International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-06, Issue-05, Aug 2020

Ergonomical aspects of human laterality, size of Smartphone touch screen and workspace noise on the performance of operators during data entry task

S Mojahid Ul Islam[1], Mohd Parvez[1], Praveen Pachauri[2], Osama Khan[3], Moied Gutto[1], Saif Rafiq Sheikh[1], Mohd Zaheen Khan[3]

[1]Al- Falah University, Faridabad, Haryana, India. [2]Noida Institute of Engineering & Technology, Greater Noida (UP), India. [3]Jamia Millia Islamia, New Delhi, India.

Abstract - The use of smartphones has significantly increased in our day to day lives not only for personal use but also for office work. It has not only find its place is human communication segment but also grabbing space in industrial automation. The automation devices, machines and drones are now being controlled with the help of mobile phone. The performance of mobile operator has raised a great concern to observe the effect of human laterality, size of touch screen and noise at workspace. The significance and interaction effects of these factors are studied in this work by conducting the experimental work under controlled parameters. The analysis consisted of 14 male participants of different dexterity who were divided into two equal groups to perform data entry task on mobile of size 5.8 inches and 6.2 inches in the environment of varying noise levels. Further the total number of words entered in ten minutes was statistically analysed. The right-motorsided subjects performed better than left-motorsided ones at each noise level. It is concluded that operators performed comparatively better on smaller mobile phones. The performance of the users decreased from 68 dBA to 82 dBA and then increased at 94 dBA. Effects of laterality, size of mobile phones, noise as well as the interaction between laterality and noise were found to be statistically significant. The interactions between laterality and type of computer and size of mobile phones and noise were statistically insignificant. Laterality was statistically significant at all noise levels and noise was statistically significant for right motor-sided operators only.

Key words: Equivalent noise level, motor-sidedness, data entry task performance, Human computer interaction, ANOVA

I. INTRODUCTION

The smartphones are gaining popularity due to their user-friendly features and consistently increasing utilization for various tasks in the business world [1]. They are handy to be carried easily and users keep them to perform many of their tasks as per urgent requirement. It is anticipated that by the year 2021 the smart-phone users will raise by more than 6.3 billion [2]. Currently, Android (Google) and iPhone (Apple) are the most promising operating systems (OS) which provide substantial number of applications which further consists of various beneficial features to the user [3]. Human computer interaction (HCI) focuses on interaction between humans and technology comprising of computers and smart-phone technologies where the user reaction time play major role while evaluating user performance. Many users were subjected to usability concerns of the interface screen which primarily involved complexity and flexibility in operation. The problems which may arise due to the physical based limitations not only restrict the interaction mechanisms but also hinders proper usage of mobile based applications [4]. Usability and comfort ability are found to be quite necessary while designing and evaluating an interface where the focus is the end-user. It is critical to understand the dynamics of a user interface while implementing new designs. New technology users encounter various forms of distraction in their daily lives. These prevent them from using the technology properly. The aim of usability is to set the design directions for the users in overcoming their frailty [5]. Various issues related to usability are (1) technical issues that are related with the network connectivity, size of the screen or life of battery (2) environmental usability deals with mental abilities, psychological factors, mobility, noise, temperature

 DOI : 10.35291/2454-9150.2020.0578

and light conditions for users and (3) social usability defines the issues of personalization, privacy, acceptance, comfort and adoption [6]. To accomplish various tasks in our daily life human hand preference is classified as left or right based on various preferences [7-8].Various researches on the abilities and constraints of human accomplishment through split brain analysis showed that the symmetrical behaviors in human lead to effective utilization of either the right or left parts of the body. This attribute is referred to human laterality. Laterality is one of the important factors for case control studies exploring risk from mobile phones [9]. Very few researches discussed on laterality under the influence of noise-induced stress in the field of HCI [8]. Most of the researches revealed health related problems in using keyboard menus to the operators [10-12]. Noise had adverse affect on the performance in the accomplishment of tasks which need attention [13]. The noise pollution creates problems at any workplace [14]. It is also revealed that unwanted sound has significantly negative effect on readability task while moving in a car [15]. Many other studies revealed that noise is of course a frazzling element that reduces the performance of human beings to work in office works or even in physical as well as simple activities [16]. Furthermore studies have to be carried to know the significance about the ill effect of sound in the usability of mobile phone. The above parameters explained in this analysis are designed to examine the effect of laterality, size of mobile phone and noise on the usability of operators. The data entry tasks by the different operators are carried under the varying noise levels. The hypotheses that are structured are:

1. Human laterality (left or right motor-sidedness) has significant influence on the overall performance of the test subject while entering data.
2. Mobile screen dimensions play a vital role on the test subjects' performance of the while entering data.
3. While entering values any simultaneous noise variation within the environment will have drastic effects on the overall efficiency of the test subject.
4. Any subsequent interaction between human laterality and noise considerably affects the test subject's performance while entering data.
5. Interaction of human laterality and size of display together for smart technology affects overall performance in data entry operation.
6. Interaction between screen dimensions of smart technology and variation in noise has a considerable effect on overall performance while following the above task.
7. Interaction of three parameters namely human laterality, size of display of smart technology and noise has a significant effect on performance of subjects while entering data.

II. METHODOLOGY

2.1. Subjects

To carry out the experimental task seven left handed and seven right handed subjects are taken. The subjects participating in the task are male and their ages vary from 18 to 25 years. The Annet's inventory was used to know whether the subject is left handed or right handed based on preference index (PI) scores [7]. If the PI is more than 0.90, the subjects are considered as right-motorsided while subjects with negative PI scores are said to be left-motorsided. All the subjects have the same experience of using smart technology and familiar with both the tablet and mobile key menus. None have any work-related musko-skeletal disorder.

2.2 Experimental Setup

In order to conduct the experimental task a chamber of size $6.3 \times 4.4 \times 3.1$ m^3 was simulated in which the subject performed the data entry task. The temperature of the chamber was maintained at 27$\pm$2°c and acoustically sealed such that no sound can be heard of the outer environment. The light intensity was kept at 340 lx as per the recommendation of International Labour Organization [16-17].The intensity of the light was regularly monitored by LX-101A light meter (Lutron electronic, Taiwan). The pre-recorded noises was played through the desktop and amplified at the required level of intensities. The sound level was maintained and over seen by sound level meter. A bell was used to trigger at the starting of the session as well as at the end of the session. An experimental session run for 10 minutes and the length of session was observed through stop watch on mobile phone. The mobile phones used in this study are iPhone X and Samsung Galaxy S9+. Both the devices feature different screen sizes to observe the effect of screen size on the performance. The iPhone X has a 5.8-inch capacitive touch screen display, whereas the Samsung Galaxy S9+ has a 6.2-inchcapacitive touch screen display The German text was given to the subjects which was in 11-pt regular Times New Roman with double-spaced. The German script was selected such that the subjects could not understand easily and thus the differences between all the subjects could minimize, if their level of expertise in English bothered them to control.

2.3. Experimental Procedure

These steps were executed before the real experiments: (a) the objectives of the task given were illustrated for experiments, (b) the instructions were given to all about the task, (c) to familiarize the subjects with the task, and they got enough training. As the subjects sat in the simulated chamber, the training as well as experimental sessions both were run followed by these steps: (a) a sheet was presented each subject which was printed German text, (b) at the starting of each session the bell was ringed to give signal, (c) the data entry task was executed by each subject for ten minutes, (d) the number of words entered were taken as the performance measure, and (d) as time ended the bell rang to

 DOI : 10.35291/2454-9150.2020.0578

stop the data entry task. The chamber was simulated with different noise levels randomly during data entry tasks. The chamber was simulated with three levels of noise, equivalent continuous sound levels (Leq) were 68, 82 and 94 dBA. During the experimental sessions a specific level was maintained and monitored constantly. A gap of 15-minutes was given between sessions to feel comfort level to the subject.

