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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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This selection of abstracts is taken from the Proceedings of the 2001 Conference of the United Kingdom Group on Human Response to Vibration. The conference was held at the Centre for Human Sciences, QinetiQ Ltd, Farnborough, 12–14 September.

K. Kato. Evaluation of the magnitude of shock in impact harshness and the effect of sound including infra-sound in cars. (8 pages, 4 figures, 3 tables, 8 references) (in English).
Author's Abstract. Vertical, fore-and-aft, and pitch vibration on the floor of cars due to impact harshness was simulated in a laboratory. Subjects sitting on a seat attached to vibrators were asked to evaluate the magnitude of shock. Results showed that the magnitude of shock could be predicted using the VDVs of seat vibration. Sounds including infra-sound and shock in cars were then simultaneously simulated to investigate the effects of sound on the evaluations given by the subjects. It was shown that sound did not affect evaluations of the magnitude of shock, but that evaluations for total discomfort were influenced by sound, and in particular by infrasound.
Topics: combined stress (noise and vibration); Subjective assessment.

F. Terauchi, M. Kubo, H. Aoki and H. Ohtani. Riding comfort of wheelchair riders in a motor vehicle. (8 pages, 6 figures, 1 table, 13 references) (in English).
Authors' Abstract. This paper aims to clarify the relations between vibration characteristics and subjective evaluation of the wheelchair riders in a motor vehicle. Five subjects seated in a manual wheelchair were exposed to vertical sinusoidal vibration in the range of 2–12 Hz. The vibration behaviour of human body was discussed with the transmissibility of the parts of the human body. Subjective evaluations such as "the feeling of stability", "the feeling of vibrating" and "riding comfort" were measured. Obtained results were divided into three frequency ranges to clarify relations between the transmissibility, the frequency and the riding comfort using multiple regression analysis. As a result, it became clear that vertical vibration of head and chest are closely related to the riding comfort. Furthermore, a simulation model with human body–wheelchair system was constructed to clarify the possibility of this riding comfort improvement. Using a FEM model of human body multiple regression equation, the reduction of the vertical vibration inducing discomfort by changing the physical properties of seat cushions was suggested.
Topics: Subjective assessment.

M. G. R. Toward. Effect of backrest interaction on seat cushion transmissibility. (10 pages, 5 figures, 4 tables, 7 references) (in English).
Author's Abstract. The presence and design of the backrest of a seat has been shown to effect the transmission of vertical vibration through a seat cushion to the subject. Transmissibility of the seat cushion has been measured, using 12 subjects, with different backrests. The effects

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of backrest bulk properties, coupling of the backrest with the back of the subject and the backrest angle have been quantified. Vibration transmissibilities from the seat base to the seat cushion surface were unaffected by the bulk properties of the seat backrest. The cushion transmissibility at resonance was slightly lower with a lubricated backrest than with a condition in which the backs of the subjects were "stuck" to the backrest. Transmissibility at resonance tended to decrease with increasing backrest inclination, but between 4·5 and 7·0 Hz this trend was reversed; these backrest angle effects were more significant with a rigid backrest than with a foam backrest.
Topics: Biodynamics; Seating (transmissibility); Body posture.

K. Ahlin and J. Granlund. Calculation of reference ride quality, using ISO 2631 vibration evaluation. (11 pages, 1 figure, 0 tables, 6 references) (in English).
Authors' Abstract. Every road authority targets good ride quality in their pavement management. Ride quality depends strongly on the experienced vibrations, induced by road roughness. International Roughness Index (IRI) is the most common way to describe road roughness. But there exist no commonly accepted limits for IRI. ISO 2631 defines how to measure human whole body vibration (WBV), as experienced by vehicle occupants during the ride. Criteria for discomfort and health justifies vibration limits in the ISO 2631 standard. Calculated WBV could therefore be useful to create relevant limits for road roughness, to be used in our pavement management systems. IRI is defined by means of a quarter car model, and the same model is here used to: (1) calculate WBV as defined in ISO 2631, and (2) to get a relation between IRI values and WBV. A software Ride Quality Meter has been developed to calculate WBV from laser/inertial measured road profiles, without involving IRI at all.
Topics: Subjective assessment; Standardization.

