

Research Project for Utilization of Human Color Information in Information Systems

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要約：人間がなんらかの形で直接関与する情報システムにおいては、視覚情報が、情報呈示の形式としてもっともよく利用されている。特に情報システムにおいては、色情報をよく利用している。しかしながら、そのようなシステムにおける視覚情報の利用について、学術的面だけではなく応用面においても、まだよく調べられていない。そこで、われわれのグループは、視覚情報とりわけ色情報の利用を促進する目的で、研究プロジェクトを実施した。ここでは2004年度における研究成果を紹介する。

Abstract : Visual information is the most used form of presentation of information in information systems concerning humans in any process. Especially, color is extensively used in information systems. However, utilization of visual information in such systems has not been well investigated, neither in scientific aspects nor in applicable aspects. Thus, our group is conducting research projects in order to enhance the utilization of visual information, especially color. We show some results of our project in 2004 academic year.

1. Structure of the project

1.1. Purpose

Visual information plays the most important role as a source of information processing related to humans. Thus, visual information

is the most used form of presentation of information in information systems concerning humans in any process. Especially, color is extensively used in information systems and technologies. However, utilization of visual

information in such systems has not been investigated, neither in scientific aspects nor in applicable aspects.

Our group will conduct research projects in order to enhance the utilization of visual information, especially color, in information systems in collaboration with the Graduate School, Department of Information Systems Engineering and Research Institute of KUT.

1.2. Outline

The term of this project will be about three more years; it has already been under way for one year for the preparation of the project.

Research projects fall within the three research regions below. Each region has sub research theme(s) currently being pursued;

(1) Perception region :

Color appearance change with the effect of larger size of chromatic area. (Leader: Keizo SHINOMORI)

(2) Operation region :

Effect of color on human performance in Human-Computer-Interfaces. (Leader: Xiangshi REN)

(3) Communication region:

Selection of color inks in color printing adjusted to each print with approximate calculation (the Genetic algorithm (GA)). (Leader: Akio SAKAMOTO)

&

Color control and calibration systems for network communication of color information. (Leader: Yutaka KIKUCHI)

Through collaborative work in these three core regions, we expect to establish an easy and accurate means of utilization of color in

information systems and technologies.

(4) Modeling region:

Construct a model(s) of human visual information processing for computer simulation.

We also expect that doctoral and masters students in the graduate school will join these research projects and will acquire high ability as specialists in color science and engineering.

1.3. Achievement in 2004 academic year

Achievements of this joint research has not been published yet because 2004 is the first year of the project. However, each member got the following achievements in the field of related research (including the work supported by Grant-in-Aid for Scientific Research).

Journal papers : 7 papers (including three articles in printing).

J. Inst. Image Inf. & Television Eng. (1), IEICE Trans. Inf. & Syst., Pt.1 (D-1) (1), J.IPSJ(1), IEICE Trans. Inf. & Syst. (D) (1), Int. J. Human-Communi. Studies(1, in printing), Information(2 in Chinese, in printing)

International conference publishing reviewed proceedings : 23 papers.

NEINE'04 (11), Comp. & Inf. Tech 2004(3), Information 2004(5), World Eng. Conv. 2004(4)

International conference : 12 presentations.

Asian Conf. on Vision 2004(4), Intl. Cong. of Psychology(2), SJCIEE2004(5), IJCNLP-04(1)

Domestic conference : 8 presentations.

Vision Soc. of Jpn. (3), Info. Proc. Interaction 2004(1), SJCIEE 2004 (2)

