12th IEEE International Conference On Advanced Computer Science and Information System (ICACSIS 2020) -- PRE-PRINT – Will be available at IEEE Xplore

An Investigation Into The Level Of Valence Offered By Different Pointing Devices Against Challenging Tasks

Eshtiak Ahmed*, Ashraful Islam*, Mohsena Ashraf†, Md. Ibrahim Khan*, Atiqul Islam Chowdhury‡, Asif Karim§
*Department of CSE, Daffodil International University, Dhaka, Bangladesh
Email: {eshtiak.cse, ashraful.cse, ibrahim15-9155}@diu.edu.bd
†Department of CSE, Ahsanullah Univeristy of Science and Technology, Dhaka, Bangladesh
Email: mohsena_ria.cse@aust.edu
‡Department of CSE, United International University, Dhaka, Bangladesh
Email: achowdhury201036@mscse.uiu.ac.bd
§Member, Institute of Electrical and Electronics Engineers, USA
Email: asif.karim@ieee.org

***Abstract*—Pointing devices are the primary media of interaction between humans and computers. The three most popular pointing devices used in computers (both portable and non-portable) are mouse, touchpad and nubs (joystick). They have their different advantages and use cases while being targeted to different user groups. The aim of this study was to investigate whether the aforementioned pointing devices have different effects on human valence. A total of 12 participants were recruited for the experiment. Each participant completed a pointing reaction test with every pointing device aforementioned, where they selected as many randomly appearing circles as possible in a given amount of time. Then, subjective ratings of emotional valence and arousal were collected, and the effects of the pointing device used on these ratings were investigated. Our study shows that the valence rating of using the mouse were significantly higher in challenging scenarios, compared to the likes of touchpad and nub.**

***Index Terms*—HCI, Pointing devices, Pointing reaction, Emotional valence, Touchpad, Mouse.**

I. Introduction

A pointing device is basically a hardware input device, allowing the user to move the cursor in a computer program or graphical user interface (GUI) based operating system. One can point at or easily manipulate any text or object using a pointing device on the screen. Pointing devices help to build a connection between humans and computer as it works as an input device. The point-and-click concept is defined as to move something which causes a corresponding movement on the screen [1]. Any pointing device can send information to the computers but do not receive any output from the computer.

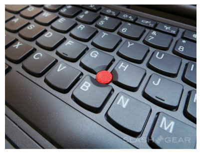
There are many common pointing devices including computer mouse, touchpad, touch screen, joysticks, trackballs etc. The most common pointing device for a desktop computer is mouse. On the other side, touchpad is used as a common pointing device for laptops. Some persons use nub i.e. joystick as a mouse for any type of computer as well. All of these devices are for interaction purpose and the uses of these devices vary from person to person. A computer mouse is a small, interactive pointing device that controls the placement of the cursor on a computer display. It can be a one, two, or three-button device. Most of the people use mouse if we compare the usage with touchpad and nub. There are wireless and wired mouses now a days. But the usage of a wireless mouse is increasing day by day for its comfortability issue. On the other hand, if we think about touchpad, then we can see that touchpads are only attached to laptops mainly. A touchpad is a pointing input device which features a tactile sensor that can translate the position and motion of a user's fingers to a relative position. It does the same job as a mouse, but it needs a motion of fingers if anyone wants to use it. So, it could be a little bit tough for some people as this device uses finger motion.

If we think about other pointing devices, we can see that there are also trackballs, nubs, joysticks which are popular now a days. But among them, nubs are sometimes attached with the keyboards. This device is like a small and isometric joystick [2], usually positioned (seen in maximum keyboards) between 'G', 'H' and 'B' keys on the keyboard. This device adds a benefit for some users by its position as users can keep their hands on the keyboard and also be able to control the mouse easily. So, it has a good beneficial factor regarding usage flexibility.

