The directional effects on cursor dragging kinematics

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Summary

There has been no study to substantiate the kinematical characteristics of cursor dragging movement. In this present study, we developed a computerized measuring program and used the quantitative experimental research method to explore the effect of moving direction on the kinematics of cursor dragging in 24 normal participants. The results of multiple one way repeated measures ANOVAs and post hoc LSD tests demonstrated that the dragging direction had effects on movement time and movement unit. Dragging leftward showed better efficiency than dragging upward and downward. These directional effects partially clarify how the dragging performances were influenced by the moving direction. Moreover, it can guide us to re-arrange the toolbars and icons under window interfaces, especially for individuals with physical disabilities, whose performances can be easily interrupted while controlling the cursor in specific directions.

Key words:

Cursor movement, kinematics, trajectory, motor control, directional laterality

1. Introduction

The kinematic characteristics of upper extremity motion have long been researched. The variables (parameters) of kinematics that have been selected as dependent variables include reaction time (RT), movement time (MT), total path, average velocity, movement unit (MU), peak velocity (PV), time to peak velocity (TPV), time after peak velocity (TAPV), the percentage of movement time where peak velocity occurred (TPV/MT), indicator of energy (PV/AV) and acceleration [1-4]. Although many studies have addressed the kinematics of human motor system, few studies have analyzed cursor movement from the concept of kinematics. The issue of cursor kinematics should be treated seriously since using the computer is very popular and kinematical information is important for guiding the computer access intervention [1-4].

Hwang et al. [1] found that disabled persons have to stop the mouse and initiate it many times while conducting cursor moving action. Their sub-movements were therefore much more than those performed by the controls. This phenomenon was related to their poor motor efficiency. However, to compare the number of sub-movements to address the characteristics of typical cursor moving or dragging in the typical participants is not appropriate in the study. The reason is that, for most typical persons, only one sub-movement is demonstrated. Besides, Hwang et al. did not substantiate the directional effect, which is not compatible with the major focus of this present study.

Phillips and Triggs (2001) substantiated the directional effects on kinematical characteristics of cursor moving [2]. They found moving rightward was slower than moving toward the other directions. According to their finding, the performance of cursor moving was affected by the moving direction. However, Phillips and Triggs did not study cursor dragging action, which is much more difficult than cursor moving action. In fact, there is no research paper to provide information about cursor dragging kinematics at this moment.

From the view of task analysis, mouse operating consists of three kinds of essential tasks: click, move and click, and dragging. Dragging is the most complex, as it combines moving and maintained clicking simultaneously. It requires the user to press the left-button down during the movement and release the button in the target area [5]. The kinematical characteristics of cursor dragging may be different from cursor moving. However, it has not been explored before. Therefore, at this moment, the on-line dynamic characteristics of kinematics during dragging cursor movement on the 2-dimension plane are still unclear, even for normal people. This present study is the first research to explore cursor dragging movement on the 2-dimensional plane.

In this present study, the variables of kinematics include the initiation time (reaction time), movement time, total path of trajectory, velocity, and movement unit [1-4, 6]. Initiation time is defined as the latency between the

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display of the start signal and the beginning of the pink square movement [2, 3, 4] (Fig. 1). Movement time is defined as the time from the beginning of the pink square movement to the end point while executing a dragging action [1, 2, 3, 4] (Fig. 1). Total path is defined as the total length of the trajectory of the pink square dragged by subjects [1-4] (Fig. 2). A movement unit is defined as one acceleration and deceleration phase. More movement units represent worse control performance [1].

2. Method

2.1 Participants

Forty eight right handed college students (12 males and 12 females) aging 19 to 25 (mean= 20.13, SD=1.26) without any neuromuscular or cerebral disease voluntarily participated in the present study. The averaged handedness quotient of self reported Edinburgh handedness inventory was 93.96 (±5.71). All the 24 participants used their right hand to conduct the experiment of this study.

