Letter from the Editor

by Richard L. Stepkin MS, CCC-A,
Enviromed Corp – Lindenwold NJ

It has been my privilege and pleasure to serve as editor of our NHCA Spectrum for the last several years. I have many things going on professionally and personally so this is a good time to step down with this last newsletter of 2014.

As editor, in addition to technical and informative articles, it has been my objective to create human interest “Spotlights” on regular and commercial members with each newsletter.

Although we are a small organization – we are a very professional community with a common bond. Each of our members has a story to tell and when it is personalized with family, experiences and points of interest, it makes us a stronger and more intimate Association.

After enlisting in the Naval Submarine Service; then College; then a Major in the Army; then the last 34 years in business - I plan to do more motorcycling around the U.S. to places I have never been and more traveling to Asia. I love driving my Mini-Cooper Convertible (a high speed mobile device).

My daughter, Trisha, will have her 1st baby (girl), my first grandchild, just before Christmas which is exciting as well.

So, I plan to work hard but play harder. I will continue to be active with NHCA - a great organization. I look forward to seeing everyone in N’Oleans. Thanks for the opportunity to serve.
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The mission of the National Hearing Conservation Association is to prevent hearing loss due to noise and other environmental factors in all sectors of society.
The US Surgeon General’s National Prevention Strategy’s vision is: Working together to improve the health and quality of life for individuals, families, and communities by moving the nation from a focus on sickness and disease to one based on prevention and wellness.

As a nation, we are facing the impact of unsustainable healthcare costs and are seeing concerted efforts to shift focus from treating illness and injury to preventing illness and injury. There appears to be recognition among high-level strategic leaders that prevention tools are key enablers of wellness, and that fostering healthy environments and health education empowers people to make better health choices leading to longer, healthier lives.

Well, how about that? In 1976, the founders of our Association, concerned with the serious problem of noise-induced hearing impairment resulting from occupational exposure to noise, created NHCA to provide a forum where other like-minded individuals could share information and improve strategies for preventing occupational hearing loss. I wonder if our first officers, Alan Feldman, Frederic Pul len, Constance Cabeza, Lennon Adams, Don Wolfe, and William H. Call knew that they were prevention way before prevention was cool?

Today, we are a multidisciplinary group of professionals with a common interest in preventing hearing loss. I believe we are leading the nation in the recognition that hearing hazards exist in all sectors of life, not only in the workplace.

I’m honored to serve as the 33rd President of NHCA, and appreciative of your confidence in me to do so. As I look back over the list of Past-Presidents, I am simultaneously proud to be associated with the caliber of our previous leaders and hopeful that I won’t pale in comparison. I do take this responsibility seriously, and assure you that I intend to work hard in achieving the organization’s goals to prevent hearing loss due to noise and other environmental factors in all sectors of society.

I extend gratitude to Beth Cooper for her dedication to the organization during her tenure as President. Beth’s perseverance and attention to detail allowed for significant improvements to the organization, specifically in work towards a balanced budget and the organization of task forces and liaisons under accountable executive council members. I appreciate her hard work and the countless hours she donated to the Association.

I also want to thank our executive council, task force members, liaisons, and numerous other volunteers who make NHCA run smoothly. Our executive director, Kim Schwartz is phenomenal – her calm demeanor, innovative ideas, and resourcefulness are valuable assets to NHCA.

This is Rick Stepkin’s last edition of Spectrum. He has worked diligently behind the scenes to make Spectrum a quality product for four years, and I’d like to thank him for his persistence and personal sacrifice for the good of the Association.

If you haven’t already done so, it’s time to register for the 2015 NHCA Conference where we will “celebrate hearing loss prevention” at the Astor Crowne Plaza in New Orleans, Louisiana, February 19-21. Your Program Chair, Jim Jerome and his team have put together a fantastic educational and networking experience intended to offer the very best in hearing loss prevention continuing education, as well as access to the latest technologies in the exhibit hall. Between Thursday’s workshops, Friday’s general sessions, Saturday’s breakout sessions, poster presentations and the exhibit hall, there is something for everyone. Be sure to take advantage of early registration rates until December 19th, and bring a friend!
Membership Spotlight

John Barry, ScD, MSPH, RS, ROH
Industrial Hygiene Engineer (Acoustical Aspects), US Department of Labor– OSHA - Bangor, Maine

Bangor — The Queen City of the East located in the State of Maine. There are several other Bangor’s in Pennsylvania, Michigan, Wales, and Ireland to name a few. Bangor is the northern most office of OSHA in the eastern United States. Except for Canadians, most folks think civilization as we know it ends at the Bangor city limits but it is my home town except for Philadelphia, the ancestral home of the Barry family in America. My 45 year career in acoustics and public health began in Bangor passed through 25 years in Philadelphia returning to my Bangorian roots so to speak in 1999.

During my college years I attended the University of Maine. Although majoring in pre-med, I was unsuccessful in getting into a medical school. My mom suggested exploring a career in public health. At the time there were only three such schools in New England: Harvard, Yale, and UMass/Amherst. Being a late applicant, I decided to apply to the University of Massachusetts School of Public Health. As luck would have it, I was accepted with a full scholarship in the environmental health program in August 1969. The two years at UMass/Amherst were exciting and challenging. Being the pre OSHA era, UMass at the time did not have formal academic programs in occupational health and industrial hygiene, my primary interests in the broader field of environmental health. By customiz-

igung my curriculum, I concentrated my program to be rich in occupational health areas.

When it was the time to begin a master’s thesis, I chose to explore the effects of amplified music on human hearing. My faculty adviser introduced me to Dr. Ian Thomas, Professor of Electrical Engineering, who was doing research in human speech and hearing aid design. The research that followed led to my master’s thesis and first publication, “A Clinical Study to Evaluate Rock Music, Symphonic Music, and Noise as Sources of Acoustic Trauma.” This paper was presented by me at the Denver meeting of the Acoustical Society of America in 1971. This was the beginning of my formal academic interest in noise, acoustics, and human hearing loss.

After receiving my MSPH degree in 1971, I began my public health career as a junior sanitary engineer with the Massachusetts Department of Public Health at Lakeville Hospital. I later received a Rotary International graduate fellowship to study occupational health at the University of Manchester in England for the 1972-73 academic year. Whilst at Manchester, I met Professor William Burns, one of the two authors of the British study on occupational hearing loss, along with many other leaders in the occupational health and hygiene fields in Britain. During my year in Britain, I applied to a new academic program in environmental noise offered by the University of Pittsburgh’s Graduate School of Public Health. It was sponsored through a grant from the US Public Health Service (NIOSH) under the new Occupational Safety Health Act of 1970 to train super compliance officers for the new national program in occupational safety and health, OSHA. Before leaving Manchester, I received notice from the University of Pittsburgh that I had been accepted with a full pre doctoral fellowship.

In late August 1973 I entered the doctoral program in environmental acoustics at the University of Pittsburgh. Both the occupational health and acoustics programs at Pitt were impressive world-class programs. The broad

Message from the Editor
I have personally known John since 1975. His education and experience led to a very informative and inside history of OSHA as it transitioned through the decades on the noise issue. Although John’s article is a bit long, it was way too interesting to not be told. He is an OSHA pioneer and one of our most valued members. John has always been a behind the scenes professional and remained outside the spotlight until today.
range of facilities and faculty at the University of Pittsburgh between 1973 and 1976 gave me an impressive multidisciplinary academic and practical background in public health engineering, industrial hygiene, ergonomics, acoustics, occupational health, and audiology which would serve me well in my future 39 year career as an OSHA industrial hygiene engineer.

For my dissertation I chose to study the effects of prolonged exposure of environmental noise on human hearing leading to a condition known as “asymptotic threshold shift”. Philosophically, one would assume that below some inherently safe sound level, there would be no change in hearing sensitivity. At some overwhelming level of sound exposure there can be no more than total loss of hearing sensitivity. Between these two exposure extremes the hearing loss produced should asymptote at some duration, plateauing and growing no more. The asymptote and the duration in time of exposure to reach it needed to be explored. This model was the basis of my doctoral dissertation, “Asymptotic Temporary Threshold Shift.” My dissertation was completed and successfully defended in December 1976 allowing me to graduate in America’s bicentennial year.

