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Summary Report on the Sixth International Congress on Noise as a Public Health Problem

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As the representative of the American Speech-Language-Hearing Association, I had the privilege of attending the 6th International Congress on Noise as a Public Health Problem, held in Nice, France, July 5–9, 1993. Although more than a year has elapsed since the conference, much of this information is not widely available in the United States and may be of interest to audiologists and other readers of the *American Journal of Audiology*.

An International Congress on Noise as a Public Health Problem is held once every 5 years. The purpose of these congresses is to bring recent advances in the field of noise effects to the professional community and to the public. The material covers both research and public policy activities. The concept of noise abatement is commended, but is not discussed. Included in each conference is a summary and review of the research conducted during the 5-year interim, as well as short descriptions of recent findings and ongoing projects. Participants come from all over the world: Russia, China, Eastern Europe, Australia and New Zealand, although the majority of participants are from Europe and the United States.

The first of these noise effects conferences was organized by ASHA, supported by the U.S. Public Health Service, and held in Washington DC in 1968. The proceedings were published as *ASHA Reports 4*. This landmark conference set an important precedent, which has continued for the last 25 years and shows every indication of continuing well into the next century. The 1973 conference took place in Dubrovnik, Yugoslavia. The principal sponsor was the U.S. Environmental Protection Agency (EPA), although ASHA took a prominent role, along with the World Health Organization (WHO) and the Union of Medical Societies of Yugoslavia. The next conference, held in 1978 in Freiburg, West Germany was also sponsored by ASHA, in addition to two German governmental agencies and the U.S. EPA. The proceedings were published as *ASHA Reports 10*.

In 1983, the Fourth International Congress was held in Turin, Italy, without ASHA support, but in 1988, the Fifth Congress in Stockholm, Sweden listed ASHA as one of its many sponsors. The present, sixth, Congress was sponsored by 18 organizations, including the Acoustical Societies of France, America, Japan, and Great Britain, the British Society of Audiology, the U.S. Air Force, and WHO, but ASHA was not an official sponsor.

During the Dubrovnik meeting in 1973, interested participants formed the International Commission on the Biological Effects of Noise (ICBEN), which provides a rotating secretariat and organizing committee for the congresses. ICBEN members have divided the various areas of noise effects among 10 teams, each with its own chair and co-chair. They are:

- Team 1 Noise-Induced Hearing Loss
- Team 2 Noise and Communication
- Team 3 Non-Auditory Physiological Effects
- Team 4 Influence of Noise on Performance and Behavior
- Team 5 Noise-Disturbed Sleep
- Team 6 Community Response to Noise
- Team 7 Noise and Animal Life
- Team 8 Noise and Combined Agents
- Team 9 Regulations and Standards

The program of the Sixth International Congress consisted of invited lectures, "free communications" (meaning oral and/or poster sessions), and workshops. Sessions were organized so that there were no competing sessions for the invited papers, although the free communication sessions and workshops did compete with each other. There were only two workshops, one on noise-induced hearing loss and the other on noise-disturbed sleep.

Noise-Induced Hearing Loss

The activities of Team 1, Noise-Induced Hearing Loss, would be of greatest interest to ASHA members. For this congress the chair was Per Nilsson of Denmark (formerly of Sweden) and co-chair was Willy Passchier-Vermeer of the Netherlands. In addition to some discussion of the topic during the Tuesday Plenary Session, Team 1 presented 9 invited lectures on Wednesday and approximately 40 contributed papers and posters on Thursday, and held a workshop with 5 speakers on Friday. Highlights of these sessions are described below.

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Plenary Session

During the Plenary Session, W. Dixon Ward summarized the knowledge of noise-induced hearing loss in certain areas. He reported that it was known at the time of the first congress that a daily average noise level of 80 dB(A) could represent a risk for some individuals, and that noise can degrade frequency selectivity and temporal integration, but that these effects have not proven to be chronic if hearing sensitivity returns to normal. He believes that the greatest non-occupational risk is recreational shooting. The relationship between occupational and non-occupational hearing loss is probably additive, but researchers are still working on this question. He also believes that it is now well documented that intermittence does reduce the hazard of permanent threshold shift (PTS), but not as much as temporary threshold shift (TTS).

