



International Conference

Music-Induced Hearing Disorders

Chicago, USA
20–22 June, 2018

CONFERENCE REPORT

The 3rd AES conference dedicated to music-induced hearing disorders took place June 20–22 in Chicago. This follow-up to the 2015 conference in Denmark brought an international focus to topics including different types of hearing disorders, hearing protection, and methods for sound exposure monitoring.

The conference took place at Columbia College in the heart of downtown Chicago, within walking distance of great music venues like Jazz Showcase and Blue Chicago.

People attended from around the world, including academics, audiologists, and representatives from industry. Attendees came from Australia, Korea, the United Kingdom, and Norway, among other nations.

PRE-CONFERENCE ACTIVITIES

The evening before the technical presentations began, there was a “meet & greet” event with an open house and tour of the labs and studios within the Department of Audio Arts & Acoustics at Columbia College, Chicago. With the support of catered drinks by Goddess and the Grocer, this event provided an opportunity for everyone to get to know each other and learn about the facilities from Benj Kanters, director of the studio and music engineering curriculum. He discussed the impor-

tance of including auditory physiology in the curriculum. The tour included two studios, multiple control rooms, post-production suites, an anechoic space, a lab for measuring sound transmission through materials, and an old bank vault that had been converted into a reverb chamber.

DAY 1 CONFERENCE OPENING

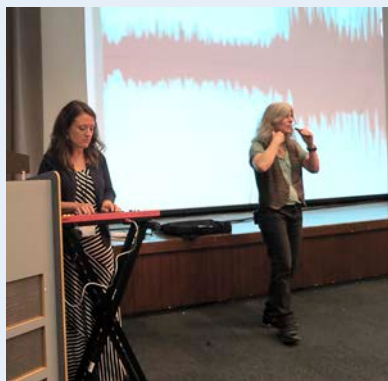
Conference cochair Robert Schulein (ImmersAV Technology, USA) opened the conference with an overview of the program and by introducing the organizing committee.

Immediately following the opening remarks, Nina Kraus (Northwestern University, USA) delivered the keynote. Nina’s talk, entitled “Music for Brain Health,” introduced the audience to her research and a wide variety of related research into the neuroscience of music. Nina focused primarily on the frequency-following response (FFR) part of the auditory brainstem response, in which the neural timing is phase-locked to a periodic auditory signal. The FFR represents, not just a representation of the acoustic signal, but indicates how a sound is perceived. As an example, she presented the recent work of Gabriella Musacchia showing that the FFR can differentiate between people who hear “Yanny” or “Laurel” in a popular illusion.



New and old friends get together at a meet and greet.

Nina gave many other examples of research showing the importance of music for brain development and health. The audience was delighted by videos of babies enjoying music and saw evidence from Laurel Trainor's lab (McMaster University) that babies who were bounced in sync with a musical beat are more helpful in a later task than babies bounced asynchronously. Of course, Nina also reviewed the breadth of research from her own lab, much of which is also available on her website at <http://brainvolts.northwestern.edu>. She showed that musical training can be beneficial for speech understanding, reading skills, and reducing the effects of age. With the assistance of Heather Malyuk on keyboard, Nina closed her presentation with a short musical performance. A patch allowed Heather to play neural recordings as keyboard notes with Nina accompanying on harmonica.



PAPER SESSION

The first paper presentation of the conference was scheduled to be Pieter Van 'T Hof (Dynamic Ear Company, The Netherlands), to discuss testing of musician's earplugs. Unfortunately, he was unable to attend.

Hearing Protection Goes Digital

Tron Vedul Tronstad (SINTEF, Norway) kindly offered to fill this time slot by presenting his recent doctoral thesis on the topic of a new hearing monitoring system. In this work he showed that, by combining frequent hearing tests with appropriate statistics, small threshold shifts (<5 dB) can be detected even without calibrated measurement equipment. Tronstad used concepts from the field of statistical process control, like CUSUM charts, to estimate when threshold shifts become significant. He showed preliminary evidence that these techniques could be used as an early warning of hearing loss.



