may be sufficient to resolve acoustic distortions imposed by reverberation. Older adults performed poorer than younger adults across time-compressed conditions, supporting previous findings on age-related declines in temporal processing. However, it is possible that declines in cognitive processing speed and auditory working memory with increasing age also contribute to this decline.

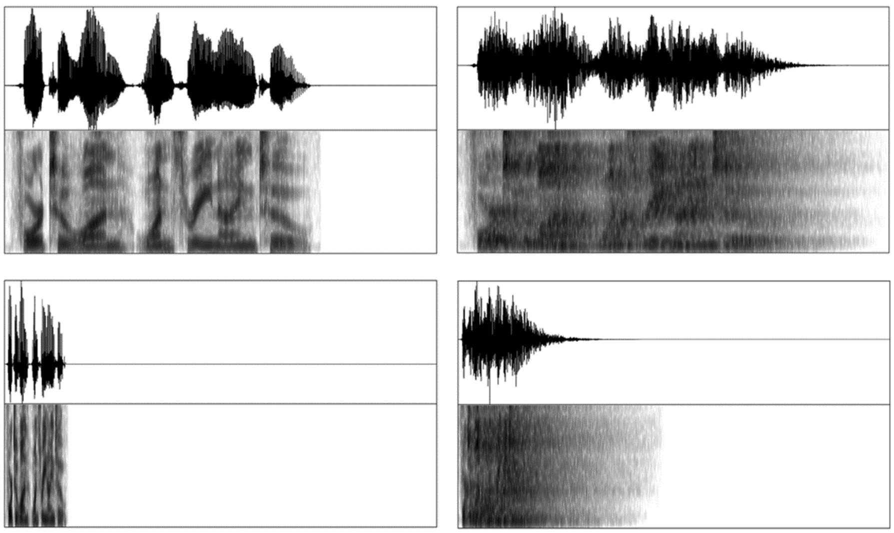


Figure 1. *Time waveforms and spectrograms of the digit string 421-1392 in four different listening conditions: unprocessed (upper left), reverberant (upper right), time-compressed (lower left), and reverberant time-compressed.*

Work supported by NIH NIDCD DC 012314 and DC008764 (PI: Billings) and by NCRAR pilot funds

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2013 NCRAR Staff Photo

October 2013: *Anechoic chamber upgrade*

Melissa Papesh. Au.D., Ph.D.

This year, I entered the second and final year of my RR&D Career Development Award-1 for which I have been exploring the possibility that exposure to high-intensity blast waves reduces the brain's ability to filter incoming sensory information. This condition could lead to sensory overstimulation resulting in complex upstream difficulties including difficulty picking out speech from background sounds, problems maintaining attention, and poor memory and recall. However, many Veterans with previous blast exposure also suffer from post-traumatic stress disorder (PTSD), a condition which is often associated with similar symptoms: hypervigilance and sensitivity to sensory stimuli. We are trying to distinguish between the effects of PTSD and blast exposure, so we are comparing performance of Veterans with blast-exposure to Veterans with PTSD but no blast-exposure (or history of head injury) and to a control group of Veterans with neither history of head injury or PTSD, on a large battery of tests and questionnaires that include behavioral listening measures, a cognitive assessment, and electrophysiological measures.

Preliminary findings reveal that a considerable percentage of blast-exposed Veterans report more subjective auditory concerns and have poorer performance on auditory tasks than control participants. This is in spite of the fact that all participants had normal hearing thresholds and that blast exposure was incurred years earlier. Behavioral performance and subjective auditory reports were also negatively impacted by a diagnosis of PTSD, although the effect was less for this participant group than among the blast-exposed group. Electrophysiological measures support the results of self-report and behavioral test measures. An example is shown in **Figure 1** which depicts the grand averaged results for each participant group in response to a P300 test paradigm. During this test, participants are asked to listen for an infrequent high-pitched tone presented among a string of repetitive low-pitched tones while measurements of neural activity are recorded from electrodes placed on the scalp. In a normally functioning brain, the change in pitch is easily distinguished and results in a large vertex-positive peak in neural electrical activity approximately 300 ms post-stimulus onset (highlighted area of Fig. 1). Higher and earlier peaks are associated with more robust neural detection of the change in stimulus. The waveforms shown in **Figure 1** reveal that the ability of blast-exposed participants' (green dashed line) brains to detect this pitch shift is considerably less robust compared to control participants (solid blue line), with PTSD participants' (dotted red line) responses revealing an

