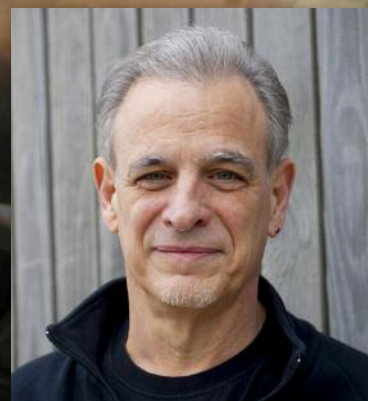


47th International Conference Music-Induced Hearing Disorders

Columbia College
Chicago, USA
20–22 June 2012

CONFERENCE REPORT

With the advent and omnipresence of portable listening devices and louder sound systems for live sound reproduction, the impact of music-induced hearing disorders is of global interest. These disorders are bothersome to workers in any industry, but for musicians and auditory engineers who depend on the integrity of their hearing for their art and their career, such disorders can be acutely problematic.



Michael Santucci, conference chair



DELEGATES MEET EACH OTHER AT THE OPENING EVENT



In response to this need the AES Technical Committee on Hearing and Hearing Loss Prevention, in conjunction with Columbia College Chicago, IL, USA, hosted the 47th AES International Conference, *Music-Induced Hearing Disorders*, with a focus on new technologies for measurement and prevention. Michael Santucci, president of Sensaphonics Hearing Conservation, conference chair, and Jörg Bitzer and Robert Schulein, papers cochairs, assembled a stellar line-up of presentations on topics including workplace noise regulations in the music industry, modeling hearing impairment, measurement techniques for portable listening devices, performance requirements for assistive listening systems, and medical therapies for protection and hearing regeneration.

Attendees from the United States, Europe, Canada, and New Zealand participated in two days of paper presentations, networking, two special events, as well as a banquet on the first night of the conference. Columbia College provided a fitting conference venue with comfortable meeting space and access to student recording and research facilities. Few cities in the world can match the character and culture of Chicago, featuring world-class dining, museums, entertainment, and accommodations in the largest and most visited city in the U.S. Midwest.

OPENING EVENT

Attendees arriving the evening before the conference were treated to an opening event hosted by the Department of Audio Arts and Acoustics of Columbia College, Chicago. Located in the heart of downtown Chicago, the department



Pantelis Vassilakis, chair of Department of Audio Arts and Acoustics, addresses attendees.

is fully equipped with labs and studios that support the diverse curriculum in acoustical engineering, live and installed sound, and audio production. A number of demonstrations were organized showing acoustic measurement, audio editing, recording studio techniques, and multichannel audio for film and television production and playback. This relaxed setting provided ample time for attendees to meet one another, renew relationships, as well as explore the student facilities.

CONFERENCE DAY ONE

Keynote Address: “Bringing Together the Cultures of Music, Audio and Hearing,” Benj Kanters, Columbia College

Following his opening remarks, Michael Santucci, conference chair, introduced keynote speaker Benj Kanters, associate professor, associate chairman, and director of the Columbia College Audio Design & Production Program. Kanters offered a dynamic presentation on bridging the cultures of music, audio, and hearing. His presentation was based on his five-year efforts developing what has become known as the Hearing Conservation Workshop. This workshop has resulted in over 50 seminars delivered to university programs in music, audio and audiology, professional organizations in audio and the hearing sciences, public health foundations, and the military. The essence of his presentation was that, once taught how one’s hearing works as well how it can be damaged, engineers and musicians develop a sense of ownership of their ears, and become concerned about their hearing health.



“New Knowledge of the Ear’s Hidden Susceptibility to Hearing Loss and the Magic Formula for Predicting SNR Loss,” Mead Killion, Etymotic Research, Elk Grove Village, IL

It has been known for some time that the correlation between hearing loss and speech intelligibility in noise (SNR Loss) were not well understood. Mead Killion’s paper presents a method of relating hearing loss to SNR performance by incorporating an estimate of the loss of inner hair cells or neural terminals. This estimate results in a term he describes as Cue Transmission Ratio (CTR), which allows the SNR loss of an individual to be predicted over a wide range of real-world conditions.



“Workplace Noise Regulations in the Music Industry: A Square Peg and a Round Hole,” Robert M. Ghent, Jr., Honeywell Safety Products, San Diego, CA



Robert Ghent’s paper provided an overview of U.S. occupational noise regulations, their history and enforcement, implications for the entertainment industry, and a look at what we might learn from European Union (EU) regulations. Recognizing that many audio professionals are familiar with community noise regulations, he noted that they have little understanding of occupational noise regulations.

He went on to state that the audio industry is subject to the same requirements of protecting the hearing of its workers as other industries, further noting that changes in sound level enforcement may soon be changing as has been the case in Europe. His take-away message was that this industry would be well served by becoming more proactive about protecting hearing with or without the threat of legal enforcement.