Morton Corn, one of my professors at Pitt, was now the new head of OSHA and encouraged me to join this new branch of the U S Department of Labor. Since its inception in the spring of 1971, OSHA’s most extensive enforcement of industrial hygiene standards was in occupational noise under several variations of the 1969 Walsh-Healey Noise Standard. The most problematic aspects of the General Industry version [1910.95] were paragraphs (b)(1) on the feasibility of engineering controls and (b)(3) continuing effective hearing conservation programs. With the advent of the noise dosimeter over hand-held sound level meters, noise became the easiest health hazard to document an effective hearing conservation program. Besides, I was from a bicentennial family, having a bicentennial degree from a bicentennial university, so why not join OSHA in the bicentennial city. So, on the Bicentennial Halloween, I joined the staff of the OSHA Regional Office in Philadelphia which included the States of Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and the District of Columbia. To this day, OSHA still does not know whether I was the trick or the treat.

My second day on the job I found myself in Huntington, West Virginia doing a discovery inspection at a glass bottle plant. Present was the OSHA compliance officer, an industrial hygienist out of the Charleston (WV) Area Office, a senior trial attorney from the Philadelphia Office and two contract engineers both legends to acousticians: Jim Botsford for OSHA, and Lew Goodfriend for the employer. The two experts were among the best in the field and the OSHA IH was typical of the Agency for 1976 with no formal training in noise control engineering. The employer being a glass container plant is one of the hardest workplaces to control for either heat or noise exposure. That second day on the job demonstrated most clearly what had to be done: I needed to perfect my practical skills in noise control [effectiveness as well as cost] and the OSHA industrial hygienists needed a lot of high intensity training in noise control engineer, noise measurement, and what makes an effective hearing conservation program.

The regional solicitor of labor arranged for me to accompany every discovery inspection team for noise and ventilation to observe and learn the skills used by our contract engineers and to learn from the DOL attorneys what our burdens of proof were and how to establish them. Of all the contract noise control engineers that I have worked with over these 39 years, one stands out way above all others – James H. Botsford. He was an outlandish Texan and one of the most brilliant and eccentric engineers I have ever had the pleasure to know and work with. He spent a long and distinguished career with Bethlehem Steel Corporation as an industrial hygiene engineer specializing in heat and noise exposures before he became an independent consultant. Going forward, the agency never lost a contested case where Botsford was our external expert. The longest OSHA noise case in history was Collier Keyworth in Maryland, and the District of Columbia which included the States of Virginia, Delaware, Maryland, Pennsylvania, New Jersey, and Missouri. OSHA never lost a contested case that Botsford represented the company!

By 1976 OSHA was losing most of its contested noise cases particularly dealing with engineering feasibility. Region 3 of the 10 regions had been moderately successful in defending (b)(1) engineering citations by hiring contract engineers from the private sector. Given this history, the assistant regional administrator of technical support out of Philadelphia [Region 3] came to Pittsburgh in an effort to recruit me to join the OSHA team in Philadelphia and build up their enforcement skills to defend contested noise cases. It sounded like an interesting assignment to me. I was interested in a field position where I could use my engineering and teaching skills to promote hearing conservation. Besides, I was from a bicentennial family, having a bicentennial degree from a bicentennial university, so why not join OSHA in the bicentennial city. So, on the Bicentennial Halloween, I joined the staff of the OSHA Regional Office in Philadelphia which included the States of Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and the District of Columbia. To this day, OSHA still does not know whether I was the trick or the treat.

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Between 1976 and 1992 I honed my engineering skills and presented numerous training classes and seminars to all the hygienists in the Middle Atlantic States of Region 3 including the OSHA on-site consultation programs and our two state plan jurisdictions, Maryland and the Common-
The national office and Region 5 [Chicago] had also developed positions similar to mine in Philadelphia to promote success in noise enforcement. In the final day of the Carter administration, the hearing conservation amendment was promulgated.

In the election of Ronald Reagan in 1982, the ways OSHA would deal with noise began to change dramatically. President Reagan had run with one platform plank being that noise was one of the most ridiculous environmental hazards. It is ironic because he suffered from hearing loss. The hearing conservation amendment was withheld until March 1983 and finally released in a much diluted version. Enforcement policy was broadened to stress economic feasibility.

Because the noise standards were pre-OSHA regulations they had not been vetted for economic feasibility. The new administration policy stated that an economically feasible noise control should not exceed the cost of the hearing conservation program for the effected employees. This new policy which carries down to the present added two new burdens on the OSHA compliance officer. Both the cost of hearing conservation and the cost of engineering controls had to be quantified before citations could be issued. These changes greatly deflated the incidence of engineering citations for noise.

In the late 80’s two noise enforcement cases in Region 3 for which I was involved did re-emphasize noise enforcement. They were the Budd auto stamping plant in Philadelphia and the USX integrated steel mill in Fairless Hills, Pennsylvania. Both focused on dysfunctional hearing conservation programs and lack of feasible engineering controls. Both cases were affirmed by OSHA and breathed new life into enforcement of the noise standards. What the agency learned in these two cases was distilled by me with help from DOL attorneys into a comprehensive Region 3 directive on noise enforcement in 1992. After on-site training in each area office for the industrial hygiene staffs, the compliance officers now had a written enforcement directive to facilitate answering the questions of economic feasibility and how to evaluate a hearing conservation program. This directive did stimulate more enforcement of noise cases in Region 3 but had less effect in the other nine regions of OSHA.

About that same time I was the victim of a drive by shooting in Philadelphia. As I was recovering, I was reassigned for light duty at the Philadelphia Area Office as the acting health supervisor. During 1992 and 1993 I directed the health enforcement program in the greater Philadelphia area. Whilst there, I must have attracted the attention of the City of Philadelphia because before returning to my former duties in regional technical support in the fall of 1993, the mayor invited me to join his administration under the Intergovernmental Personnel Act (IPA) with a four year appointment. The deputy regional administrator in Philadelphia researched the IPA, the mayor’s request, and coordinated with the new Clinton administration.

In April 1994 I relocated, on loan, from the OSHA regional office in Philadelphia to City Hall as the assistant safety director and industrial hygiene engineer in the new Risk Management Division of the Finance Department responsible for the occupational safety and health of 25,000 municipal employees of the City of Philadelphia. With my arrival at City Hall, a huge hearing loss case hit the Philadelphia Fire Department (PFD). With my extensive experience as federal OSHA’s chief technical expert
on noise and occupational hearing loss, I quickly found myself with a new set of turnout gear, utility work uniform, and reserve appointment as a HAZMAT officer. The Philadelphia Fire Department was America’s fourth largest with 2600 officers, firefighters, paramedics, 60 engine companies, 30 ladder companies, one heavy rescue company, two HAZMAT companies, an aviation division, and three ocean-going fire boats. By comparison, I was a staff of one with no special budget, and an instrument inventory of 10 M15 noise dosimeters, several sound level meters, a real time analyzer, graphic level recorder, and an audio tape recorder. An initial literature survey, mostly NIOSH health hazard analyses, indicated no problem! It was summarized as the NIOSH paradox – no significant occupational noise exposure relative to the OSHA noise standards; however, classic configuration occupational hearing loss notches in the audiograms consistent with duration in the fire service. To complete the assignment, the mayor and fire chief wanted a definitive scientifically valid answer as soon as possible. For the first six months of my detail to the city, I was fully involved with the noise problem in the fire department. With a short time line, few assets, and a non-supportive literature base (no useful internet at this time), I decided to focus on the worst first and take a crash course in how to become a municipal firefighter as fast as possible because the hazards that face the men and women of the Philadelphia Fire Department were nothing like what I had encountered in my prior 18 years with OSHA. The assistant fire commissioner for operations identified the busiest, average, and slowest companies in the PFD to target for data collection. By this point in my life, Jean and I now had four children, Patti, John, Jim, and Jean.

