J. Human Ergol., **37**: 57-66, 2008

MOBILE COMPUTING WITH SPECIAL REFERENCE TO READABILITY TASK UNDER THE IMPACT OF VIBRATION, COLOUR COMBINATION AND GENDER

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The last 20 years have seen a tremendous growth in the field of computing with special reference to mobile computing. Ergonomic issues pertaining to this theme remains unexplored. With special reference to readability in mobile computing, an experimental research was conducted to study the gender effect on human performance under the impact of vibration in a human computer interaction environment. Fourteen subjects (7 males and 7 females) participated in the study. Three independent variables, namely gender, level of vibration and screen text/background colour, were selected for the experimental investigation while the dependent variable was the number of characters read per minute. The data collected were analyzed statistically through an experimental design for repeated measures. Results indicated that gender as an organismic variable, the level of vibration and screen text/background colour revealed statistically significant differences. However, the second order interaction was found to be statistically non-significant. These findings are discussed in light of the previous studies undertaken on the topic.
Key words: visual display unit; human computer interaction; gender; vibration; screen text/background colour; readability task

INTRODUCTION

With the rapidly increasing pace of computerization in every aspect of life, the use of visual display units (VDUs) has been continually on the increase. The information technology (IT) explosion has created a new work concept. The use of computers in the mobile environment has become commonplace. Networking technologies such as Wide Area Networks (WAN), Wireless Application Protocol (WAP) and Virtual Private Networks (VPN) have given new dimensions to the use of computers in the mobile environment.

Literature survey results reveal that researchers have investigated the effect of various factors such as text/background colour combinations, screen resolution, effect of luminosity, subjects-to-screen distance, vibrations and gender. Choice of profession involving the use of soft computing technologies by female professionals is increasing rapidly as compared to their male counterparts. The use of computers for onscreen reading in the mobile environment is very much under-researched.

Developments in information system design suggest that the use of VDUs will only increase as a medium for presentation of connected text as observed in videotext, electronic journals and similar applications. In addition the recently emerging WAP-based systems like laptop computers, etc. are expected to be commonplace entity in the HCI (human computer interaction) environments of tomorrow. Such systems are being widely used by executives while moving to their offices.

Griffin and Hayward (1994) reported that during exposure to fore-and-aft vibration, reading speed was significantly reduced at frequencies between 1.25 Hz and 6.3 Hz. Whole body vibration

Received 5 February 2007; accepted 30 December 2008.

has been found to have acute detrimental effects on visual acuity equilibrium and manual dexterity and caused muscular fatigue (Lewis and Griffin, 1976). Lewis and Griffin (1980b) showed that vibration in terms of the seat-to-head relation has an affect on human performance. Griffin and Brett (1997) revealed that the performance of tasks in which the head had to be positioned close to objects in a moving vehicle caused the most difficulties in the frequency range of 1 to 4 Hz for horizontal vibration. The fore-and-aft, lateral and vertical forces on a seat and a backrest have been investigated in the frequency range of 0.25-10 Hz at four vibration magnitudes (0.125, 0.25, 0.625 and 1.25 m/s^2) and the results indicated that forces on the seat depended on whether the feet were supported on a foot rest or not (Nawayseh and Griffin, 2005).

The task performance in the mobile HCI environment under gender effect has been a less investigated subject. The threshold of tolerance to vibration is different for males and females because of different body structures. It is important to investigate the effect of vibration on the abilities of male and female operators in performing different kinds of occupational and non-occupational tasks. Wang et al., (2004) studied the biodynamic response of male and female-seated subjects exposed to vertical vibration and showed that the hand in lap posture yields a larger primary resonant frequency and higher vertical apparent mass as compared to the hands on steering wheel posture; and this apparent mass of seated occupants has significant bearing on whole body vibration.

The literature review shows that computer-related task capabilities of the operators have not been studied in a major way under the impact of vibration from the point of view of gender effect. Study of this kind becomes more important since an increasing number of women is entering the job arena.