July 2014: *Naomi Bramhall joins the NCRAR as a PI*

August 2014: *Sarah Theodoroff becomes an NCRAR PI*

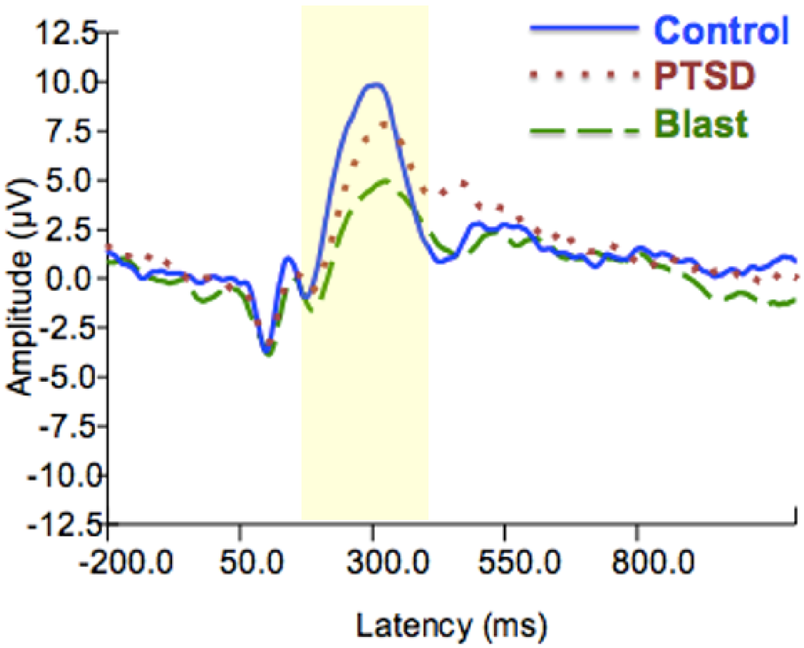

Figure 1. Group average responses to the P300 deviant stimulus elicited using a tonal oddball paradigm.

April 2015: Bob Peterka joins the NCRAR as a PI

intermediate status between the blast-exposed and control groups. Overall, these results indicate that PTSD can contribute to auditory dysfunction, but does not appear to fully account for the significant auditory deficits measured among blast-exposed participants.

Figure 2. Dr. Papesh with T-35 student Kelly Hanscom following Kelly's end-of-summer research presentation to the NCRAR staff.

Work in my lab this past year benefited from the work of three students: Alyssa Stefl, Kelly Hanscom and Sarita Patel. Alyssa, an Au.D. student from Northern Illinois University, completed her final externship year here at the NCRAR and is now working as a clinical audiologist; Kelly (**Figure 2**) completed an NIH T-35 student training program during the summer during which she analyzed P300 responses and assessed relationships between these data and behavioral measures. She presented this data at the 2018 American Auditory Society meeting. Sarita completed an internship in the lab this past fall during which she helped run participants and analyzed data related to our sensory gating hypothesis. We will publish this data soon.

2015 NCRAR Staff Photo

Work supported by VA RR&D CDA-1 IK1RX001820

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Robert Peterka, Ph.D.

It is well established that imbalance is a major contributor to falls, falls increase with age, and falls are a leading cause of death in older individuals and a substantial contributor to healthcare costs. The development of strategies and methods to reduce falls is highly relevant to Veterans health since the median age of Veterans is greater than the US population as a whole. Additionally, imbalance is also a major consequence of traumatic brain injury that affects Veterans of all ages.

The long-term goals of my research are to understand the mechanisms that maintain balance during stance and walking gait, to exploit new methods to accurately measure how age and other neurological conditions affect these mechanisms, and to develop balance aids that improve balance during gait.

Current ongoing research in my lab, supported by a VA Merit Award to characterize age-related changes in balance control during gait, is focused on understanding the neural mechanisms that regulate two different aspects of balance during movement and how these mechanisms change with age. One aspect involves the integration of information from multiple sensory systems for the control of ‘body orientation’ in space and with respect to changing environments. The other involves understanding how the nervous system maintains ‘dynamic balance’, which refers to the oscillating pattern of body motion that occurs during gait, when confronted with perturbations that could lead to loss of stability and falls if inadequately controlled.

