SYNOPSIS

INVESTIGATIONS ON VIBRATION INDUCED STRESSES IN OPERATORS WORKING IN A DRIVING ENVIRONMENT

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People have been using different means of transportation for moving from one place to another from the very primitive days of human civilization. However, a revolutionary development in this context has been the evolution of automotives. The twentieth century witnessed a technological development, that has tremendously changed the face of human life. Today a very large segment of human population interacts with the automobile world in almost every walk of life. Moving to office, visiting the natives and friends, attending the parties/celebrations right from morning till late nights, the automobile is the companion of people. Yet due attention has not been paid to the human factors with the result that the present days human-vehicle systems are in dire need of being redesigned more ergonomically so that these become more compatible and comfortable for the end-users of the vehicle, thereby avoiding their health impairments. One of the important factor which is responsible for discomfort/health impairment is the vehicle vibration. Present study made an attempt to explore the effect of vibration on humans in a driving environment.
In all, nine studies were undertaken to investigate the effects of organismic variables—sex, age, and laterality—on human performance under the impact of the vibration induced stresses in humans while moving in four wheelers. A pool of subjects was selected through an analysis of the data related to organismic characteristic of sample population and the sample sets with appropriate subject characteristics were selected for different studies constituting the present research. Performance of the operators was measured in terms of human response time through a human response measurement system, developed indigenously in the Ergonomics Laboratory of the Department of Mechanical Engineering, Aligarh Muslim University, Aligarh (India). The reaction time (measured in milliseconds) of the operator was measured when the task was carried out under varying levels of vehicular vibration. Two independent variables—viz., vibration level and difficulty index level—having 4 and 3 levels respectively were explored in all the nine studies undertaken in the present work. The third factor that varied from study to study was sex (study -1, -2, and -3), age (study -4, -5, and -6) and laterality (study -7, -8, and -9). A 2 (the varying factor) x 4 (vibration level) x 3 (difficulty index level) kind of factorial design with repeated measures on the last two factors was employed in all the investigations except the one involving age where the varying factor i.e., age was at 4 levels.

Experimental task performed by the subjects was explained and subjects were asked to respond to the stimuli presented to them at varying levels of vibration. For this purpose, two boards, one operated by experimenter having three bulbs (Red, Green, and Blue) and the other operated by subject, having three locations—namely location 1, having Red bulb, location 2, comprising of Red and Green bulbs, and location 3, with Red, Green, and Blue bulbs—were used. The subject was asked to switch on at location 1 after the bulb of the same colour is observed to be glowing on the experimenter’s board. The subject was having prior information that red bulb will be illuminated (simple reaction time). Same procedure was to be used in the second setting with the difference that out of the two bulbs on the experimenter’s board any one could be lighted and by seeing the colour of the lighted bulb, the subject had to switch on the bulb of same colour present at location 2, this being a case of the choice reaction time having two alternatives. Similarly for
the third setting, experimenter switched on anyone of the three bulbs present on the board and the subject responded by switching the same coloured bulb on present at location 3 (choice reaction time having three alternatives).

The first experiment (study -1) investigated the effect of sex on human performance in the task of varying difficulty index levels under no vibration and three other power average levels of vibration while moving in a ‘cityway’ kind of driving environment. 14 subjects (7 males and 7 females) participated in the study. Results indicated that (1) there is no effect of gender on humans under the impact of vibration induced stresses when they performed the cognitive task of the type considered in the present study (2) vehicular vibration was found to have a significant effect on human performance (3) difficulty index level significantly affects human performance (4) the relationship between reaction time and difficulty index level for varying power average level of vibration and that between reaction time and vibration level for varying levels of difficulty index were found to be linear in nature

Second study (study -2) investigated the effect of sex on human performance in the cognitive task under varying power average levels of vibration on the ‘rural road’ driving environment. 14 subjects (7 males and 7 females) participated in the study. Results indicated that (1) there is no effect of gender on human performance (2) the power average of vibration level does not have a significant effect on performance (3) level of difficulty index plays a significant effect on human performance (4) the relationship between reaction time and difficulty index level under the impact of the varying power average level of vibration and that between the reaction time and power average of vibration for varying levels of difficulty index were found to be linear in nature.

In the third study (study -3) the effect of sex while performing the cognitive task at varying levels of power average of vibration was investigated in the context of the ‘highway’ kind of driving environment. 14 subjects (7 males and 7 females) participated in the study. Results indicated that (1) there is no effect of gender on performance (2) vehicular vibration has a significant effect on human performance (3) difficulty index has a significant bearing on human performance (4) the relationships between reaction time and difficulty index for varying levels of
vibration and that between the reaction time and power average level of vibration for varying levels of difficulty index were found to be linear in nature (5) the analysis of simple main effect indicated significant effect of power average level of vibration for all the difficulty index levels of the task. The difficulty index level was also significant for all the four levels of power average of vibration.

