Advantages of Magnetic Mice over Trackballs as input devices on moving platforms

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Abstract

Although ergonomic studies show that cursor control with a computer mouse is faster and sometimes more accurate than cursor control with a trackball, trackballs are the standard input device for cursor movements on many moving platforms such as airplanes and ships. One reason for this is that trackballs can be fixed to the workstation, which prevents involuntary cursor movements that could otherwise be induced by movements of the platform. In this study, standard trackballs and computer mice with magnetic adhesion to the mouse pad were evaluated by 18 sailors of the German Navy after 26 days of computer operation on their moving ship. Results show that users of magnetic mice performed better and showed less muscular fatigue than trackball users. Thus, magnetic mice should be considered as the standard input device on moving platforms.

Introduction

Although the standard input device for cursor control in the operation of most computer systems is the computer mouse, trackballs are commonly used for cursor control on moving platforms such as ships or airplanes. There are two reasons for this preference of trackballs: first, on many moving platforms, there is only limited space to accommodate the human-computer-interface and less space is required for the operation of a trackball. Second, trackballs can be fixed to the workplace, which is intended to prevent motion-induced shifts of the device and the cursor on the computer screen.

Ergonomic research has found that compared to mouse use, trackball use can be associated with a number of disadvantages. Studies of user performance in fixed laboratory settings show that computer mice allow for a faster and more precise cursor control than trackballs (Grandt et al., 2004; Isokoski et al., 2007). Similar results were obtained in an experiment with participants experiencing simulated ship movements while performing a Fitts task. Trackball-controlled cursor movements to a target location were as accurate as mouse-controlled cursor movements, but on average 500 ms slower (Lin et al., 2010). Results on muscular strain associated with mouse and trackball use are rather inconclusive. While trackball use during a five-minute period of office work was found to cause less muscular activity in shoulder

In D. de Waard, J. Sauer, S. Röttger, A. Kluge, D. Manzey, C. Weikert, A. Toffetti, R. Wiczorek, K. Brookhuis, and H. Hoonhout (Eds.) (2015). Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2014 Annual Conference. ISSN 2333-4959 (online). Available from http://hfes-europe.org

and neck, it led to a higher wrist extension than mouse use. Neither of these differences was reflected in the subjective strain ratings of the study participants (Karlqvist et al., 1999).

The studies referred to above were mostly conducted in stationary environments and with rather short periods of work. The objective of the present investigation was to study performance and strain differences between mouse use and trackball use on a seagoing platform and over extended periods of time. The computer mice used in this study were secured against motion-induced shifts by magnetic adhesion to the mouse pad. This results in a certain resistance that must be overcome when starting to move the mouse. Another purpose of this study was to find out whether the computer mice thus modified would show the same advantages over trackballs as the standard devices used in previous studies.

Methods

A sample of 18 male sailors of the German Navy participated in this study. They performed their usual tasks with a computer system in the Combat Information Centre (CIC) of a German frigate (for an example of typical workstations in a CIC see figure 1).

Tasks included the radar-based detection and classification of airplanes and vessels, acquisition of potential threads, thread engagement and weapon control. Type of input device was manipulated in a between subjects design. Ten participants used a recessed trackball and eight participants used an optical mouse as input device. Inside their housing, the mice were equipped with neodym magnets that provided adhesion to ferromagnetic mouse pads. Special care was taken to keep the magnetic adhesion and thus the necessary force to overcome the adhesion when moving the mouse as low as possible. Participants tested their input device for a period of 26 days during transit voyages and a weapon exercise. The mean duration of consecutive computer operation was four to six hours each day. Wave heights during the trial period were between 0.5 and 4 metres.

After the end of the trial period, participants gave their subjective evaluation of the input device on a seven-point rating scale with the questionnaire from ISO 9241-420, appendix D.1. This questionnaire contains items regarding the performance in cursor control (speed, accuracy, smoothness of cursor movements), the difficulty of operating the device (force, effort), and fatigue of fingers, wrist, arm, shoulder and neck. Higher ratings in this questionnaire indicate a better evaluation. Two additional scales of the questionnaire with summary ratings (overall satisfaction and usability) were not considered in the analysis because they contain no additional information beyond the specific items on performance, difficulty and muscular fatigue.

Figure 1. Typical workstations in a Combat Information Centre of a German frigate. Note the recessed trackball at the bottom of the picture. © Bundeswehr.

Ratings of mouse and trackball users were compared with t-tests for independent samples. Due to the multiple testing, a Šidàk-correction (Abdi, 2007) was applied and the test-wise alpha level was set to .0051 in order to keep the family-wise alpha level at 0.05.

Results

Means, standard deviations and test statistics of all items are displayed in table 1. Results regarding performance, difficulty and muscular fatigue are summarized below the table. In the box plots used for graphical data representation, horizontal bars indicate the median of the distribution. Boxes cover the central 50% of the data range and vertical lines cover observed values of up to 1.5 times the central data range. Individual values beyond that point are represented by dots.