PANEL DISCUSSION

“In-Ear Monitors & Safe Sound”

Sound levels on stage can be especially dangerous. In this panel discussion, a group of experts discussed ways to provide safer sound. Mark Frink (monitor engineer for Tony Bennett, k.d. lang, the Super Bowl, and others), Matt Engstrom (Shure, USA), Michael Santucci (Sensaphonics, USA), and Heather Malyuk (Soundcheck Audiology, USA) presented their thoughts and invited the audience to join the discussion.

Santucci talked about the benefits of in-ear monitors (IEMs), such as improved sound quality, pitch perception, and timing. He argued that IEMs could reduce feedback and performer fatigue. He also pointed out that devices like “db Check” can be used to monitor signal levels.

Mark Frink recommended equalizing for loudness control and taking frequent breaks while practicing. He pointed out that typical exchange rates for exposure limits require either 3 dB or 5 dB decreases in level when the duration is doubled, but this does not match perceived loudness (which takes roughly 10 dB level change). Mark noted that it’s generally better to use IEMs than wedges, but



wedges are probably better than using one IEM. He also pointed out that focused mixes can allow reduced exposure levels, but it is important to provide timing and intonation cues from the other performers.

Matt Engstrom provided an overview of how IEMs work, the benefits (including reduced vocal strain), and what types of products are available on the market. He pointed out that Shure provides a free online resource for selection and operation of personal monitor systems.

Heather Malyuk shared her personal experience as a musician, who happens to also be an audiologist. Her anecdotes provided insights that triggered a discussion with the other panelists and the wider audience. In fact, after a quick vote, everyone decided to delay lunch so they could continue the discussion a bit longer.

PAPER SESSION

Disorders of Sound Tolerance

The first paper of the afternoon session was presented by Marc Fagelson (East Tennessee State University, USA), who presented a framework for categorizing and treating hyperacusis and diplacusis. He defined hyperacusis as an abnormal sensitivity to loud sounds that can be broken down into sensitivity due to loudness perception, fear, annoyance, and/or pain. Diplacusis is the sensa-



tion of at least two pitches in response to a single tone. Fagelson reviewed evidence that exposure therapies can provide relief for hyperacusis (particularly loudness hyperacusis) but emphasized that more work is needed to identify the best ways to manage diplacusis.

Musicians and the Prevention of Hearing Loss

Invited speaker Marshall Chasin (Musicians’ Clinics of Canada), presented a pragmatic review of hearing loss based on both research and his clinical experience with musicians. He discussed exposures that could cause permanent threshold shifts and those that might cause temporary threshold shifts (and/or cochlear synaptopathy or “hidden hearing loss”). Chasin pointed out that, although music can be considered a type of noise, exposure levels, durations, and spectral characteristics can be different from typical industrial noise. He presented data showing that many instrumentalists routinely produce levels far exceeding 85 dBA and advocated the use of musician’s earplugs as well as environmental and behavioral strategies to limit exposure.



Otoacoustic Emissions in Band Musicians with Music Overexposure

Sridhar Krishnamurti (Auburn University, USA) presented some recent research in which he and his colleagues collected otoacoustic emission data from over 600 people—non-band students, marching band performers, and band directors. They found that both distortion-product emissions (in response to two tones) and transient-evoked emissions (in response to a click) were strongest for the non-band students and weakest for the band directors. This was consistent with their expectations, given the idea that marching band students are likely exposed to more loud music than non-band students but less than band directors. The result that transient-evoked otoacoustic emissions appear to be sensitive to noise-induced hearing loss was particularly interesting. These results appeared to be quite reproducible, indicating that they might provide a very easy way for clinicians to quickly and easily monitor hearing health.