J. F. Golding, W. Bles J. E. Bos, T. Haynes and M. A. Gresty. Active and passive head tilts aligned versus misaligned to the acceleration resultant of low-frequency horizontal translational oscillation: effects on motion sickness. (9 pages, 3 figures, 4 tables, 15 references) (in English).
Authors' Abstract. Background—Accelerating, braking and cornering in cars, coaches and trains, produces horizontal forces in the low-frequency range (< 1 Hz) which can provoke motion sickness. Hypothesis—Our intention was to determine whether compensation for the tilting resultant (gravity + horizontal translational acceleration) would protect against motion sickness when tilting was either "active" self-initiated (Expt. 1) or "passive" by suspension machinery (Expt. 2). Method—Expt. 1: Twelve subjects were exposed to continuous translational oscillation whilst making head tilts which were either aligned or misaligned (180° out of phase) with respect to the acceleration resultant. The two sessions were 1 week apart at the same time of day, counterbalanced for order. Subjects were seated upright during continuous horizontal translational sinusoidal oscillation through the body x-axis ($3{\cdot}095\,m/s^2$ peak acceleration, 0·20 Hz frequency). They made head tilts controlled by tracking a moving LED display with a head-mounted laser pointer. Verification of head trajectory was via head-mounted accelerometry. Motion continued until moderate nausea was achieved (motion endpoint) or until a 30 min maximum time cut-off was reached. Expt. 2: A different group of 12 subjects were seated upright and exposed to continuous horizontal translational sinusoidal oscillation through the body x-axis ($1{\cdot}96\,m/s^2$ peak acceleration, 0·176 Hz frequency). They were seated in a cab which was tilted by suspension machinery around y-axis of the ears so that the resulting acceleration vector was aligned with the body z-axis or misaligned (180° out of phase). Other experimental details were as in Expt. 1. Results—Expt. 1: Mean $\pm$ SD time to motion endpoint was significantly longer for

aligned 19·17 $\pm$ 11·9 min than for misaligned 17·75 $\pm$ 12·98 min ($P < 0{\cdot}05$, 2-tail). Symptom scores were similar between conditions. Expt. 2: Mean $\pm$ SD time to motion endpoint was significantly shorter for aligned 21·83 $\pm$ 10·88 min than for misaligned 26·33 $\pm$ 8·61 min ($P < 0{\cdot}01$, 2-tail). Symptoms scores were worse for aligned versus misaligned conditions ($P < 0{\cdot}05$, 2-tail). Conclusions—Longer motion exposure times were necessary to elicit sickness when active head tilts were aligned with the direction of the acceleration resultant indicating reduced nauseogenic potential of translational oscillatory motion with compensatory tilt as compared to misaligned head tilt. However, with passive tilting, as occurs in the new high-speed tilting trains, the reverse was true.
Topics: Motion sickness; Complex vibration (lateral and roll).

M. I. Bellman, I. Baumann, P. Hillebrand, V. Mellert and R. Weber. Comfort inside cars: effect of seating and steering-wheel vibrations. (13 pages, 6 figures, 2 tables, 13 references) (in English).
Authors' Abstract. Interior sound and vibration in cars impair the subjective comfort. Desirable are objective signal parameters which describe and are able to predict subjective assessments of sound and vibration. One testing method in car industry is to judge the quality of booming noise, seat and steering-wheel vibrations by professional testers. In this study, seat and steering-wheel vibrations as well as sound are recorded inside of 16 middle class cars (one type) in idle running conditions simultaneously with the subjective ratings. From the 19 channel-recordings objective signal parameters for the seat and steering-wheel vibrations are calculated which correlates significantly with the subjective ratings and consequently describe the subjective vibration comfort. In the correlation analysis signal parameters from car industry and from existing standards (e.g., ISO 2631-1/2, DIN-4051-1/2, ISO 5349, VDI 2057-1/2/3) are used. It turns out that psychophysically motivated vibration signal parameters as proposed in the ISO 2631-1/2 (1997, 1989) give significantly higher correlation coefficients with the subjective assessments than spectrally unweighted vibration parameters. This holds only for the steering-wheel vibrations. For the seat vibrations spectrally unweighted but band limited vibration signal parameters show significant high correlation coefficients with the subjective ratings.
Topics: Subjective assessments; Complex vibration (multiple axis).

