

# Support Method for Improving the Ability of People with Cerebral Palsy to Efficiently Point a Mouse at Objects on a GUI Screen

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**Abstract.** Many people with cerebral palsy work in social welfare companies as data entry operators etc. Because of spastic reactions and involuntary motion, they find it difficult to use their upper limbs for movement and positioning tasks such as pointing a mouse at an object on a GUI screen. It would be of great benefit to secure the movement distance and the target size which are appropriate for people with cerebral palsy on a GUI screen, so they can perform pointing device operation effectively. However, it is not possible to increase the screen size beyond a certain limit. Therefore, ideal conditions may not be achieved. In such a situation, an effective environment for positioning tasks can be created by controlling the D/C gain, which is calculated by dividing the movement distance of the pointer by that of the input device. This study investigated the effect of changes in the D/C gain on motion time (MT) for pointing tasks and attempted to determine the D/C gain for minimizing the MT. It was found that the D/C gain for minimizing the MT could be obtained by using an appropriate combination of the target distance and target size. Further, the relation between the D/C gain and the positioning time is found to be linear or second-order curvilinear, depending on the target distance and target size.

**Keywords:** GUI, Mouse operation, D/C gain, User interface.

## 1 Introduction

People with cerebral palsy have spasticity or involuntary movements. Therefore, they often experience difficulties with regard to movement and positioning their upper limbs. When one uses a PC that runs on a CUI (Character User Interface) OS, keyboard operations are required for data entry and command inputs. When the distance between the keys is very short, movement time against unit movement distance tends to be longer. A GUI (Graphical User Interface) OS has been developed that lets the user run application software and choose a function on the menu by a positioning operation using a mouse. A positioning operation is defined as the operation in which one moves the pointer on the desktop, positions the pointer on a shortcut icon or a menu icon, and clicks the icon.

Many people with cerebral palsy work in social welfare companies performing data entry tasks and other operations. It would be of great benefit to secure a movement

distance and target size that are appropriate for them so that they can perform positioning operations effectively. This study investigated the effect of changes in the D/C gain on motion time (MT) during pointing tasks and attempted to determine the optimum D/C gain for minimizing the MT. Furthermore, the influence of the D/C gain on the MT is discussed in order to determine the best approach to minimize the MT.

## 2 D/C Gain

MacKenzie I.E. pointed out that an effective environment for positioning tasks can be created by controlling the D/C gain [1]. The D/C gain is calculated by dividing the movement distance of the pointer by that of the input device shown in Formula (1).

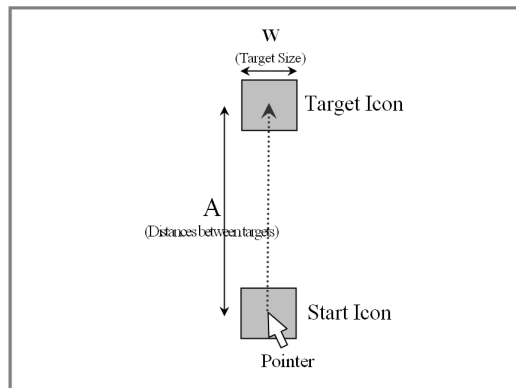
$$D/C \text{ gain} = \text{movement distance of the pointer} / \text{movement of the input device} \dots$$

While operating a pointing device, the distance between targets or the target size can be changed by adjusting the D/C gain. Selecting a target and clicking on it is made up of the pointer operation and positioning the pointer on the target icon. Furthermore, the pointer movement time and the positioning time on the target icon will change relative to the adjustment of the D/C gain.

## 3 Method

### 3.1 Experiment Task and Equipments

In this study, the pointer operation task was created by using Microsoft Visual Basic Version 5.0. Subjects were required to operate the mouse in order to move the pointer onto the target icon and click the left button (cf. Fig. 1). The experiment task was shown on a 15-inch TFT monitor with a pixel resolution of  $1024 \times 768$ . An optical mouse with two buttons was used as a pointing device.



**Fig. 1.** The diagrammatical view of the experiment task on the desktop

## 3.2 Participants

Five people with cerebral palsy participated in this experiment. They were classified to the second grade in obstacle class and were employed in a social welfare company in Tokyo. All the participants operated PCs as part of their jobs and input/edited printed matter. Consequently, it can be said that the subjects were familiar with PC operation.

