Effect of Cursor Orientation on Left- and Right-Hand Mouse Control

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Many factors, such as cursor orientation, cursor shape, and direction of movement have previously been found to impact human performance in graphical user interfaces. However, the majority of, if not all, previous research has focused on right-hand mouse control of cursors. The current study examined both left and right hand mouse control of cursor with a 2 (response hand; left vs. right) x 3 (cursor type; left-oriented arrow, right-oriented arrow, and neutral-orientated cross-hairs) x 8 (target location) within-subjects design. The purpose was to examine the effects of response hand and cursor orientation on performance of moving cursors into different target locations. Results showed that there was a difference in the three cursor types for right handed individuals, as well as in left- and right-hand mouse control for right-handed, left-handed, and ambidextrous individuals. Implications for interface design and future research are discussed.

INTRODUCTION

Most graphical user interfaces (GUIs) utilize arrow cursors oriented to the upper left mainly out of popularity and familiarity (see Po, Fisher, & Booth, 2005). Many people might not think twice about or even notice the cursor they move across their computer screen on a regular basis, however, small differences in the appearance (e.g., orientation) of cursors we use could play a role in our performance (Finch, Phillips, & Meehan, 2008; Morgan & Glennerster, 1991; Phillips, Meehan, & Triggs, 2003; Po, et al., 2005).

Related Work on Cursor Orientation

Human performance has been found to improve under certain circumstances but appears dependent on cursor orientation, size of targets, and input devices (Finch, et al., 2008; Phillips, et al., 2003; Phillips, Triggs, & Meehan, 2001; Po, et al., 2005). Specifically, current research found cursor orientation to impact performance limited to targets between 4 and 8mm (Finch, et al., 2008; Phillips, et al., 2003). Other researchers examined human performance across a variety of input devices including the mouse, pointer, and pen, and discovered that cursor orientation had more effect on performance during pointer use than pen or mouse use (Po, et al., 2005). Additionally, this research found orientation neutral cursors to bolster performance over directionally oriented cursors across GUIs (Po, et al., 2005).

To briefly explain why cursor orientation or cursor shape may affect human performance, one must first understand the principle of stimulus-response (S-R) compatibility: Responses are faster and more accurate when the location or direction of the responses are congruent with that of the stimuli (Fitts & Seeger, 1953; Proctor & Vu, 2006; Worringham & Beringer, 1989). In the context of cursor-mouse control, the cursor is the stimulus, and the mouse is the response device. When the orientation of the cursor is consistent with the movement direction of the mouse, performance is predicted to be better than when it is inconsistent.

Left-Hand Use of the Mouse

The majority, if not all, previous research on this topic has focused on right-hand use of cursors with right-handed individuals. Little research has explored how cursor orientation impacts left hand performance, which leaves a gap to be bridged. With computers and GUIs becoming an indispensable part of most individuals' everyday lives, at work and at home, controlling a mouse with one's left hand is not uncommon. For example, a right-handed user who has used her or his right hand moving the mouse for several hours at work may want to switch to the left hand due to fatigue in the right hand. Let alone a left-handed user may prefer to use her or his dominant hand to control the mouse if the interface is designed suitably for this purpose. Note that approximately 10% of the world's population is left-handed (Hardyck & Petrinovich, 1977).

Designers have certainly considered this possibility of controlling the mouse with the left hand. As an example, there is an option in mouse settings to switch the "primary" between the left and right buttons on the mouse to accommodate left-hand uses on Windows systems. However, there is no similar option that can be set easily for adapting the cursor for left-hand uses. This design apparently either assumed that user performance and experience is not influenced by cursor appearance or it ignored the possibility of left-hand mouse control.

Current Study

The current study aimed to determine how cursor orientation impacts right- and left-hand performance.

Left and right hands are different not only in terms of dominant versus non-dominant hands, but also in that the grasping directions are opposite. The upper-left arrow cursor may be intuitive for right-hand use (see Po et al., 2005), given that it is inline with the grasping orientation of the right hand, but this orientation may not fit the left-hand use. In addition, the right hand is typically located on the right side of the screen yet the left hand is often on the left side. Research has shown that the side on which a response is made may also influence human performance (e.g., Conde et al., 2011; Seibold, Chen, & Proctor, 2015).