Y. Oishi. Discriminability rise of time of vibrotactile perception. (8 pages, 8 figures, 4 tables, 4 references) (in English).
Author's Abstract. In acoustics the envelope of a sound wave has a large effect on the perception of tone. Especially, the rise time is important. If we are sensitive to the rise time of vibration in the same way, a difference in rise time might be employed to add more information when using vibration to communicate. This paper reports a study of the discriminability of rise time for vibrotactile perception. Experiments were conducted to determine how precisely humans can discriminate differences in the rise time of vibration presented on the middle finger. The results indicated that many factors such as the intensity, frequency and order of presentation affect discriminability, and that there is a large inter-subject variability. The results suggest that the discrimination of rise time is not solely sensuous but highly intellectual.
Topics: Subjective assessment; Hand-transmitted vibration.

M. O'Boyle. The effect of hand and arm volume on the transmissibility of gloves according to current standards. (9 pages, 8 figures, 3 tables, 4 references) (in English).
Author's Abstract. The effect of hand and arm volume on the vibration transmitted by gloves, measured according to ISO 10819 (1996), has been obtained for three gloves tested

on 20 subjects. In addition, the glove transmissibilities were determined as a function of vibration frequency (over the range 30–1250 Hz) and the effect of hand and arm volume at frequencies of 50, 100, 200, 400, 800 Hz was investigated. No significant correlations were found between the corrected transmissibilities tested with the M and H vibration spectra required by the standard and the subject's hand or arm volumes, except for the H spectrum tested on glove 3. However, the trends indicated that increasing hand volume increased glove transmissibility with these spectra. At several specific frequencies, increasing hand and arm volume resulted in statistically significant increases in transmissibility for each of the three gloves.
Topics: Hand-transmitted vibration; Anti-vibration devices (gloves).

C. G. de Oliveria and J. Nadal. Transmissibility of vibration through the spine of helicopter pilots during the flight. (6 pages, 4 figures, 1 table, 10 references) (in English).
Authors' Abstract. This study investigates the transmissibility of the vibration through the column of 10 helicopter pilots during flight. One accelerometer was fixed to the pilot seat and miniature accelerometers to the skin over the spinal process of L3 and T1 vertebrae. All signals were registered in the vertical direction. Before the flight, a free oscillation test was performed to estimate and further remove the effect of resonance of skin–bone system on the measurements. The transmissibility was calculated as the ratio between the RMS-vibrations of two different sites. The mean (SD) transmissibility L3/seat, T1/L3 and T1/seat was, respectively, 1·4 (0·7), 2·5 (3·2) and 3·2 (4·6), showing no statistical difference when comparing taxi, cruise and landing. The estimated load in the L3 disc due to the gradient of vibration between T1 and seat could reach almost twice the one without vibration. This may explain the large incidence of degenerative diseases of the spine in these professionals.
Topics: vibration measurements (helicopters); Biodynamics (transmissibility).