In this study, three specific pointing devices has been taken into account. They are mouse, touchpad and nub, shown in Figure 1. The main motive of this research is to analyze the usage of these pointing devices and their different effects on human valence. Valence can be interpreted as the pleasantness of any kind of activity. It is deemed higher in a situation where a user has a significantly positive experience in doing any task. The level of valence being low interprets to an unpleasant or less pleasant experience. In this study, a challenging task has been taken into account to understand the valence ratings.

(a) Mouse

(b) Touchpad



(c) Nub (Joystick)

Fig. 1. Different types of pointing devices

The aim is to understand if there is a significant difference in valence when people use different pointing devices for a challenging task, and to what extent. The participants of the study have completed a pointing device reaction test using the three mentioned devices. After the reaction test, the valence level of the participants were recorded using self assessment questionnaires. Finally, mathematical analysis has been done to get a more in depth look on the data.

The rest of this paper is organized as follows. Section II will discuss related works regarding this area. The method will be discussed in section III. The results regarding the method will be elaborately described in section IV. Finally, section V is about the conclusion of this article.

II. Related Works

Nowadays, smart interfaces have become very much popular among users and a lot of work has been done to the journey toward them [3] [4] [5]. While touch and gesture based touch interfaces have become more and more useful and user friendly, pointing devices has not become obsolete. There have been previous studies about different pointing devices; considering their usability, ease of access in different situations as well as their applications in different domains. According to a study by Loricchio in 1992, computer mouse is a more accurate pointing device than a nub [6]. In addition, Lee in 2005 published research on the relative ergonomics of computer mice versus touchpads which did not manifest in any significant results [7].

In [8], Hussain et al. surveyed a comparison of the mouse and the touchscreen-based pointers on age groups, task requirements, technology experience, speed, and accuracy trade-off. They claimed that indirect devices are suitable for older adults while direct devices are for the younger generation. Moreover, they concluded that the steering task is difficult with a mouse and dragging task is slower on a touchscreen. However, the touchscreen is easier for steering, crossing, dragging, and pointing tasks. In a similar study [9], the authors evaluated three game input methods i.e. a thumb-based touchpad, thumbstick, gyrosensor and compared them with the mouse in a Fitts' law pointing experiment. They got the best throughput for the mouse, after that touchpad, then the gyrosensor, and at last for the thumbstick. They concluded that the touchpad and the gyrosensor are good alternatives to the thumbstick.

The size and textures of pointing devices have also been investigated in some studies. In such an study [10], the authors focused on the effects of touchpad size on pointing, gestural input area and performance. They conducted their study with two touchpads having the same surface materials and concluded that there is no significant effect of increased touchpad size on the pointing or gestural input area and performance. Moreover, they found that for dragging, pinch-zoom or scroll tasks, 95% touches occur on the small touchpad area. In another study [11], the author assessed the user preference of Mylar surface films for laptop touchpads with different degrees of roughness. It was evaluated by 30 individuals using Fitts' law task. Values perception, texture sensation, and preference were collected. Experimental results indicated the effects of touchpad roughness on reaction time, error rate, and user experience though there was an absence of different hand conditions.

In this investigation, the Self-Assessment Manikin (SAM) has been used as the evaluation of users' pleasantness and arousal ratings. SAM has been used in such kind of studies quite many times. In [12], the SAM is known to be a picture oriented questionnaire which is developed to measure three central features of an emotional response. These three features are: valence/pleasure of the response (from positive to negative), perceived arousal (from high to low levels), and perceptions of dominance/control (from low to high levels). The authors tried to find out the emotions of south Indian subjects and classical dancers using SAM rating in [13]. They used the International Affective Picture System (IAPS) for this purpose. The experiment was carried out by 55 participants whose perceived emotions were recorded in valence, arousal and dominance domain. The authors concluded that the valence scoring was the same while there was variance in arousal and dominance space. Moreover, the three perceived emotions of the classical dancers were much better.