Investigation of the gender revealed a small measurable difference in computer anxiety between male and female subjects with males being more anxious than females (King et al., 2002). When stimuli were presented to male and female subjects it was found by Landauer et al. (1980) that females were quicker in decision making than males while they were shown to be slower than their male counterparts in movement time. When viewed in the context of responding to stimuli it was found that females were superior to males in their cognitive competence (Rizvi, 1984). On the basis of the measured vibration transmissibility of a cushion seat with occupants they showed that the vibration transmissibility of a seat occupant system is strongly affected by the gender (Laurent, 1996).

Ling and Schaik (2002) investigated the effect of colour and aimed to set design guidelines for the use of colour on the web. They showed that higher contrast between text/background colour led to faster searching. Researchers (Wang and Chen, 2003) used white on black, black on white, blue on white, red on white, blue on yellow and green on white text/background colour combinations and revealed that higher colour difference gave good reading performance. Shieh and Lin (2000) and Wang et al. (2002) revealed that visual preference increased as the luminance contrast of text/background colour combination became greater.

The pace of research in the field of transportation vibration exposure specifically in computer-related tasks has been rather slow in comparison to the growth rate of the wide-spread use of four wheelers. The present study was designed to explore how the ability of males and females could be affected in terms of their text-reading performance while working on a laptop computer under the impact of the varying levels of vibration and screen text/background colour.

METHODS

Subjects

One of the important requirements of investigation was the selection of appropriate types of subjects. Fourteen subjects (7 males and 7 females) participated in this study. Mean height, weight and the age of subjects who participated in different experimental investigations undertaken in the present study are shown in Table 1. All the subjects had normal vision either with or without glasses. The subjects had almost the same educational qualification with similar working experience of VDUs. None had any previous history of neuromuscular disorders. All the experiment sessions were conducted between 0900 hours and 1300 hours, so as to have no temporal effects on experimental results. Before the experimental task was performed, informed consent was obtained from all the subjects for the participation in the study.

Table 1. Means and standard deviations of age, height and weight of subjects who participated in the study.

	Age (Yr)	Height (m)	Weight (kg)
Male	28.3 ± 3.2	1.78 ± 0.05	60.5 ± 6.6
Female	27.5 ± 2.8	1.68 ± 0.09	55.6 ± 4.4

Stimuli and experimental task

To assess the accuracy of the read text an eight-item comprehension test was adopted (Bernard et al., 2003; Shieh, 2000). Since it was difficult to ascertain reading accuracy with text having no meaning, text with meaning was adopted in the experiments. Six passages each consisting of 1800 words were presented to subjects for readability task to avoid any learning effect. Presentation of text was completely randomized to nullify inter-subject variability.

Stimuli in the form of plain text (each passage of 1800 words) displayed on the laptop screen were presented to the subjects. As the experimental task under investigation was merely to investigate readability performance and not the technical know-how of the subjects, plain texts easily understandable were presented to the subjects. However it was assured that tradeoff between speed and accuracy would not occur by introducing eight-item comprehension test at the end of each passage. The text was written in the Malay language, which uses Roman script. The characters per screen of text were arranged in 25 lines with spacing between lines of 1 mm. Three texts of required length were presented to the subjects as a readability task to avoid any learning effect. They were instructed to scroll through the stimuli by clicking the down arrow button on the scroll bar as they read. Based on the literature survey it was found that no conclusive result had been drawn in the selection of colour combination except the fact that higher order colour produced better results in terms of readability, search and a similar kind of computer-related task.

Therefore for this study, three combinations were also chosen, i.e., black text on a white background, white text on a black background and blue characters on a white background. The subjects were required to sit on the vehicle seat (without a back rest) with the two hands on the keyboard (as observed to be the practice of the end-users) while working on VDUs. They were required to respond to the voice signal "start" for starting the reading task taking care of both speed and accuracy. Juola et al. (1995) reported that the effect of speed at 171 and 260 wpm was not significant. However, it was found that the effect of speed on reading performance was similar to those found in English leading displays (Juola et al., 1995). Each subject participated in two different experimental sessions: one involving zero level vibration and the other associated with the vibration level of 1.1056 m/s2. Human performance was measured in terms of the number of characters read per minute when the task was carried out by the subjects.