As the data rolled in, its interpretation was fascinating. In general, the literature is relatively correct, when one limits the view to only the concept of the daily OSHA noise dose, there seems to be little or no problem. Even the busiest companies daily noise doses equaled or exceeded fifty percent. Most companies were zero to twenty five percent. My survey was rather unique compared to all fire department noise studies in the past. Each firefighter, medic, and officer as well as myself were sampled for the full shift [a 10 hour day watch and a 14 hour night watch]. I went on all runs and kept a comprehensive written journal of each watch. Firefighters and medics are infrequently exposed to loud noises, the apparatus siren [125 dBA], apparatus horn [106 dBA], fireboat engine room [106 dBA], diesel engine and water pump [72 -100 dBA], power tools [95 – 115 dBA], etc. Generally, the noise is below 85 dBA. There are some other factors in the epidemiology of fire service hearing loss, stress, ototoxic chemicals [e.g. carbon monoxide].

By the fall of 1994 most of the field data had been collected. Data review, analysis, and reduction took a bit longer with the final report coming out in September 1997 titled: “Occupational Noise Exposure in the Philadelphia Fire Department.” Some of the conclusions of this study were as follows. All exposures were longer than the traditional 8 hours, being 10 hours on days and 14 hours on nights. RF interference from cell phones, walkie-talkies, and apparatus radios affected the readouts on the noise dosimeters obviating practical use of 3 dB exchange doses vs. 5 dB doses. All data were presented as OSHA 5 dB exchange rate numbers. Whilst a number of noise sources produce very high levels, their relative duration is brief [seconds or minutes] causing the daily noise doses relative to the OSHA standards to be generally below 90 and 85 dBA. The only clear exceptions were the marine engineer in an operating fireboat engine room, busy paramedics, and the busiest engine company. The most significant noise source was the apparatus mechanical siren which produces a constant sound level of 125 dBA at 10 feet with all the acoustic energy in the 1000 Hz octave band. Every time a siren is operated the ceiling level of the OSHA noise standard is exceeded with out benefit of hearing protection. Medics had the greatest exposure because the trucks run to the scene with the siren, transport to the hospital with the siren, and often leave the hospital with siren to the next call. Other apparatus only run to the scene with siren. The return trip is relatively quiet [the 72 dBA idle of the diesel engine].
My tour with the city lasted through July 1998 when I returned to the OSHA regional office. Since the internet had eliminated many positions in technical support, including mine, I was reassigned as a program manager in the OSHA VPP program. VPP is the crown jewel of OSHA’s many programs and recognizes employers with exceptionally good safety and health programs.

After a year in VPP I transferred back to Bangor, my home town, as the new assistant area director and health supervisor. When the Bangor office was demoted from an area office to a district office, I was re-assigned to regional technical support duties again in Boston but with my duty station in Bangor. During this time I drafted a noise directive for the Boston region similar to the one in Philly but it was not adopted. In 2008 I was reassigned to my current post as a field industrial hygiene compliance officer in Bangor.

During this time the Barry family grew expanded and grew up. We added a fifth child by adopting our foster son Melvin and also gained a son in law and a daughter in law and the family dog, Siren, a Dalmatian of course. My photo shows all the Barry clan, Siren, John, Melvin, Jim, Jean my wife, Chandra, Jims wife, Tony, Patti’s husband, me of course, young Jean, and Patti. The sports car is my 1987 Toyota MR-2. With retirement looming in 2015, I traded in my MR-2 on a new red 2014 Dodge Grand Caravan this summer to accommodate our first grandchild, Felicity Jean Reaves born in July 2014.

2014 Outstanding Lecture & Poster Awards

Every year attendees have an opportunity to vote on the Outstanding Lecture and Outstanding Poster awards from all those who have presented at our conference. Winners at the 39th annual NHCA conference in Las Vegas were:

Outstanding Poster Award:

**Alyssa Stanard**, B.A., PhD Candidate, Central Michigan University for her poster entitled, A Survey of Individuals Exposed to Wind Turbine Noise.

Outstanding Lecture Award:

**Dr. Jennifer Tufts**, PhD, CCC-A, Associate Professor of audiology in the Department of Speech, Language, and Hearing Sciences at the University of Connecticut for her presentation entitled, Canal Segment Length of Custom Earplugs: Effects on Attenuation (and Comfort).

The awards consist of a check to Dr. Tufts for $250.00 and a check to Ms. Stanard for $150.00. Congratulations to both for their outstanding contributions to the NHCA conference, to their university, and – most importantly – to hearing conservation and hearing loss prevention.
Just after I sat down to write this, I received a call from my son’s high school explaining that because of a predicted winter storm, classes will be dismissed two hours early tomorrow. Such is life in Minneapolis, Minnesota. I like the snow. No, I don’t do many winter activities. While there is a sledding hill across the street that I took my son to almost every winter day when he was younger, and the city makes a rink just another block over where my family goes skating, I actually just like having snow around, and I even like to shovel it.

I do have to think a little bit more tonight because of the new snow. Nearly every workday I ride my bicycle from my modest 1900-era house in south Minneapolis a few miles to the office of Benson Medical Instruments Co., which is in a 19th-century office building downtown. The new snow will cause some changes to my routine. I’ll have to ride more slowly and will need warmer clothes, but I’ll ride every day just the same. There are several people in our office who ride their bicycles year-round, and it’s not uncommon in Minneapolis. I’m often asked if I have a special bike with knobby or spiked tires for the snow, but the answer is no; balance plays a larger role than traction in my experience.

Earlier this weekend I picked out some organ music to play at an upcoming church service. In high school, it seemed that I played somewhere every Sunday, but that fell off when I went to college, and several years ago I started up again in a neighborhood church. In order to practice, I always had to travel to a church that had an organ I could use, and then only when it was available. In the colder months, when churches only heat their sanctuaries for a brief time during the week, this can also be a chilling experience. To simplify practicing, I took on a project a few years ago in which I converted an old vacuum-tube organ (found in a thrift store) to generate MIDI signals; a computer then uses the signals to produce sampled organ sounds when I play. This allows me to practice in my home while wearing headphones whenever the urge hits me. I can also record my playing to the computer’s hard drive. While I usually play much simpler things, I like to learn Bach chorales and shorter works by César Franck.

A couple of years ago we adopted a pair of cats named Renzo and Gracie, who are brother and sister. We adopted them from a man who covered mixed martial arts for ESPN, and from him learned that Renzo Gracie is a retired champion of that sport, as well as namesake to our cats. While both were raised as indoor cats in a small town, Renzo loves to run around the nearby blocks, and can’t wait to get outside at any opportunity. Gracie is much more the homebody. It’s not uncommon to find them intertwined and sleeping in the same chair. My son’s school is just across the Mississippi River from my work, and he will walk from there tomorrow afternoon to see me at the office. My wife works there, too—for several years now she has written the user’s manuals for our products. It seems that all of my activities are within just a few miles of where I live, which suits me fine. I’ve lived in the same house since just a short time after graduating from college, and it has adapted with my changing life. It’s a running joke that we’ve been remodeling the house for fifteen years, and with my life expectancy, I might just be able to finish someday. Painting and hanging pictures are the last things on our minds; we’re just happy to have the walls up.

With my son in school, our family schedule is fairly regimented, and most days revolve around catching the school bus and making sure that homework is complete. I do make sure to attend an Iyengar yoga class just down the street one evening each week to break the routine. Vacations can only be planned for school release times like in the summer or Christmas break, when we usually go to see my family in upstate New York. The past few summers, we have visited the Grand Canyon, Las Vegas, San Diego, and the Black Hills. This coming summer we’re considering a trip to Ireland, where my wife spent a year as a child. I attended my first NHCA conference in 1996 in San Francisco, and have attended each year since, except for 2000, the year my son was born. I’m sure that I go for the same reasons as everyone else: the great people and casual atmosphere, and for a good cause, no less. I’ve participated in some council activities and special projects over the years, and would like to be more involved in creating published standards and position papers. This coming February, you’re sure to see me standing at the same table again in the exhibit room, and I hope you’ll stop and talk.
NHCA Approaching 40th Anniversary

by Kim Schwartz
NHCA Executive Director

The National Hearing Conservation Association is approaching its 40th anniversary, and there is no time like the present to become more involved as a member or share all the benefits of belonging to an organization dedicated to hearing conservation with a colleague, friend, or business acquaintance.