In 2017 we completed data collection in young Veterans (ages 25-43) and older Veterans (ages 65-82) on balance during stance and during stepping-in-place while balance was perturbed by different types and magnitudes of disturbances. Preliminary results show that older subjects were generally more affected than young during both stance and stepping tests, but that these differences were small and probably not functionally relevant for stance tests. However, older subjects were considerably more affected on the stepping-in-place tests indicating that they have reduced ability to control dynamic balance during gait—particularly when disturbances are larger in magnitude. We are continuing the analysis of this data set using innovative state-of-the-art system identification methods and model-based assessments to quantify the sensory and motor contributions to balance control to better understand exactly what is changing in the balance system of older adults that causes them to have poorer balance than

September 2015: *7th Biennial NCRAR Conference: Hearing Loss as a Public Health Concern*

March 2016: *Dr. Henry receives the Paul B. Magnuson Award for outstanding achievement in rehabilitation research and development from VA RR&D*

younger subjects, and why dynamic balance in particular is affected by aging.

In addition to the work in my lab, I am a co-investigator on two DoD grants in collaboration with Dr. Laurie King (OHSU Neurology and NCRAR). I will be identifying specific balance deficits due to mild traumatic brain injury (mTBI) using methodology developed in my laboratory. So far we have collected data from about 20 individuals with mTBI who have chronic balance complaints and about 50 controls. The results from the control subjects have been used to establish clinical norms for new tests that have potential utility for characterizing balance deficits. The data show that the subjects with mTBI had a variety of different balance deficits but no single pattern has emerged. This indicates that injury associated with mTBI can affect multiple aspects of balance control. The ability to accurately identify which component of balance control is dysfunctional may allow rehabilitation therapy to be more effective by focusing on the identified deficit.

Figure 1. NCRAR custom balance test device. Test subjects stand or step in place while facing the plaid pattern of the visual surround. Balance is perturbed by rotation of the visual surround or the stance surface. Body sway motions, surface forces, and foot placement are measured and related to the perturbing stimulus to assess balance control behavior.

Work supported by VA RR&D I01 RX001951, DoD W91XWH-15-1-0620 (PI King), DoD W81XWH-16-PHTBIRP-CTRRA (PI King).

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***November 2016:** New NCRAR branding and logo unveiled*

VA RR&D
NCRAR

***April 2017:** Dr. Henry receives Jerger Career Award for Research in Audiology from the American Academy of Audiology*

Gabrielle Saunders, Ph.D.

Work in my lab focuses on evidence-based methods and approaches to audiological rehabilitation. Our goal is to determine how to best promote health behavior change for hearing behaviors so that the oft-quoted statements *'It takes 7-10 years between first noticing hearing difficulties and seeking help'* and *'Only 20% of people who would benefit from hearing aids actually them'* become obsolete. We are doing this in several studies that use patient-centered approaches to rehabilitation. Two are highlighted below.

In a study we are conducting in collaboration with colleagues at University of South Florida we are examining whether health behavior models are predictive of hearing health behaviors and if so, how these can be used to develop theory-based interventions to promote hearing help seeking and intervention uptake. All 588 participants in that study failed a hearing screening. We are tracking their hearing health behaviors for up to three years. So far, we have learned that within the initial 6-months post-screen failure, 21.6% of participants sought help. This number decreased to about 10% in each following six-month period. The individuals in this study were recruited during 191 community hearing screening events. Data from the 1954 people whose hearing we screened taught us that while percentage of community-living individuals who fail the pure tone screening increases linearly with age from <20% for ages below 45 yr. to almost 100% for individuals aged 85 yr. and older, the percentage of individuals who fail a self-report screener (HHI-S) remains unchanged at approximately 40% for individuals age 55 yr. and older (**Figure 1**, following page). While it might be possible to develop age-specific HHI-S failure criteria to adjust for this, it is not recommended because perceived difficulties are the best predictor of hearing health behaviors. Instead it is proposed that a public health focus on education about hearing and hearing loss would be more effective [Saunders et al., (in press). *Journal of the American Academy of Audiology*].