2.2 Apparatus and Measuring Program

The dragging task was performed upon a 1.8GHz Pentium 4 laptop (ASUS, Taiwan) with 14” XGA screen. A computer measuring program was developed to detect the on-line kinematic characteristics during cursor movement. The measuring program recorded data every 100ms. In the initial process of data analysis, the trajectory of cursor moving and the log file can be exhibited on the screen (Fig 1). The log file contained the information of cursor position and time of each 100ms. After that, this log file were outputted and the data were automatically transformed into more kinematic variables in the Excel File (Fig 2). Some values of variables were further managed by our calculations. Finally, we merged all data in a SPSS.sav file and conducted the statistics.

Participants used a 4D optical mouse (E.Sense, Taiwan) with standard settings, to drag a cursor from four different home positions to their opposite ways. The home positions were 2.5 cm from the bottom, 0.8 cm from the top, 3.8 cm from the left and 6.5 cm from the right of the screen respectively. There was a tracing line from the home position to the end point. Participants dragged a square with 5 and 5 pixels to the end point of the tracing line. The endpoints were situated 18.3 cm away from the home positions.

2.3 Experimental Design and Procedure

Each participant conducted two blocks of dragging task (four directions in each block). The order of 4 directions was pseudo-randomized and counterbalanced in each block across 24 participants. Therefore, the experiment included 24 different sequences (4! = 4×3×2×1) and each was conducted by one participant (24×1=24). The target area and the distance were same in all directions and therefore the two important factors that might confound the results were controlled well.

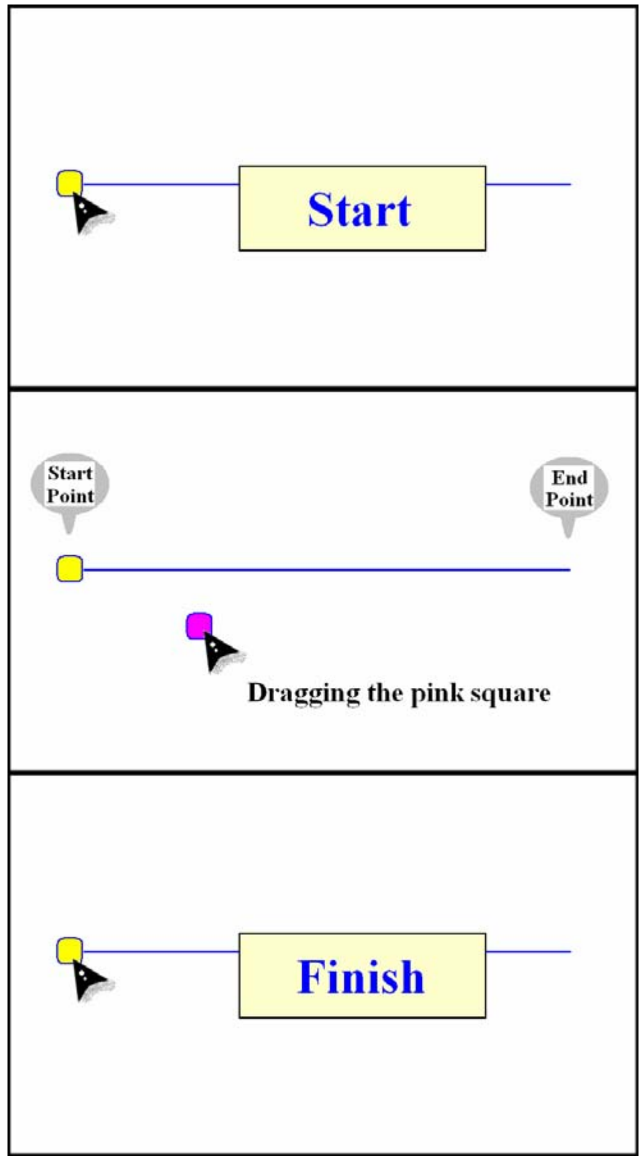

Fig. 1. The procedure of the dragging task. Subjects were required to press the left button of the mouse and drag the pink square from the left to the right until reach the end point of the straight line.

2.4 Statistics

The values of each variable in each direction of two blocks were averaged in each participant. The multiple one-way repeated measures ANOVAs were used to survey the effect of dragging direction on different kinematic variables. The multiple post hoc LSD tests were conducted to compare the difference between two directions if the ANOVAs reach a statistical significance.