“Modeling Hearing Impairment and Its Affect on Auditory by Auralization,” Rainer Huber, Universität Oldenburg and HoerTech, Oldenburg, Germany

In order to better understand the effect of hearing impairment on the perception of audio signals and speech in everyday life, a thorough understanding of the underlying mechanisms and factors influencing audio and speech reception in various listening conditions is highly desirable. Rainer’s presentation reviewed a series of studies by his group to model audio and speech reception in normal and hearing-impaired listeners in a multidisciplinary approach. In order to make the effect of hearing impairment accessible to normal listeners, teachers, and students, an auralization technique was described that includes both an “attenuation” component of hearing loss and a “distortion” component.



“Dietary Supplements for Protection of the Inner Ear,” Colleen Le Prell, Department of Speech, Language, and Hearing Sciences, University of Florida, Gainesville, FL

Colleen’s paper presented research and development that she has been doing in the area of pharmaceutical approaches to mitigating hearing loss due to high-level sound exposure. Data was presented

that related the fact that intense metabolic activity drives the formation of free radicals (short-lived, unstable, highly reactive clusters of atoms) in the inner ear. She presented further data on animals, clearly showing that free radicals formed during and after noise importantly contribute to NIHL (Noise Induced Hearing Loss). Her work has shown that free radical scavengers (“antioxidants”) reduce NIHL in animal subjects. Investigators at multiple institutions have shown the combination of β -carotene, vitamins C and E, and magnesium reduces NIHL in animals, and supporting data have been obtained in clinical trials. Her work now involves human trials where the objective is to show that NIHL can be mitigated by such pharmaceutical approaches.



“New Tools for Hearing Loss Screening and Tinnitus Diagnosing,” Bozena Kostek, Gdansk University of Technology, Multimedia Systems Department, Gdansk, Poland



Hearing loss and tinnitus are major occupational maladies affecting 10–20% of musicians, typically initiated by exposure to excessive sound pressure levels. Coping with and treating these issues benefits greatly from practical and efficient methods of characterization through screening. Bozena’s paper presented the results of a smartphone based test methodology for hearing loss, speech in noise understanding and tinnitus sound

signature matching. The system described was based on iOS-based mobile devices and has been evaluated all over the world. Current work involves clinical trials with a focus on refining what was described as a tinnitus dithering process.

“New Measurement Techniques for Portable Listening Devices: Technical Report,” Cory D.F. Portnuff, Department of Speech Language and Hearing Sciences, University of Colorado, Boulder

Gathering data on actual sound pressure levels associated with portable listening devices (PLDs), has been a subject of much interest due to the large public use of headphones. Where as the details of accurate measurement methods are well known, there has been a need to make such measurements on a more practical basis allowing the collection of real-world data. Cory’s presentation provided a review of standard laboratory techniques as background and then gave two new practical methods based on a dosimeter technique calibrated to the electrical drive level of the earphone, and a probe microphone method using readily available clinical equipment. Further details were presented that relate the correlation between exposure guidelines and the influence of ear canal resonance on data acquisition.



“Value of DPOAEs in Detecting Changes Associated with Music Overexposure,” Sridhar Kishnamurtie, Department of Communications Disorders, Auburn University, Auburn, AL Distortion Product Otoacoustic Emissions (DPOAE) is a relatively new measurement technique focused of the auditory per-

formance of the cochlea. Once the external ear has been excited by a sound, the hair cells within the cochlea will generate an acoustic response that can be detected with sensitive microphones and signal processing techniques. This measurement technique has proven to be a tremendous benefit to young children as it now allows a fast and efficient means of detecting hearing problems at birth, requiring no conscious response from the child. Building on these techniques, Sridhar's paper deals with a study he conducted looking at the relationship between traditional threshold loss and OAE (Otoacoustic Emissions) for two groups between the ages of 19 and 29. One group was musicians who were frequently exposed to loud sounds and the other non-musicians. Although the sample size (24) was relatively small, the results were quite significant in that both groups showed little difference in threshold loss, but the musicians showed lower than normal OAE readings. The potential benefit to this technique is that it can predict the onset of hearing loss before actual threshold loss is measurable.



“A Pilot Study of Changes in Otoacoustic Emissions After Exposure to Live Music,” Rodrigo Ordonez, Acoustics Department Aalborg University, Aalborg, Denmark



Two common methods for measuring Otoacoustic Emissions (OAE) involve an acoustic stimulation of the cochlea, one involving a twin-tone excitation, and the other using a short pulse. In either case the measurements depends on the tiny hair cells in various parts of the cochlea responding with a very low-level acoustic response. Rodrigo's paper involved a pilot study using both techniques on a group of concert attendees before and after the concert. The objective was to look for changes in emissions dependent upon the level of sound exposure. Results presented demonstrated that the twin tone or

Distortion Products Otoacoustic Emissions (DPOAE), were easier to implement in noisier environments than the transient technique. Both measurements were able to demonstrate reduced emissions however following exposure to sound levels in the range of 83 to 112 dB SPL(A)_{EQ}.