Important Papers in achivemetns in 2004

1. Keizo Shinomori: "Vision Psychophysics (3):

- Front-End in Color Vision -From L-, M- and S-cones to XYZ Color System-", the Journal of the institute of image information and television engineers, vol. 58, No.3, pp.313-318, 2004.
2. Masaharu Hirayama and Keizo Shinomori: "Temporal Summation between Eyes Measured by Double Pulses", Progress in Biochemistry and Biophysics Vol.31 Supplement, pp.29, 2004.
 3. T. Kawachi and A. Sakamoto: "Graph Coloring with Multi-Decode Method", SJCIIE 2004, 1-28.
 4. Kazuhito Hujimura and Mamoru Okada: "Recognition the Sign Language with Binocular parallax", SJCIIE 2004, 1-294.
 5. Kazuhito Hujimura, Mamoru Okada: Recognition the Sign Language Using the ocular Parallax, International Conference Next Era Information Networking NEINE'04, pp.441-446 ,2004.
 6. Kenichi Nagami, Satoru Matsushima, Yutaka Kikuchi and Ikuo Nakagawa: "Managemnet System for Internet Routing Information using the OSPF", IEICE Trans. Vol. J87-D-1, No. 5, pp. 572-579, 2004.
 7. Z. Guan, X. Ren, Y. Li and G. Dai: "Zoom Selector: A pen-based interaction technique for small target selection", Journal of IPSJ, Vol.45, No.8, pp.2087-2097, 2004.
 8. N. Osawa and X. Ren: "Virtual 3D gearbox widget technique for precise adjustment by hand motion in immersive VR", IEICE Transactions on Information and System, Vol.E87-D, No.10, pp.2408-2414, 2004.
 9. X. Ren and J. Kong: "A study of the optimal sizes for pen-input character boxes (in Chinese)", to appear in Information, Vol.7, No.6, 2004.
 10. S. Zhai, J. Kong and X. Ren: "Two types of speed-accuracy trade-offs in Fitts' law tasks - on the equivalency of actual and nominal pointing precision", to appear in Int. J. Human-Computer Studies.

2. Research achievement in perception region (I)

We summarize the research achievement in perception region by two papers that are published by Haruki Mizushima, Keizo Shinomori and Mamoru Okada (NEINE '04), and Ryuma Ohkubo and Keizo Shinomori (NEINE '04), respectively. This chapter shows the first paper as shown below.

Effects of Different Depth Cues on Displacement Visual Perception during a Saccadic Eye Movement
Haruki Mizushima, Keizo Shinomori and Mamoru Okada

Abstract

We utilize several kinds of cues for depth perception, such as binocular disparity and occlusion. It is very important to know how different depth cues affect stereoscopic visual perception in the development of the display device. Meanwhile, we often make rapid, ballistic eye movements, called "saccade", to obtain image information from the external world. We perceive the world as stable despite the saccade, then our visual system should process the retinal information to perceive the stable world even we move our eyes. It is known that visual sensitivity for displacement of a stimulus degrades during a saccade. This might be one aspect of the mechanism that obtain stable perception of the world when we make a saccade. In our previous

study, we found that displacement of a large stimulus during a saccade was hard to be detected. This result implies that visual system assumes that a large stimulus as background that is non-movable and a small stimulus as an object that is easy to move. In this study, we measured probability of displacement perception during a saccade when binocular disparity and occlusion defined the stimulus depth. The results show that probability of displacement perception for near stimulus was higher than for far stimulus in all subjects when depth was defined by binocular disparity. On the other hand, when depth was defined by occlusion not all subjects showed similar results as binocular disparity. These results indicate that different depth cues affect different ways on displacement perception during a saccade.

2.1 Introduction

We utilize several kinds of cues for depth perception. Images into left and right eye are different slightly when objects are located on

different depth planes. Human visual system uses this difference as a depth cue, that is called binocular disparity. Recently, three-dimensional image display devices, such as 3D television, have been developed. Some of them use the binocular disparity as a depth cue. Meanwhile, objects located far from us are sometimes hidden by that located near by us. This situation is called occlusion. It often has been used for depth cue in traditional image display device. Thus, it is very important to know how different depth cues affect stereoscopic visual perception in the development of the device.

In these days, large-sized screen devices have been developed to present strong visuals. We often make eye movements to observe such a large display. It is important to know how stimulus depth affects our visual perception during eye movements. The rapid, ballistic eye movement is called "saccade". We perceive the world as stable in spite of the saccade, so our visual system should process the retinal information to perceive the stable

