

AES 58th International Conference Music-Induced Hearing Disorders

Aalborg, Denmark
28–30 June 2015



CONFERENCE REPORT

The second AES conference on music-induced hearing disorders took place in central Aalborg, Denmark on June 28–30, 2015. The venue was the newly restored Comwell Hvide Hus, where lectures were given in the spacious “Ny Kilden” room offering a refreshing view to the neighboring park. Almost fifty participants from three continents, sixteen countries, and a wide range of interests and professional fields met to exchange views on the interdisciplinary challenges relating to the adverse effects of loud music. The conference facilitated discussions with professionals that on an everyday basis are required to produce high-level sound at live events, and audiologists and hearing aids experts fighting the challenge of enabling good-quality music experiences for individuals with impaired hearing. The conference brought together a truly interdisciplinary group, all joined by the shared vision of developing innovation solutions for hearing loss prevention and hearing loss alleviation.



Dorte Hammershøj opens the conference on the first day.



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Brian Moore addresses the audience during his keynote.

Refreshments were enjoyed in the exhibition area adjacent to the lecture room, and the buffet lunch served one floor down allowed participants to mingle and make new contacts. The social program also included a visit at the acoustic laboratories of Aalborg University, and a spectacular banquet at the North Sea Oceanarium.

EFFECTS OF HEARING AND PERCEPTION PRODUCED BY EXPOSURE TO MUSIC

The technical program started with the keynote lecture by Brian C. J. Moore, Professor Emeritus Cambridge University, introducing the audience to the most common perceptual consequences of hearing loss and aided perception of music. The necessity for wider bandwidths was (among other things) discussed in view of music quality, and Moore also raised attention to animal studies by colleagues in the field that suggest that the pathophysiological changes in our inner ear may take effect at much lower exposure levels than currently presumed. Moore also discussed “dead regions” in the ear, and the perceptual consequence of high amplification. It is possible, that there is a higher prevalence of this in hearing-impaired rock musicians, and that it is better to identify such regions, and to “back off” rather than employ high amplification.



Annie Jamieson

In the following talk, Annie Jamieson presented a survey about hearing protection among sound technicians working in various musical environments. Although a pilot study, Jamieson’s findings reveal that a great majority of sound technicians have some kind of hearing disorder. Most are aware of the potential risks of their jobs, and face the problem that hearing protection limits their ability to perform critical listening.

Bozena Kostek, presented a modified loudness scaling procedure using musical sounds and a more restrictive evaluation scale. The motivation for the work is to investigate alternative measures of hearing diagnosis that are fast and accurate and can be used in clinical settings. Results presented gave a good agreement between a standardized loudness matching procedure and the proposed method.



Bozena Kostek

The last talk in this session was given by Tron Tronstad. He presented accumulative effects on hearing in subjects that participate in music festivals. Dosimetry measures and both threshold shifts and changes in otoacoustic emission were presented from participants at two Norwegian festivals. A clear accumulative effects from several days of “festival life” could be observed, showing that music exposures that last for several days can result in greater effects than stand-alone exposures.

DETECTION OF MUSIC-INDUCED HEARING DISORDERS

In his invited talk, Eric LePage reviewed his findings from the National Acoustic Laboratory in Australia. A large database of click-evoked otoacoustic emissions reveals (among other things) that people enjoying music from portable players show the same decline of otoacoustic emissions as those exposed to industrial noise—possibly with an earlier onset. LePage also showed results that suggest that our susceptibility for acquiring hearing damage may depend on medical history and general health.



Eric LePage during his invited presentation

In the subsequent talk, Annelies Bockstael compared the protective effects of five different musician ear-plugs. Distortion Product Otoacoustic Emissions (DPOAE) measured before and after music exposure showed only insignificant differences in DPOAE levels, but stressed the importance of the length and diameter of the plug and how easy it is for the subjects to obtain a good seal of the ear-canal with the ear-plug.



Annelies Bockstael

A new probe system for the assessment of “high-frequency” OAEs was presented by Dan Mapes-Riordan. The probe system facilitates a forward pressure calibration, and also includes a center opening for endoscopic examination of the ear canal during deep insertion of the measurement probe.

In the following talk, Anders Tornvig Christensen presented his custom-built OAE probe designed for “low-frequency” OAE measurements. The probe had made it possible to demonstrate the prevalence of DPOAE down to 90 Hz, and there is no indication that DPOAEs shouldn’t also exist for even lower frequencies. His results also demonstrate that the optimal ratio depend on frequency in a way similar to the frequency dependency of the equivalent rectangular bandwidth.