Thus, in the current study, we examined participants' performance in using different types of cursors (left arrow, crosshairs, and right arrow; see Figure 1) with both left- and right-hand responses. To the best of our knowledge, the present study is the first to look at the cursor effect on left-hand mouse control. Moreover, unlike previous studies (e.g., Po et al., 2005), the left- and right-oriented arrows in the current study are designed to be more similar to actual arrow cursors used in current computer operating systems. In addition, the different cursor types were tested in different blocks rather than mixed within blocks, due to the reason that real-world users seldom use various cursors alternatively on a frequent basis.

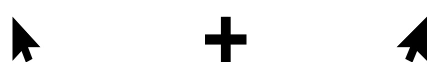

Figure 1. Cursor types used in the current study (left to right): left arrow, crosshairs, and right arrow.

METHOD

Participants. Sixty-one undergraduate students at New Mexico State University were recruited through an online system, and participated in the current study to fulfill part of their course requirements in a psychology class.

Materials and procedure. Participants read and signed an informed consent statement. Then, they were instructed to sit approximately 60 cm from a computer monitor in a quiet cubical room. Each participant performed a task of moving a cursor into a target circle on the screen with a mouse, using their left and right hands in two sessions, respectively. An experimenter was present in the room at all times to make sure that the participant used the assigned hand. There was a three-minute break between the sessions, and the order of the sessions was counterbalanced among participants.

Within each of the two sessions, there were three blocks, each including one of three types of cursors (left arrow, crosshairs, and right arrow). There were eight possible locations of the target circle (see Figure 2), which were equally distant from the center of the screen. The order of the cursor-type blocks was randomized for each participant, and the target location was also randomized for each trial. The cursors were 5 mm × 7 mm in size, and the target circle was 1 cm × 1 cm in size.

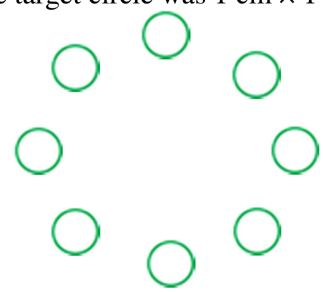

Figure 2. Target locations (starting at 12 O'clock going clockwise): 1, 2, 3, 4, 5, 6, 7, 8. On each trial, only one target circle appeared on the screen.

During each trial, a cursor and target circle appeared on the screen at the same time, with the cursor located in the center of the screen and the target randomly appearing in one of the eight possible target locations. Participants were instructed to move the cursor into the target circle as quickly and accurately as possible. After the cursor was moved inside the target circle, both stimuli disappeared, followed by a blank screen lasting for 1 second. Then the next trial began.

All factors were within-subjects, and thus, this was a 2 (response hand; left vs. right) × 3 (cursor type; left arrow, crosshairs, vs. right arrow) × 8 (target location) within-subjects design. There were 5 repetitions for each combination of the factors. The dependent variables were reaction time (RT; the time from the cursor and target circle onset time to when the participant first moved the mouse), total time (TT; stimuli onset time to the time when the cursor was first moved inside the target circle), and movement time (MT; total time minus reaction time). In each block, participants were presented with eight practice trials and 40 real trials for a composite of 240 total trials.

At the end of the experiment, participants reported their demographic information, along with completing the Edinburgh handedness inventory (Oldfield, 1971). In total, the study took approximately 25 minutes.

RESULTS

Of the total 61 participants (45 female), ages ranged from 18-48 years of age with a mean age of 21.39 (*SD* = 5.79). Additionally, the majority of the sample was Hispanic/Latino (64%) or Caucasian (20%).The Edinburgh handedness inventory (Oldfield, 1971) identified 30 participants as right handed, 16 as ambidextrous, and 15 as left handed. For the right-handed, their scores ranged from 41 to 100, with a mean score of 87.16 (SD = 14.54); for the ambidextrous, the scores were from -40 to 40, with a mean score of -12.55 (SD = 28.42); for the left-handed, the scores ranged from -100 to -39, with a mean score of -76.97 (SD = 17.72). Trials that were more than ±2.5 standard deviations away from each participant's individual mean reaction times, movement times, and total times respectively were removed from subsequent analyses. Separate repeated-measure analyses of variance (ANOVAs) on reaction time, movement time, and total time were conducted, with response hand, cursor type, and target location as within-subjects factors, for right, ambidextrous, and left handed individuals separately. All results are reported in milliseconds.