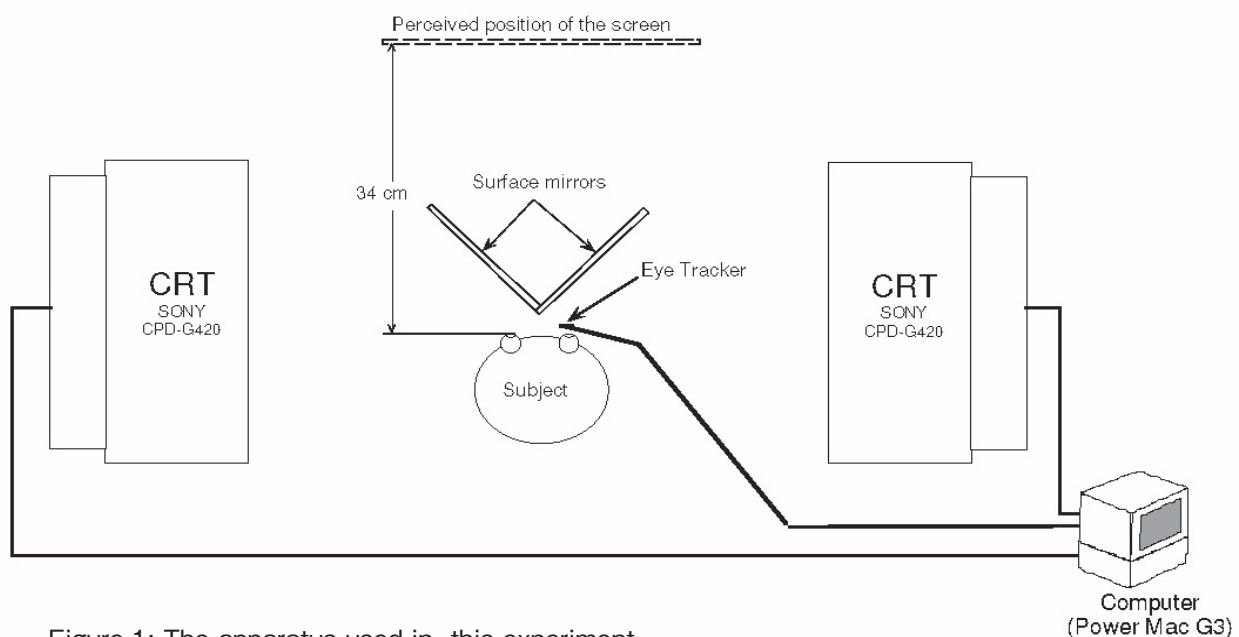


Figure.1: The apparatus used in this experiment.

world even we move our eyes. It is well known that visual sensitivity for displacement of the stimulus is reduced during a saccade. [1] We think that this might be one aspect of the mechanism that obtain stable perception of the world when we make a saccade. In our previous study we found that displacement of a large stimulus during a saccade was hard to be detected for the left-direction. [2] This result implies that visual system assumes that a large stimulus as background that is non-movable and a small stimulus as an object that is easy to move. Generally we recognize a stimulus located near by us as the object and that located far from us as the background. In this study, we measured probability of displacement perception during saccade for stimuli located in different depth planes by binocular disparity or occlusion.

2.2 Methods

2.2.1 Apparatus

We used a mirror stereoscope, shown as Figure.1, to present stimuli on different depth plane by binocular disparity. Images from the left and the right CRT screen were presented to left and right eye separately. A fused image was perceived at the front of the subject. The screen subtended 53.7 x 42.7 deg of visual angle. Viewing distance was 34 cm.

Eye position was derived from a limbus-tracker, which consisted of two photo-sensors (Matsushita ON2270). In this method, eye position was estimated by difference of reflectance of iris (black part) and sclera (white part) of the eye. Each sensor was consisted of an infrared LED and a phototransistor. This device was placed in front of the subject's

right eye. The output voltages from the two photo-sensors were subtracted and amplified to calculate the position of the subject's right eye. These voltage signals were sampled with a sampling rate of 70 Hz and were digitized via an A/D converter (NATIONAL INSTRUMENTS PCI-1200) with 12 bits resolution. These signals were differentiated to obtain the velocity of the eye movement. We could then take an appropriate value of the velocity (50 deg/s) as a trigger for changing a stimulus during a saccade. Presentation of stimulus and acquisition of eye position data were controlled by a personal computer (Apple Power Mac G3). The subject's head was fixed with a bite bar.

2.2.2 Stimulus

The test stimulus was consisted of two white squares (6 x 6 deg) arranged in above and below the eye level. In the disparity condition, these two squares were presented in different depth planes by binocular disparity. In the occlusion condition, stimulus depth was defined as a partial overlapping of the squares (about 1 deg in overlapping). The fixation point was presented at 6 deg left from the center and the saccade target was presented 6 deg right from the center. The luminances of the stimulus items and the background were 13.6 cd/m² and 0.038 cd/m², respectively.

2.2.3 Procedure

At the beginning of the trial, the test stimulus, the fixation point and the saccade target were presented on the screen and the subject reported which stimulus square was near. Then the subject fixated the fixation point and pressed a button. After a delay

selected randomly to be between 1000 and 2000 ms, the saccade target was flashed. Then the subject made a 12 deg rightward saccade towards the saccade target as soon as possible. The test stimulus was shifted during the saccade. One of above and below square or both squares changed their position(s) independently. The subject responded whether the square(s) changed the position during the saccade.