Moreover, Xie et al. in [14] used VR games as emotional materials for arousing basic emotions while evaluating the arousal effects with SAM. They verified the validity of the Mehrabian emotion model with SAM. They standardized the games according to the picture, video, and audio for affective simulation and concluded that VR games with targeted emotional stimuli had better levels of proactiveness, interactivity, and efficiency. In [15], the authors proposed an Affective Virtual Reality System (AVRS) and verified it with SAM measurement. They used arousal as an indicator for comparing the difference between virtual reality materials and video materials through objective and subjective assessment. They claimed VR scenes to achieve the same emotion elicitation as video whereas, measures of Fearful in SAM evaluation indicated that VR emotion materials were expected to deliver a good effect on negative emotional scenes.

All the devices in consideration in this study have been proven to be important inventions and useful in many circumstances. However, there has not been any specific studies where the comparative enjoyment of using different types of pointing devices have been investigated. The aim of this study is to understand if there is any difference in pleasantness (valence) and excitement (arousal) of using a computer mouse, a laptop's touchpad, or a pointing nub.

III. Method

A. Experimental Design

In this experiment, the effects of using different input devices were studied: mouse, touchpad, and pointing stick or nub. Pointing devices allow users to input information, however, depending on the device, the speed and accuracy may vary. This variation along with users' previous experience with the devices is expected to have a significant effect on their valence (pleasantness) and arousal levels.

As an empirical study, this experiment contains one independent variable which has three levels and two dependent variables. Our independent variable is the pointing device, which has mouse, touchpad, and nub as the three levels. The dependent variables are valence and arousal. The participants used each device for a specific amount of time; after the usage participants were asked to fill in a self-assessment questionnaire to report their thoughts. The SAM questionnaire was employed to measure the valence and arousal ratings. The valence ratings were reported using a bipolar scale which ranged from -2 to +2, 0 being the neutral point, -2 rating denoted an unpleasant experience, and +2 denoted a pleasant experience. The arousal ratings were reported with a scale ranging from 0 to 4, 0 denoted calmness while 4 denoted high arousal.

The study was designed to be a within-subject experiment. All the devices were used and reported one by one by each participant. In addition to that, a counterbalancing system was used for each group of participants to randomize the order of the devices used. The participants were divided into three subgroups for the counterbalancing and each group had to use the devices in a different order. The order of use for each group are the following:

- First group
  - Mouse
  - Touchpad
  - Nub
- Second group
  - Nub
  - Mouse
  - Touchpad
- Third group
  - Touchpad
  - Nub
  - Mouse

Fig. 2. Experimental task screen: randomly appearing, expanding and then contracting red disks

Although we gathered data for both valence and arousal ratings during the experiment, we decided only to consider the valence (pleasantness) rating data for the results analysis part.

B. Participants

A total of 12 participants, 6 female and 6 male, were recruited for the experimental study through both online and offline invitations. For this purpose, an invitation letter was prepared for potential participants explaining the target and details of the experiment.

At the start of the experiment, each participant was briefed about the target, procedure and other details of the study. Then they were asked to sign a consent form which included the risks and benefits of the study as well as the rights of the participants regarding the study. After that, each participant was asked to fill in a background information questionnaire which included information about their age, gender, hand movement capability, dominant hand and frequency of using the pointing devices.

The average age of the participants was 22, ranging from 19 to 25. All of them reported normal hand movement capabilities, 11 out of 12 reported their right hand as dominant, 4 of the participants used a mouse on a daily basis while the others used it on either a weekly or monthly basis. 8 of the participants used a touchpad on a daily basis while the others used it either weekly or monthly, 9 of the participants reported that they have never used a nub before and the other 3 used it less than once a month. This information indicated that all the participants were at least familiar with using a mouse or a touchpad while most of them did not have prior experience of using a nub.

C. Apparatus

All the experimental tasks were conducted using a laptop, Dell Latitude 7440 running a Windows 10 operating system. A free-to-access online web application which helps the user test their mouse accuracy, agility; was used for the tasks [16]. The application was accessed using the Mozilla Firefox web browser. The mouse used was Microsoft Wireless Mobile Mouse 4000.