Ward's goals include (1) the development of a better metric than L_{eq} (the 3-dB rule) to describe the relationship between noise level and duration; (2) the conduct of a long-term, longitudinal study of hearing threshold level in humans; (3) continued research on the effects of intermittence and the appropriate correction factor (to be applied to the criteria for continuous noise); and (4) nullifying the "effects of anti-noise activists that make people suspicious of all technical recommendations."

Henning von Gierke's Plenary Session speech was mainly concerned with national and international standards activities. He reported the existence of 21 international working groups in the noise area, such as those developing standards for hearing protector attenuation, evaluating the effectiveness of hearing conservation programs, guidelines for the design of low-noise workplaces, and guidelines for the design of low-noise machinery and equipment.

Ansgar Vogel of the German government reported that at the recent worldwide environmental conference in Rio de Janeiro, noise was barely mentioned. He concluded that the participants believe noise is a local problem, whereas most pollutants cross boundaries, even national ones.

Invited Presentations

In her lead-off presentation, Willy Passchier-Vermeer identified a daily average of 75 dB(A) as the level of potential onset of hearing loss. She also identified the level of noisy toys as 80 to 100 dB(A), with firecrackers and shooting exceeding these levels. She advocated limits on the noise emission of certain products intended for children.

Peter Alberti of Toronto discussed the possibility of hearing loss from urban noise in some of the world's noisier cities, citing *average* levels of 100 dB (L_{eq}) in Bangkok. He also described the asymmetrical hearing losses that frequently result from occupational exposures, such as mining, tractor driving, violin playing, and several jobs in construction and forestry.

British researcher Mark Lutman reported on a large-scale study of hearing threshold level in which noise exposure history was established by means of a questionnaire. He found that the hearing levels of non-noise-exposed populations were somewhat worse than earlier studies would indicate, which was especially true of young people. He also found no systematic effect on hearing of gunfire or other leisure noise activities.

A paper by the French research team of Remy Pujol and Jean-Luc Puel discussed the innervation of outer and inner hair cells and their respective neurotransmitters. Dr. Puel, who presented the paper, pointed out the property of the outer hair cells (OHCs) to react to sound stimulation by feeding energy back into the basilar membrane, thereby transmitting energy to the inner hair cells (IHCs). The IHCs, the "real sensory cells", passively encode the message and send it to the brain. Pujol and Puel are studying the role of the neurotransmitter glutamate, which is secreted in excess by loud sound. Acute, short-term secretions of glutamate cause temporary swelling of auditory dendrites, which may explain TTS. More severe doses may lead to neuronal death, helping to explain PTS. The researchers believe that "an era of cochlear neuropharmacology is just opening and one could speculate about some clinical applications," such as differential protection against toxicity at the IHC and OHC levels.

Contributed Papers and Posters

During the "Free Communication" session, authors were given only a very short time to summarize their papers or posters, so that attendees could study the poster or read the proceedings at a later time. Some of the more interesting presentations are highlighted below.

Al-Masri, Martin, and Nedwell of the UK's Institute of Sound and Vibration Research reported on current research of noise and hearing levels under water. They found that underwater thresholds are somewhat better than previously thought, and that the threat of hearing loss to professional divers is significant due to the high sound levels that are typically encountered.

French researcher Paul Avan and his colleagues have been investigating the use of otoacoustic emissions for early diagnosis of noise-induced hearing loss. They have concluded that neither distortion-product emissions (DPOE) nor transient-evoked emissions (TEOE) are very sensitive predictors of moderate high-frequency hearing loss, without the consideration of other more complex parameters (such as the slope of DPOE amplitude vs. stimulus level).

