Journal of Sound and Vibration (1999) **228**(5), 1217–1221
Article No. jsvi.1999.2588, available online at http://www.idealibrary.com on IDEAL®

HUMAN RESPONSE TO VIBRATION

ABSTRACTS

Prepared by M. J. Griffin and J. Griffin, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton SO17 1BJ, England

A. J. Brisben, S. S. Hsiao and K. O. Johnson 1999 *Journal of Neurophysiology* **81**, 1548–1558. Detection of vibration transmitted through an object grasped in the hand. (11 pages, 8 figures, 1 table, 54 references) (in English).

Authors' Abstract. A tool or probe often functions as an extension of the hand, transmitting vibration to the hand to produce a percept of the object contacting the tool or probe. This paper reports the psychophysical results of a combined psychophysical and neurophysiological study of the perception of vibration transmitted through a cylinder grasped in the hand. In the first part of the psychophysical study, 19 subjects grasped a cylinder, 32 mm diameter, with an embedded motor that caused vibration parallel to the axis of the cylinder. The relationship between threshold and frequency was the traditional U-shaped function with a minimum between 150 and 200 Hz. Except for a study by Békésy in which subjects grasped a rod that vibrated parallel to the skin surface, thresholds above 20 Hz were lower and the slopes were steeper than any reported previously, and thresholds were $< 0{\cdot}01\ \mu$m in some subjects. Data from both the psychophysical and the neurophysiological studies suggest that detection performance at frequencies > 20 Hz was based on activity in Pacinian afferents. The extreme sensitivity compared with previous reports may have resulted from differences in contact area, direction of vibration, contact force, and the shape of the stimulus probe. The effects of each of these variables were studied. At 40 and 300 Hz (frequencies near the lower and upper end of Pacinian range) thresholds were 9·8 and 18·5 dB (68 and 88%) lower, respectively, when subjects grasped the cylinder than when a 1-mm-diameter probe vibrated perpendicular to the skin. These differences were accounted for as follows: (1) thresholds at a single fingerpad obtained with the large cylindrical surface were, on average, 20 and 60% lower, respectively, than thresholds with the punctate probe; (2) thresholds at the palm were, on average, 15 and 40% lower, respectively, than at the fingerpads; (3) thresholds obtained when the subjects grasped the cylinder averaged 40 and 20% less, respectively, than when the cylinder contacted only the palm; (4) thresholds with the cylinder contacting two fingers were 10 and 30% lower, respectively, than thresholds with the cylinder contacting a single finger; and (5) thresholds with vibration parallel to the skin surface were, on average, 10 and 30% lower, respectively, than thresholds with vibration perpendicular to the skin. Contact force, which was varied from 0·05 to 1·0 N, had no effect.

0022-460X/99/501217 + 05 $30.00/0

Topics: Vibration sense (thresholds).

P. Remy, M. Zilbovicius, J.-D. Degos, A.-C. Bachoud-Lévi, G. Rancurel, P. Cesaro and Y. Samson 1999 *Neurology* **52**, 571–577. Somatosensory cortical activations are suppressed in patients with tactile extinction. A PET study. (7 pages, 2 figures, 3 tables, 45 references) (in English).
Authors' Abstract. Objective—To investigate whether tactile extinction alters the cortical somatosensory activations induced by hand vibration. Background—Tactile extinction occurs mainly after right-brain lesions and consists of the inability to perceive a contralesional cutaneous stimulation when a similar stimulus is applied to the mirror region of the ipsilesional hemibody. The pathophysiology of tactile extinction is poorly understood, but it is considered to be a deficit of selective attention of somatosensory stimuli. Although other theories have been proposed, our understanding of the pathophysiology of tactile extinction may benefit from functional imaging studies. Methods—We selected three patients with pure tactile extinction and a mainly subcortical right-brain lesion that spread the primary sensorimotor cortex (SM1). We used PET to investigate the responses to unilateral and bilateral hand vibration in SM1 and the secondary somatosensory cortical area (SII). Results—During bilateral hand vibration, activation was normal in the left SM1, suppressed in the right SM1, and markedly decreased in both SII, which was consistent with the extinction of the left-hand stimulus. During unilateral left-hand vibration, the activation of the right SM1 was still markedly impaired, but the activation of both SII was normal. Conclusions—We found marked changes in the activation of cortical somatosensory area induced by hand vibration in patients with tactile extinction. The role of selective attention in cortical activation is also examined.
Topics: Vibration sense (sensory mechanisms).