In the fourth experiment (study -4), the effect of age on the cognitive task performance of humans under varying power average levels of vibration induced in humans during the 'cityway' kind of driving was investigated. The subjects 28 in number, divided consciously into four age levels (20-30 y, 30-40 y, 40-50 y, and 50-60 y) with seven subjects in each level participated in the study. Results indicated that (1) age has a significant effect on human performance (2) power average of vibration level also affected the human performance, statistically, significantly (3) cognitive task of the type considered plays a significant role on human performance (4) the relationship between reaction time and difficulty index level for varying power average level of vibration and that between reaction time and vibration level for varying levels of difficulty index was found to be linear in nature.

In the fifth study (study -5), the effect of age on cognitive performance under varying power average levels of vibration was investigated in the 'rural road' kind of driving. 28 subjects divided into four age levels with 7 subjects in each level on the lines similar to the previous study (study -4) participated in the study. Results indicated that (1) age under the impact of vibration induced stresses plays an important role in cognitive performance of humans (2) power average level of vibration has a significant effect on human performance (3) difficulty index effects the human performance significantly (4) the power average level of vibration at the three levels of difficulty index significantly affected the human performance when the interactive effects of difficulty index and power average of vibration level was investigated for age level -1 and -2 (20-30 y and 30-40 y). However, the power average level of vibration for difficulty index level -1 for age level -3 and -4 (40-50 y and 50-60 y) was found to be statistically non significant whereas for difficulty index levels -2 and -3 and the difficulty index level for all the four power average level of vibration significantly affected the human performance.
In the sixth experiment (study -6), the effect of age on cognitive performance under varying power average levels of vibration was observed on a 'highway' kind of driving. The four age levels (as in previous study) with seven subjects in each level were selected for the study. Results indicated that (1) age does not have a significant effect on human performance (2) the power average level of vibration has a statistically significant effect in the kind of driving environment considered (3) the difficulty index level affects significantly on human performance (4) the simple main effect of power average of vibration level for difficulty index levels significantly affected human performance and so was the case with the difficulty index level for all the four power average levels of vibration (5) the relationships between reaction time and difficulty index for varying power average level of vibration and reaction time with power average level of vibration for varying levels of difficulty index were found to be linear in nature.

The seventh study (study -7) investigated laterality or motor-sidedness effect on human performance under varying power average levels of vibration when subjects performed the cognitive task in the 'cityway' kind of driving. 7 right-sided and 7 left-sided subjects classified on the basis of Annet's inventory system, participated. Results indicated (1) laterality characteristics of human does not have an effect on the performance of the task of the kind considered in the study (2) power average level of vibration has a significant effect on human performance (3) level of difficulty index has a significantly effects on human performance (4) linear relationship was found to exist between reaction time and difficulty index for varying power average level of vibration. Same was the case with nature of variation between reaction time and vibration level for varying levels of difficulty index of the task.

In the eighth study (study -8), the effect of motor-sidedness on humans under varying levels of power average of vibration in the performance of the cognitive task on a 'rural road' kind of driving was investigated. In this study, 14 subjects (7 right-handed and 7 left-handed) participated. Results indicated that (1) laterality does not have a significant effect on human performance (2) the power average level of vibration also does not play a significant role in having a bearing on human performance (3) difficulty index has a significant effect on the human
performance (4) graph between reaction time and difficulty index level for varying power average level of vibration and that between reaction time and vehicular vibration for varying levels of difficulty index revealed linear nature of variation.

In the ninth experiment (study -9), the effect of motor-sidedness on human performance under varying power average levels of vibration in the cognitive task on the 'highway' kind of driving was studied. In all 14 subjects, 7 right-sided and 7 left-sided participated in the study. Results indicated that (1) laterality plays a significant role on human performance (2) the power average of vibration level has a significant bearing on human performance (3) level of difficulty index significantly affects human performance (4) the analysis based on the simple main effects indicated that for both left-motor-sided and right-motor-sided persons under the impact of power average level of vibration for all the three levels of difficulty index and difficulty index level for all the four power average levels of vibration considered were statistically significant (5) the relationship between reaction time and difficulty index level for varying power average levels of vibration and that between reaction time and vehicular vibration for varying levels of difficulty index were found to be linear in nature.

The above presented findings led to the following inferences, conclusions and recommendations.

1. The vibration induced stresses in humans moving in vehicles should be given proper and due attention while designing human vehicle system ergonomically.
2. With the increase in the level of difficulty index, the response of humans got slowed down. This was revealed by all the studies undertaken in the present work implying thereby that the future system designers would have to take care of information loading of those subjected to the vehicle induced stresses due to the vibration.
3. Human motor-sidedness emerged to have a significant effect on human performance on 'highway driving'. This important finding opens up new avenues for human factor specialists. The future system designers in the light of this findings would have to evolve a system that is compatible to the two laterally distinct kinds of human populations.
4. The findings of the present study indicated that age has a significant effect on human performance when driving is carried out on 'cityway' and 'rural road' kind of driving environment. This implies that youngsters and old people are stressed differently in the specific environments of driving and therefore the stress management strategies evolved for them would have to be designed differently so as to minimize the number of accidents on road. This becomes all the more important when a sizable increase in old-age people is observed in almost all the countries of the world.