Invited Talk: Hidden Hearing Loss from Sound Overexposure

Following a short break, Sharon Kujawa (Harvard Medical School, USA) presented an invited talk on hidden hearing loss. Her research at Harvard Medical School triggered an immense interest in this topic when she published a 2009 paper showing that, after lab animals recover from a temporary threshold shift, permanent cochlear nerve damage remains. For the AES audience, Kujawa presented an overview of research in the past decade. She showed evidence that the neuron/hair-cell synapses are particularly vulnerable and can be destroyed while the hair cell survives. She showed evidence that this occurs in a wide variety of mammals, including evidence from human temporal bone studies. This synaptopathy is strongly associated with changes in auditory brainstem responses in lab animals and appears to precede hair cell loss and permanent threshold shifts as part of age-related hearing loss.



PAPER SESSION

Computational Models to Predict Safety Limits for Aided Music Listening

Jon Boley (GN Advanced Science, USA) presented some results of computer modeling that suggested people with hearing loss are less susceptible to permanent threshold shifts due to noise exposure. He used two different models of hearing loss to explore the relationship between prior and subsequent hearing loss, and to propose specific exposure limits based on an individual's audiogram. The models agreed on an 8-hour exposure limit of 85 dBA for listeners with normal hearing thresholds and predicted higher limits when hearing loss is already present. However, he emphasized that these limits are based on several assumptions (for example, an average ear canal response, limited frequency range, and relevance of temporary threshold shifts) that remain to be tested.



Investigating the Use of Sound Level Management Software in Live Indoor Music Venues

Jos Mulder (Murdoch University, Australia) presented some preliminary results of a sound-level management system that was installed at a live music venue. During the first phase, sound levels were recorded over the course of several nights. The venue was asked to then set a target level (chosen to be 98 dB based on a 15-minute average) and the sound engineer was provided with a visual display of the sound level in the second phase. Overall, the average sound level was 93–94 dB in both phases, but there was some evidence that the time spent at high sound levels may have been reduced in the second phase.



DINNER AND A SHOW

Dinner, catered by Goddess and the Grocer, was influenced by owner Debra Sharpe's travels as the backstage caterer for star acts



Left, dinner on the Thursday evening. Right, Glass Mountain trio performs American folk songs recorded by a head-and-torso simulator.

such as Paul McCartney, the Rolling Stones, and Madonna.

After dinner, Glass Mountain performed a set of six American folk songs for everyone. This local trio (Heather Malyuk, Sara Leginsky, and Ari Bolles) collaborated with Bob Schulein of ImmersAV Technology to provide a unique listening experience. You can hear binaural recordings of three songs at: "Hop High" <https://youtu.be/Bif2AUQObzc>; "Don't Laugh" <https://youtu.be/HkA7p51lhP0>; "Cool Water" <https://youtu.be/43qG5VHQtDk>

In addition to a more traditional PA system for sound reinforcement, the audience was able to listen to a binaural stream from an acoustic manikin on stage. The binaural sound was streamed to several sets of wireless headphones and the audience was encouraged to personalize their own listening levels.

DAY 2 PAPER SESSION

Hidden Hearing Loss? Effects of Recreational Noise on Evoked Potential Amplitude and other Auditory Test Metrics

Colleen Le Prell (University of Texas at Dallas, USA) started the second day with a review of hidden hearing loss research over the past few years. She showed that, although auditory nerve synapses are damaged by noise exposure in laboratory animals, several studies of humans have failed to show any relationship between auditory function and self-reported sound exposure. On the other hand, she described two studies providing evidence that music students and frequent concert attendees have worse high-frequency thresholds and may have degraded recognition of words in noise when compared to others. More research is needed to determine what exposures are likely to cause neural damage and what the perceptual implications are.



Music and Hearing Aids

Invited Speaker Marshall Chasin (Musicians' Clinics of Canada) recommended some ways to optimize the music listening experience when using hearing aids. He suggested some practical ways for both manufacturers and end-users to avoid peak limiting at the input stage. Chasin discussed some limitations of smartphone-based hearing apps, such as limited dynamic range and increased latency. He



then suggested that the optimal frequency response and compression depends on the hearing loss, but frequency compression should be disabled.