Experimental set-up

Experimental investigations were carried out in a real-life driving environment on a passenger car (Waja) manufactured in Malaysia (specifications of the car are given in appendix-A). This particular type of car was chosen because of the fact that around 65% of the people use this car. The setup comprised the following sub-systems shown through a schematic diagram in Figure 1.

1) Vibration level meter (Bruel & Kjaer Deltatron, Type 4504)
2) A 12-volt battery for energizing amplifier (Bruel & Kjaer, Type 2260)

3) Digital lap-top Compaq: Armoda (1500 model)
4) Piece of connecting wires, battery charger, distilled water, etc.

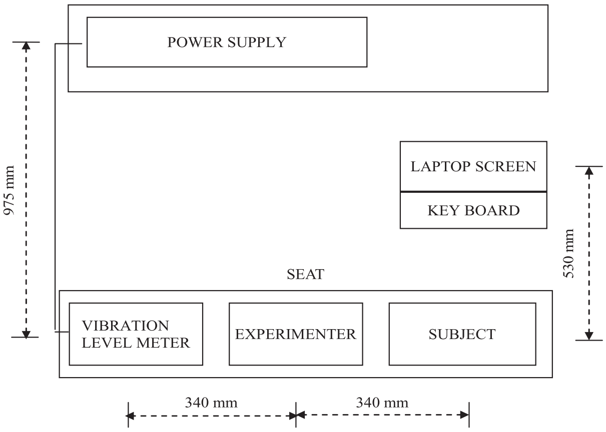

Fig.1. Schematic diagram of the experimental setup employed in all the experimental investigations undertaken in the present study without vibration or with vibration of 1.1056 m/s^2 in the HCI environment.

General experimental procedure

Digital laptop Compaq: Armada (E500 model) was employed in all the experiments. The VDT with 1024x768 screen resolution setting was used by the subjects. Viewing distance as one of the parameters for the kind of task under investigation was kept controlled between 60-70 cm. The experiments were carried out between 0900 and 1300 hours during the daytime and it was found that sunshine was a major source of glare on the VDT screens. Reflection properties of the displays were assessed in accordance with the ISO-9241-7(1998) procedures. By means of these procedures, diffuse (R_D) and specular reflectance (R_S) of a display were evaluated. All three reflectances for LCD were found to be less than 0.01 (R_D=0.07, R_S"EXT"<0.001, R_S"SML"<0.001). Lighting of the work station was maintained in accordance with ISO-8995:2002(E). The VDT screens and in some circumstances the keyboard can suffer from the reflection causing disability and discomfort glare. In the present investigation, glare from screen was also noticed while assessing the readability task specifically in the mobile working environment. Therefore, side and back windows of the car were covered. This was also necessary to make ambient lighting conditions conducive and also to put equal operational loading on all the subjects. Luminance contrast between the characters and the background was measured with the help of a Minolta Analiser CS-100. Values of luminance contrast were monitored and were 0.12 ± 0.04 throughout the experimental session.

Three text back ground/ colour combinations were used in the study, which are: black on white, white on black and blue on white. The CIE coordinates of the three colours used in the research are shown in Table 2. The sensor of the vibration level meter was kept at a specially designed platform which did not affect the impact of vibration, and the display was kept in front of the experimenter to constantly monitor the level of vibration.

The mean value of the angle between the eye-sight level and the centre of the screen of the laptop computer for all the subjects remained at approximately 15^0 (SD: ± 3.16°). The temperature of the vehicle was maintained at approximately 26 ± 3 degrees Celsius. While performing the experimental task, the level of vibration in the driving environment was kept at a pre-specified value by constantly monitoring the level of vibration in the x, y and z directions and running the vehicle at the desired speed. For each trial of experiment, vibration magnitude was constantly monitored by the experimenter. The digital display screen of the vibration-meter gave the vibration level values with passage

Table 2. The CIE coordinates of three columns used in the study.