Reaction Time

RT is an index of the time required to plan the movement (Phillips, et al., 2003). To test if RT differed based on response hand, cursor type, or target location, a 2 (response hand; left vs. right) × 3 (cursor type; left arrow, crosshairs, vs. right arrow) × 8 (target location) ANOVA was conducted. Table 1 shows all *F*, *p*, and η_p^2 values for this analysis, and Table 2 shows the mean values. The main finding was that for all participants, including the left-handed, ambidextrous, and right-handed, right-hand responses were faster than left-hand responses. In addition, on average, responses were fastest for target position 2 and slowest for target position 5.

*Table 1***.** Reaction time ANOVA results for right-, left-, and ambidextrous handed individuals. Bolded numbers indicate statistical significance at the .05 level. Cursor = Cursor Type, Resp.Hand = Response hand, and T.Location = Target Location.

Reaction Time	Right Handed			Ambidextrous			Left Handed		
	F	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
Cursor	1.56	.219	.05	.16	.852	.01	.70	.508	.05
Resp.Hand	21.35	**< .001**	.42	14.21	**.002**	.50	10.90	**.006**	.46
T.Location	5.80	**< .001**	.17	8.33	**< .001**	.37	5.24	**< .001**	.29
Cursor x Resp.Hand	.78	.463	.03	.16	.221	.10	.16	.851	.01
Cursor x T.Location	1.29	.211	.04	2.04	.069	.13	.24	.998	.02
Resp.Hand x T.Location	.53	.814	.02	1.68	.170	.11	1.97	.068	.13
Cursor x Resp.Hand x T.Location	.60	.863	.02	1.76	.118	.11	.89	.575	.06

Table 2. Reaction times (ms) for right-handed, ambidextrous, and left-handed individuals as a function of target location and response hand.

Target Location	Reaction Time					
	Right Handed		***Ambidextrous***		***Left Handed***	
	Right Hand	*Left Hand*	*Right Hand*	*Left Hand*	*Right Hand*	*Left Hand*
1	317	368	300	361	282	348
2	301	355	287	345	281	341
3	314	352	313	332	289	326
4	321	363	336	363	298	339
5	336	377	341	383	322	361
6	311	355	305	364	303	342
7	309	355	313	355	276	335
8	308	351	295	348	284	333
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Movement Time

Movement time is the time that the participant used to move the cursor into the target, after planning to do so. To test if MT differed based on response hand, cursor type, or target location, we conducted a similar repeated measures ANOVA as for RT. Please refer to Table 3 for all *F*, *p*, and η_p^2 values for movement time. The result patterns are described below for right-handed, ambidextrous, and left-handed participants separately.

*Table 3***.** Movement time ANOVA results for right-, left-, and ambidextrous handed individuals. Bolded numbers indicate statistical significance at the .05 level. Cursor = Cursor Type, Resp.Hand = Response hand, and T.Location = Target Location.

Movement Time	Right Handed			Ambidextrous			Left Handed		
	F	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
Cursor	3.42	**.040**	.11	.62	.546	.04	2.34	.143	.15
Resp.Hand	168.21	**< .001**	.85	17.55	**< .001**	.56	10.76	**.006**	.45
T.Location	1.57	.146	.05	1.39	.251	.09	2.36	**.029**	.15
Cursor x Resp.Hand	.67	.507	.02	.12	.885	.01	1.11	.346	.08
Cursor x T.Location	.44	.963	.02	.81	.572	.06	.93	.528	.07
Resp.Hand x T.Location	2.34	**.025**	.08	2.85	**.009**	.17	1.54	.163	.11
Cursor x Resp.Hand x T.Location	.83	.642	.03	1.48	.192	.10	1.17	.306	.08

Right-Handed Participants. MTs during right-hand trials (M = 704.25, SD = 21.91) were significantly faster than MTs during left-hand trials (M = 1109.34, SD = 38.92). In addition, MTs were significantly faster for orientation neutral cursors (M = 890.87, SD = 26.13) than for left-oriented cursors (M = 927.47, SD = 33.29), p = .048, and numerically faster than for right-orientated cursors (M = 902.06, SD = 25.98), p = .972. The main effect of target location, and the planned pairwise comparison displaying the interaction between target location and response hand is displayed Table 4.