H. M. Borchgrevink of the Norwegian Defense Department reported that the incidence of high-frequency hearing loss in 18-year-old male conscripts grew steadily from about 15 percent in 1981 to around 31 percent in 1990. This increase appeared to parallel the sale of portable stereo systems. In 1992, the incidence decreased to 25 percent, which Dr. Borchgrevink speculates was due to a widespread media campaign against the hazards of loud music. A later presentation by Rosenhall, Axelsson, and Svedberg, however, failed to find any difference in high-frequency hearing threshold levels of 18-year old Swedish men between 1970–1977 and 1992.

Two speakers presented information about the use of noise cancellation in hearing protection devices. C. Carme of France described the development of earmuffs providing

25 to 35 dB attenuation in the low frequencies, which, when combined with passive attenuators, give a very effective flat attenuation across frequencies. A presentation by R. L. McKinley of the U.S. Air Force reported on the rapid growth of active noise reduction technology in recent years. McKinley also highlighted the abilities of these devices to reproduce faithfully the spectrum of incoming signals, and to improve speech intelligibility over their passive counterparts, especially in high levels of noise (105–115 dB). These devices have increased the allowable exposure to jet noise from 85 minutes to 8 hours.

French physician J.-B. Causse described a portable sound level meter or "Audio Protect System," which may be worn to concerts or sporting events, that registers a green light at levels below 80 dB, an orange light between 80 and 105 dB, and a red light above 105 dB.

Chinese investigators Chen, Zhou, Chen, and Ye reported on a large epidemiological study of hearing threshold level in a non-noise exposed, otologically normal population. They found that the hearing of adults up to age 40 was only slightly different than the control group (15–19 years old), and concluded that age corrections before age 40 were unnecessary. They also found no significant differences between the hearing threshold levels of male and female groups.

American researchers R. Hamernik and D. Henderson discussed the "toughening" effect, in which the auditory system may develop a resistance to threshold shift with repeated exposure to noise. Dr. Hamernik reported threshold recoveries of as much as 30 dB in subsequent days of exposure compared to the initial threshold shift. Dr. Henderson also found a reduction in TTS from certain prophylactic exposures, but the transfer across bandwidth was not good. A "toughening" exposure to a low-frequency band of noise followed by exposure to a high-frequency band actually produced more permanent threshold shift than the high-frequency exposure alone.

Loth and his colleagues described measurements of the sound output of portable CD players. These devices can produce levels of 125 to 127 dB with average levels (L_{eq}) of 110 dB. The investigators believe that because of the wide dynamic range and low distortion, portable CDs pose a greater risk to hearing than the ordinary portable stereo system.

C. Nixon and his colleagues from the U.S. Air Force reported on hearing threshold level measurements following high-level, short-duration aircraft flyovers at 115 to 130 dB(A). Two subjects exceeded the 10-dB TTS criterion from the 130-dB(A) flyover, but none of the others did. There were no significant differences between the hearing threshold levels of left (protected) and right (unprotected) ears.

A study by the Dutch researchers Van Den Berg and Passchier-Vermeer used a simplified method for measuring hearing protector attenuation in the field. To accomplish this, the investigators had constructed a special "deep" audiometric earmuff that would not touch the insert protector. They found that field attenuation at the 500-Hz frequency was the best predictor of overall A-weighted attenuation.

Workshop

A workshop entitled "Central Control of Auditory System Vulnerability to Noise Exposure" took place on Friday, co-chaired by Edgar Shaw and W. Dixon Ward. As the title implies, the main focus of the workshop was mechanisms of noise-induced hearing loss, particularly with respect to the neural processes involved. It appears that considerable progress has been made in understanding these mechanisms. Here are some of the highlights of the workshop:

Erik Borg of Sweden's Karolinska Institute gave a paper on the relationship of the acoustic reflex (AR) and noise-induced hearing loss. He stated that, contrary to popular opinion, the acoustic reflex does not adapt in many industrial conditions, because the noise environment is time-varying, promoting the reactivation of the reflex. Borg and his colleagues also found that when the threshold of the AR shifts due to noise-induced hearing loss, the shift is primarily associated with damage to the inner hair cells. Thus an AR shift may assist in characterizing the site of lesion.