CIE colour coordinates	Colour		
	Black	White	Blue
X	0.282	0.256	0.140
y	0.317	0.275	0.103
L (cd/m^2)	2	92	17

of time. The road condition of the highway chosen for the experimental task was such that the variation in the vibration magnitude at particular speed was negligible. The stretch of the highway was 20 km, having no hindrance in the form of traffic signals, school areas, accident prone areas, etc. As far as the zero level vibration condition was concerned, the readability performance was measured before running the test vehicle.

Before performing the readability task experiment in the mobile environment, the subject sat in the test vehicle at a prespecified level of vibration for a period of 60 min and then the subjects started the reading task experiment. Each subject performed the readability task for 15 min and with a rest period of 5 minute repeated the readability task for two more periods, thus approximately consuming one hour to complete the readability task per subject. Human performance in terms of characters read per unit time was recorded at approximately the same time of the day on each day of the experiment. This was kept in view in order to eliminate any temporal effect in experimentation that might have had its impact on the subject s' performance.

Measurement of vibration

For the vibration measurement, ISO 2631-5:2004E standard was consulted and according to its recommendation the evaluation procedure of ISO 2631-1: 1997 was adopted. A tri-axial accelerometer (Bruel & Kjaer Deltatron, Type 4504) was mounted on the test vehicle seat to register the vibration level. The measuring range for the above accelerometer was 5 m/s^2 to 7500m/s^2. The frequency range in which this instrument could work was 1 to 1000 Hz. In this instrument, simultaneous 3-channel measurement in X, Y and Z direction can be made. The vibration levels were measured with respect to the standard biodynamic coordinate system according to ISO 2631-1(1997). The vibration level meter was calibrated in X, Y and Z directions prior to the measurement.

To check the suitability of the basic evaluation method, the crest factor was calculated for X, Y and Z directions. According to ISO 2631-1 (1997), the crest factor is defined as the modulus of the ratio of the maximum instantaneous peak value of the frequency weighted acceleration signal to its RMS value. The peak is determined over the duration of measurement. The crest factor values for X, Y and Z directions obtained were within the limit prescribed by ISO-2631-1(1997). As per ISO 2631-1:1997 recommendations, for vibration with crest factors below or equivalent to 9, the basic evaluation method is normally sufficient. The accelerometer was connected to the whole body vibration instrument (Bruel & Kjaer Type 2693) and this was connected to the modular sound level meter which in this case was used for data collection and display (Bruel & Kjaer, Type 2260) and the data was later downloaded to a personal computer for further analysis. Total equivalent vibration was calculated as per the recommendations of ISO 2631-1(1997). Equivalent vibration level means the power average of the amount of vibration measured in a specific period of time and has been derived from the equivalent noise level of the sound level meter.

$$\text{Total equivalent vibration} = [(1.4a_{wx})^2 + (1.4a_{wy})^2 + (awz)^2]^{1/2}$$

where a_{wx} , a_{wy} and a_{wz} are the weighted rms acceleration values in the X, Y and Z direction and the factor 1.4 is the ratio of the longitudinal to the transverse acceleration limits for the frequency range in which humans are sensitive.

Experimental design

A 2 (gender level) X 2 (levels of vibration) X 3 (text/background colour) factorial design with repeated measures on the last two factors was employed for the analysis of variance (ANOVA). All the tests were conducted at the significance level of 0.05.

RESULTS

Analysis of variance

Mean values of the number of characters read per minute (NCRPM) for both females and males under different conditions of testing were obtained as presented in Figure 2 and Figure 3. The data collected were analyzed through 3–factor repeated-measures analysis of variance (ANOVA). Results of the ANOVA implied that the gender effect was statically significant ($F (1, 12) = 4.75$; $p<0.05$). This indicated that the performance on readability task, expressed in terms of the number of characters read per minute, was not independent of the gender of the operator. The gender factor also significantly interacted with the variable vibration ($F (1, 12) = 4.75$; $p<0.05$) and so was the case with the variable text/background colour ($F (2, 24) = 3.40$; $p<0.05$). However, the second order interaction, i.e. between gender, vibration and screen text/background colour angle, was found to be statistically non-significant ($F<1$; NS). Further the results indicated that levels of vibration also significantly affected human performance in terms of the number of characters read per minute in the HCI environment. The factor vibration also significantly interacted ($F(2,24) = 3.40$; $p<0.05$) with the factor screen text/background colour when operators performed the experimental task.