2.4. Noise Levels

In order to simulate the chamber for different working conditions, a pilot study was done to figure out the three levels of equivalent noise in which all the subjects were given the tasks on mobile phones. The noise intensity levels at The Great India palace Mall, Terminal 3 of the Indra Gandhi International Airport and the platform of New Delhi Railway station, were taped in the mobile for 15 minutes, representing different environments. They represented noise levels in office, traffic and factory environments respectively. The three levels of noise measured by the sound level meter were 68, 82 and 94 dBA respectively.

2.5. Statistical Analysis

An experimental array 2x2x3 (human laterality × size of mobile phone x level of noise), was used to conduct the experimental for conducting analysis of variance (ANOVA) with repeated measures to examine and investigate the effects of the independent parameters. Human laterality-motor sightedness as well as sound intensity levels Leq of 68, 82, and 94 dBA constituted the independent variables. The performance of the subject that is the number of words entered in 10 minutes was taken as dependent variables.

3. Results:

The performance of the subjects which was expressed as number of words entered in 10 minutes is presented in Table 1. It is evident that with an increase in sound intensity, both right and left motor-sided entered fewer words during the session. Though number of accurate words entered increase with increase in noise level as the concentration of the subject was more in higher noise level. Moreover, the number of words entered was more on mobile of small size than the larger mobile by both motor-sided subjects at each level of sound intensity. The result revealed by ANOVA can be summarized that the effects of laterality, size of mobile, noise as well as were statistically significant as shown in Table 2. Simultaneously, the interaction of motor-sidedness with noise and motor-sidedness with size of mobiles are found to be significant. While interaction of size of mobiles and noise level, as well as interaction amongst motor-sidedness, size of mobiles and noise level, were found to be statistically insignificant. Figure 1 represents the relationship between estimated means of the words entered during task and size of the mobile phones at 68 dBA sound intensity for different motor-sided subjects when right and left motor-sided operators entered data on mobiles. Similarly, Figure 2 and Figure 3 are expressing relationships at 82 dBA and 94 dBA, respectively. All the three figures are depicting that at each level the performance is better for smaller mobile phone. The number of words decreases from 68 dBA to 82 dBA and further increase at 94 dBA, as shown in figure 4.

Table 1:- Number of words entered at constant light intensity by different gender.

	Mobile of size 5.8"			Mobile of size 6.2"		
	N1	N2	N3	N1	N2	N3
Right Handed	96	87	93	94	86	87
	91	84	88	87	85	88
	92	78	83	92	77	86
	92	88	90	90	85	89
	93	85	88	90	82	88
	98	85	85	88	82	84
	96	88	94	93	90	88
Left Handed	76	72	75	64	65	62
	80	75	78	76	70	72
	82	76	80	85	73	80
	80	70	85	68	72	78
	85	75	80	82	62	82

 DOI : 10.35291/2454-9150.2020.0578

ISSN : 2454-9150 Vol-06, Issue-05, Aug 2020

	72	76	76	62	62	61
	73	70	75	65	60	66

Table 2. Analysis of Variance of the number of words entered on touch screen mobile of sizes 5.8 inches and 6.2 inches at varying noise levels

Dependent Variable: Performance

Source	Sum of Squares	df	Mean Square	F
Correction Factor	547727.25			
Total	7671.75			
Between Subjects	5682.58	13		
Within Subjects	1989.16	71		
Laterality	4680.10	1	4680.10	56.02
Subjects within Group (Error I)	1002.47	12	83.53	
Size of Mobiles	416.29761	1	416.29	25.64
Laterality × Size of Mobiles	121.44	1	121.44	7.48
Size of Mobiles × Subject within groups (Error II)	194.76	12	16.23	
Noise	612.92	2	306.46	19.46
Laterality × Noise	67.78	2	33.89	2.15
Noise× Subject within groups (Error III)	377.95	24	15.74	
Size of Mobiles × Noise	3.16	2	1.58	0.20
Laterality ×Size of Mobiles × Noise	7.73	2	3.86	0.49
Size of Mobiles × Noise × Subjects within Group (Error IV)	187.09	24	7.79	