In another study, we used NCRAR pilot funding to examine whether photovoice methodology has application to audiology either as a clinical too or for research. Photovoice is a participatory action research method in which individuals take photographs to represent aspects their daily lives that are being studied, with a view to documenting issues of concern/ interest. We conducted four experiments in which we evaluated the use of photovoice as (1) as a tool for providing specific communication strategies advice, (2) a post-hearing aid fitting counseling tool, (3) as a tool to encourage spousal discussion and problem-solving about hearing loss and (4) as a method for understanding what it means live with hearing loss. We

October 2017: *8th Biennial NCRAR Conference—Translating Tinnitus Research Findings into Clinical Practice*

October 2017: *NCRAR Center Grant renewed* have learned that people are very open to taking photographs that represent their hearing struggles in daily life and that the photographs are extremely useful as a tool for providing highly tailored hearing counseling, and as a facilitator of patient-centered and between-spouse communication (**Figure 2**). Photovoice would thus seem to have huge potential as a tool for intervention selection, communication counseling, facilitator of family-centered care.

We are lucky to have Lauren Dillard, an Au.D. extern, working in the lab this year. She has taken on a retrospective data analysis of large VA datasets to determine whether there are predictors of sub-populations of Veterans whose hearing aid treatment outcomes deviate substantially from the mean. If so, this will potentially allow clinicians to provide additional clinical support to them before they become disillusioned with their hearing aids.

Posters from recent research conferences hang in the hallways

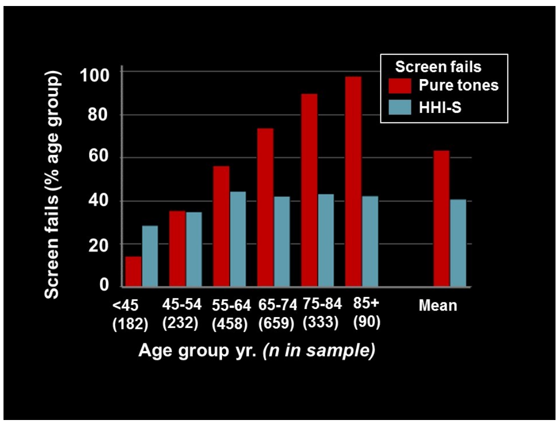

Figure 1. *Percentage of pure tone (red bars) and HHI-S (blue bars) screen failures by age group. Number of individuals in each age group is shown in parentheses.*

The interior of one of NCRAR's ten sound-attenuated test booths

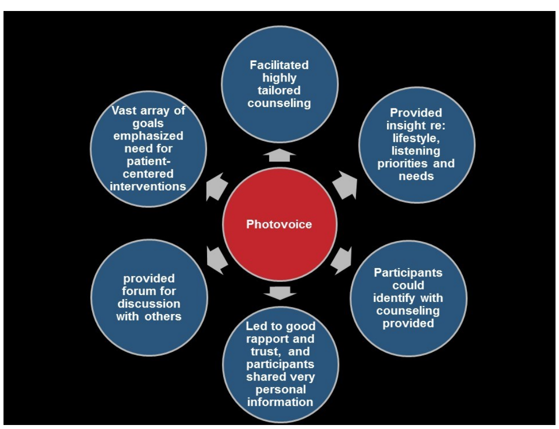

Figure 2. *Advantages of photovoice methodology as a clinical tool.*

Work supported by NIH NIDCD R01DC013761, VA RR&D I50 RX002361-01 and NCRAR (pilot funding)

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Saunders NCRAR webpage

Sarah Theodoroff, Ph.D.

Work in my lab focuses on developing new approaches to assess and treat auditory complaints that are not adequately captured by the standard test battery nor effectively treated. Too often people with tinnitus and other auditory complaints that are not well understood (e.g., hyperacusis) are told nothing can be done to help them. Sometimes the clinical testing itself, which consists of presenting moderate to loud sounds, can exacerbate their conditions. Part of the work I do includes increasing awareness of the needs of, and resources for, patients with tinnitus and hyperacusis. In the absence of clinical practice guidelines on how best to diagnose and assess hyperacusis, many clinicians are at a loss for what to do with their patients. This avenue of research will generate recommendations for a clinical test battery that could be used for just that purpose. In the past year, I have been involved in multiple projects to advance these goals. Two are highlighted below.