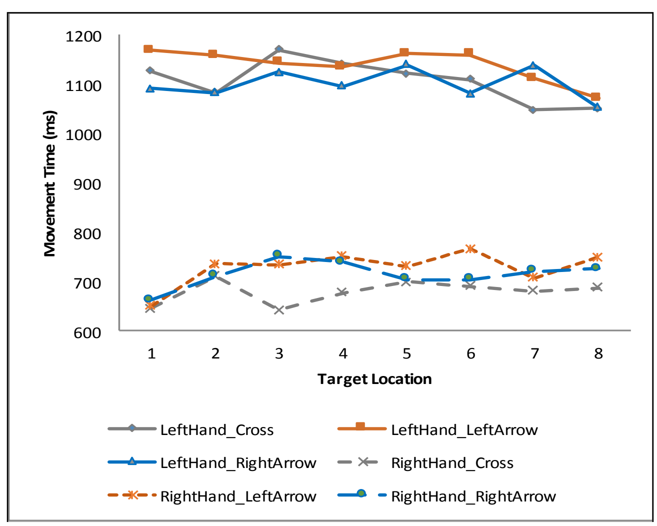

Figure 3. Movement time for right-handed particiapnts as a founction of target location, curosr type, and response hand.

Although no three-way interaction between cursor type, response hand, and target location, emerged, it is interesting to see that when using left hand, the right arrow (blue solid line in Figure 3) outperformed the left arrow (orange solid line) in almost all target locations, and the difference reduced for the right-hand trials (blue dashed line vs. orange dashed line).

Ambidextrous Participants. MTs during right-hand trials (M = 754.16, SD = 21.91) were significantly faster than MTs during left-hand trials (M = 1020.03, SD = 38.92). The main effect of target location, and the planned pairwise comparison displaying the interaction between target location and response hand is displayed Table 4.

Left-Handed Participants. Similar to the right-handed and ambidextrous participants, MTs during right-hand trials (M = 749.05, SD = 53.69) were significantly faster than MTs during left-hand trials (M = 903.58, SD = 66.23). The main effect of target location is displayed Table 4.

Table 4. Movement times (ms) for right-handed, ambidextrous, and left-handed individuals as a function of target location and response hand.

Target Location	Movement Time					
	Right Handed		***Ambidextrous***		***Left Handed***	
	Right Hand	*Left Hand*	*Right Hand*	*Left Hand*	*Right Hand*	*Left Hand*
1	653	1116	804	974	709	838
2	714	1114	794	1012	756	851
3	705	1141	713	1081	699	946
4	720	1118	779	1075	782	913
5	706	1131	733	988	757	891
6	718	1109	748	1007	758	933
7	699	1099	721	1020	761	898
8	719	1048	741	1002	771	958
Mean	704	1109	754	1020	749	904

Total Time

Total time is the time that was taken to complete the whole task on each trial. To test if TT differed based on response hand, cursor type, or target location, we conducted a similar repeated measures ANOVA as for the previous two measures. Table 4 shows all F, p, and η_p^2 values for TT. For all participants, the TTs were faster for right-hand responses than left-hand responses. In addition, for right-handed participants, there was an interaction between response hand and target location, which was mainly due to the difference between the two response hands being greater in Position 1 and smaller in Position 8 than in other target positions.

Table 5. Total time ANOVA results for right-, left-, and ambidextrous handed individuals. Bolded numbers indicate statistical significance at the .05 level. Cursor = Cursor Type, Resp.Hand = Response hand, and T.Location = Target Location.

Total Time	**Right Handed**			**Ambidextrous**			**Left Handed**		
	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2
Cursor	1.57	.218	.05	.46	.634	.03	2.52	.129	.16
Resp.Hand	155.41	**< .001**	.84	21.44	**< .001**	.61	13.28	**.003**	.51
T.Location	2.39	**.023**	.08	1.75	.158	.11	2.43	**.025**	.16
Cursor x Resp.Hand	.55	.581	.02	.63	.540	.04	.85	.439	.06
Cursor x T.Location	.52	.925	.02	.95	.465	.06	.99	.466	.07
Resp.Hand x T.Location	2.58	**.014**	.08	1.80	.095	.11	1.17	.326	.08
Cursor x Resp.Hand x T.Location	.74	.732	.03	1.22	.265	.08	1.22	.264	.09

Table 6. Movement times (ms) for right-handed, ambidextrous, and left-handed individuals as a function of target location and response hand.