“This membership offer is a way to introduce the NHCA family to those who have thought of joining NHCA before but just never have,” said NHCA Executive Director, Kim Schwartz. “Our hope is that new members and existing members alike can improve their skills, practices, and services by associating with each other. Fresh ideas and new connections can benefit everyone.”

The mission of the NHCA is to prevent hearing loss due to noise and other environmental factors in all sectors of society. NHCA is a network of leading experts, early adopters, and trendsetters in the field of hearing conservation and hosts one of the best networking opportunities in the field through its annual conference.

The 2015 annual conference will be held in New Orleans, Louisiana at the Astor Crowne Plaza from Thursday, February 19th to Saturday, February 21st.

The schedule on Thursday consists of workshops focusing on the basics of hearing loss prevention, new product offerings, tinnitus, cell death associated with hazardous noise, assessment of hearing protection attenuation, a forum for professional service providers, and the opportunity to sign up for a CAOHC Professional Supervisor of the Audiometric Monitoring Program workshop.

Friday attendees will gain knowledge from a wide variety of research presentations and a keynote address focusing on “Stories, characters, and events from a peripatetic journey through 75 years of hearing conservation, and the role of NHCA.” The luncheon speaker, Johnny Random, will both educate and amuse attendees with his knowledge of composing music with found objects. Saturday will open with the opportunity to chat about hot industry topics during breakfast round table discussions followed by breakouts focusing on hearing protection, fit testing, firearms, and noise control. The meeting will then conclude with additional research presentations.

Time will also be set aside during the conference to network in a more social atmosphere. On Friday evening, attendees will have the opportunity to network with fellow industry leaders while touring the historic French Quarter on a guided walking tour. The tour will end at a reception hosted in the same ballroom that hosted the Victory Ball for the Battle of New Orleans in 1815. You, too, can stand on the same balcony where Andrew Jackson stood and addressed his victorious American Army.

Everyone in the industry can benefit from an NHCA membership. Join NHCA or become more involved with the mission to prevent hearing loss. In the words of Benjamin Franklin, “An ounce of prevention is worth a pound of cure.”

Act now by becoming a member or spreading the word. The complimentary membership offer will expire on February 21, 2015. Please visit the following links:

Register for the Conference
www.hearingconservation.org/events/event_details.asp?id=346526

Become a Member
nhca.site-ym.com/general/register_member_type.asp?
Noise and Hearing Loss

Noise remains one of the most common problems in the workplace. In the USA, approximately 22 million workers are exposed to daily hazardous occupational noise levels (Tak et al., 2009). In a sample of over 1.1 million American workers, 18% had hearing loss, with prevalence being especially high in mining, wood product manufacturing and construction (Masterson et al., 2013). Noise-induced hearing loss is particularly prevalent in the military. In the Canadian Forces, 42% of service members showed at least a mild hearing loss and 26% developed a moderate to severe hearing loss by midlife, with some military trades such as infantry, artillery and flight engineers being the most at risk (Abel, 2005). In the USA, it was found that veterans were 30% more likely to have severe hearing loss than non-veterans after adjusting for age and current occupation (CDC, 2011).

Hearing loss is most often described or thought of as a loss of sensitivity to soft sounds (or loss of audibility), expressed as elevated hearing thresholds on the audiogram. Distortion, a second component of hearing loss that relates to the supra-threshold processing of sounds, is equally important and can often explain why individuals with identical audiograms typically do not reach similar performances on tasks involving speech understanding in noise. This two-component conceptualization of hearing loss (audibility and distortion) was initially suggested by Plomp in 1978. It is important to point out that the “distortion” component is perceptual in nature and related to sub-optimal auditory processing (e.g. loss in spectral or temporal resolution) or other individual factors such as age and cognitive issues affecting speech understanding. While the audibility component is described by the degree of hearing loss, speech perception in noise tests are often used to characterize the distortion component to quantify the generally greater signal-to-noise ratio (SNR) required by individuals with hearing loss to reach performances similar to those with normal hearing. In such cases, deviation from normal performance is expressed as a SNR loss in dB (Killion & Niquette, 2000).

In Figure 1, speech recognition thresholds (SRTs) at which half of the sentences are correctly understood in quiet (upper panel) and in noise (lower panel) are plotted as a function of the best-ear five-frequency pure-tone average (PTA) hearing thresholds. The data are for a sample of 80 individuals with normal hearing, up to moderate-severe hearing losses, from two studies (Giguère et al., 2010; 2015). All individuals were tested with the American English version of the Hearing-In-Noise Test (HINT) (Vermiglio, 2008).

Speech recognition thresholds in quiet (presentation level in dBA for 50% correct) increase (worsen) with increasing hearing thresholds in Figure 1, as expected. The slope of the regression function is about 0.6 dB/dB, indicating that speech recognition thresholds in quiet increased by 3 dB on average for each 5-dB increase in PTA hearing thresholds in this dataset. However, there is a large variability with increasing hearing thresholds, likely related to the wide range of hearing loss etiology and configuration as well as to age differences among individuals. Variations in speech recognition thresholds in quiet of up to about 25 dB are seen for individuals with nearly identical PTA hearing thresholds.

The speech recognition threshold in noise (presentation level in dB SNR for 50% correct) increase (worsen) with increasing hearing thresholds in Figure 1, as expected. The slope of the regression function is about 0.6 dB/dB, indicating that speech recognition thresholds in quiet increased by 3 dB on average for each 5-dB increase in PTA hearing thresholds in this dataset. However, individuals with similar pure-tone hearing
thresholds may have SRTs in noise that differ by as much as 6-7 dB. Given that the psychometric function relating recognition scores to SNR grows at about 10%/dB near the SRT, this can correspond to a large difference of 60-70% in sentences correctly understood in noise among individuals with nearly identical pure-tone hearing thresholds. Of note, it can be seen that some individuals have composite SRTs in noise that are above 2 dB, while the normative value is -6.4 dB (Vermiglio, 2008), indicating large SNR losses exceeding 8 dB.

**Protection and Communication in the Workplace**

To protect hearing and promote a safe workplace, engineering noise control is by far the preferred mitigation method (Suter, 2012). But it is not always feasible to reduce noise to safe levels in some working environments or for some occupations, and in these cases, short-term or long-term supplementary methods such as the use of personal hearing protection devices (HPDs) become necessary (Berger, 2003; Gerges & Casali, 2007; Canetto, 2009). Conventional HPDs are the most widely used type of hearing protection. These passive devices provide a fixed amount of attenuation across a wide range of noise levels in the work environment. When properly selected and fitted, they are adequate for most situations involving workers with normal hearing. However, in some situations they may interfere with aural communication tasks (sound detection, sound localization and speech communication) and task performance in workers with hearing loss (Berger, 2003; Canetto, 2009; Casali, 2010; Giguère et al, 2010; Themann et al, 2013ab). For these individuals, the combined effect of hearing loss and hearing protection may be such that important sounds from the environment become inaudible or masked. In focus group meetings with industrial workers and military personnel (Morata et al, 2005; Abel, 2008), serious concerns were raised about job performance and safety when working in noise with a hearing loss, especially when HPDs are used.

Since conventional HPDs reduce speech and other important sounds from the work environment, in addition to hazardous noise, a certain compromise may be needed in the amount of attenuation provided in order to optimize both protection and communication needs. Hearing protector standards such as CSA Z94.2-02 R2011 and EN 458:2004 recommend that the protected noise level falls 5-10 dB below the criterion limit, thus typically in the 75-80 dBA range, for a good overall protection outcome. However, this goal is difficult to achieve in practice. Firstly, the field attenuation provided by hearing protectors can vary widely across individuals and is poorly related to current performance ratings of hearing protectors. Secondly, even if a good estimate of the attenuation can be ascertained, workplace noise levels are rarely constant over time or uniform spatially, and thus the protected level achieved during the course of a given work day may deviate considerably from the targeted range. Finally, such broad selection guidelines do not specifically take into account the hearing profile of the user, the masking properties of the noise (spectral and temporal characteristics), the characteristics of the signals to attend to, and the aural communication tasks at hand. Such difficulties are recognized in some standards. For example, EN 458:2004 recommends that tests be performed in the actual workplace in various noise conditions over a typical working day or week to verify proper audibility of signals and adequate ability to communicate by the individuals wearing the selected HPDs.