Patents and recent publications hang in the NCRAR hallway

In a recently completed study, we evaluated a specific protocol for use with transcranial magnetic stimulation (TMS) for tinnitus. This pilot study was conducted to measure the degree of accuracy of the 10-20 method for placing the TMS coil on the scalp overlying the neural target (i.e., primary auditory cortex). We used magnetic resonance imaging (MRI) to locate the optimal scalp location and compared it to the location identified using the 10-20 method. We learned that there was substantial inter-participant variability in the location of the where the 10-20 method placed the TMS coil compared to the optimal location. Although the 10-20 method is considerably less expensive and less time-consuming than performing imaging to identify a neural target, we found that the 10-20 method cannot provide the same level of individual accuracy as using an MRI-based coil positioning method (**Figure 1,** following page).

The front desk in the NCRAR waiting area

In a new project, my lab is taking a novel approach to assessing hyperacusis in tinnitus patients. As mentioned above, current clinical protocols often result in temporarily worsening patients' symptoms without offering any insight into the underlying nature of the problem. This study is investigating a new behavioral metric, categorical loudness scaling (CLS), as an option for measuring loudness discomfort levels but without the need to present loud sound. Data collection is ongoing, but preliminary results show that using CLS, which can be performed without presenting sounds at high intensity levels, results in less testing anxiety than current clinical procedures and shows promise for predicting the intensity level at which a sound would be judged as "uncomfortably loud"—without the need to present a loud sound (which could exacerbate the tinnitus and hyperacusis). The next phase of this project will be to include a physiological measure to help characterize hyperacusis and possible subtypes.

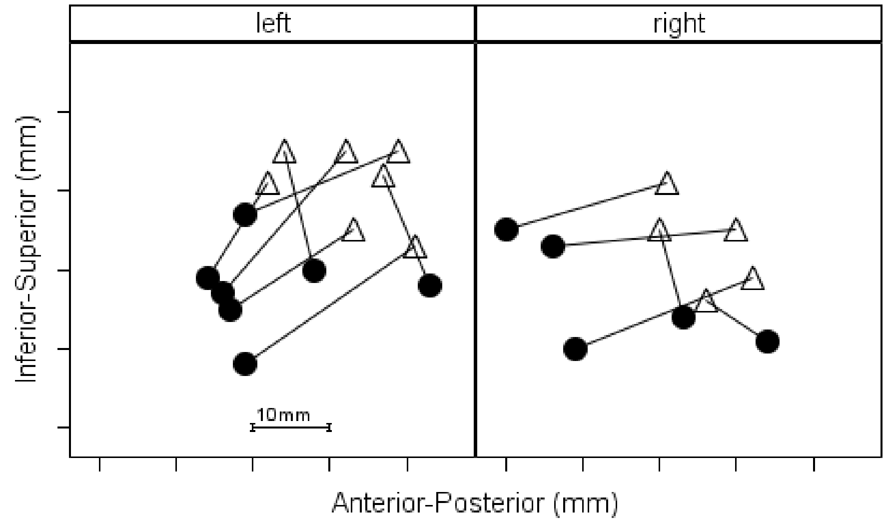

Figure 1. *Scalp location of where the TMS coil was placed using the 10-20 method (open triangles) compared to the optimal TMS coil location (filled circles). This figure is included in a manuscript recently accepted for publication in Brain Topography and is available online ahead of print.*

Work supported by OHSU Medical Research Foundation #1510 and by the American Tinnitus Association PVARF #403002.

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Theodoroff NCRAR webpage

The NCRAR waiting area

The Columbia River Gorge

Mount Hood

NCRAR Educational Programs

In October 2017 NCRAR hosted its 8th biennial conference titled *'Translating Tinnitus Research Findings into Clinical Practice.'* It took place, as always, in Portland, Oregon. This was our most well-attended conference yet, with over 220 registrants originating from 6 countries and 28 states across the US. Almost half of the attendees had a VA or DoD affiliation, some were students and the rest represented academic institutions, hospital/healthcare systems, industry, and private audiological practices. We were pleased to award 15 scholarships to students and clinical audiologists so they could attend the meeting.

The conference topics included the epidemiology and current neurophysiological models of tinnitus, techniques and challenges for developing tinnitus interventions, approaches to tinnitus measurement, and outcome and effectiveness of approaches to tinnitus management, with a view of understanding how to best translate theory into clinical practice so that individuals with tinnitus receive the most effective treatment. Fourteen experts were invited to present over the 3-day conference and we held a poster session one afternoon to facilitate networking among the attendees.