D. Greenstein and R. C. Kester 1998 *Angiology* **49**, 915–922. The role of leukocytes in the poathogenesis of vibration-induced white finger. (8 pages, 3 figures, 1 table, 26 references) (in English).
Authors' Abstract. Vibration white finger (VWF) is an occupational disorder associated with long-term exposure to hand-transmitted vibration. The condition exhibits features of secondary Raynaud's phenomenon. The etiology is unknown. The aim of this study was to examine the role of leukocyte rheology in the pathogenesis of VWF. Fifty-two subjects divided into two groups were exposed to controlled acute hand-transmitted vibration. One group consisted of 29 workers who have all had occupational exposure to handheld vibration and all suffered from VWF (mean age 46·9 yr, range 22–66). The second group consisted of 23 controls. Venous blood was analyzed from the dorsum of the hand before and after vibration to determine granulocyte deformability, granulocyte morphology, and white-blood cell count with differential. There was a subpopulation of hard and poorly deformable granulocytes in the VWF group when compared with controls ($p < 0{\cdot}05$). Acute hand-transmitted vibration had no *in vitro* effect on leukocyte rheology in either group. Leukocyte rheology may play a role in the pathogenesis of

microvascular disease and tissue ischemia in VWF, although whether this is a cause or an effect of the disorder is not clear.
Topics: Vibration syndrome (vibration-induced white finger), physiological effects (cardiovascular).

R. Lundström, T. Nilsson, L. Burström and M. Hagberg 1999 *American Journal of Industrial Medicine* **35**, 456–464. Exposure–response relationship between hand–arm vibration and vibrotactile perception sensitivity. (9 pages, 2 figures, 4 tables, 26 references) (in English).
Authors' Abstract. Background—The objectives of the study were to examine whether occupational use of vibrating hand-held tools was associated with an impaired vibrotactile perception, whether any exposure–response relationship exists, and whether the different populations of mechanoreceptive afferent units are equally affected. Methods—Vibrotactile perception thresholds have been measured at seven frequencies (8–500 Hz) and evaluated among 125 vibration-exposed and 45 non-exposed male employees in a heavy engineering production workshop. Vibration exposure measurements were assessed on tools in accordance with ISO 5349. Vibrotactile perception thresholds have been individually graded in stages and placed in relation to individual vibration exposure. Results—The outcome did not reveal a clear relationship between vibration exposure and reduced vibrotactile sensitivity on an individual basis. There was a clear tendency on a group basis towards elevated thresholds when the study population was divided into three exposure categories. A four-fold increase in relative risk of reduced vibrotactile sensitivity for test frequencies above 40 Hz was observed between the highest exposure category compared to the non-exposed. Conclusions—It was concluded that reduced tactile sensitivity is related to the degree of vibration exposure but it is not at present possible to delineate an exposure–response relationship.
Topics: Vibration syndrome (neurological effects).

J. Lewald, H.-O. Kamath and W. H. Ehrenstein 1999 *Experimental Brain Research* **125**, 389–398. Neck-proprioceptive influence on auditory lateralization. (8 pages, 6 figures, 0 tables, 61 references) (in English).
Authors' Abstract. The effect of transcutaneous vibration of the posterior neck muscles on the lateralization of dichotic sound was investigated in human subjects. Two-alternative forced-choice (left/right) judgements were made on acoustic stimuli presented with different interaural level differences via headphones during neck-muscle vibration. A shift of the subjective auditory median plane toward the side contralateral of vibration was found, indicating that the sound was perceived as shifted towards the side of vibration. The mean magnitude of the vibration-induced intracranial shift was 1·5 dB. The results demonstrate a neck-proprioceptive influence on sound lateralization and suggest that this proprioceptive input is used for a central-nervous transformation of auditory spatial co-ordinates onto a body-centered frame of reference.
Topics: Perceptual mechanisms (proprioception).

J. D. Prothero, M. H. Draper, T. A. Furness, D. E. Parker and M. J. Wells 1999 *Aviation, Space, and Environmental Medicine* **70**, 277–283. The use of an independent visual background to reduce simulator side-effects. (7 pages, 3 figures, 1 table, 19 references) (in English).