A second class of HPDs, powered-electronic hearing protectors, is rapidly being introduced into the marketplace. The purpose of these devices is to protect individuals against loud noises while enhancing the audibility of softer sounds by providing a small amount of amplification in low noise conditions. Unfortunately, the available research on the effects of level-dependent powered electronic HPDs during communication tasks is rather limited (see Casali, 2010 and Giguère et al, 2011 for reviews), particularly for hearing-impaired users, the most likely beneficiaries. Cur-
rent level-dependent HPDs often have different modes of operation and several user-adjustable settings and options, some allowing radio communications, which can complicate the selection of the best solution for each particular situation. Moreover, detailed information on the electro-acoustic characteristics of the devices is often not supplied by the manufacturers or made readily available, which compounds the problem.

Methods to promote the selection of the most appropriate HPDs are needed as well as the identification of the types of hearing protection and/or amplification devices that are most beneficial to the population of hearing-impaired workers (Themann et al, 2013ab).

University of Ottawa Hearing Research Laboratory – Research program The Faculty of Health Sciences at the University of Ottawa houses the Noise and Communication Unit of the Audiology Research Laboratory. This facility is dedicated to research on noise, speech communication, sound localization and functional hearing assessment. One research focus is on quantifying the effects of the main variables affecting speech perception with HPD equipment, including the individual’s hearing status, the noise characteristics, and the attenuation and other parameters of HPDs. This article summarizes findings from two studies performed in our laboratory on the interaction of hearing loss and HPDs on speech recognition in noise when wearing different types of hearing protection and/or amplification devices.

Effects of conventional passive HPDs The aim of this study, reported in Giguère et al (2010), was to develop and validate a predictive model of speech perception that can account for the hearing status of the listener, the characteristics of the noise, and the attenuation of hearing protectors. The model was developed using speech recognition data from unprotected normal-hearing individuals tested in different workplace noises ranging in overall level from 87 to 95 dBA. This step served to establish the baseline psychometric function relating intelligibility and SNR for each noise. Then, corrections are applied to the psychometric functions taking into account hearing loss and HPD attenuation. To validate the model, 35 individuals with hearing profiles ranging from normal hearing to severe hearing losses took part in further series of speech recognition listening tests, with and without hearing protection for two devices (one earmuff with a NRR of 30 dB, one earplug with a NRR of 22 dB).

Pure-tone audiometry and the HINT tests on the participants served to document the audibility and distortion components of their hearing loss, if present. Individual hearing thresholds (250-8000 Hz) and the five-frequency (500, 1000, 2000, 3000, 4000 Hz) PTA in the best ear were used to classify participants into four profiles (Normal = hearing thresholds ≤ 25 dB HL at all frequencies; Slight/Mild = PTA ≤ 25 dB HL with one or more threshold above 25 dB HL; Mild/Moderate = PTA between 26 and 40 dB HL; Moderate/Severe = PTA between 41 and 55 dB HL). While the audibility component of a hearing loss manifests mainly as an increased SRT in quiet, the main consequence of the distortion component is an elevated SRT in noise. In this study, the SNR loss across individuals ranged from -1 to +9 dB.

Unprotected and protected thresholds were also measured for each participant to document HPD attenuation at five one-third octave bands (250-4000 Hz), prior to speech listening tests in selected workplace noises using the same fit. Figure 2 summarizes the word recognition data (protected vs unprotected) by hearing loss profile. Each data point represents a pair of unprotected-protected measurement in the same noise at the same SNR by a given participant. Different SNRs were used across participants and noises. Except for two data points, passive hearing protection did not hinder speech recognition for participants with normal hearing, which in some cases was even improved. However, when hearing loss was present, particularly as the degree of loss increased, the HPDs generally reduced speech recognition due to the loss of audible speech cues that they created. The effect was greater with the earmuff because of the higher attenuation achieved by the participants with this device (23-38 dB) compared to the earplug (11-22 dB) in the frequency range important for speech understanding (250-4000 Hz). In some cases, protected speech recognition scores dropped to 0%, indicating clear cases of overprotection in the dataset. This was intended in order to test the model under the widest possible conditions.
The measured recognition scores in Figure 2 were compared to our model’s predictions in the same workplace noises, taking into account the audibility (pure-tone hearing thresholds) and distortion (SNR loss) components of the hearing loss for each participant, and the individually-measured attenuation of the HPDs. To determine how the accuracy of the model depended on the audibility and distortion components of the hearing loss, predictions were also performed without applying any corrections for hearing loss as well as when applying corrections to account for the audibility component or the distortion component in isolation.

Figure 3 summarizes the model prediction results. As expected, a large mean over prediction error of 26% was obtained when the participants were assumed to possess normal hearing (0 dB HL at all frequencies, no SNR loss). Applying either audibility or distortion component corrections to the model nearly halved the mean over prediction error. When both components of the hearing loss were taken into account, the predictive ability of the model was very good with a mean error of -0.1%, essentially indicating no bias. The residual error bars in Figure 3 are related to the test-retest variability in measuring the speech recognition scores for each participant and the uncertainty in estimating the input parameters of the model (hearing thresholds, SNR loss, HPD attenuation) (Giguère et al, 2010).

**Effects of level-dependent hearing protectors**

This study, reported in Giguère et al (2015), focused on the interaction between the degree of hearing loss and the amplification settings of two level-dependent HPDs, one earmuff and one insert-type device, on speech perception in two military noises (89 and 95 dBA). The lower-level noise had a narrow dynamic range of about 4 dB and the higher-level noise had a wider dynamic range of about 15 dB. Both devices showed level-dependent characteristics similar to hearing aid compression, one resembling output automatic gain control (AGC) circuitry and the other input AGC. At low noise levels, these devices provide some amplification. As the level increases, the gain is reduced and then the devices provide gradually more attenuation until the maximum attenuation is achieved. For each device, three different level-dependent settings were investigated (OFF = passive attenuation of the HPD, low = maximum gain of about -4 dB, high = maximum gain of about +10 dB). As in the first study, participants (45) were grouped into four hearing profile categories ranging from normal hearing to severe hearing loss and the SNR loss was measured. Then, speech recognition listening tests were carried out in the two military noises, unprotected and protected for each of the three selected settings of the level-dependent devices. As in the previous study, different SNRs were used across participants in order to avoid floor and ceiling effects in the baseline unprotected condition. As such, hearing-impaired individuals were tested at higher SNRs to compensate for the distortion component of their hearing loss.

Figure 4 presents the unprotected against protected results obtained with the earmuff-type device for each setting (OFF, low gain and high gain) for all participants grouped into the four hearing profile categories. When the level-dependent mode was switched OFF to simulate conventional hearing protection, results were consistent with those of the previous study. There were large differences across hearing profile categories; participants with normal hearing showed little effect of wearing the device while participants
in the most hearing-impaired category showed large decrements in scores compared to unprotected listening. For the different categories of participants, performance in the passive mode of the level-dependent devices was very similar to that measured with conventional HPDs with the same attenuation. Activating the level-dependent mode of the devices produced speech recognition benefits over the passive mode at both low and high gain settings for individuals with hearing loss. While the AGC circuitry produces larger amounts of attenuation with increasing noise levels, the passive attenuation limits of the device was seldom reached given the dynamic range of the noises used in this study, allowing the hearing-impaired listeners to benefit from lower amounts of attenuation in the quieter periods. The category of participants with the most impaired hearing benefitted the most from the level-dependent mode. Similar conclusions were drawn for an insert-type level-dependent device (Giguère et al, 2015). Such findings indicate that the level-dependent hearing protection circuitry can provide substantial benefits in speech perception in noise for individuals covering a wide range of hearing losses.