D. Experimental task and Stimuli

The experimental task was a reaction test that tracked target efficiency and clicking the accuracy of the user. Participants had to select randomly appearing, expanding and then contracting red disks before they disappeared, demonstrated in Figure 2. For each pointing device, the task had to be done twice. First, the participant was given 30 seconds to get familiar with the device and the stimuli, completing the task on easy difficulty and with large circles. After the practice test, the actual test was done on normal difficulty with medium circles, lasting 90 seconds.

On the screen, rhythmically expanding and contracting red disks randomly appeared and were used to create the stimuli. The user had to click on the disks before they disappeared. Faster clicks resulted in better scores. The stimuli were chosen based on an assumption that the task would evoke more frustration to the user when completed with a pointing device that is harder to use. Thus, the stimuli could trigger emotions that would ultimately help to evaluate the pleasantness and arousal of the use of the pointing devices.

E. Procedure

The experiment was done in a controlled environment, in this case, a usability lab. Each participant was called into the usability lab of the university one by one for the experiment. No video or voice was recorded, however, one member acted as the moderator and a couple of team members were employed as observers during the test.

At first, the participant was seated in front of the computer which included all the devices in contention for the test. The moderator stayed with the participant, keeping a distance of at least one meter. The moderator started the test procedure by describing the experiment, risks, benefits, duration and explained the rights of the participant. Here, the participant had not been informed about the actual target of the test which was analysing their valence and arousal ratings. Instead, they were presented with a cover story that stated they were participating in a reaction test. This was done so that the participants would not have a biased mindset while completing the self-assessment questionnaires. Upon agreement from the participant, the moderator handed out the consent form to the participant.

After the consent was taken, a background questionnaire was given to the participant to fill up which contained their age, gender, hand movement capability, dominant hand and frequency of using the devices in contention. After that, the moderator provided the participant with the general description of the experimental task and showed them the devices that are going to be used, explaining how each device worked along with their pointing techniques. They were also shown an example task by the moderator so that they know exactly what they had to do.

For each participant, there was a specific order in which they were asked to use the pointing devices for the task. At this point in time, the participant was given 30 seconds of time to use the device to have a test run and get familiar with the task. This test run was done with large disks and easy difficulty. After the test run, the test parameters were changed to be 90 seconds long, with medium-sized disks and normal difficulty. After the task was completed, the participants were presented with the SAM questionnaire to report how pleasant their experience was and how aroused they were by using that specific device. For each of the 3 devices, this process was repeated.

After completing all the tasks, each participant was briefed about the true aim of the experiment.

F. Data Analysis

Although the SAM questionnaire measures two variables, for our data analysis we decided to focus solely on the valence variable. We decided to use a single variable as we believe the valence effect is more relevant to the initial inquiry we wanted to answer, the pleasantness level produced by the use of different pointing devices. In conclusion, the experiment was a within-subjects design with a pointing device as a factor. The subjective ratings data were analysed with a Friedman test [17]. Bonferroni-corrected Wilcoxon signed-rank tests [18] were used for post hoc tests.

IV. Result

Firstly, we determined the normality of the data distribution using a Q-Q Plot (see Figure 3) to see the distribution of our dependent variable. The Q-Q plot showed was not normally distributed thus we decided to use non-parametric methods to analyse the data. Figure 4 shows the mean valence ratings and the standard error of the means (SEMs) for the three different pointing devices in our study, mouse, touchpad, and nub. Friedman's test results (see Table I), showed that there was a statistically significant effect of pointer device, $X^2(2) = 8.8$, $p < 0.05$.

Post hoc pairwise comparisons with Wilcoxon signed-rank tests (see Table II), showed that the selections using the mouse were significantly more valenced (pleasant) than the selections using the nub, $Z = -2.51$, $p < 0.05$. Other pairwise comparisons were not statistically significant.