Here are some of the key take-home messages from the meeting:

- *The underlying mechanisms by which tinnitus is generated are not fully understood thus it is challenging to develop a pharmacological cure.*
- *Generation of tinnitus and the psychological reactions it evokes is complex involving both auditory and non-auditory systems.*
- *Tinnitus cannot be objectively measured. The closest we can currently come is to assess its perceptual attributes such as pitch and loudness, and reported impacts on function and mental status.*
- *Individual differences greatly impact how each patient perceives his/her tinnitus and what (s)he finds bothersome about it.*
- *Tinnitus management should be multifaceted and individualized, and the patient's management preferences, mental health status, and comorbid conditions should be taken into account.*

The bottom line is that we still have a lot to learn about tinnitus!

A special issue of the *American Journal of Audiology* will be coming out later in 2018 in which papers from some of the conference presenters will be published.

We are extremely grateful to the sponsors of the meeting. These were NIH-NIDCD (Grant # R13DC016549), VA Rehabilitation Research and Development, Oticon, American Tinnitus Association, Starkey, Phonak, Widex, Insignia and Otoharmonics.

Note: The next NCRAR conference will take place in Portland, Oregon in September 2019. The topic area is yet to be finalized.

In the past year, four Au.D. students completed their externship year at the NCRAR (Sarah Faucette, Nicole Fox, Cattie Milligan and Alyssa Steffl), and three are currently completing their externship (Lauren Dillard, Mike Kurth and Chris Niemczak). These externships are funded by the VA Office of Academic Affiliations (OAA). In addition, in 2017 we welcomed four summer students who were funded by an NIH-T35 grant (Rachel Etzler, Kelly Hansom, Paige Heeke and Emily Wilson), one OAA fellow (Tess Koerner), and 3 post-docs (Dr. Will Bologna, Dr. Apollonia Fox, Dr. Ramesh Muralimanohar). *Student and post-doc opportunities tend to arise on an annual basis so check the NCRAR website for information.*

NCRAR 2017 Publications

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NCRAR 2017 Honors and Leadership Roles

Name	*Organization*	*Role*
C. Billings, Ph.D.	Ear and Hearing	Section Editor
M. Cameron, M.D., P.T.	MS Center of Excellence West	Co-Director
F. Gallun, Ph.D.	Journal of Speech Language and Hearing Research	Editor-in-Chief, Hearing Section
F. Gallun, Ph.D.	Journal of the Acoustical Society of America	Associate Editor
F. Gallun, Ph.D.	Acoustical Society of America	Chair, Tutorials Committee
F. Gallun, Ph.D.	Association for Research in Otolaryngology	Chair, Finance Committee
J. Henry, Ph.D.	Journal of the American Academy of Audiology	Associate Editor
D. Konrad-Martin, Ph.D.	American Speech-Language-Hearing Association	Appointed Member, Research and Scientific Affairs Committee (RSAC)
D. Konrad-Martin, Ph.D.	International Journal of Audiology	Associate Editor for Special Issue: DoD Hearing Center of Excellence, Pharmaceutical Interventions for Hearing Loss Working Group, Ototoxicity-Special Topics in Clinical Monitoring
M. Papesh, AuD, Ph.D.	Joint Defense and Veterans Audiology Conference	Co-Chair, Field Presentation Committee
T. Penman, Au.D.	Department of Veterans Affairs (VA)/Department of Defense (DoD) Tinnitus Working Group	Chair
T. Penman, Au.D.	Joint Defense and Veterans Audiology Conference	Member: Program Committee
T. Penman, Au.D.	American Speech-Language-Hearing Association (ASHA)	Reviewer: 2018 Convention Program Committee (CPC)
T. Penman, Au.D.	American Speech-Language-Hearing Association (ASHA)	SIG 8 Professional Development Manager
G. Saunders, Ph.D.	International Collegium for Rehabilitative Audiology (ICRA)	Elected Member
G. Saunders, Ph.D.	American Academy of Audiology	Chair, Honors Committee
G. Saunders, Ph.D.	NCRAR	Chair, Biennial Conference
G. Saunders, Ph.D.	School of Medicine, University of Nottingham, England	Elected Honorary Associate Professor
G. Saunders, Ph.D.	Assistive Technology Journal	Associate Editor

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