Since all the variables investigated were found to be statistically significant, further analysis of the data was necessary to establish which means statistically differed from each other. Accordingly simple main effects analysis was carried out to determine statistical significance of various factors and the effects on the performance of the operators (male and female) under the two levels of vibrations. The results are shown in Figure 2 and Figure 3.

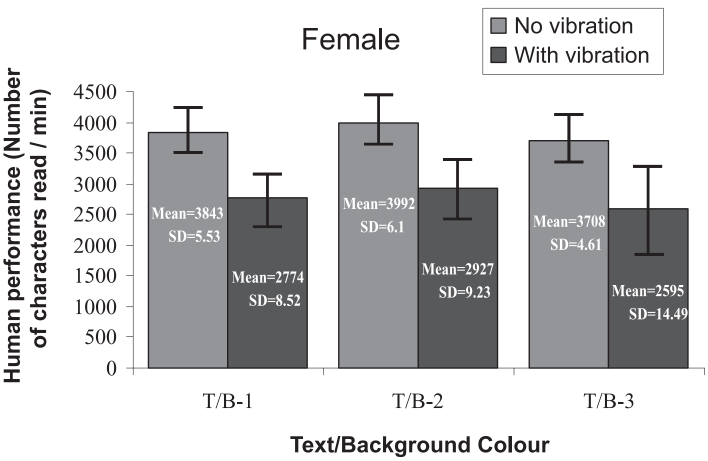

Fig. 2. Human performance (expressed in MNCRPM: mean number of characters read per minute) exhibited by female operators in zero-level and 1.1056 m/s^2 vibration in the HCI environment under varying levels of text/background colour of the laptop. Sample size (n) = 7.

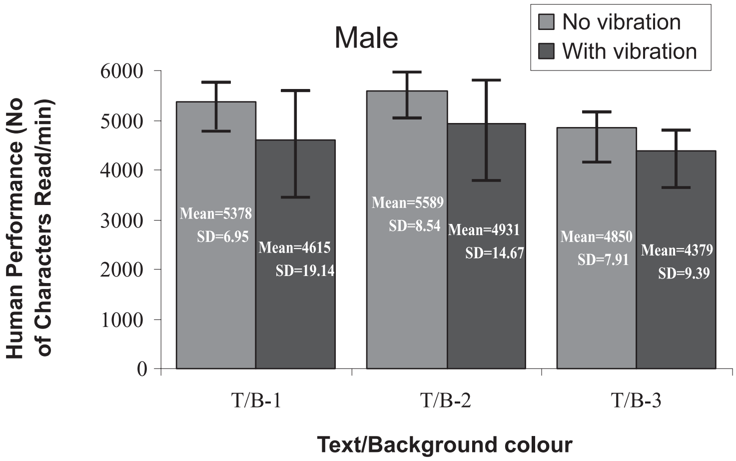

Fig. 3. Human performance (expressed in MNCRPM: mean number of characters read per minute) exhibited by male operators in zero-level and 1.1056 m/s^2 vibration in the HCI environment under varying levels of text/background colour of the laptop. Sample size (n) = 7.

Analysis based on simple main effect

The significant interaction between gender and vibration necessitated the analysis of the simple main effects. The results of the analysis revealed that the variable gender was statistically significant at both the levels of vibration. However, the same was not found in the case of impact of vibration on males and females. The effect of vibration was found to be statistically significant only for female operators. The result of the simple main effect analysis for significant interaction between gender and screen text/background showed that the difference by gender of the operators was significant at all the three levels of screen text/background colour. However, the factor screen text/background colour was not found to be statistically significant for either male or female operators.

The results of the simple main effect for significant interaction between vibration and screen text/background indicated that the factor vibration was statistically significant at only one level (T/B)[1] out of the three levels undertaken. However, the variables of screen text/background colour was not found to be statistically significant at either zero-level or 1.1056 m/s^2 level of vibration.

