Session I: Bioresponse to Vibration I and Noise II: Combined Effects of Noise and Vibration on Humans

Olavi Manninen, Chairman

Department of Public Health, Medical Faculty, University of Tampere, P. O. Box 607, SF-33101 Tampere, Finland

Chairman's Introduction—1:00

Invited Papers

1:05

I1. Complex environmental exposures and hearing functions. Olavi Manninen (Department of Public Health, Medical Faculty, University of Tampere, P. O. Box 607, SF-33101 Tampere, Finland)

This study deals with changes in TTS_2 values, cardiovascular functions, haemodynamic activity, upright body sway, ratios of urinary catecholamines, and correlations between these changes in complex exposure situations. The study was based on a factorial experimental design with a total of 12 exposure combinations. Each individual experiment took 6 h with a pause of 1 h at noon. The subjects ($n = 60$) were exposed to noise and whole-body vibration at two different dry bulb temperatures. The changes were dependent on the combinations of noise, vibration, and temperature to which the subjects were exposed. The TTS_2 values at 4 kHz were associated with the haemodynamic index (HDI) values when the subjects were exposed simultaneously to noise and stochastic vibration at 35 °C. The TTS_2 values at 6 kHz were associated most strongly with the HDI values after exposure to a combination of noise, stochastic, or sinusoidal vibration, and a temperature of 20 °C. The TTS_2 values at 4 and 6 kHz correlated positively with the noradrenaline/adrenaline (NA/A) ratio when subjects were exposed to noise at 35 °C. The association between the TTS_2 values and the 10A/NA ratio and especially the A/NA ratio was very strong when subjects had been simultaneously exposed to noise and sinusoidal or stochastic vibration at 35 °C. Furthermore, the highest positive correlation coefficients were found between the TTS_2 values at 4 kHz and the upright body sway values in the X direction when the subjects had been exposed to noise and sinusoidal vibration at 20 °C.

1:35

I2. The effects of noise and vibration on a complex task. J. Sandover and C. S. Porter (Department of Human Sciences, University of Technology, Loughborough LE11 3TU, England)

Investigations of the interactive effects of noise and whole-body vibration on task performance have been dogged by such problems as the direct effects of vibration on control and the resistance of simple tasks to the environmental stress. The paper describes an attempt to overcome some of these problems and at the same time to consider conditions of practical relevance. Subjects were exposed to heat, noise, and vibration singly and in combination. The environmental magnitudes were typical of some occupations and exposure duration was approximately 6 h. Subjects were asked to perform a visual vigilance and decision making task, a visual monitoring and decoding task, and a battery of simple tasks. The former tasks were designed to place a significant cognitive load on the subject and strategy was emphasized by performance of both tasks at the same time. The tasks had relevance to a real work situation that the subjects were used to. Subjective and physiological measurements were also taken. The paper will present the results of the series of experiments just completed.

2:05

I3. The influence of whole-body vibration on noise-induced hearing loss: A review of animal experiments. Roger P. Hamernik, William A. Ahroon, Robert I. Davis (Auditory Research Laboratory, SUNY at Plattsburgh, Plattsburgh, NY 12901), and Donald Henderson (Communicative Disorders and Sciences, SUNY at Buffalo, Buffalo, NY 14260)

There is the suggestion in the literature that vibration may potentiate the effects of noise and may pose an increased risk of hearing loss. However, in human experimental studies, which, by necessity, are limited to low levels of TTS, the effects measured are consistent but relatively small. A very limited number of animal studies have also shown an enhanced hearing loss, but the scope of these studies is limited by a large intersubject variability and a small number of subjects. Also, the high levels of stimulation that were used in some of these animal experiments were not realistic. Our recent animal studies (chinchilla) have used a 30 Hz, 3-g-rms cage

vibration in combination with continuous noise (95–dB, 0.5-kHz octave band) and impact noise (113-, 119-, or 125-dB peak SPL) exposure paradigms. All exposures lasted for 5 days. The impact noise exposures were designed to have an equal total energy. Temporary (compound) and permanent threshold shifts were measured using evoked potentials. Sensory cell populations were evaluated with the surface preparation technique. The results obtained from each of the above paradigms were consistent in showing that the presence of vibration did not have a statistically significant effect on hearing thresholds. A parallel set of experiments using a 20 Hz; 2–g-rms vibration is in progress. Preliminary conclusions are essentially the same as those of the 30-Hz experiments. The suitability of the chinchilla as an animal model for use in vibration experiments will also be discussed. [Work supported by NIOSH.]