$F_{(1,12),0.5}$= 4.75 and $F_{(2,24),0.5}$= 3.88

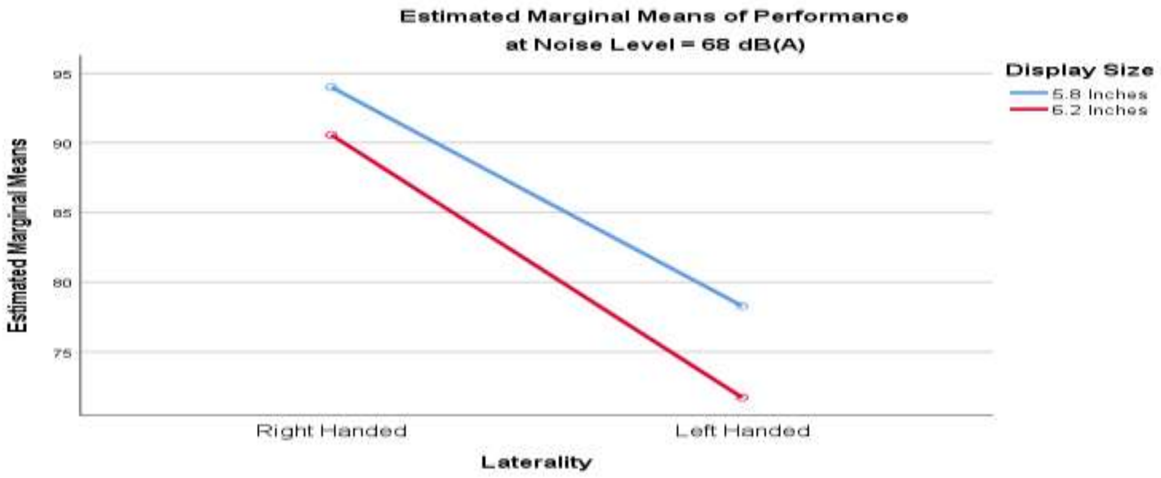

Figure 1. Relationship between task performance of right and left motor-sided operators on different size screen mobile phones at 68 dBA

 DOI : 10.35291/2454-9150.2020.0578

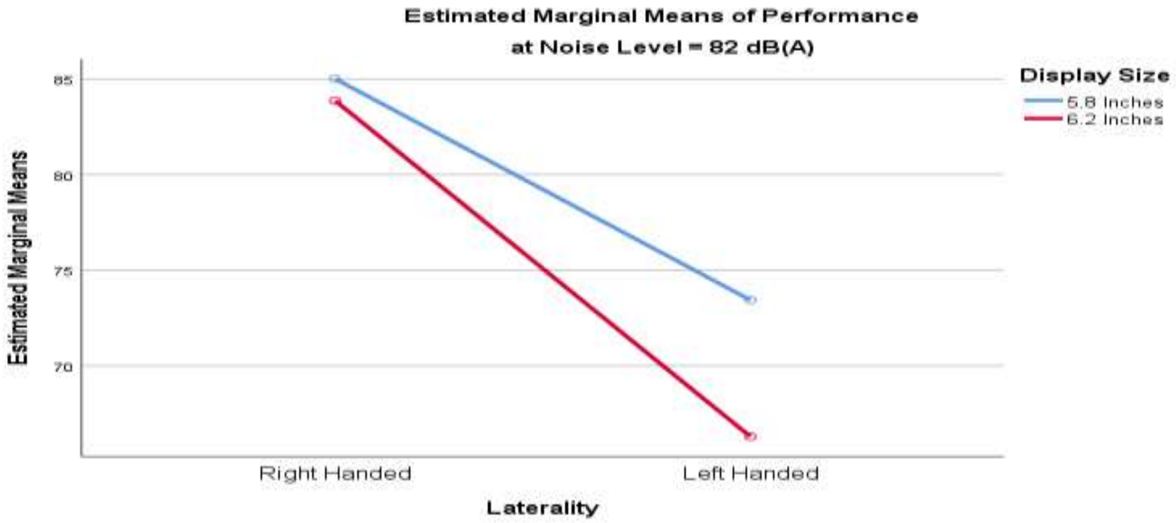

Figure 2. Relationship between task performance of right and left motor-sided operators on different size screen mobile phones at 82 dBA