The statistical analysis indicates that the valence rating of using both a mouse and a touchpad for a stressful and challenging task is quite high. The users participating in this study have reported to have a pleasant experience using them for the particular task. On the contrary, most of the users reported a disturbing experience while using a nub. This could be the result of many factors, their unfamiliarity with a nub or

TABLE I
FRIEDMAN'S TEST FOR THE VALENCE RATINGS OF THE THREE POINTING DEVICES

Test Statistics[a]	
N	12.000
Chi-Square	5.895
df	2.000
Asymp. Sig.	0.052

[a] Friedman Test

TABLE II
WILCOXON TEST FOR THE VALENCE RATINGS OF THE THREE POINTING DEVICES

Test Statistics[a]			
	Touchpad-Mouse	Nub-Mouse	Nub-Touchpad
Z	-0.723[b]	-2.521[c]	-2.360[c]
Asymp. Sig. (2-tailed)	0.470	0.012	0.018

[a] Wilcoxon Signed Ranks Test
[b] Based on negative ranks
[c] Based on positive ranks

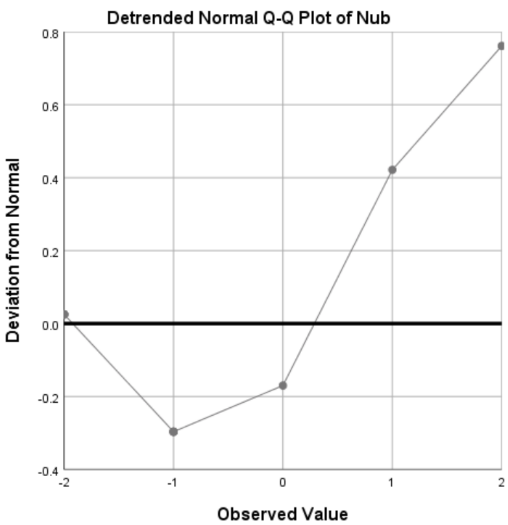


Fig. 3. Normally distribution Q-Q plot to assess nub ratings

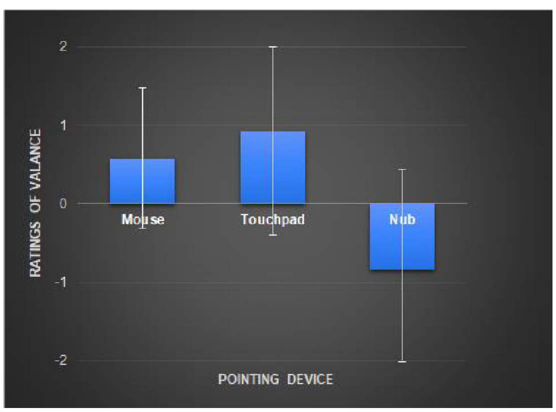


Fig. 4. Mean valence ratings and S.E.M.s for the three pointing devices

just the difficulties of using them in such a situation. Overall, in terms of valence, the nub comes on the bottom.

V. CONCLUSION

Our research results indicate that nubs are significantly less pleasant to use than computer mice. Although our findings were significant, only one version of each pointing device was used for the experiment, so the external validity of the results may be limited - it is possible that low valence results come from using this particular nub, not nubs in general.

Combined with previous research exploring the differences in speed between different pointing devices (Loricchio, 1992) [6], this would indicate that nubs are inferior to computer mice in every way. Future qualitative research is needed to explore why users find nubs harder and less pleasant to use, and a long term study would be useful to verify whether the disparity in usability comes from the device itself or from lack of experience with using particular devices.

The results of our research could encourage laptop manufacturers to invest in improving nubs, or decide to stop embedding nubs into laptop keyboards entirely.

REFERENCES

[1] A. U. Batmaz and W. Stuerzlinger, "Effects of 3d rotational jitter and selection methods on 3d pointing tasks," in *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*. IEEE, 2019, pp. 1687–1692.