Before starting the experiment, the purpose of this experiment was explained by the caseworker, and only people who approved participated. Furthermore, the participants performed a number of rehearsals to familiarize themselves with the experiment task before starting the experiment.

## 3.3 Experiment Conditions

The movement direction of the pointer was set by only one condition of the upper direction for the following reason: the MT was not affected by the directionality of the pointer movement in the past experiment [2]. Additionally, when we use application software such as word processors, menu icons are usually displayed in the upper part of the screen.

The conditions of the target distance ( $A$ ), the target size ( $W$ ), and the D/C gain are described below. One pixel is equivalent to 0.3 mm on the 15-inch TFT monitor.

- 1) Target distance: 30 mm, 90 mm, and 150 mm (3 conditions).
- 2) Target size: 6 mm, 9 mm, 12 mm, and 15 mm (4 conditions).
- 3) D/C gain: 1.3, 2.4, 3.9, 5.1, 7.5, 9.5, and 12.1 (7 conditions).

The subjects performed every experiment task three times in each condition.

## 3.4 Data Analysis

The MT was measured using the “GetTickCount” function with a precision of 10 ms. The  $x$  and  $y$  coordinates of the pointer were measured by determining the pixel unit every 10 ms. The coordinate origin was set in the top left corner of the screen.

The speed wave pattern of the pointer on the GUI screen was classified into the movement aspect and the positioning aspect, and the time taken for each movement was calculated.

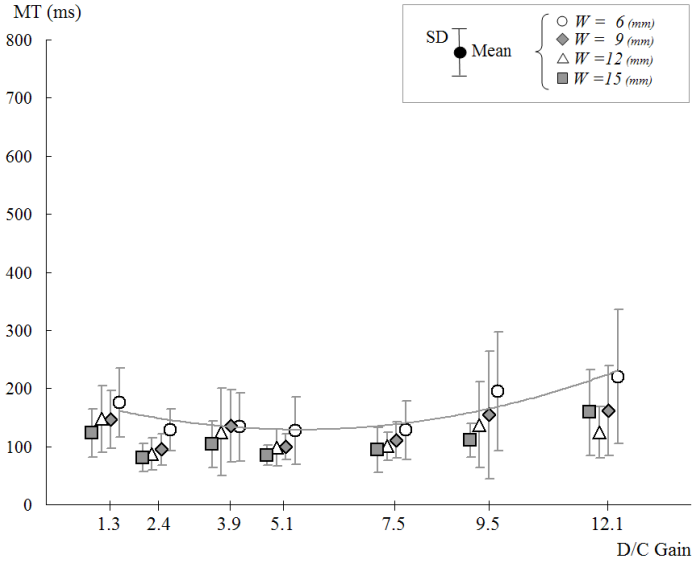
# 4 Results and Discussion

## 4.1 Relationship between the D/C Gain and the MT

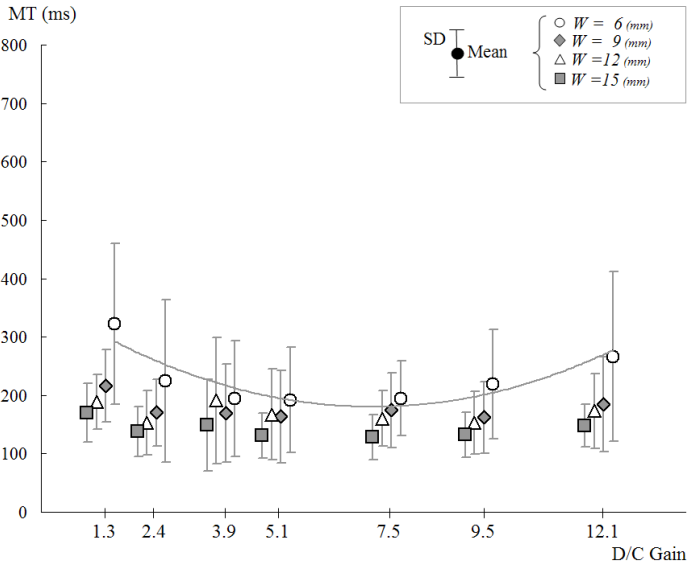
The relationship between the D/C gain and the MT of the cerebral palsy group under the three target distance conditions ( $A$ ) are shown in Figs. 2, 3, and 4. It can be seen that the MT tended to be longer when the D/C gain was low (D/C gain = 1.3) or high (D/C gain = 12.1). When the D/C gain was between the two abovementioned values, the MT was shorter.