BANQUET

Following the formal presentations of the first day of the conference, attendees were treated to a banquet catered and served by Chicago-based Feast. The menu was selected by owner Debra Sharpe, known as the backstage caterer to such musical stars as Paul McCartney, the Rolling Stones, and Madonna. After dinner Jan Abildgaard Pedersen, AES president, spoke to the group about his reactions to the conference and the future of the AES.

CONFERENCE DAY TWO

“Electroacoustic Performance Requirements for Assistive Listening Systems for Hard of Hearing and Hearing Impaired,” Peter Mapp, Peter Mapp Associates, Colchester, UK



The primary function of assistive-listening systems is that of speech intelligibility, which often fall short in delivering the intended results. Peter's paper focused on those attributes of many system designs that are most responsible for optimum performance. AFIL (Audio Frequency Inductive Loop) systems are quite popular due to their low cost, simplicity of transmission, and the fact that many hearing aids contain an induction-receiving coil. Infrared (IR) and FM wireless systems also see common use, however each has its problems with signal strength and interference. Whereas all systems can be made to perform well, many systems fall short due to a collective group of issues, involving improper design, lack of adjustment, and poor maintenance. Peter's paper provided a review of current practice and proposed a number of guidelines structured to help improve the situation.



Jan Abildgaard Pedersen, AES president, addresses the conference during the banquet.

Some of the culinary delights enjoyed during the banquet

Delegates enjoy the opportunity to network with each.

“Estimating Individual Sound Pressure Levels at the Eardrum in Music Playback Over Insert Headphones,” Ville Sivonen, Cochlear Nordic AB, Vantaa, Finland

Ville Sivonen’s paper was the second of three presentations on the subject of measuring sound pressure levels at the tympanic membrane for purposes of audiometry and sound level exposure. Recognizing the practical limitations of probe microphones placed in the ear canal, this paper proposed the use of a small microphone located in proximity to the earphone speaker or receiver as a means of measuring the acoustical input impedance of the user’s ear canal. By further characterizing the source impedance of the earphone, sound pressure levels unique to each user can be obtained. Having established this means of calibration, user-preferred listening levels were measured for a variety of music selections under different conditions of ambient noise. Results reported for a group of eight male subjects between the ages of 25 and 35 years were presented regarding safe-listening-time predictions for normal and loud playback conditions.



sented at the May 2009 AES convention, “A New Methodological Approach to the Noise Threat Evaluation of the Selected Physiological Properties of the Human Hearing System.” The proposed dosimeter has a very important feature, which is its ability to estimate the shift in hearing threshold already at the time of exposure to a specific type of noise. Test results demonstrated that the growth and recovery phases of TTS (Temporary Threshold Shift) were correctly determined from exposure to both constant and impulsive noise components. The authors have placed monitoring stations based on PND (Psychoacoustic Noise Dosimetry) in clubs frequented by students, where ongoing studies of TTS measures suggest that the PND algorithm and resulting damage-risk index may be a useful tool in noise assessment.

“Noise Dosimetry Made Simple,” Patty Niquette, Etymotic Research, Elk Grove Village, IL

Patty Niquette’s paper served to introduce the subject of dosimetry measurements with a focus on extended periods of exposure to music. A personal monitoring system was described that allowed test subjects to attend a variety of music and sports events where sound pressure levels were continuously measured as well as the cumulative percent of a daily dose. Results clearly demonstrated that the exposure risk many students are subjected to as a part of involvement with both music creation and concert attendance is potentially damaging to their hearing health. Further data was presented showing how exposure can be extended by as much as a factor of 100 using readily available broadband attenuating hearing protection.



“Musical Instrument Recognition in Combined Electric and Acoustic Cochlear Implant Simulations,” Shaikat Hossain, School of Behavioral and Brain Sciences, University of Texas, Dallas, TX

Shaikat Hossain’s paper presented the results of studies designed to learn more about the ability of individuals with cochlear implants to recognize the difference between various musical instruments and performance styles. Rather than use actual test subjects fitted with cochlear implants, a group of 18 normal hearing listeners were used. Music samples were processed by an 8-channel cochlear implant simulator, which had been developed for earlier studies. Stimuli included short excerpts from bass, guitar, horns, percussion, piano, strings, and synthesizer. Individual test results were analyzed by means of a two-factor ANOVA based on percent-correct responses. By analyzing results of the study, Shaikat intends to use the data to improve the signal processing algorithms used in cochlear implant applications. Particular aspects of this work include optimizing the perception of rhythm and improving the differentiation between musical instruments.