[2] A. S. Rodrigues, V. K. da Costa, R. C. Cardoso, M. B. Machado, M. B. Machado, and T. A. Tavares, "Evaluation of a head-tracking pointing device for users with motor disabilities," in *Proceedings of the 10th International Conference on PErvasive Technologies Related to Assistive Environments*, 2017, pp. 156–162.

[3] M. Luria, G. Hoffman, and O. Zuckerman, "Comparing social robot, screen and voice interfaces for smart-home control," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, ser. CHI '17. ACM, 2017, p. 580–628.

[4] E. Ahmed, M. M. Hasan, M. O. Faruk, M. F. Hossain, M. A. Rahman, and A. Islam, "Icons for the mass: An approach towards text free smart interface," in *2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT)*. IEEE, 2019, pp. 1–4.

[5] A. Nijholt and A. Minuto, "Smart material interfaces: Playful and artistic applications," in *2017 IEEE International Conference on Imaging, Vision Pattern Recognition (icIVPR)*. IEEE, 2017, pp. 1–6.

[6] D. F. Loricchio, "A comparison of three pointing devices: mouse, cursor keys, and a keyboard-integrated pushbutton," in *Proceedings of the Human Factors Society Annual Meeting*, vol. 36, no. 4. SAGE Publications Sage CA: Los Angeles, CA, 1992, pp. 303–305.

[7] T.-H. Lee, "Ergonomic comparison of operating a built-in touch-pad pointing device and a trackball mouse on posture and muscle activity," *Perceptual and motor skills*, vol. 101, no. 3, pp. 730–736, 2005.

[8] I. Hussain, A. Khan, I. A. Khan, S. S. Hussain, and A. Rehman, "A survey on usage of touchscreen versus mouse for interaction," *Sci Int (Lahore)*, vol. 29, pp. 83–88, 2017.

[9] A. Ramcharitar and R. J. Teather, "A fitts' law evaluation of video game controllers: thumbstick, touchpad and gyrosensor," in *Proceedings of the 2017 chi conference extended abstracts on human factors in computing systems*, 2017, pp. 2860–2866.

[10] A. Avera, C. Harper, N. Russi-Vigoya, and S. Stoll, "Effects of touchpad size on pointing and gestural input area and performance," in *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 60, no. 1. SAGE Publications Sage CA: Los Angeles, CA, 2016, pp. 825–829.

[11] Y.-K. Ou, "User preference and usability assessments of touchpad surface tactile in laptops," *Human Factors and Ergonomics in Manufacturing & Service Industries*, 2020.

[12] T.-M. Bynion and M. T. Feldner, "Self-assessment manikin," *Encyclopedia of personality and individual differences*, pp. 1–3, 2017.

[13] B. Geethanjali, K. Adalarasu, A. Hemapraba, S. P. Kumar, and R. Rajasekeran, "Emotion analysis using sam (self-assessment manikin) scale," 2017.

[14] T. Xie, M. Cao, and Z. Pan, "Applying self-assessment manikin (sam) to evaluate the affective arousal effects of vr games," in *Proceedings of the 2020 3rd International Conference on Image and Graphics Processing*, 2020, pp. 134–138.

[15] D. Liao, L. Shu, G. Liang, Y. Li, Y. Zhang, W. Zhang, and X. Xu, "Design and evaluation of affective virtual reality system based on multimodal physiological signals and self-assessment manikin," *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, 2019.

[16] N. or Die, "Mouse accuracy, agility and target training," accessed: 09-06-2020. [Online]. Available: https://mouseaccuracy.com/

[17] D. W. Zimmerman and B. D. Zumbo, "Relative power of the wilcoxon test, the friedman test, and repeated-measures anova on ranks," *The Journal of Experimental Education*, vol. 62, no. 1, pp. 75–86, 1993. [Online]. Available: https://doi.org/10.1080/00220973.1993.9943832

[18] J. M. Bland and D. G. Altman, "Multiple significance tests: the bonferroni method," *BMJ*, vol. 310, no. 6973, p. 170, 1995. [Online]. Available: https://www.bmj.com/content/310/6973/170