The relationship between the D/C gain and the MT was a second-order curvilinear relationship under the following conditions (cf. Table 1):

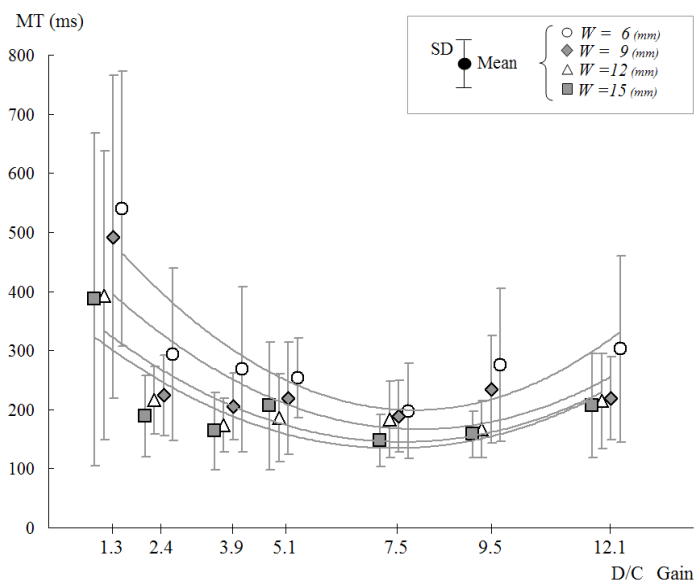
- 1)  $W = 6$  mm when  $A = 30$  mm or  $A = 90$  mm.
- 2) All  $W$  when  $A = 150$  mm.



**Fig. 2.** Relation between D/C gain and MT ( $A=30$ mm)



**Fig. 3.** Relation between D/C gain and MT ( $A=90$ mm)



**Fig. 4.** Relation between D/C gain and MT (A=150mm)

**Table 1.** The regression line of MT of cerebral palsy group

A(mm)	W(mm)	Equation of Regression	Coefficient of Correlation	Significance
30	6	$y = 2.13x^2 - 22.07x + 186.15$	0.434	$p < 0.05$
90	6	$y = 3.58x^2 - 49.31x + 350.19$	0.363	$p < 0.10$
150	6	$y = 6.64x^2 - 101.25x + 584.82$	0.534	$p < 0.01$
	9	$y = 5.17x^2 - 82.19x + 492.93$	0.511	$p < 0.01$
	12	$y = 4.50x^2 - 69.94x + 416.77$	0.510	$p < 0.01$
	15	$y = 4.50x^2 - 69.96x + 406.14$	0.458	$p < 0.05$

( $y$ : MT,  $x$ : D/C gain, unit: ms)

## 4.2 The Optimum D/C Gain for Minimizing the MT

The optimum D/C gain for minimizing the MT of the cerebral palsy group is shown in Table 2. The relationship between the D/C gain and the MT was found to be a second-order curvilinear relationship under the condition of  $W = 6$  mm when  $A = 30$  mm and  $A = 90$  mm.

The optimum D/C gain for minimizing the MT was estimated to be 5.2 when  $A = 30$  mm and 6.9 when  $A = 90$  mm. On the other hand, second-order curvilinear relationships were observed under conditions of all  $W$  when  $A = 150$  mm. The optimum D/C gains for minimizing the MT were estimated at 7.6 when  $W = 9$  mm and 7.8 when  $W = 12$  mm or 15 mm.

From these results, it was concluded that the MT could be shortened by decreasing the D/C gain when the pointer moves a short distance on the GUI screen.

**Table 2.** The D/C gain for minimizing MT

A (mm)	W (mm)	D/C gain							
		1.3	2.4	3.9	5.1	7.5	9.5	12.1	
30	6				★(5.2)				
	9								
	12								
	15								
90	6					★(6.9)			
	9								
	12								
	15								
150	6					★(7.6)			
	9					★(7.9)			
	12					★(7.8)			
	15					★(7.8)			

★ The D/C gain to minimize MT.   ■ The condition in which the D/C gain to minimize MT cannot be found.