**How do HPDs affect speech understanding in noise in normal-hearing and hearing-impaired users?**

Taken together, the two studies highlight a strong interaction between HPDs and the hearing status of the user on speech perception in noise. While conventional passive hearing protection does not appear to interfere with speech perception in noise in normal-hearing users, sizeable performance decrements may be noted with hearing-impaired users and unacceptable overprotection can sometimes result. In such cases, the combined effect of HPD attenuation and hearing loss produces a significant loss of audible speech cues. Viewed in a different way, speech perception in normal-hearing users is quite insensitive to the effective attenuation of the device, but with increasing degrees of hearing loss, the speech perception outcome is critically dependent on the selection of the HPD and the attenuation achieved. It is unclear if simple guidelines on the desirable protected level to be achieved, as proposed in some standards, are sufficient to ensure a good protection outcome for all users in most situations. While predictive models taking into account the characteristics of the noise spec-
trum, hearing loss and the HPD attenuation curve may be helpful in making more informed decisions regarding HPD selection, they require considerably more effort to deploy.

On the other hand, level-dependent HPD devices can provide significant speech perception benefits for individuals with hearing loss. Our results indicate that when the level-dependent circuitry is activated, the protected-unprotected difference in speech recognition can become much less sensitive to the degree of hearing loss up to moderate-severe hearing losses, free of gross overprotection effects in noise levels up to about 90-95 dBA, at least with some devices, and this greatly simplifies the selection process for this group of HPD users. At increasingly higher noise levels, the attenuation of level-dependent HPDs gradually converges to the residual passive attenuation of the device shell and no particular benefit is expected compared to conventional hearing protection; however, in this noise range, just reliable face-to-face speech communication is very difficult to achieve for everyone, even when shouting at close range unprotected (ANSI S3.14-1977 R1997).

Looking Ahead

Situational awareness in the noisy workplace is not only dependent on speech communication; it also involves a wider range of aural communication skills, including signal detection and sound localization. Further work should continue to address all these dimensions in drawing up guidelines to obtain the best overall solution for each particular user given the task demands.

In the case of conventional passive hearing protectors, standardized procedures are needed to determine the hearing loss and/or noise conditions under which special features such as flat/uniform-response HPDs or filtering options can be beneficial to the user. From a design standpoint, powered-electronics hearing protection devices are increasingly incorporating sound processing functions typically found in hearing aids. Further integration of technologies, such as bilateral gain-frequency shaping, can be expected. This holds promise in providing better solutions tailored to the individual needs of hearing-impaired workers to achieve both protection and good situational awareness in noisy environments. One obstacle is the sparse disclosure of electro-acoustic specifications by manufacturers of powered-electronics HPDs, in sharp contrast to the situation found in the hearing aid industry. Important parameters affecting speech communication such as the directional characteristics of the microphone mounting, and the frequency response, compression dynamics and harmonic distortion of the level-dependent circuitry, among others, are not conveyed. Hence, it remains difficult to project protection outcomes from the technical specifications of the devices. This information is however essential to assist in the selection of the most appropriate device in the field.
References


Introduction
Noise remains a common contaminant in many workplaces. A number of workers with a personal or occupational hearing loss must, on a daily basis, face the consequences of diminished hearing sensitivity, which can compromise one’s safety and that of others because of the attendant difficulties it creates in perceiving auditory signals, in understanding speech in noise and in identifying the location of sound sources (localization). Hearing aids can potentially be used in the workplace to maintain auditory awareness of the surroundings and allow hearing-impaired individuals to work in a safe, effective, and autonomous manner. This option however raises concerns as to the effectiveness of hearing aids in optimizing those hearing abilities required to perform various job duties and in amplifying sounds to levels deemed safe, while at the same time reducing industrial noise to limit further worsening of the hearing loss.

Very few scientific studies have addressed the use of hearing aids in noisy workplaces. Thus, little is known on the frequency of this practice and its associated risks. It should be noted that, in this context, noisy workplaces are not limited to work environments characterized by noise levels exceeding regulatory limits, but also include softer environments in which the use of hearing aids could potentially lead to over-amplification. To guide future research endeavors in this field, a research activity was carried out by means of gathering information from health care professionals, manufacturers and the scientific literature, which focused on:
1) documenting the frequency of hearing aid use in noisy workplaces,
2) identifying the tools available to health care professionals to document the risk of over-amplification,
3) determining whether or not hearing aids can support listening and communication needs without further exacerbating the hearing loss or compromising safety, and
4) determining if other amplification and protection technologies (for example level-dependent hearing protectors) can help improve, or at least not hinder, auditory performance at work.

The multi-pronged activity was supported/funded by the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST, Quebec). This article briefly summarizes a portion of the work, particularly the literature review on the effects of directional microphones and noise reduction algorithms on speech perception in noise, and that of hearing aids on sound localization.

Frequency of hearing aid use in noisy workplaces
While the research activity did not allow precise identification of the number of workers using hearing aids in noisy Quebec workplaces, 84% of the health care professionals surveyed (n=198) reported that they have been confronted, at least once during the last 5 years, by a worker using, or considering using, hearing aids in a noisy workplace. The lack of valid tools to assess the risk of over-amplification, of clear guidelines on how to adequately manage these cases, and of solid mechanisms for collaboration amongst the various professionals involved in the worker’s care, were often cited as significant obstacles to an optimal, client-centered, approach to case management. In addition to the role of each professional not being clearly understood, sharing information between the various professionals seems to be lacking when it comes to identification of the noise characteristics (type, level, spectrum) at a workstation, the auditory requirements of the job and the recommendations to be made to both the worker and the employer. In many instances, recommendations are aimed at protecting a worker’s residual hearing; hence, the use of hearing aids is discouraged. However, such a discouragement may underestimate the need to understand in noise for safe and effective work performance. Health care professionals have every reason to feel ill-equipped since a literature review neither revealed any clear conclusions as to the risk of over-amplification with hearing aids, nor allowed identifying a valid, reliable and standardized method to document or predict this risk, while also taking into consideration current technologies.
Literature review on the effects of hearing aids on speech understanding in noise and on sound localization

To better guide health care professionals in their decision to recommend or discourage the use of hearing aids in noisy workplaces, it was deemed essential to first document the effectiveness of hearing aids in supporting those hearing abilities that are required for safe, efficient and autonomous performance at work. More specifically, the effects of noise reduction algorithms and of directional microphones on speech perception in noise, and that of hearing aids on sound localization, were investigated.

Reference documents in audiology and in occupational health and safety were extracted from various databases. Given the rapid growth in hearing aid technologies, only articles published after 2000 were retained for further analysis.

The following sections briefly summarize the state of knowledge. At the outset, it should be noted that most articles deal with sound environments that poorly reflect the acoustical conditions (sound levels, frequency content, reverberation time, etc.) of typical noisy workplaces, which greatly limits the generalization of results to the target population of noise-exposed workers.

Effect of noise reduction algorithms on speech perception in noise

Despite different methodologies used from one study to the next to assess the potential improvement in speech perception in noise associated with noise reduction algorithms, a significant improvement was noted in only 4 (Chung et al., 2009; Prosser et al., 2009; Peeters et al., 2009; Oliveira et al., 2010) of the 18 articles selected for further analysis; no improvement nor deterioration was found in the other studies. Noise reduction algorithms could however help reduce overall noise exposure levels (i.e. Chung et al., 2009). It is imperative during the intervention process to instill realistic user expectations as to their potential benefits, such as improved listening comfort, listening effort and sound quality (i.e. Zakis et al., 2009), even despite the sometimes minimal information made readily available to health care professionals on the specific algorithms developed by various hearing aid manufacturers.

Effect of directional microphones on speech perception in noise

In a sample of 21 articles selected for analysis, variability was noted not only in the methodology used to document the benefit of directional microphones for speech perception in noise relative to the performance of omnidirectional microphones, but also in the magnitude of this benefit. While the directional benefit (compared to omnidirectional) on measures of speech reception thresholds was found to be as much as 15 dB (i.e. Compton-Conley et al., 2004), the majority of articles reported an average benefit of 2-5 dB (i.e. Keidser et al., 2007; Klemp & Dhar, 2008; Kim & Bryan, 2011). It would seem that the magnitude of the directional benefit is highly dependent on methodological elements, among others, the type and number of noise sources, the position of the noise sources relative to that of the target speech, the number of microphones on each hearing aid, the directivity pattern (cardioid vs hyper-cardioid) and type (adaptive vs fixed) of directional microphone, and the type of ear mold fitting (open vs closed). Adaptive directional microphones can yield an additional advantage over fixed directional microphones (i.e. Blamey et al., 2006), but this advantage diminishes in the presence of diffuse noise (i.e. Valente et al., 2006). Furthermore, compared to closed ear mold fittings, open fittings seem to reduce the directional benefit (Magnusson et al., 2013).