Target Location	Total Time					
	Right Handed		***Ambidextrous***		***Left Handed***	
	Right Hand	*Left Hand*	*Right Hand*	*Left Hand*	*Right Hand*	*Left Hand*
1	970	1484	1105	1335	991	1187
2	1015	1469	1081	1357	1037	1193
3	1019	1493	1026	1414	988	1272
4	1042	1481	1114	1438	1080	1251
5	1042	1508	1074	1372	1079	1252
6	1029	1464	1054	1372	1061	1274
7	1008	1455	1034	1374	1037	1233
8	1027	1399	1036	1350	1055	1292
Mean	1019	1469	1065	1376	1041	1244

DISCUSSION

In the present study, left-handed, right handed, and ambidextrous participants used both their left and right hands to move three types of cursors to eight target locations on the screen while reaction, movement, and total times were measured. The results of this study indicate that the left-hand and right-hand mouse control did make a difference. First, for right-handed and ambidextrous individuals, the movement time for left and right hands differed among target locations. Second, the left-oriented arrow cursor tends to be better for right-hand mouse control and the right-oriented arrow cursor tends to be better for left-hand mouse control, at least for right-handed users. These results imply that when designing the cursor/mouse, it will be beneficial to take into consideration the hand users may use and to allow for setting options to change both the mouse and the cursor.

Another major finding in the current experiment is that cursor type affects only movement times and only appears to affects right-handed participants. Specifically, for the right-handed participants, the orientation-neutral cursor offered faster movement times than the right-oriented cursor, which is faster than the commonly used left-oriented cursors. This result was in line with previous findings by Po et al. (2005), and indicates that orientation neutral cursors do affect human performance positively and should be taken into consideration when designing or selecting interface settings for GUIs.

Note that the arrow cursors used in the current study strived to emulate the actual interface as closely as possible. By utilizing an arrow that is similar, in terms of the angle and orientation, to the ones used on current Windows and Macintosh operating systems, one side of the arrow was vertical and the other was tilted. However, previous studies (e.g., Finch et al., 2008; Po et al., 2005) used arrows that have both sides titled with 45-degree angles. It is possible that this difference in orientations led to no significant results in reaction time and total time in the current study. If this is the case, then researchers should be cautious when claiming the effect of arrow orientations, because the results might speak only for the cursor types they used but not for the actual interface. Future research is needed to compare these different arrows systematically in one study to determine whether the angle of the arrows is a critical factor.

A common belief that dominant hand reaction, movement, and total times would be faster than non-dominant hand was not supported for left-handed or ambidextrous users. Their right-hand performance was faster than their left-hand performance, in terms of reaction, movement, and total times, although these hand differences were smaller than the difference for the right-handed participants. It is worth noting that several left-handed and ambidextrous participants reported using their right hand exclusively for the mouse because of the right-hand dominated world they have to constantly adapt to. This directly displays why more research is needed on mouse and cursor design for both left and right hands.

It is important to consider potential limitations that this study may suffer from. First, the sample sizes of the left-handed and ambidextrous participants were not as large as that of the right-handed participants, due to the lack of participants in the former two groups. Thus, the current results of the left-handed and ambidextrous participants should be taken with caution. Another limitation is that the use of only one larger target size (1 cm) rather than several target sizes. This might have impacted results since previous research found significant effects for cursor type with only specific sized targets. Specifically, Finch and colleagues (2008) found an effect of cursor orientation on movement time to be significantly longer in trials with small (4mm) targets but not in trials with large (8mm) targets. However, Phillips and colleagues (2003) found significant effects for medium sized (8mm) targets only.

Given the limitations, replications are needed, along with more data on left-hand and ambidextrous use of the mouse to determine the overall effect of cursor type on human performance. Potential future directions could also move towards conducting studies which utilize more real life stimuli such as actual web pages or tasks individuals carry out on computers rather than the generic circle or square target stimuli used in the current study.

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