3. Results

3.1 The one-way repeated measures ANOVAs

The one-way repeated measures ANOVAs demonstrated that there were no significant differences across four directions in initiation time (F(2.140, 49.220)=0.547, *p*=.594), total path (F(1.292, 29.721) =0.686, *p*=.450), and average velocity (F(1.041, 23.943) = 2.622, *p* = .118). However, the significant differences existed across four directions in movement time (F(3, 69) =8.861, *p*=.000) and movement unit (F(3, 69) =3.053, *p*=.034).

3.2 The post hoc LSD tests

The mean value of each variable in each direction on the variables of movement unit and movement time was listed on the Table 1. Post hoc LSD tests (Table 2) showed that dragging leftward needed much less movement time than dragging toward other three directions. Dragging leftward also needed much less movement unit than dragging upward and downward. However, there was no significant difference in any other paired comparisons (upward vs. leftward, leftward vs. rightward, upward vs. rightward).

3.3 The interaction between velocity and time series

The interaction between grand veraged velocity (pixel/ms) of Y-axis and time of X-axis (100ms) of 24 participants in each dragging direction is showed in Fig 3. The bell-distribution with peak velocity located toward left is obvious in each direction.

4. Discussion

The results demonstrated that movement time and movement unit were affected by dragging direction. Dragging leftward showed better efficiency than dragging upward and downward. The findings imply the discrepancy might exist between dragging toward different directions [2]. This effect has also been found by Phillips and Triggs [2].

However, our findings are different from the cursor moving study conducted by Phillips and Triggs. Phillips and Triggs found that moving rightward was slower than moving toward the other three directions. For dragging the cursor, we have to use our index to press the left button down first, and then maintain the pressing position and move the mouse simultaneously. It loads more task demands than just moving the mouse without pressing the button [5]. Therefore, we infer that the mechanism difference between the two actions is the one reason that resulted in the different findings in kinematics.

Recently, we also conducted a single subject experimental research to address the directional effects on cursor dragging kinematics [6]. In that study, four participants were recruited, and the alternating treatments design was used. From analyzing the parameters of deviation from the straight guiding line, velocity, movement unit and execution time, the efficiency to move on the horizontal direction (left to right or right to left) was better than the vertical direction (up to down or down to up). The findings were partially similar to the ones in this present study. However, the typical participants in the aforementioned single subject research used their dorsal hand to control the trackball mouse. This is the way to simulate individuals with spinal cord injury.

In this present study, dragging upward and downward were the most inefficient. It is possible that dragging upward and downward are not compatible with our body from the view of the human factor and body mechanism [7]. Aside from the normal participants in our study, we did, in fact, find patients with physical disabilities that had the tendency to perform worse in specific directions while controlling cursor movement [6]. Therefore, to find the better computer access approach is important to help this population to access computers without interruption by the effect of direction [7-12].

Although some menu bars or toolbars are also located on the top or bottom of the monitor, we usually “move” and seldom “drag” the cursor to those targets. Therefore, the weaker performance of dragging downward and upward might relate to fewer experiences of people.

The interaction between the grand veraged velocity (pixel/ms) of the Y-axis and the time of the X-axis (100ms) of the 24 participants in each dragging direction is shown in Fig 3. The bell-distribution with a peak velocity located toward the left is obvious in each direction. This characteristic on the 2-dimensional plane is different from that of the human motion system in a 3–dimensional space. However, in this present study, similar to the human motion studies, the peak velocity that occurred earlier during the dragging means people need more time to decelerate for the purpose of reaching the target smoothly

Table 1. The mean values of kinematic variables of each direction and the results of ANOVAs

	Downward	Upward	Rightward	Leftward	*F* value	*p*
Reaction Time	622.917	631.250	614.583	695.833	F(2.140, 49.220) =0.547	.594
Movement Time	4272.917	3895.833	3797.917	3195.833	F(3, 69) =8.861	.000
Total Path	716.581	683.350	707.365	776.040	F(1.292, 29.721) =0.686	.450
Movement Unit	10.333	9.792	9.438	8.625	F(3, 69) =3.053	.034
Average Velocity	0.185	0.201	0.214	0.316	F(1.041, 23.943) = 2.622	.118