Finally, user-reported subjective benefits related to directional microphones have been documented in some studies (i.e, Bentler, 2005), although not in all (i.e. Gnewi-kow et al., 2009). In one study (Palmer et al., 2006), it was reported that a third of users could not subjectively differentiate between directional and omnidirectional modes, one third of users preferred the omnidirectional mode and the remaining third favored the directional mode.

Effect of various hearing aid technologies on sound localization

For sound localization, the 18 reviewed articles explored various different conditions of hearing aid use, including aided vs unaided performances, unilateral vs bilateral amplification, open vs closed fittings, microphone position and directivity pattern, various processing strategies (noise reduction algorithm, binaural communication, frequency compression), the hearing aid acclimatization period, and different combinations thereof. The effect of many of these factors on sound localization remains inconclusive, with positive, neutral and/or negative effects being reported in the literature.

In general, sound localization performances are better unaided than aided, particularly in the front/back dimension (i.e. Vaillancourt et al., 2011), and bilateral amplification yields better results than unilateral amplification (i.e. Kobler et al., 2002). The effect of microphone position remains inconclusive, with contradictory results stemming....
from various studies. Moreover, contrary to a common belief amongst professionals, directional microphones could prove superior to omnidirectional microphones, particularly for the resolution of front/back confusions (i.e. Silotto, 2007; Chung et al., 2008; Groth et al., 2011).

Different signal processing strategies can also impact on sound localization abilities, particularly if they substantially modify the cues used by the auditory system to identify where sounds originate. Indeed, dynamic compression operating differently in both ears can hinder spatial perception by creating a sensation that sounds are diffuse and in movement (i.e. Wiggins et al., 2012). It is difficult to draw any clear general conclusions as to the effect of various hearing aid parameters on sound localization given the small number of studies addressing specifically a given parameter, the interaction between various parameters and the diversity of methodologies used to study their effect.

Finally, sound localization performances of a hearing aid fitting can improve over time compared to that measured immediately after fitting, although not necessarily (i.e. Best et al., 2010). The acclimatization period, during which the user gradually becomes more proficient with amplification, can last a few months; its duration varies as a function of, among others, the user’s age and cognitive functions.

**Lessons to be learned from the literature**

Results from the literature review are, for the most part, not readily generalizable to the target population of this research activity (noise-exposed workers with hearing impairment). The stimuli, the noisy environment, the work organization, the listening and communication requirements specific to the workplace, as well as the hearing status and other characteristics of individual workers, can prove to be significantly distinct from the methodological elements found in the articles selected for analysis. Briefly stated, the available scientific data do not allow demonstrating clearly that hearing aids can be used to fully support all hearing abilities required to perform work tasks in a safe and autonomous manner. However, neither do the data demonstrate, with any degree of certainty, that the use of hearing aids poses a risk to worker safety.

**Other available options?**

Given the uncertain impact of hearing aids on the hearing abilities required for safe and effective job performance, a review of alternative or complementary options to hearing aid use was warranted. One such option is the use of powered level-dependent hearing protectors that amplify soft sounds while protecting against loud sounds. Despite significant technological advancements in the field of level-dependent hearing protectors, and their generally favorable appreciation by workers compared to conventional hearing protectors, it seems that no single device has yet been sufficiently well-designed and demonstrated to fully and reliably restore environmental awareness in all listening conditions to a level obtained without hearing protection. Furthermore, a flexible and personalized adjustment and fitting, based on the hearing-impaired worker’s characteristics and needs, remains relatively limited with powered hearing protection, especially when compared to what is possible with hearing aids. It is also difficult to select a specific product that could meet the needs of both the worker and the workplace, given the limited disclosure by manufacturers as to the parameters and operational modes of their products. Hence, before systematically recommending their use to hearing-impaired workers, further studies are required which also take into account various safety issues.

**A “good-practice” guide for health care professionals**

The multi-pronged research activity, carried out over the past two years, raised more questions than it provided answers. It is however clear that a collaborative and multidisciplinary effort is urgently required to develop a “good practice” guide for the management of hearing-impaired workers in noisy workplaces by hearing health professionals. To reach this objective, at least three research endeavors are anticipated: 1) development of a valid method to assess noise exposure levels with hearing aids, in order to avoid over-amplification, 2) development of an intelligent hearing aid/hearing protector specifically designed for use in noisy workplaces, and thereafter, 3) development and maintenance of a guide to assist in the selection of an adequate device that can play the dual role of protecting hearing and improving listening and communication abilities. Hopefully these projects will be completed in the near future as there is a pressing need for such tools within the community of health care professionals who deal with hearing-impaired workers. And while our research activity focused on the context at play in Quebec, it is foreseeable that similar needs are felt in many industrialized countries.

In conclusion our team currently recommends that health care professionals use the precautionary principle by which hearing aids should only be considered for use in noisy workplaces as a last resort after an initial consideration of noise reduction in the workplace and of all other options. The other options include adaptation of the workstation/workplace to modify the listening, communication and lo-
calization requirements of the job function and to allow, where possible, support from or reliance on other sensory modalities (visual, vibratory). In cases where hearing aids are deemed appropriate, the risk of over-amplification and the worker’s safety must be systematically accounted for and adequately managed by all concerned professionals. In the absence of clear, evidenced-based guidelines, consultation, coordination and cooperation among the various stakeholders is critical to achieve recommendations that do not compromise the worker’s health and safety, or that of others.

References


Mobile Apps for Hearing Health

by Amy Boudin, Au.D.; Gayla L. Poling, Ph.D.; and COL (RET) Kathy Gates

Editorial note by Kristy Casto
The Department of Defense (DoD) established the Hearing Center of Excellence (HCE) to focus on the prevention, diagnosis, mitigation, treatment and rehabilitation of hearing loss and auditory injury. The HCE was legislated by Congress in the FY 2009 National Defense Authorization Act (NDAA) and directed to partner with the Department of Veterans Affairs (VA), institutions of higher education and other appropriate public and private entities.

The HCE’s mission is to heighten military readiness and optimize quality of life through collaborative leadership and advocacy for hearing and balance health initiatives. The HCE works to consolidate and distribute the latest information about hearing loss prevention, hearing conservation, and clinical care and research advancements in best practices for hearing loss and auditory injury from military, industry and academic resources.

None of the Apps listed in this article have been tested or approved by HCE. The Sound Level Meter Apps do not meet OSHA Type 2 measurements for use in Hearing Conservation.

We Live in a Noisy World
An estimated one out of every three cases of hearing loss is caused by excess noise exposure, known as noise-induced hearing loss, or NIHL. Noise and hearing loss create a significant burden for our military, since noise exposure is one of the primary environmental hazards faced by all service members, regardless of specialty. Moreover, our service members, veterans, family members, and friends are exposed to noise hazards in recreational settings that increase their risk for NIHL.

Therefore, it is critical that hearing loss prevention strategies become a daily practice, not just for those whose jobs are known to involve noise-hazardous risks. Advancing technologies and mobile applications (apps) offer easily accessible, affordable, and interactive ways to focus on hearing health.

Get Connected
Several affordable and interactive smart phone and tablet apps are currently available to bring awareness to hearing health. There are several options that not only help lead to the identification of hearing difficulties, but can help alleviate symptoms of hearing loss and tinnitus. Additionally, there are apps with educational materials for all ages that focus on reducing risks for NIHL — and they are just fun! While mobile apps can increase awareness of hearing, tinnitus, and hearing loss prevention, they do not replace the need for evaluation and treatment by an audiologist or hearing healthcare provider.