2:35

I4. Combined effect of whole-body vibration and noise on the dopamine turnover in the rat brain. Akira Okada, Hiroyuki Nakamura, Hideki Nakamura, and Seiichi Nohara (Department of Public Health, School of Medicine, Kanazawa University, Takaramachi 13-1, Kanazawa 920, Japan)

In order to clarify the combined effects of whole-body vibration and noise on dopamine (DA) metabolism within the brain, which is known to regulate the response of the organism to various stimuli, the DA turnover rate in regions of the rat brain was determined. The rats were divided into five groups: (1) control; (2) whole-body vibration (4 G, 20 Hz, 90 min) exposure alone; (3) noise [70 dB(A), 90 min] exposure alone; (4) noise [100 dB(A), 90 min] exposure alone; and (5) combined exposure for 90 min to whole-body vibration (4 G, 20 Hz) and noise [100 dB(A)]. Changes of plasma corticosterone levels were examined as indices of the pituitary-adrenal function (PAF). The whole-body vibration exposure alone caused increases in the DA turnover rate [an increase of homovanillic acid (HVA) or HVA/DA] in the frontal cortex and nucleus accumbens. Noise exposure alone caused metabolic increases in the amygdala. The combined effect of whole-body vibration and noise on the DA neuron systems suggested that the response of the PAF to the combined stimulus was greater than that to each stimulus alone.

Contributed Papers

3:05

I5. Results of periodic medical examinations of workers who are exposed to combined noise and vibration. Klaus Ruppe (Institute of Occupational Medicine, Humboldt-University Berlin, Postbox 140, Berlin 1040, GDR) and Gottfried Enderlein (Central Institute of Occupational Medicine of the GDR, Berlin, GDR)

Synergistic effects of combined exposures to noise and vibration on hearing loss have been recognized under laboratory conditions by some authors. However, there are few studies of the chronic effects of combined workplace factors upon workers. An evaluation of the results of periodic medical examinations of workers who have been exposed to combined exposures during a great part of their working life showed a significant influence of the combination of factors upon hearing loss. In a population of 270 000 male workers, 52.6% were exposed to noise with levels more than 85 dB(A), 15.0% to whole-body vibration (WBV), and 4.1% to hand–arm vibration (HAV). Exposure to noise occurred in 70% of workers also exposed to WBV, and in 80% exposed to HAV. Hearing loss (more than 30 dB in 4 kHz) occurred in 16.7% of the group of workers with exposure to noise alone, but in 18.5% of the group of workers with combined exposure to noise and HAV. The prevalence of medical findings and a restricted capacity to work were significantly higher in the groups with combined exposures.

3:20

I6. Building noise criterion curves, BNC, for interior spaces. Leo L. Beranek (BBN Laboratories, 10 Moulton Street, Cambridge, MA 02238)

This paper presents an updated set of noise criterion (NC) curves that are renamed building noise criterion (BNC) curves. They are based, in part, on the latest definition of four-band speech interference level and on "spectrum balance," that is to say, the premise that the loudnesses of all bands containing the same number of critical bands should be equal, as

calculated by Stevens Mk. VII perceived loudness method. The curves are extended downward in frequency to include the two octave bands with mean frequencies at 16 and 31.5 Hz. Finally, the high-sound level, low-frequency region of the curves [Blazier, Noise Control Eng. 16, 64–73 (1981)] are demarked to show where human annoyance will probably result from vibrations caused by such noise levels in contemporary building construction. The paper details the use of the BNC curves in writing a specification for building construction and in determination of the conformance of the measured result to the specification, or in rating an existing noise. Particularly important are the procedures given for determining "spectrum imbalance." The handling of two typical types of imbalance are discussed: (1) an acceptable speech interference level accompanied by high low-frequency band levels; (2) acceptable low-frequency band levels accompanied by a very low speech interference level.

3:35

I7. Vibrotactile intensity difference thresholds measured by two methods. George A. Gescheider (Department of Psychology, Hamilton College, Clinton, NY 13323), Stanley J. Bolanowski, Jr. (Department of Physiology, University of Rochester Medical School, Rochester, NY 14642), and Ronald T. Verrillo (Institute for Sensory Research, Syracuse University, Syracuse, NY 13233)

The difference threshold for the detection of changes in vibration amplitude was measured as a function of the intensity and frequency of stimuli delivered through a 2.9-cm² contactor to the thenar eminence. Stimuli were either 25- or 250-Hz sinusoids or narrow-band noise centered at 250 Hz or wideband noise. Thresholds were measured by two-interval forced-choice tracking under two methods of stimulus presentation. In the two-burst method, subjects had to judge which of two 700-ms bursts of vibration separated by 1000 ms was more intense. In the increment-detection method, subjects had to detect an increment in the amplitude of vibration. Thresholds were consistently lower for detecting increments in the amplitude of continuous vibration than in detecting amplitude differences be-