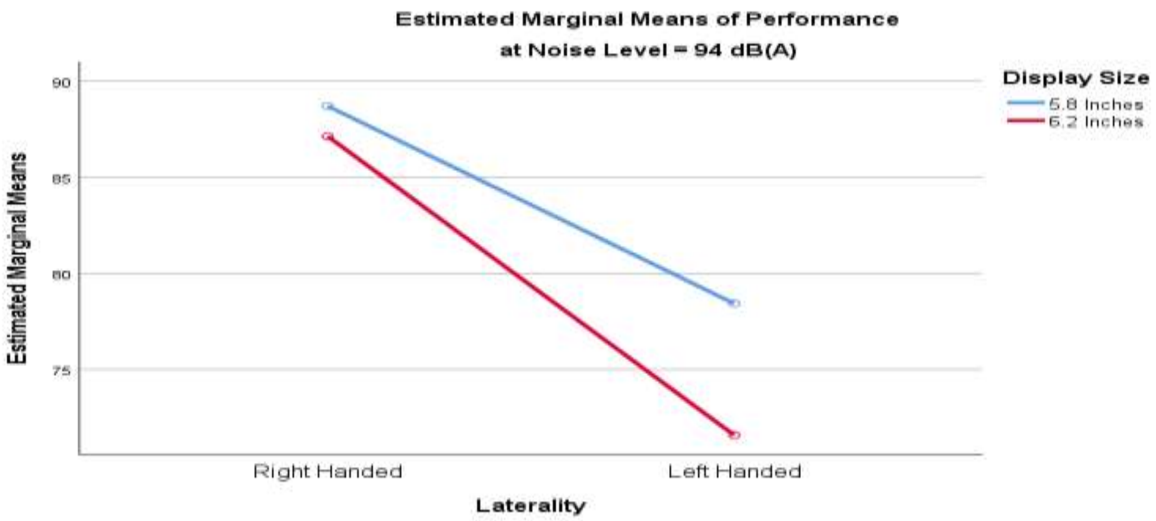

Figure 3. Relationship between task performance of right and left motor-sided operators on different size screen mobile phones at 94 dBA.