Performance

The distribution of the performance ratings is illustrated in figure 2. The magnetic mouse received significantly better mean ratings on all performance items of the questionnaire, i.e. speed (6.4 vs. 2.5, p<.001), accuracy (6.3 vs. 4.2, p<.001) and smoothness of movements (5.8 vs. 3.4, p<.001).

Difficulty

The data of the difficulty ratings are depicted in figure 3. For a more intuitive comprehension of the plot, values were reflected to have higher levels of force and effort indicated by higher values. Mouse users reported significantly more comfortable levels of force required in the use of their input device (5.8 vs. 3.4, p=.003). The average effort ratings did not differ significantly (p>.0051).

Table 1: Descriptive and inferential statistics of mean ratings of trackball and magnetic mouse.

	Magnetic Mouse		**Trackball**			**t-test**	
Item	M	SD	M	SD	t	df	p
1. Force	5.8	1.3	3.4	1.5	3.58	15.9	.0025
2. Smoothness	5.8	0.9	3.4	1.1	5.08	16.0	.0001
3. Effort	6.0	1.8	3.2	1.9	3.20	15.6	.0057
4. Accuracy	6.3	0.7	4.2	1.2	4.44	14.7	.0005
5. Speed	6.4	0.7	2.5	1.7	6.43	12.8	>.0001
6. Satisfaction	6.5	0.8	2.3	1.4	8.05	14.2	>.0001
7. Overall usability	6.4	0.7	3.5	1.6	4.92	13.1	.0003
8. Fatigue of finger	6.5	0.9	2.9	1.3	6.89	15.9	>.0001
9. Fatigue of wrist	6.4	0.7	2.9	1.7	5.91	13.0	>.0001
10. Fatigue of arm	6.0	0.9	3.6	1.7	3.79	14.3	.0019
11. Fatigue of shoulder	6.0	1.2	3.8	1.9	2.96	15.2	.0096
12. Fatigue of neck	5.9	1.6	3.3	2.1	2.91	16.0	.0102

Notes. M: Mean rating on a scale from 1-7. SD: standard deviation. t: test-statisticof t-test. df: degrees of freedom, corrected for inequalities of variances. p: significance. The table contains questionnaire data in their original form, with higher values consistently indicating more positive evaluations (e.g. less fatigue, more accuracy).

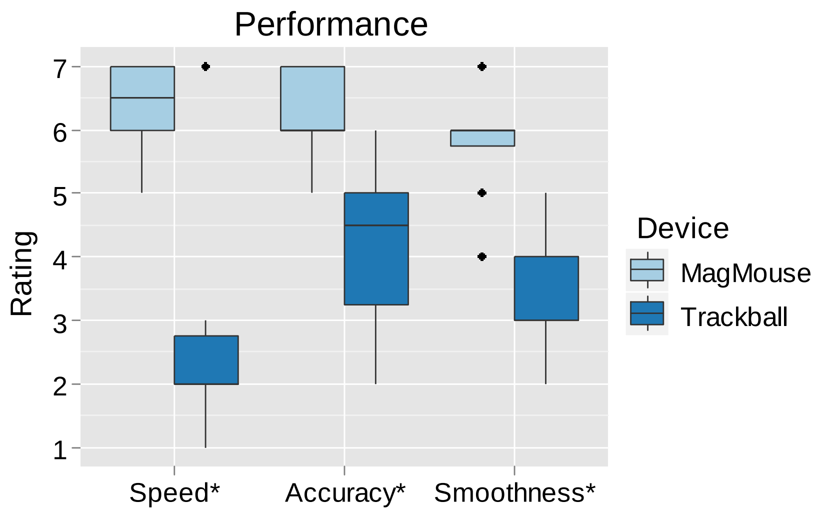

Figure 2. Boxplot of performance ratings of mouse users and trackball users. Significant differences (p<.0051) are marked with an asterisk. Higher values denote better performance