A Bonferroni test revealed that pair-wise comparison of male (5272 wpm) and female (3848 wpm) subjects showed significant difference ($p<0.05$) for zero level of vibration. On the similar lines, Boferroni test for vibration of 1.1056 m/s^2 level showed significant difference (p,0.05) for males (4642 wpm) and females (2765 wpm).

DISCUSSION

As an increasing number of males and females are joining the operators handling portable systems like laptop computers, the present study becomes very important. The study has indicated that males and females are not equally efficient in performing readability task on a laptop. It appears that either no or very few studies are available in literature pertaining to the theme under reference, and therefore the present results could be discussed in light of other related studies. The findings of the present study may get support from many researches. Thompson et al. (1981) and Sherman (1967) reported that males and females differed in their performance on spatial and cognitive tasks. Irwing and Lynn (2005) carried out a meta-analysis of 22 studies of university samples on the Progressive Matrices and found the male advantage averaging between 3.3 and 5.0 IQ points. A similar nature of study was carried out by Lynn and Irwing (2004) as to sex differences on the Standard and Advanced

Progressive Matrices and found that adult men exceeded adult women by an average of 5.0 IQ points. In yet other studies males have been found to have greater test score variance than females, being over-represented at both the high and the low extremes (Deary et al., 2003; Hedges and Nowell, 1995). Rizvi (1984) showed that males and females differ in their cognitive competence. Fatkin and Hudgens (1982) also found gender difference in risk taking capabilities. Results of some studies (Voyer et al., 2004; Rilea et al., 2004) did not support the findings of the present study. It might have been so because the tasks in these studies primarily involved body twist resulting in demonstration of gender-independent human performance.

The present study revealed that the vibration-induced stress resulted in a deteriorated readability task performance in a mobile HCI environment. Also the interaction between vibration and gender was found to be statistically significant. Studies in the past have revealed that females are quicker in decision making (reaction time) than males while they are slow in movement time. The significant interaction between vibration and gender may be due to that reading from a laptop involves reaction time only. Male and female subjects may consume different time to accomplish the reading task due to difference in their reaction time to complete a given job.

Another major finding of the present study was that the vibration significantly affected human performance. It was found that the performance was better when subjects performed the readability task in “no vibration” environment. Such a finding gets support from the study conducted by Lewis et al., (1980a) who reported that with different seating conditions, the effect of vibration on reading accuracy was found to be significant at all three levels of vibration. Also Andresson and Hofsten (1999) reported that reading capability of subjects during vertical vibration of modern aircraft was affected due to the complexity of symbols. Thus, orientation of symbols has significant bearing on reading performance. Presence of vibration in a working environment acts as a stress and may lead to poor performance. Ishitake et al. (1998) found that the disturbances of visual performance were dependent on the vibration frequency with the maximum reduction of visual acuity at 12.5 Hz. Mills and Griffin (2000) found that the relative nauseogenicity of fore-and-aft or lateral oscillation depends on the support given to the upper body. Fairley and Griffin (1988) investigated the discomfort caused by simultaneous vertical and fore-and-aft vibration with seated subjects.

It has been well established through research that colour combination of a text background has significant bearing on the operator’s task performance. Higher colour difference of text/background results in better reading performance (Wang and Chen, 2003). In the present study, it was also found that higher colour difference resulted in better performance in readability. It was found that white characters on a black background gave the highest performance as compared to other combinations in a mobile HCI setting. This might be due to the fact that readability performance in a black background prone to be less glare-prone in a mobile. setting resulting. The present study also revealed that the text/background colour of the screen of the laptop also had a significant effect on human performance. It was observed that performance in terms of the number of characters read per minute decreased initially but improved when the screen text/background colour was maintained as white characters on black background.

Initially the text/background colour was black characters on a white background as the usual practice. Considering this as baseline in terms of text/background colour, we find that the performance of the operators decreased as we moved to (T/B)2 level and again improved as (T/B)3 was employed. The possible reason of improvement might be due to the fact that in a driving environment the outside light also has its influence and the glare effect may be more pronounced in the case of (T/B)1 and (T/B)2 levels as compared to (T/B)3 level. The black background can absorb light from the outside source more effectively to make the readability task easy for white characters in this case. These findings are corroborated by previous investigations like Wang et al. (2002) who reported that subjects searching performance on leading display was improving when the colour difference of text/background became large. Also Shieh and Lin (2000) indicated that visual identification performance and subjective preferences increased as the luminance contrast of text/background colour combination became greater.