Authors' Abstract. Background—Simulator sickness (SS) is a major problem which potentially limits interface applications that feature simulated motion. While display imperfections play a role, a large part of SS is motion sickness (MS). Sensory rearrangement theory holds that MS is related to conflicting motion cues; in the case of simulators, mainly a conflict between inertial cues (usually indicating no self-motion) and visual stimuli from the display (indicating self-motion). It is suggested that MS does not arise from conflicting motion cues *per se*, but rather from conflicting rest frames selected from these motion cues. There is strong evidence that the visual rest frame is heavily influenced by the visual background. Providing an independent visual background (IVB) consistent with the inertial rest frame may reduce SS, even when the simulator's content-of-interest (CI) is not consistent with the inertial rest frame. Methods—In two experiments, a circular vection stimulus was shown for 3–4·5 min in a head-mounted display, comparing see-through (i.e., IVB) to occluded (i.e., no IVB) modes. Measures included a standard SS questionnaire and a pre-exposure ataxia measure. Experiment 2 added a visual task which forced attention into the Cl and a post-exposure ataxia measure. In both experiments, subjects rated the Cl as significantly more visible than the IVB. Results—A large effect was found for the reduction of SS and ataxia in the first experiment, and for pre-exposure ataxia in the second. Conclusions—Future research will test the IVB idea and examine applications to high-end simulators.

Topics: Motion sickness (visually induced).

O. Hämäläinen, S. K. Toivakka-Hämäläinen and P. Kuronen 1999 *Aviation, Space, and Environmental Medicine* **70**, 330–334. +Gz associated stenosis of the cervical spinal canal in fighter pilots. (5 pages, 4 figures, 0 tables, 16 references) (in English).

Authors' Abstract. Previous magnetic resonance imaging (MRI) studies have shown that repeated exposure to +Gz forces can cause premature degenerative changes of the cervical spine (i.e., a work-related disease). This paper reports on two clinical cases of +Gz-associated degenerative cervical spinal stenosis caused by dorsal osteophytes in fighter pilots. Conventional X-rays and MRI were used to demonstrate narrowing of the cervical spinal canal. The first case was complicated by a C6-7 intervertebral disk prolapse and a congenitally narrow spinal canal. The second case involved progressive degenerative spinal stenosis in the C5-6 disk space which required surgery. The findings in this case were confirmed by surgery which showed posterior osteophytes and thickened ligaments compressing the cervical medulla. These two cases suggest that +Gz forces can cause degenerative spinal stenosis of the cervical spine. Flight safety may be jeopardized if symptoms and signs of medullar compression occur during high +Gz stress. It is recommended that student fighter pilots undergo conventional X-rays and MRI studies in order to screen out and reject candidates with a congenitally narrow spinal canal. These

examination methods might be useful in fighter pilots' periodic medical check-ups in order to reveal acquired degenerative spinal stenosis.
Topics: Physiological effects (skeletal).

B. M. Nigg and W. Liu 1999 *Journal of Biomechanics* **32**, 849–856. The effect of muscle stiffness and damping on simulated impact force peaks during running. (8 pages, 6 figures, 0 tables, 35 references) (in English).
Authors' Abstract. It has been frequently reported that vertical impact force peaks during running change only minimally when changing the midsole hardness of running shoes. However, the underlying mechanism for these experimental observations is not well understood. An athlete has various possibilities of influencing external and internal forces during ground contact (e.g., landing velocity, geometrical alignment, muscle tuning, etc.). The purpose of this study was to discuss one possible strategy to influence external impact forces acting on the athlete's body during running, the strategy to change muscle activity (muscle tuning). The human body was modelled as a simplified mass–spring–damper system. The model included masses of the upper and the lower bodies with each part of the body represented by a rigid and a non-rigid wobbling mass. The influence of mechanical properties of the human body on the vertical impact force peak was examined by varying the spring constants and damping coefficients of the spring–damper units that connected the various masses. Two types of shoe soles were modelled using a non-linear force deformation model with two sets of parameters based on the force–deformation curves of pendulum impact experiments. The simulated results showed that the regulation of the mechanical coupling of rigid and wobbling masses of the human body had an influence on the magnitude of the vertical impact force, but not on its loading rate. It was possible to produce the same impact force peaks altering specific mechanical properties of the system for a soft and a hard shoe sole. This regulation can be achieved through changes of joint angles, changes in joint angular velocities and/or changes in muscle activation levels in the lower extremity. Therefore, it has been concluded that changes in muscle activity (muscle tuning) can be used as a possible strategy to affect vertical impact force peaks during running.
Topics: Limb vibration (feet), anti-vibration devices (shoes).

NOTE: copies of all papers in this section will be found in the Human Response to Vibration Literature Collection at the Institute of Sound and Vibration Research, University of Southampton. The papers may be used by persons visiting the Institute.

Contributions to the Literature Collection are invited. They should be sent to Professor M. J. Griffin, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, SO17 1BJ, England.