**4.3 The Influence of the D/C Gain on the Movement Time and the Positioning Time**

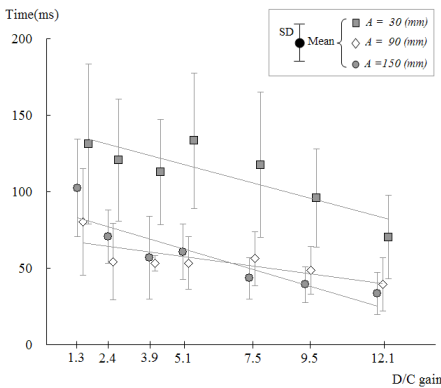
**(1) In the case of W = 6 mm**

The unit movement distance was defined as 10 mm, and the movement time against unit movement distance was calculated. The relationship between the D/C gain and movement time against unit movement distance is shown in Fig. 6. As a result, the relationship between the D/C gain and the movement time was found to be linear. In the case of A = 30 mm, movement time against unit movement distance was prolonged when compared to the conditions of A = 90 mm or 150 mm.

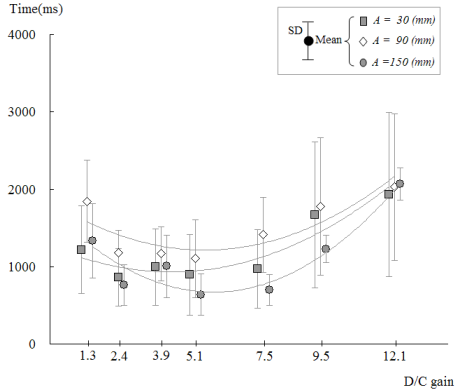
On the other hand, the relationship between the D/C gain and the positioning time was found to be a second-order curvilinear relationship (cf. Fig. 7). As a result, the D/C gain affected the positioning time and therefore had an effect on minimizing the MT.

**(2) In the case of W = 9 mm**

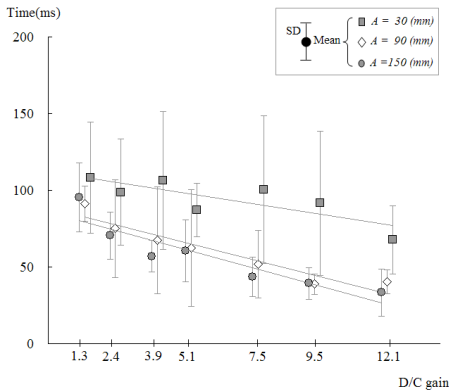
The relationship between the D/C gain and movement time against unit movement distance is shown in Fig. 8. The relationship between the D/C gain and the movement



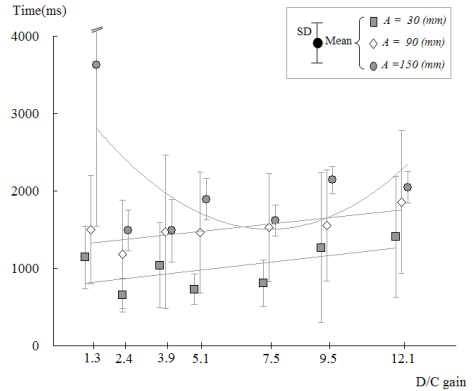
**Fig. 6.** Relation between D/C gain and movement time (Cerebral palsy group, W=6mm)



**Fig. 7.** Relation between D/C gain and positioning time (Cerebral palsy group, W=6mm)



**Fig. 8.** Relation between D/C gain and movement time (Cerebral palsy group,  $W=9\text{mm}$ )



**Fig. 9.** Relation between D/C gain and positioning time (Cerebral palsy group,  $W=9\text{mm}$ )

time was found to be linear, just as in the case of  $W = 6\text{ mm}$ . In the case of  $A = 30\text{ mm}$ , movement time against unit movement distance was longer than it was in the other conditions.

Under the condition of  $A = 150\text{ mm}$ , the relationship between the D/C gain and the positioning time was a second-order curvilinear relationship, and it was observed that the positioning time was minimized by adjusting the D/C gain (cf. Fig 9). However, this relationship was linear under the conditions of  $A = 90\text{ mm}$  or  $A = 30\text{ mm}$ .

## 5 Conclusion

The D/C gain on which people with cerebral palsy can effectively operate a pointer on a GUI screen is usually decided by trial and error. However, the optimum D/C gain for minimizing the MT can be estimated by referring to Table 2 when the average pointer movement distance and the target size are provided. This method for minimizing the MT effectively increases the productivity of people with cerebral palsy when performing positioning operations, and it will be the effective document of the job guidance for the caseworker. Furthermore, the D/C ratio for minimizing the MT can be estimated by adding data using this experiment method when pointer operating conditions are changed by enlarging or decreasing the screen size.

## References

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