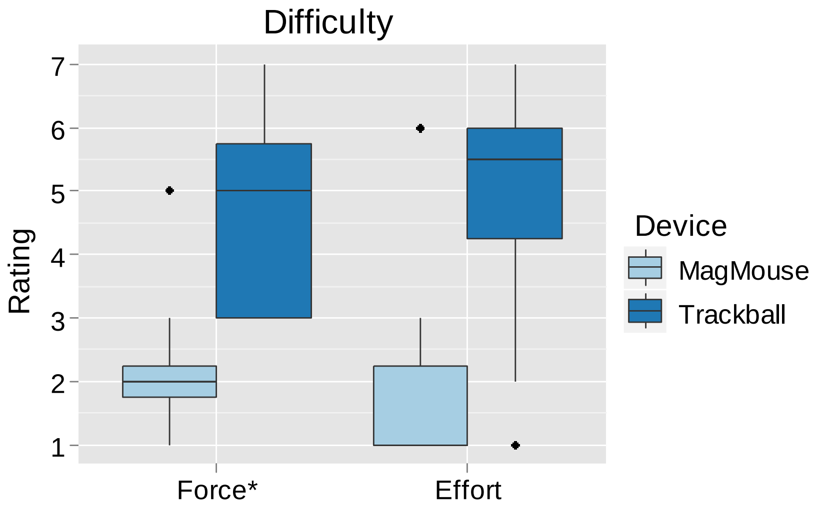

Figure 3. Boxplot of difficulty ratings of mouse users and trackball users. Data were mirrored for graphical depiction, higher values indicate higher levels of force and effort. Significant differences (p<.0051) are marked with an asterisk.

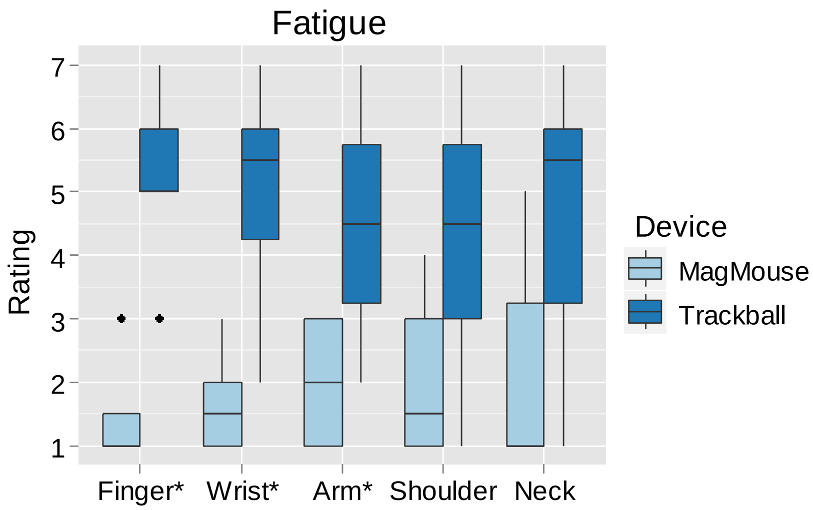

Figure 4. Boxplot of fatigue ratings of mouse users and trackball users. Data were mirrored for graphical depiction, higher values indicate higher levels of fatigue. Significant differences (p<.0051) are marked with an asterisk.

Fatigue

An overview over the reflected fatigue ratings of mouse and trackball users can be found in figure 4. Significantly less fatigue, as indicated by better and thus higher ratings in the questionnaire, were found for fingers (6.5 vs. 2.9, p<.001), wrist (6.4 vs. 2.9, p<.001) and arm (6.0 vs. 3.6, p=.002) of mouse users. No significant difference was found for experienced fatigue in shoulder and neck (p>.0051).

Conclusion

This paper presented a field study on the consequences of cursor control with trackballs and magnetic mice. Compared to laboratory investigations of this topic, we could exercise rather little experimental control.

Although the tasks accomplished with magnetic mice and the trackballs were reported to be similarly demanding, they were not identical. And we could reasonably assume, but not assure that the participants of the mouse group and the trackball group had the same level of proficiency in computer operation. Thus, the internal validity of our study is lower than that of laboratory investigations.

However, our study was conducted to add results with a higher external validity to the literature on mouse use and trackball use. To this end, the investigation was carried out on a moving ship, with the actual tasks of operators, over an extended period of 26 days with 4-6 hours of consecutive computer operation each day. Under these circumstances, the previously reported performance advantages of mice over trackballs (Grandt et al., 2003; Isokoski et al., 2007; Lin et al., 2010) were replicated with mice that were magnetically secured against involuntary movements. Despite the necessity to overcome the magnetic adhesion of the mice when starting to move them, the data show that use of a magnetic mouse still leads to less muscular strain of the operators than the use of a trackball.

Interestingly, the differences in experienced muscular strain found in our study did not occur in the study of Karlqvist et al. (1999), which is most probably owed to the much shorter task duration of only 15 minutes in that study. Another noteworthy pattern of results is that the strain difference between mouse and trackball becomes the smaller the more distal the rated body part is from the input device. Based on informal observations, we assume that the higher strain of fingers and wrist is caused by the fact that these parts of the body have to move more often and to cover longer distances to produce the same cursor movement on the screen with a trackball as compared to a mouse.

To sum up, it can be concluded that the use of magnetic mice instead of trackballs is beneficial for operators' performance, for their health and thus for their long-term work capability. Designers of computer workstations for moving platforms should consider magnetic mice as the standard input device for cursor control and should be aware that the advantage of trackballs in modest space requirement trades off with disadvantages in operator strain and performance.

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