On the other hand, Wang and Chen (2003) found that the interaction between jump length and colour combination of the leading display also had a significant effect on the subjects' reading performance. The present study was designed to address both of these issues. As far as human-computer interaction (HCI) in a mobile setting is concerned, it involves a large number of variables that might influence the operators' performance from the readability point of view. Better results may be obtained provided a more number of parameters are considered together while keeping other variables in control. The responsibilities of future ergonomists to design such a system that may reduce vibration-induced stress in humans may increase manifold in light of the fast changing dynamic scenario of HCI.

It seems that vibration-induced stress when applied on males takes less time to readjust themselves due to quicker movement time than in the case of their female counterparts. Different time consumption by males and females dealing coupled with the text background color cancels the difference in time to accomplish the task under reference. As the gender and colour interaction effect in the context of the mobile HCI setting is still in an infancy stage, further research in this area is required to establish some sound footing.

ACKNOWLEDGEMENT

The author acknowledges the research grant provided by Universiti Sains Malaysia, Penang that has resulted in this article.

APPENDIX

1. Engine: S4PH 4- cylinder 16-valve DOHC
2. Maximum power: 82 kW @ 6000 rpm
3. Maximum torque: 148 Nm @ 4000 rpm
4. Fuel system: Multi-point fuel injection
5. Bore and stroke: 76.0 mm x 88.0 mm
6. Displacement: 1597 cc
7. Front suspension: MacPherson strut with stabilizer bar
8. Rear suspension: Multilink with stabilizer bar
9. Maximum speed: 190 km/h
10. Overall length: 4465 mm
11. Overall width: 1740 mm
12. Overall height: 1420 mm
13. Wheelbase: 2600 mm

REFERENCES

Andersson, A and Hofsten, CV (1999) Readability of vertically vibrating aircraft displays. *Displays*, **20**: 23-26.

Bernard, ML, Chaparro, BS, Mills, MM and Halcomb, CG (2003) Comparing the effects of text size and format on the readability of computer-displayed Times New Roman and Arial Text. *Int. J. Hum-Comput. St*., **59**: 823-835.

Deary, IJ, Thorpe, G, Wilson, V, Starr, JM and Lawrence, J (2003) Population sex differences in IQ at age 11: The Scottish Mental Survey 1932. *Intelligence*, **31**: 533-542.

Fairley, TE, and Griffin, MJ (1988) Predicting the discomfort caused by simultaneous vertical and fore-and-aft whole-body vibration. *J. Sound Vib*., **124**: 141-156.

Fatkin, LT, and Hudgens, GA (1982) Human Performance: More psychological and physiological sex differences. Aberdeen Providing Ground, M.D *U.S Army Human Engineering Laboratory*.

Griffin, MJ, and Hayward, RA (1994) Effects of Horizontal Whole-Body Vibration on Reading. *Appl. Ergon*., **25**: 165-169.

Griffin, MJ, and Brett, MW (1997) Effects of fore-and aft, lateral and vertical whole body vibration on a head-positioning task. *Aviation, Space Environ. Med*., **68**: 1115-1122.

Hedges, LV, and Nowell, A (1995) Sex differences in mental test scores, variability, and numbers of high-scoring individuals. *Science*, **269**: 41 45.

International Standard Organization, 2004 (E). ISO 2631-5, "Mechanical vibration and shock- Evaluation of human exposure to whole-body vibration," Geneva, ISO.

International Standard Organization, 1997. ISO 2631-1, “Guide for the evaluation of exposure to whole body vibration, General req-uirements,” Geneva: ISO.

International Standard Organization. ISO 8995: 2002(E). “Lighting of Indoor Workplaces”. Geneva, ISO.

International Standard Organization, 1998. ISO 9241-7(1998). “Ergonomic Requirements for Office work with Visual Display Terminals (VDTs)-Part-7: Requirements for Display with Reflections”. Geneva, ISO.