Table 2. LSD post-hoc tests

	Movement Unit		Movement Time	
	Main Difference	*p*	*Main Difference*	*p*
Downward vs. Upward	0.542	.326	377.083	.079
Downward vs. Rightward	0.896	.242	475.000	.094
Downward vs. Leftward	1.708**	.004	1077.083***	.000
Upward vs. Rightward	0.354	.528	97.917	.651
Upward vs. Leftward	1.167*	.021	700.000**	.001
Rightward vs. Leftward	0.813	.181	602.083**	.007

*Note. * p<.05 **p<.01 ***p<.001*

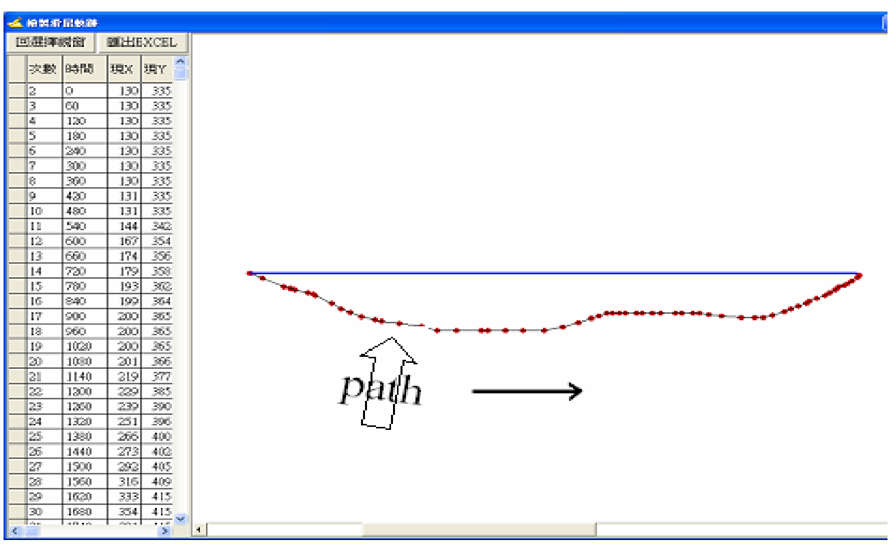

Fig.2 The track points of every 100 ms during the dragging task. The output data presented aside were the log file of the recording data that could be exported to Excel for the further transformation and analysis.

and successfully.

This present study is the first research to address the directional effect by using kinematics during dragging action. In the future, we can use the data of this present study as the basis of comparison with other groups. For example, the performance of motion-impaired users can be delineated more clearly.

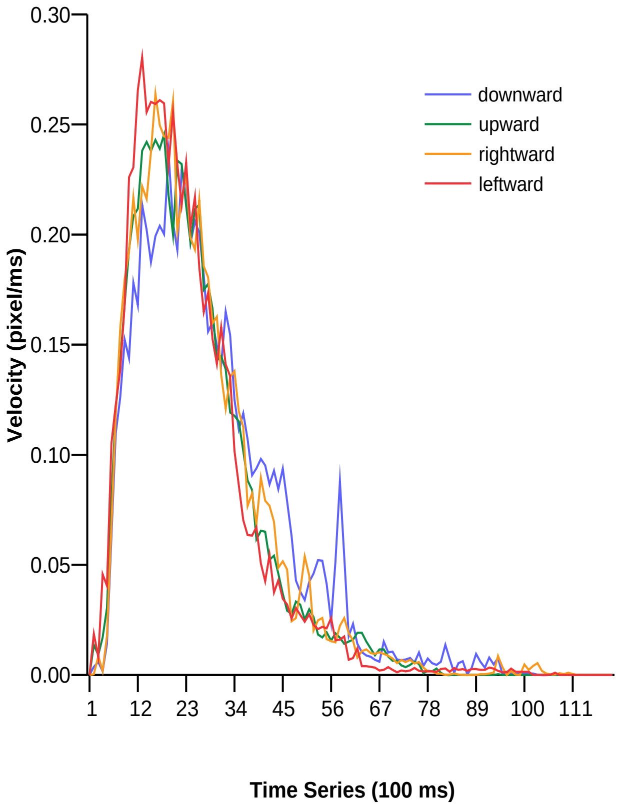

Fig. 3 The interaction between velocity (pixel/ms) of Y-axis and time of X-axis (100ms) in each dragging direction

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