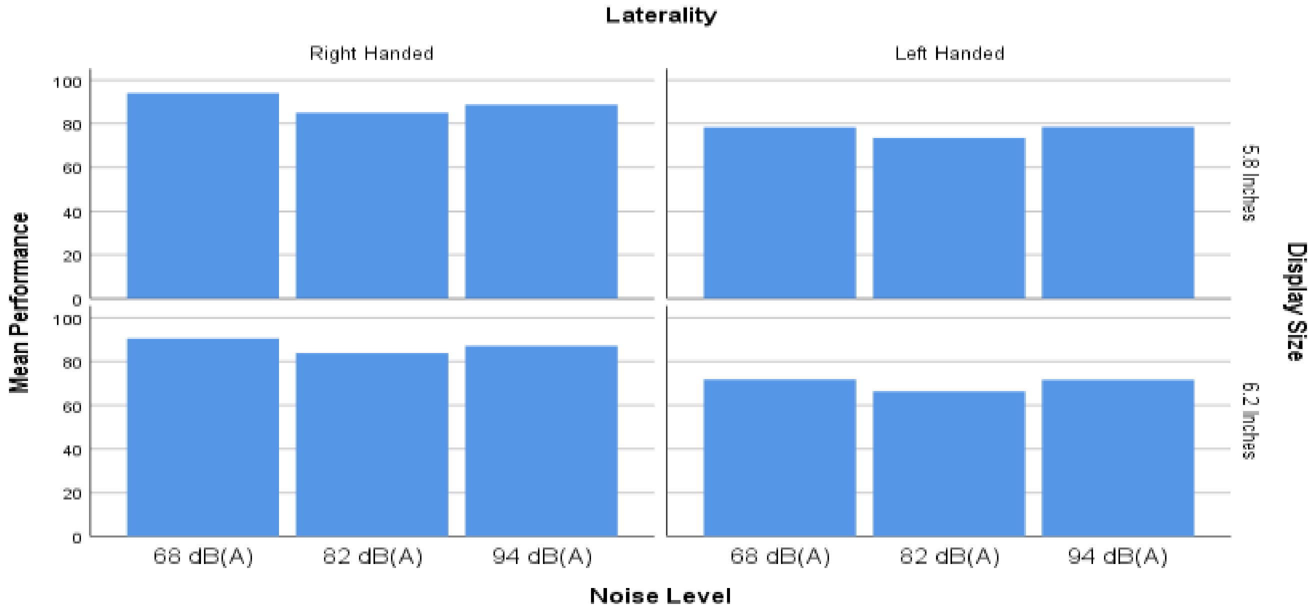

Figure 4. Relationship between task performance of right and left motor-sided operators on varying noise levels

 DOI : 10.35291/2454-9150.2020.0578

III. Discussion

The hypotheses indexed in section 1 were examined by using ANOVA approach. There are very few studies to support the effects of motor-sidedness under HCI to find their performances. Though there are few researches on laterality to support findings. Landaeur et.al.[18] and Daniels's [19] revealed in their findings that there is significant differences in left handed and right handed people on sensory motor co-ordination. Hobday [20] examined in his findings that right motor-sidedness people differed from left motor-sidedness ones in the performance of pressing keys. In his study, Badar [21] explored that human performances is affected due to motor-sidedness under varying light intensities in the environment of human-computer interaction. Deluca et.al. [22] gave an idea that differences in right-handed people from left-handed is a sign of alteration in the metabolic properties that occurs in muscle fibres as adopted functional use. Other researches also revealed the significance effect of human laterality while performing different tasks [23-24]. Hence the results of present study reflect that there is requirement of co-ordination of both the hands, hence laterality play a major part in completing the task.

The major finding of this study revealed that the size of mobile phones has significant effect on the performance of the user. The number of words entered on different mobiles is different due to inherent design which defines the comfortable level. The environment of the surroundings affects the usability of hand-held devices. In present study the findings symbolizes that the different noise level has a significant effect on human performance. There is deterioration in the performance with increase in noise intensity.

IV. Conclusions

The following conclusions are drawn from the results we get from this study.

i. Right-handed subjects achieved a higher rate of data entry as compared to left-handed subjects.
ii. Size of the mobile has a significant effect on the performance. The present study shows that mobile phones of small size are more efficient for data entry task than the larger one.
iii. Noise in the environment also has a significant effect on the performance. At the ranges considered in the study, the performance of the subjects degraded with the increase in the noise intensity.
iv. The interaction of laterality and mobile size is insignificant.
v. The interaction of laterality and noise level is significant in effecting the performance.
vi. The interaction of mobile size and noise level also has a insignificant effect on the performance.
vii. The interaction of all 3 factors is also insignificant.

References

[1] Iqbal M.W., Ahmad N. and Shahzad S.K , Usability evaluation of adaptive features in smartphones Procedia Computer Science Volume 112, 2017, p. 2185-2194

[2] Andone, I., Błaszkiewicz, K., Eibes, M., Trendafilov, B., Montag, C., & Markowetz, A. How age and gender affect smartphone usage? In Proceedings of the ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct. 2016. p. 9-12.