Examples of mobile apps for hearing health include:

Sound Level Meters
1. dB Volume Meter: This free app allows iOS users to measure noise levels in any environment. With prior education about unsafe noise levels, the user can assess their environment for these hazards and use preventive measures to avoid the risk.
   Developer: Amanda Gates
   iTunes Rating: 4 ½ stars/5 reviews
   Cost: Free

2. Sound Meter: This free app allows Android users to measure noise levels in any environment. With prior education about unsafe noise levels, the user can assess their environment for these hazards and use preventive measures to avoid the risk.
   Developer: Smart Tools Co.
   Google Play Rating: 4 ½ stars/109,416 reviews
   Cost: Free
Hearing Screeners/ Hearing Loss Simulators

1. Hearing-Check: This iOS- and Android-compatible app was created by Action on Hearing Loss, the official hearing foundation in the United Kingdom. This app tests the user’s hearing by scoring the entry of numbers on a keypad as they are spoken in the app.
   - Developer: Action on Hearing Loss
   - iTunes Rating: 2 stars/5 reviews
   - Cost: Free
   - Google Play Rating: 3 stars/63 reviews
   - Cost: Free

2. Play It Down: This is an iOS-compatible, all-inclusive, and interactive app. It simulates hearing loss by changing the characteristics of the user’s music, conducts an ultra-high frequency tone-detection test, and has a sound level meter that indicates the “danger zone” for listening levels.
   - Developer: Red Deluxe/playitdown.org
   - iTunes Rating: 3 stars/17 reviews
   - Cost: Free

Listening Assistance

1. i-Hear Free – Hearing Aid: This iOS app allows the user to hear the sounds around them amplified through the phone using standard headphones.
   - Developer: Idan Sheerit
   - iTunes Rating: 4 ½ stars/7 reviews
   - Cost: Free

2. EarMachine: “This work is funded by the National Institutes of Health . . .” states the description of this iOS app. It allows the user to listen to surrounding sounds or to music from their phone’s library. The app is easy to use, with the ability to adjust multiple processing parameters based on your own preferences or using the app’s recommendations.
   - Developer: Ear Machine LLC
   - iTunes Rating: 4 ½ stars/12 reviews
   - Cost: Free

3. EarTrumpet: This app is available for use with iOS systems. Its description stresses that it is intended for entertainment purposes only. The app simulates a hearing test, which yields a report and generates a filter that can be used to amplify sounds and decrease background noise.
   - Developer: Praxis BioSciences, LLC
   - iTunes Rating: 4 ½ stars/7 reviews
   - Cost: $3.99

4. SoundFocus: This free iOS app plays music to match the user’s hearing loss as defined by in-app testing that can be completed with headphones or by using car stereo speakers. The hearing profile can be recalculated repeatedly, making it possible to optimize the sound for myriad environments. Music plays from the user’s personal library or from Spotify, which runs within the app.
   - Developer: Symphonic Audio Technologies
   - iTunes Rating: 5 stars/114 reviews
   - Cost: Free

Tinnitus and Aural Rehabilitation

1. Relax Melodies: This free app is a sound generator for iOS and Android users. A sleep timer and alarm clock allow the user to fall asleep and wake up to mixes that (s)he has created. With 50 sounds to choose from, the user can create a variety of 10 sound mixes. Relax Melodies Premium is available for purchase, which among other additional features, offers more sounds to choose from and has the ability to run while other apps are being used.
   - Developer: iLBSoft (iOS); Ipnos Software (Android)
   - iTunes Rating: 5 stars/4,523 reviews; 5 stars/615 reviews
   - Cost: Free; $2.99
   - Google Play Rating: 4.5 stars/58,512 reviews; 5 stars/8,133 reviews
   - Cost: Free; $2.99

2. Hear Coach: This free app is available for iOS and Android devices. It has a suite of listening games that allow the user to increase in difficulty and access new levels as performance improves.
   - Developer: Starkey Laboratories
   - iTunes Rating: 4 stars/19 reviews
   - Cost: Free
   - Google Play Rating: 4.5 stars/10 reviews
   - Cost: Free

3. Coping with Hearing Loss: This is an iOS- and Android-compatible educational app. There are 15 chapters that cover how the ear works, diseases/disorders one might have and how they are diagnosed, and rehabilitation options. The description indicates that the $0.99 price is promotional only and that the regular price is $14.99.
   - Developer: AppWarrior (iOS); KoolAppz (Android)
   - iTunes Rating: Not yet rated
   - Cost: $0.99
   - Google Play Rating: 5 stars/1 review
   - Cost: $1.36
Anatomy

1. **Ear Nose Throat Decide - Point of Care Patient Education for Healthcare Professionals:** This iOS app allows the clinician to create digital handouts for patients using the patient's radiological imaging or the company's stock photos and videos. This is available by subscription, with a free 14-day trial.
   - Developer: Orca Health, Inc.
   - iTunes Rating: Not yet rated
   - Cost: Free 14-day subscription
   - Fee-based monthly or annual subscription

2. **Ear ID:** This iOS and Android app is designed for use by students, patients, and professionals. The app shows the anatomy of the outer, middle, and inner ear; identifies and describes the function of each structure; and has animations and video of the function of several structures within the ear. The user can further tailor the use of this app by drawing directly on the screens using the whiteboard feature. Also available are Middle Ear ID and Inner Ear ID apps, each for $4.99, and the Ear ID eBook. The eBook provides a comprehensive introduction to the structure of the human ear. Included in the Ear ID are 12 animations and 120 detail illustrations. Within the multimedia capabilities of this eBook is easy access to 99 glossary entries of terms and definitions, fully cross-referenced.
   - Developer: Blue Tree Publishing, Inc.
   - iTunes Rating: 2 stars/13 reviews
   - Cost: $2.99 / $4.99 (Middle and Inner Ear ID)
   - Google Play Rating: Not yet rated
   - Cost: $2.99 / $4.99 (Middle and Inner Ear ID)

3. **aVOR:** This iOS-compatible app demonstrates the anatomy and function of the vestibular system. When the iPhone or iPad is moved, the app shows the user which semicircular canals are activated and the resulting eye movement in functional and dysfunctional systems.
   - Developer: Liberty IT
   - iTunes Rating: 5 stars/6 reviews
   - Cost: Free

Just for Fun

1. **Ear Match:** This is an educational app, compatible with iOS and Android tablets. The user can learn the parts of the ear through a match-and-memory game.
   - Developer: Blue Tree Publishing
   - iTunes Rating: Not yet rated
   - Cost: $2.99
   - Google Play Rating: Not yet rated
   - Cost: $2.99

2. **Ear Doctor and Ear Doctor 2:** This app is iOS (Ear Doctor 2) and Android (Ear Doctor) compatible. It is a children's game that allows the child to remove wax, test hearing, and use professional methods to help virtual patients with their problems.
   - Developer: Hugs N Hearts (iOS); Bluebear Technologies, Ltd. (Android)
   - iTunes Rating: Not yet rated
   - Cost: Free
   - Google Play Rating: 4 stars/6,520 reviews
   - Cost: Free

3. **HearStrike:** This iOS app utilizes the user's auditory skills to aim for a target. The more central and loud the tone sounds, the closer the user is to the center of the target. Points are awarded based on accuracy of the shots.
   - Developer: MDV Ingegneria Elettronica Sas
   - iTunes Rating: Not yet rated
   - Cost: $0.99

4. **Sound ID:** This app is compatible with iOS or Android tablets. It is an interactive app that allows the user to guess which sounds belong where on a noise thermometer.
   - Developer: Blue Tree Publishing
   - iTunes Rating: Not yet rated
   - Cost: $2.99
   - Google Play Rating: 4 stars/6,520 reviews
   - Cost: $2.99

5. **iEducate Drag Drop** (Inner Ear, Labyrinth, and Middle Ear) These are each iOS and Android tablet compatible, allowing the users to build the structures of the ear from a bank of images.
   - Developer: Blue Tree Publishing
   - iTunes Rating: Not yet rated
   - Google Play Rating: Not yet rated
   - Cost: $2.99

Hear to Live

The above are just a few of the examples of mobile apps for hearing health. We live in a noisy world and learning more about your hearing through these mobile apps can help you learn about hearing and hazardous noise levels. You can also discover ways to protect your hearing so that you can enjoy lifelong hearing.

*Availability, ratings, and cost are current as of November 7, 2014.

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