“Verification of Flat Attenuation Characteristics of Musicians Earplugs,” Brian Fligor, Children’s Hospital, Boston MA

Devices known as musician’s earplugs have been available for a number of manufacturers for some time. Such earplugs incorporate an attenuation module that is fitted into a custom ear mold for each user. Elmer Carlson, then with Industrial Research Products, invented this attenuator module in the late 1980’s (USP 4,897,612). Unlike basic earplugs designed to attenuate sound as much as possible, these devices have been designed to provide a uniform level of attenuation (typically 9, 15, or 25 dB) allowing musicians to play with ensemble of balance while at the same time protecting their hearing. Brian Fligor’s paper presented details of a probe microphone measurement procedure suitable for determining in-situ performance of a given device. Examples were shown of both proper performance as well as poor performance due to ear-mold fit errors.



Dorte Hammershoi questions one of the speakers during a papers session.

“Noise Monitoring System Employing Psychoacoustic Noise Dosimetry,” Bozena Kostek, Gdansk University of Technology, Multimedia Systems Department, Gdansk, Poland

Unlike traditional dosimetry based on A-weighted and C-weighted sound pressure level measures, the authors conducted a study based on a new methodology previously described in AES paper number 7813 pre-

“Protection and Measurement Methods and Devices for Occupationally Hazardous Sound Levels in Pro Audio,” Michael Santucci, Sensaphonics Hearing Conservation, Chicago, IL

This presentation focused on the design aspects of in-ear monitors (IEMs) and passive-attenuation earplugs as well as tools available to help users evaluate and maintain their hearing acuity. An IEM design was shown that allows musicians to control the balance between a monitor sound level and the level of ambient sounds with natural tonal balance and spatial accuracy. Another technol-

ogy was presented that allows musicians to monitor their actual SPL exposure over time, and thus predict their susceptibility to exceeding a safe daily sound dose. In closing Santucci indicated that combined with routine hearing tests, these devices collectively provide concerned musicians an ability to perform while knowing that their hearing is being protected.

“New Electronic Earplugs for Musicians,” Mead Killion, Etymotic Research, Elk Grove Village, IL

In this paper Mead Killion presented the results of his recent work in developing an electroacoustic earplug for musicians. This work was based on earlier research in the development of an insert ear-phone style of electronic hearing protector that provides automatic attenuation for sounds exceeding a specified SPL. With an emphasis of the needs of musicians, Killion related the design optimization that evolved from actual use by performing musicians.

“Potential Errors of Real-Ear-to-Coupler-Difference Method Applied for a Prediction of Hearing Aid Performance in an Individual Ear,” Oleg Saltykov Siemens Hearing Systems Inc, Piscataway, NJ



This paper was the third presentation dealing with the subject of determining actual sound levels at the tympanic membrane (TM) of a user without the need for a probe microphone very close to the actual TM. The methodology described by the authors involved what was described as the real ear-to-coupler difference (RECD), meaning the difference between

what would be measured at the TM of a real ear and that measured in a 2-cc acoustic coupler. Motivation for this technique is for fitting infants and young children with hearing instruments, where the occurrence of small occluded ear volumes can produce quite large errors in hearing aid sound levels. Recognizing the potential for errors with this technique, Saltykov presented a set of guidelines that can significantly improve measurement accuracy.

TECHNICAL TOUR AND GRANT PARK SYMPHONY CONCERT

Following Friday’s papers presentations, attendees were invited to a facilities tour and concert at the famous Jay Pritzker outdoor pavilion



Jonathan Laney hosts a tour of the sound systems at Millennium Park in Chicago.



Michael Santucci, chair



Linda Pink, treasurer



Robert Schulein (left) and Jörg Bitzer, papers cochairs



Benjamin Kanters, facilities



Jack Kontney, publicity

COMMITTEE

ion at Chicago’s Millennium Park. Sound-system designers David McNutt, and Jonathan Laney hosted the tour.

The architectural design of the pavilion is unique in that its acoustic trellis, which arches above the audience, features downward-facing loudspeakers. Audio signals feeding these speakers are enhanced by specialized Lexicon LARES electronics to simulate sound reflections typical of the world’s finest indoor concert halls.

Later that evening participants enjoyed a concert by the Grant Park Symphony Orchestra and Chorus, which included Strauss’ Don Juan, Britten’s Piano Concerto, and Mozart’s Symphony No. 41, Jupiter.

CONCLUSION

In his closing remarks Michael Santucci, conference chair, declared the meeting an outstanding success, bringing together scientists, clinicians, audio engineers, musicians, and a host of students who will be the next generation to tackle these key issues.

Editor’s note: Go to <http://www.aes.org/e-lib/> to purchase copies of the AES 47th Conference papers discussed in this article.