[3] Jindal, G., & Jain, M. A comparative study of mobile phone's operating systems. International Journal of Computer Applications & Information Technology. 2012. 1(3). p. 10-15

[4] Wesson, J. L., Singh, A., & Van Tonder, B. Can adaptive interfaces improve the usability of mobile applications? In Human-Computer Interaction. Springer Berlin Heidelberg. 2010. p. 187-198

[5] Brodić D., Amelio A. Analysis of the Human-Computer Interaction on the Example of Image-Based CAPTCHA by Association Rule Mining. In: Gamberini L., Spagnolli A., Jacucci G., Blankertz B., Freeman J. (eds) Symbiotic Interaction. Symbiotic 2016. Lecture Notes in Computer Science. Vol. 9961. Springer, Cham. 2017. p. 38-51.

[6] Hussain, A., &Kutar, M. Apps vs devices: Can the usability of mobile apps be decoupled from the device?. IJCSI International Journal of Computer Science. 2012. 3. p. 11-16.

[7] A classification of hand preference by association analysis by Marian Annett

[8] A Study on the Effect of Human Laterality, Type of Computer and Noise on Operators' Performance of a Data Entry Task Zahid A. Khan Sayed Aliul H. Rizvi

[9] Cardis, E., 2010. Brain tumour risk in relation to mobile telephone use: results of the Interphone international case-control study. Int. J. Epidemiol. 39, 675–694

[10] Hobday SW. Keyboard design to fit hands and reduce postural stress. In: Brown ID, Goldsmith R, Coombes K, Sinclair MA, editors. Proceedings of the 9th Congress of the International ErgonomicsAssociation, Bournemouth, UK. London, UK: Taylor & Francis; 1985. p. 457–8.

[11] Green DM, Fidell S. Variability in the criterion for reporting annoyance in community noise surveys. J Acoust Soc Am. 1991;89:234–43.

[12] SmithAP.Noiseandaspectsofattention. Br J Psychol. 1991; 82:313–24.

 DOI : 10.35291/2454-9150.2020.0578

[13] Kjellberg A, Landstrom U. Noise in the office: Part II- The scientific Basis (knowledge base) for the guide. Int J Ind Ergon1994;14:93-118.

[14] Kjellberg A, Landstrom U. Noise in the office: Part I - Guidelines for the practitioner. Int J Ind Ergon 1994;14:87-91

[15] Khan IA, Mallick Z, Khan ZA. A study on the combined effect of noise and vibration on operators' performance of a readability task in a mobile driving environment. International Journal of Occupational Safety and Ergonomics (JOSE). 2007;13(2):127–36

[16] M C. Repertoire of knowledge of a number of factories in Shiraz city at Noise and its complications in the workplace. Proceedings of the Second National Congress of Occupational Health. Tehran University, 2007. (Persian).

[17] International Labour Office (ILO). Working with visual display units (OSH series, No. 61). Geneva, Switzerland: ILO; 1989.

[18]. Landaeur AA, Armstrong S, Digwood J. Sex differences in choice reaction time. Br J Psychol. 1980;71:551–5.

[19] Daniels FS. Do the eyes have it? American Rifleman. 1981;129:38–48.

[20] Hobday SW. Keyboard design to fit hands and reduce postural stress. In: Brown ID, Goldsmith R, Coombes K, Sinclair MA, editors. Proceedings of the 9th Congress of the International Ergonomics Association.

[21] Badar MA. Studies on the effects of age and laterality under varying levels of illumination in an HCI environment [Master of Science thesis]. Aligarh, India: Aligarh Muslim University, Mechanical Engineering Department; 1990.

[22] Deluca CJ, Sabbahi MA, Roy SH. 1986, Median frequency of the myoelectric signal. Effects of hand dominance. Eur J Appl Physiol. 1986;55:457–64.

[23] Cornell E, McManus IC. Differential survey response rates in right- and-left-handers. Br J Psychol. 1992;83:39–43. 19.

[24] Jone GV, Martin M. Handedness dependency in recall from everyday memory. Br J Psychol. 1997;88:609–19.

 DOI : 10.35291/2454-9150.2020.0578