Barbara Canlon, also of the Karolinska Institute, resumed the discussion of the "toughening" effect or "sound conditioning," the auditory system's ability to modulate the adverse effects of noise. Guinea pigs exposed for 24 days to a 1-kHz tone at 81 dB before being exposed to the same tone at 105 dB for 72 hours showed 20 dB less TTS than their nonconditioned counterparts. The conditioned animals recovered completely after one month, whereas the nonconditioned ones retained a PTS of approximately 25 dB. There also was significantly less outer hair cell damage in the experimental group, but no significant difference in inner hair cell damage. Donald Henderson and his colleagues continued the discussion of the toughening effect, reiterating the frequency dependence of the effect.

French researcher Jean-Luc Puel elaborated on his earlier discussion of cochlear innervation and noise-induced hearing loss. Results in animals exposed to moderate levels of pure tones suggested that active mechanisms were affected. By blocking with strychnine the action of the medial efferent neurones connected to the OHCs, significantly greater threshold shifts were produced. Dr. Puel concluded that the medial efferent system acts as a protector against auditory fatigue. More intense noise exposure levels, however, produced drastic swelling of the afferent dendrites under the IHCs. Five days post-exposure the cells remained damaged, but the hearing threshold levels had partially recovered and the IHCs had become fully reconnected to the afferent dendrites. Using a glutamate antagonist in the cochlea during the same exposure protected the dendrites from swelling, indicating that excessive secretion of the neurotransmitter glutamate is an important contributor to noise-induced hearing loss.

Ramesh Rajan of Monash University in Australia continued the discussion of the protective function of the efferent nerve fibers, identifying the olivocochlear bundle as the site of the protective mechanism. This protection may be manipulated by electrical stimulation of efferent fibers or by the presentation of a low-level training sound in the opposite ear before the onset of the damaging sound. Experiments in guinea pigs have been replicated in cats with the same results. This paper served as a logical summary to the preceding presentations in this workshop.

Other Areas of Interest

Besides hearing loss, several other effects of noise were discussed in considerable depth. Some of the more interesting papers will be briefly summarized here.

Noise and Communication

Some new developments in noise and communication are of particular interest. Tammo Houtgast of the Netherlands has developed an "Expert System" to predict speech and warning signal perception in noise. The system takes into account: (1) the signal source, such as direct speech, telephone speech, or public address system; (2) characteristics of the environment (ambient noise, reverberation); and (3) listener characteristics, such as listening in one's native or non-native language, hearing loss, and the use of hearing protection devices. The system may be used to predict both the Articulation Index (AI) and Speech Transmission Index (STI).

German researcher Hans Lazarus discussed German and international standards to predict and assess speech communication and warning signals. There are nine ISO and EC standards in this area, either completed or being developed. They include such subjects as the influence of ambient noise, distance between speaker and listener, wearing of hearing protectors, hearing loss, and shouted speech. A recently completed standard relating to acoustic warning signals specifies parameters according to the degree of urgency and the ability to alert.

Sharon Abel of Toronto reported on an investigation of the ability of subjects to localize acoustic signals while wearing hearing protectors. Localizing an 80-dB tone in a background of white noise at 65 dB, subjects' performance decreased significantly when wearing hearing protectors. Average correct responses were approximately 70 percent in the ears-open condition and 20–50 percent in the occluded condition. When the stimulus tone was presented at 500 Hz, responses did not differ between plugs and muffs. When a 4,000-Hz tone was used, however, the ability to localize was significantly more difficult when subjects wore a level-dependent muff than when a conventional muff or plug was used.

British psychologist Judy Edworthy presented an important paper on the design of auditory warning signals. She noted that there may be 50 different acoustic warning signals in a hospital emergency room, so many that the staff does not know what they all mean. Dr. Edworthy described the results of a series of experiments exploring the perceived urgency of a large number of spectral, temporal, and melodic characteristics of sound. The results led to a predictive model based on warning signal urgency, and subsequent testing showed that the results and predictions agreed quite well. The warning signal parameter that correlated most closely with urgency was signal speed, followed by repetition and sound frequency. The results of these investigations have implications for many kinds of emergency situations.