Other papers presented were:
D. J. Whitehouse. The effect of contact location and probe size on vibrotactile thresholds at the fingertip.
A. J. L. Welsh. Comparison between two venous occlusion plethysmographs for finger blood flow measurement.
S. Takahashi, M. Iwamoto, M. Yoshimura, S. Shirono, T. Fujimura, H. Morita, T. Fukada and N. Harada. Autonomic nervous response to cold water immersion test in hand–arm vibration syndrome patients.
I. M. Dudnyk, O. V. Partas, S. C. Pandey, N. S. Chaudry, S. Verma and V. I. Dudnyk. Comparison of clinical symptom-complexes and X-rays signs of vibration disease among drivers of carrier tip-lorries.
A. Darby. Vibration exposure of a coach driver—a case study.
S. D. Smith, A. R. Artino, R. J. Newman and J. A. Hodgdon. Human vibration analysis in a military propeller-driven aircraft.
I. M. Dudnyk, J. S. Owcharek, N. V. Ramana and V. I. Dudnyk. Whole body vibration in trolleybuses' cabins and occupational protection of drivers.
Y. Qiu. Measurement of seat transmissibility for fore-aft vibration in a car.
R. Tamemura, F. Terauchi, M. Kubo, H. Aoki, M. Isobe and K. Okubo. A study on riding and sitting comforts of polyurethane car seats under real driving situation.
T. P. Gunston. A method of estimating the damper characteristics for a suspension dynamic model.
N. J. Mansfield and J. P. Irvine. Development of a seat pad for measuring motorcycle seat vibration.

A. van der Merve. An air suspension cushion to reduce human exposure to vibration—the pilot study.
C. Nelson. The physical agents (vibration) directive: a regulator's view.
A. J. Scarlett and R.M. Stayner. A study of the association between whole-body vibration emission values and daily exposure—case of farm workers.
P. Brereton. Expectation and use of information on the risk of hand-transmitted vibration injury supplied with powered hand-tools.
S. Clemes and P. Howarth. Changes in virtual simulator sickness susceptibility over the menstrual cycle.
S. R. Holmes, C. A. Arrowsmith and C. T. Turner. The effects of modafinal and sleep deprivation on motion sickness susceptibility.
C. Carr. Overview of the motion sickness desensitisation programme at the Centre of Human Sciences.
M. S. Shayaa, J. A. Giacomin, E. Dormegnie and L. Richard. Human perception of sinusoidal rotational steering wheel vibration.
J. Venor. Comfort assessment and vibration quality as part of the vehicle design and development process.
M. Morioka. Sensitivity of Pacinian and non-Pacinian receptors: effect of surround and contact location.
T. D. Dobbins, S. Samways. J. Terry and S. Searle. The use of a navigation tactile interface system in establishing the blind world water speed record.
N. Nawayseh. The non-linear behaviour and the two dimensional movement of the human body in response to vibration.
M. Kubo, F. Terauchi, H. Aoki, T. Arrizumi, N. Kuriki, N. Takata and S. Yamada. On a 3-D dynamic fem model of human body seated in a passenger car seat.
C. H. Lewis. An adaptive electro-mechanical model for simulating the driving point force response of the human body with different input motions.
J. Z. Wu, R. G. Dong, S. Rakheja, A. W. Schopper and W. P. Smutz. Modelling of biomechanics of two-point discrimination tests of fingertips.
M. Ksiazek and J. Tarnowski. Influence of hand pushing on handle on displacements and accelerations of operator's hand measured by a non-contact method.
G. Paddan. Effect of measurement period on the testing of anti-vibration gloves.
D. Welcome, S. Rakheja, R. G. Dong, B. Westfall and A. W. Schopper. A preliminary study of the relationship of hand grip and push forces to total coupling force.
J. Förstberg and B. K. Kufver. Ride comfort and motion sickness in tilting trains.
B. Lobb. A frequency weighting for motion sickness susceptibility in the lateral axis.
H. V. C. Howarth. A comparison of motion sickness with 2-dimensional and 3-dimensional visual scenes.
R. G. Dong, D. Badger, D. Welcome, S. Rakheja and A. W. Schopper. An accurate method for measuring the exposure duration of hand transmitted vibration.

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.