Irwing, P and Lynn, R (2005). Sex differences in means and variability on the Progressive Matrices in university students: A meta-analysis. *Brit. J. Psychol.*, **96**: 505-524.

Ishitake, T, Ando, H, Miyazaki, Y and Matoba, F (1998) Changes of visual performance induced by exposure to whole-body vibration. *Kurume Med. J.*, **45**: 59-62.

Juola, JF, Tiritoglu, A and Pleunis, J (1995) Reading text presented on a small display. *Applied Ergonomics*, **26**: 227-229.

King, J, Bond, T and Blandford, S (2002) An investigation of computer anxiety by gender and grade. *Comput. Hum. Behav.*, **18**: 69-84.

Landauer, AA, Armstrong, S and Digwood, J (1980) Gender differences in choice reaction time. *Brit. J. Psychol.*, **71**: 551-555.

Laurent, R (1996) A study of the effect of gender on the transmissibility of car seats.*UK Informal group Meeting on Human Responses to vibration, UK*.

Lewis, CH and Griffin, MJ (1976) The effects of vibration on manual control Performance. *Ergonomics*, **19**: 203-216.

Lewis, CH and Griffin, MJ (1980b) Predicting the effects of vibration frequency, and axis and seating conditions on the reading of numeric displays. *Ergonomics*, **25**: 485-501.

Lewis, CH and Griffin, MJ (1980a) Predicting the effects of vertical vibration frequency, combinations of frequencies and viewing distance on the reading of numeric displays. *J. Sound Vib.*, **70**: 355-377.

Ling, LJ, and Schaik, PV (2002) The effect of text and background colour on visual search of Web pages. *Displays*, **23**: 223-230.

Lynn, R, Irwing, P (2004) Sex differences on Progressive Matrices: A meta-analysis. *Intelligence*, **32**: 481-498.

Mills, KL, Griffin, MJ (2000) Effect of seating, vision and direction of horizontal oscillation on motion. *Aviat. space Envir. Med.*, **71**: 996-1002.

Nawayseh, N and Griffin, MJ (2005) Tri-axial forces at the seat and backrest during whole body fore-and-aft vibration. *J. Sound Vib.*, **281**: 921-942.

Rilea, SL, Ewoldsen BR and Boles, D (2004) Sex differences in spatial ability: A lateralization of function approach. *Brain Cognition*, **56**: 332-343.

Rizvi, SAH (1984) Effects of organism and environmental factors on controls in a two wheeler driving configuration. *Unpublished Doctoral Thesis, IIT Kanpur, India*.

Sherman, JA (1967) Problems in sex differences in space perception and aspects of intellectual functioning. *Psychol. Rev.*, **74**: 290-299.

Shieh, KK (2000) Effects of Reflections and Polarity on LCD Viewing Distance. *Int. J. Ind. Ergonom.*, **25**: 275-282.

Shieh, KK and Lin, CC (2000) Effects of screen type, ambient illumination, and color combination on VDT visual performance and subjective preference. *Int. J. Ind. Ergonom.*, **26**: 527-536.

Thompson, EG, Mann, IT and Harris, LJ (1981) Relationship among cognitive complexity, sex and spatial task performance in college studies. *Brit. J. Psychol.*, **24**: 249-256.

Voyer, D, Rodgers, MA and McCormick, PA (2004) Timing conditions and the magnitude of gender differences on the mental rotation test. *Mem. Cognition*, **32**: 72-82.

Wang, W, Rakheja, S and Boileak, PE (2004) Effects of sitting postures on biodynamic response of seated occupants under vertical vibration. *Int. J. Ind. Ergonom.*, **34**: 289-306.

Wang, AH and Chen, CH (2003) Effects of screen type, Chinese Typography, text/background color combination, speed, and jump length for VDT leading display on users’ reading performance. *Int. J. Ind. Ergonom.*, **31**: 249-261.

Wang, AH, Chen, CH and Chen, MT (2002) Effects of leading display design of dynamic information on users’ visual performance and visual fatigue. *J. Chinese Inst. Ind. Eng.*, **19**: 69-78.