Non-Auditory Effects of Noise

There were relatively few new findings in the non-auditory (or extra-auditory) health effects of noise. Wolfgang Babisch reported on a collaborative epidemiological study with British researchers on traffic noise and the risk of heart disease. Preliminary results from two British towns were equivocal, and results from the German city (Berlin) showed a small increased risk of ischemic heart disease that was not statistically significant. Unfortunately, the British segment of the study was not designed to include noise and only 10 percent of the subjects were in the highly exposed group.

A study of Chinese textile workers by Zhao and his colleagues did show dose-response relationships between a cumulative measure of noise exposure (level plus duration) and hypertension. Noise exposure followed age, parental history of hypertension, and salt intake in importance.

Hartmut Ising of Germany elucidated the connection between noise exposure, increased magnesium secretion (and therefore depletion), and the risk of angina and cardiac infarction. On the basis of his research, Dr. Ising believes that annoyance or disturbance from the noise is the key to these adverse effects, rather than simply the noise itself.

Noise and Sleep Disturbance

One of the most controversial presentations was given by John Ollerhead of the U.K. Civil Aviation Authority. A large study of the effects of aircraft noise was carried out in individuals' homes as opposed to the laboratory. The parameter was frequency of awakening as measured by a device called an "actimeter" strapped to the subject's wrist. The investigation showed relatively few awakenings from aircraft flyovers at outdoor maximum sound levels as high as 80 dB(A). Although the levels for awakening obtained in the laboratory have traditionally been lower, these results agreed with the findings of Pearsons and his colleagues for other in-home studies. Ollerhead and his colleagues have concluded that the impact of aircraft noise on sleep has been overestimated.

Other researchers have objected to the British study's conclusions. They believe that it is insufficient to measure only awakening without taking into account shifts of sleep stage, which occur at much lower sound levels. For example, Swedish researcher Evy Ohrstrom found effects on subjective sleep quality and tiredness without a significant increase in awakenings.

Effects of Noise on Performance and Behavior

Two papers by British investigators Andrew Smith and Dylan Jones highlighted the adverse effect of speech (even irrelevant speech) on the performance of certain tasks. Dr. Smith reported that the effect of irrelevant speech is independent of intensity for a range of 55 to 95 dB, and that the best course would be to use a masking noise rather than noise reduction. Dr. Jones found that distracting speech caused a reduction of up to 40 percent in performance of a visual memory, whereas there was almost no disruption from comparable levels of white noise.

An international team of investigators reported on a most interesting study of the effects of noise on psychological, cognitive, and quality-of-life parameters in children. Hygge, Evans, and Bullinger studied both behavioral and physiological variables before and after the closing of an existing airport and the inauguration of a new one in Munich, Germany. Preliminary results were made available on comparisons between a group living near the old airport and a matched control group. They showed no effects on reaction time and certain other performance tasks, but significant decrements on such measures as long-term recall, reading comprehension, and an insoluble puzzle (an estimate of tolerance for frustration). Blood chemistry tests revealed a significant difference in adrenaline levels between the exposed and nonexposed population.

Summary

Although many of the papers at this congress were reiterations of previous work, or at least variations on the same theme, there were a number of new and exciting findings. Examples of these were the papers on the role of cochlear efferents in noise-induced hearing loss by the French researchers Pujol and Puel, the work of Al-Masri and his colleagues on underwater hearing thresholds, the work of Edworthy on warning signals, the sleep study by Ollerhead, and the Munich Airport study by Hygge *et al.* One cannot help but notice that the majority of the presentations, especially the most innovative and important ones, were given by non-U.S. researchers. This is also true of the activities in the international standards arena. It is quite clear that the United States has taken a back seat in noise effects research and regulation. Greater involvement and support by ASHA would be useful, but without federal government interest and support, the situation is unlikely to change.

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