Best Practices for Fitting, Dispensing, and Verifying Hearing Protection Devices for Musicians

Invited Speaker Cory Portnuff (University of Colorado Denver School of Medicine, USA) presented his recommendations for fitting musicians' earplugs. These included deep ear impressions, proper user training, and verification of real-ear attenuation. Portnuff shared his analysis indicating that attenuation does not need to be measured at all frequencies but should be verified at four frequencies (250 Hz, 2 kHz, 4 kHz, and either 500 Hz or 1 kHz). He concluded by emphasizing the importance of counseling musicians on topics like the benefits of monitoring hearing health over time and learning to play at a normal intensity with hearing protection.



PANEL DISCUSSION: "MANY OUNCES OF PREVENTION WHERE THERE IS NO POUND OF CURE"

Benj Kanter (Columbia College Chicago and HearTomorrow.org) moderated a panel discussion addressing teaching strategies for hearing awareness and conservation.

Panelists included Marshall Chasin (Musicians' Clinic of Canada), Heather Malyuk (Soundcheck Audiology), Jos Mulder (Murdoch University), and Joel Styzens (relax-your-ears.com). The attendees actively participated and discussed their responses to questions such as "How do you start a conversation about hearing loss prevention?" and "Who is your primary/secondary audience?"

Michael Santucci pointed out the importance of taking time in the clinic to talk about motivations, and Mark Frink mentioned that, even for musicians, music may not be the only source of dangerous sound (there are also power tools, guns, and the like). Heather and Joel talked about the importance of focusing, not on thresholds, but disordered hearing, which can include hearing in noise, tinnitus, and hyperacusis. Several people discussed the limitations of talking about SPL limits based on noise and models that assume exposures occur for 40 hours per week.

Benj continued the discussion by asking the panel for their opinion on mobile apps. Marshall pointed out that apps are limited by calibration accuracy. Benj mentioned that an app from NIOSH provides level, dose, and calibration options. He also mentioned an



app called SoundPrint that provides awareness by informing users of noise levels in restaurants. Heather recommended a device called dBCheck for monitoring exposure levels and Benj pointed out that inexpensive SPL meters can be very useful.

Benj and Heather discussed the lack of buy-in from hearing protection manufacturers. Meanwhile, Marshall discussed using earplugs with no filter (in other words, just a tuned vent) for simply rolling off high frequencies, although Brian Fligor recommended flat tuning for good communication. Scott Snyder and Michael Santucci closed the conversation with a discussion about the need for an earphone measurement standard.

PAPER SESSION

Development of Guidelines for Protecting the Hearing of Patrons at Music Venues: Practicalities, Pitfalls, and Making Progress

Jos Mulder (Murdoch University, Australia) opened the final afternoon session with a presentation of recently established guidelines for Australian music venues. These recommendations, based on a review of several European regulations, include providing earplugs and rest areas, restricting access to loudspeakers, monitoring and recording sound levels, and voluntary sound level limits. Jos discussed the various perspectives for setting limits and the difficulty of reaching a consensus that provides safety for both attendees and employees while also fitting existing regulatory systems. He mentioned that ongoing research to better understand typical recreational exposures may be helpful in establishing limits.

The Lantos 3D Scanning System and Computer Aided Design of Musicians' Earplugs

Brian Fligor (Lantos Technologies, USA) demonstrated a digital workflow for scanning an ear canal, computer-aided design, and 3D printing of custom musicians' ear plugs. With some pilot data, he showed the importance of plugging deep into the ear canal and described how computer modeling could be used to predict the acoustic mass of the sound bore. With this fully digital workflow, Brian suggested that custom earplugs can become more accurate, consistent, and effective.



CLOSING REMARKS

Conference cochair Michael Santucci (Sensaphonics Hearing Conservation, USA) closed the conference by thanking the audience for their contributions to some great discussions. He invited everyone to provide feedback to him and other organizers for future conferences.



Editor's note: AES Members can access the conference papers free of charge via the AES E-library at <http://www.aes.org/e-lib/>