HEARING AID TECHNOLOGY FOR MUSIC AND TREATMENT

In his invited talk, Nicolai Bisgaard presented a historical review of hearing aid technology, and how different types of signal process-

ing affect the perception of music. The first priority for hearing aids has traditionally been to improve speech intelligibility, and much of the required signal processing has undesired effects for music. Space limitations and an extremely challenging power budget in hearing aids make it difficult to reproduce broadband signals of acceptable quality, and there is limited experience with the possible advantages of such strategies. The integration of the hearing aid with wireless communication and smartphone control may open for new possibilities with more appropriate customization for different sound environments.

The adverse effects of hearing damage was the key topic of Jaime Serquera's presentation on strategies for tinnitus treatment. Serquera had studied a tinnitus treatment procedure using musical signals to match the pitch of a patients' tinnitus in an interactive manner. One of the main conclusions of the pilot study is that the pitch-matching task is critical for the success of the treatment, and that training in psychoacoustics tasks in general may help improve the outcome.



Jaime Serquera

The challenges for optimal hearing aid fitting were addressed by Esther Rois-Merz. Her presentation focused on the qualitative



Heather Malyuk poses a question to Esther Rois-Merz.

dialog between the patient and the audiologist in which patient requirements and expectations are framed. Rois-Merz utilized a special device (Klangfinder) that allows the patient to listen, switch, and compare the sound of different types of hearing aids in the same real-time situation. Rois-Merz also made a strong case for teaching the audiologist music theory and the basics of sound engineering so that the audi-

ologist can better translate the patient's description of the listening experience and make better adjustments to the parameters in the hearing aid. This is particularly useful when fitting hearing aids for users listening to music and musicians.

SOUND LEVEL MANAGEMENT AND CONTROL

Johannes Mulder presented the first of three talks related to stakeholders at live concerts. Not only musicians and concert attendees, but also the sound reinforcement industry, local authorities, event planners, and the local community are stakeholders at live concerts. Mulder's presentation provided a sociological perspective of the dynamics and outlined the impor-



Johannes Mulder

tance of sound level monitoring for prevention of hearing damage for staff, artists, and attendees, and annoyance and disturbance of neighbors. The significance of proactive dialogues with all stakeholders was stressed.

Marcel Kok subsequently gave an overview of the tasks and challenges that exist for monitoring and controlling large sound reinforcement systems. Kok stressed the importance of assigning and accepting a "sound guard" that has sovereignty with respect to level management. This role needs to be negotiated and agreed upon by stakeholders prior to the event, so that prompt action can be taken, when required.

The significance of intuitive and reliable monitoring tools was presented by Jacob Navne in the subsequent talk. Sound exposure limits in existing legislation all use some variations of equivalent continuous A-weighted sound pressure levels averaged over given time periods. It is therefore insufficient to display the instantaneous level. An estimate of the exposure level (the temporal integral) needs also to be computed, and used to make level budgets for the remaining concert time. This is the only way the sound engineer can stay within limits for the entire concert.

Carsten Borg presented exposure levels measured at the Roskilde Festival in Denmark from 2009 to 2014. The measurements were carried out with a modified behind-the-ear hearing aid, and logged data for approximately 50 volunteers during varying periods of the festivals. The sound measurements made with the hearing aids are on average in good agreement to the levels registered by the sound management system, and adds insight into the range of individual exposures occurring, day variations, etc. The overall results suggest that the levels at the Roskilde Festival have not changed drastically in the past six years. Questionnaires revealed that the majority (63%) wear ear-plugs at some point during the festival. Another delegate at the conference stressed that this would not be the case at American festivals.

PANEL DISCUSSIONS

Two panel discussions were organized around topics identified by the conference participants prior and during the conference. In the first panel discussion, including panelists Jakob Navne (10EaZy), Marcel Kok (dBControl), Thomas Lund (TC Electronics), Michael Santucci (Sensaphonics), and Johannes Mulder (Murdoch University), the challenges relating to level control at live events were further discussed. The panel discussion touched on the dilemma for sound engineers that may be forced to produce high level sound, and abstain from hearing protection in spite of the known risks. Hearing protection is, for fair reasons, considered an impediment for ensuring the quality. The discussion also touched on the need for better education and training by professionals in the field, and general mediation of knowledge to concert participants. Most know what sound pressure level means, but don't understand the signifi-



Panel discussion: from left, Jakob Navne (Denmark), Marcel Kok (Netherlands), Thomas Lund (Denmark), Michael Santucci (U.S.), and Johannes Mulder (Australia).



Technical cochair Rodrigo Ordoñez, left, with Jan Larsen.

cance of exposure levels and how to relate to this.

Another panel discussion related to “listening to music behind an ear-plug,” including hearing aids technology. The panelists for this discussion included Nikolai Bisgaard (GN Resound), Bozena Kostek (Gdansk University), Eric LePage (OAEricle), Heather Malyuk (Sensaphonics), and Brian Moore (Cambridge University). One of the points made during the panel discussion was that ear-plugs don’t necessarily degrade music quality. Although the attenuation is not ideal, it enables the hearing to work in the dynamic range it is meant for. Another part of the discussion touched on the possibility that dizziness among the audience of live concerts may also be explained by excessive exposure.

HEARING PROTECTION IN THE MUSIC INDUSTRY

On the last day of the conference, Michael Santucci and Heather Malyuk shared experiences from their work with musicians, and their needs and requirements for monitoring during performance, for example by in-ear monitors, in their invited presentation. The prevention and treatment of music-induced hearing loss remains a taboo among many musicians, but experience reveals that patience and perseverance move barriers. In-ear monitors not only help reduce exposure levels, but also affect user behavior. “One is worse than none”, claimed Michael Santucci, when considering the use of one in-ear monitor as opposed to two or none.

Pieter van’T Hof presented an electroacoustic system for measuring the acoustic seal of ear plugs intended for musical purposes. Most ear plugs for music have a channel running along the length of the ear plug in which one can apply different acoustical filter configurations. The method can be used to test the manufacturing quality of custom-made ear pieces and to teach people how to obtain a good seal with a given ear plug.

The last paper on the early Tuesday morning session included a presentation by Anders K. Møller. He presented a study of the significance of the position of the recording microphone on devices placed in the ear (e.g. electronic hear-through earphones). Measurements on humans demonstrated that the directional dependence was very low for frequencies below 3–4 kHz, but varied across microphone position point and individuals for higher frequencies.



Pieter van’T Hof



Delegates enjoy the banquet at the North Sea Oceanarium.

HEADPHONE SOUND EXPOSURE AND MEASUREMENT STANDARDS

The last invited talk was given by Thomas Lund on the work being done by the CENELEC to establish EN safety standards for portable music players in Europe. Lund gave an overview of the so called “loudness wars” that have fueled the music industry to produce excessively compressed music in order to maximize loudness of signals that are limited only by peak levels. Lund presented the ongoing CENELEC work on EN 50332-3, where an attempt is made to implement the current EU dosimetry requirements.

In the subsequent talk, Dorte Hammershøi presented measurements on 20 randomly selected earphones, and the variations in dose predictions that would follow, if the proposed method in EN 50332-3 was followed. The draft EN 50332-3 is based on player output alone, which given the range of variation in earphone sensitivities would leave a considerable uncertainty in the dose estimate. It was argued that any dosimetry estimate would need to include key data for the earphone, if it should ever provide reliable



Thomas Lund gives an invited talk on loudness control.



Members of the conference committee, from left, Anders Tornvig Christensen, Michael Santucci, Rodrigo Ordoñez, Dorte Hammershøi, Bozena Kostek, and Jan Voetmann. (absent, Bob Schulein)

information for the user.

The last presentation was given by Flemming Christensen, who had compared pinnae dimensions and head-related transfer functions as a function of age and gender. Through the presentation Christensen showed the specific differences in morphology of the outer ear as a function of age and the related changes in head-related transfer functions. The analysis of the results showed that males have a statistically significant differences in pinnae size as they grow older and this is accompanied with a slight change in the diffuse field HRTF where the maximum values moves down in frequency and increases in level.

CONCLUSION

A general challenge in the community seems to relate to mediating the concept of exposure levels as opposed to simple level regimes for key stakeholders. Examples of best practice were shown, and proposals for standardized efforts communicated. The need for interdisciplinary efforts was also a recurring discussion, and central to the adjustment of expectations for hearing aid users. Finally, the implications of earlier findings by Sharon Kujawa and colleagues, which suggests that loss of hair cells in the inner ear is not the first response to over-exposure, was a recurring discussion. No method for monitoring the early changes (in synaptic organizations) has been presented.

Editor's note: Papers from this conference can be downloaded from the AES E-Library at: <http://www.aes.org/e-lib/>

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