Each subject performed 10 and 6 sessions in the disparity and the occlusion condition, respectively. Each session consisted of 49 trials.

2.2.4 Subjects

Three males, TM, HM, TT and one female, MH served as subjects for the experiment. The subject, HM is one of authors. All subjects had normal vision and could perceive a depth defined by binocular disparity.

2.3 Results and discussion

Figure.2 and Figure.3 show the probability of detecting displacement as a function of the stimulus displacement in the disparity and the occlusion condition, respectively. Open circles denote the probability for near stimulus and filled circles denote the probability for far stimulus. Each panel shows the result for TM,

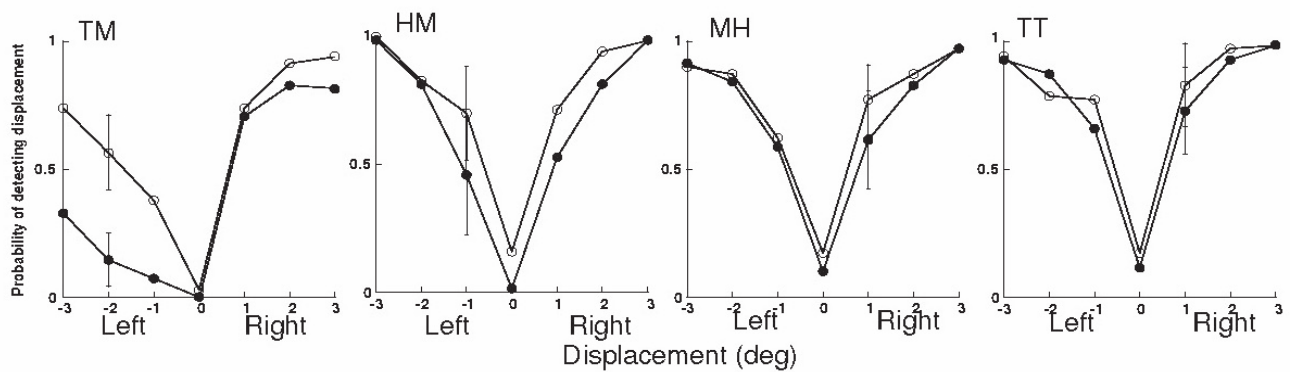


Figure.2: Probability of displacement perception as a function of the stimulus displacement in the disparity condition. Open circles denote the probability for near stimulus and filled circles denote that for far stimulus. Error bars show the standard deviation of mean derived from the probabilities measured in each session.

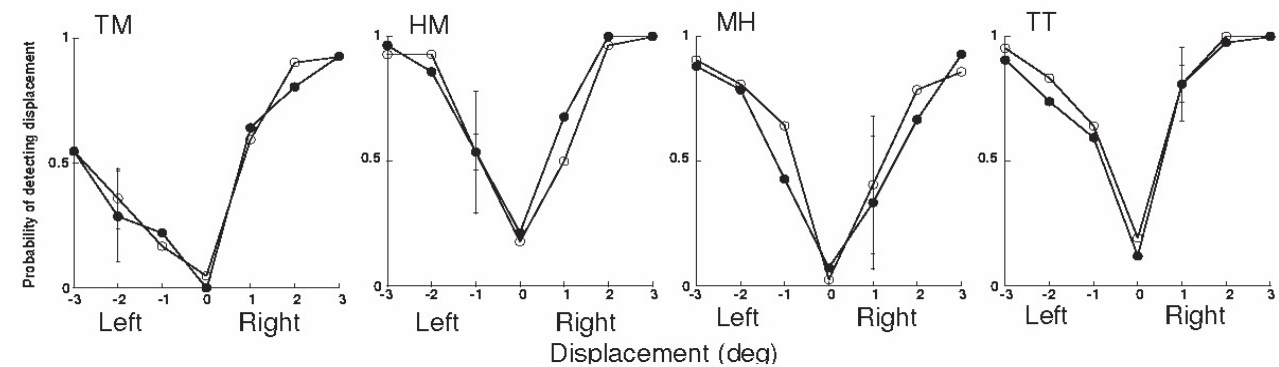


Figure.3: Probability of displacement perception as a function of the stimulus displacement in the occlusion condition. Open circles denote the probability for near stimulus and filled circles denote that for far stimulus. Error bars show the standard deviation of mean derived from the probabilities measured in each session.

HM, MH and TT, respectively.

These results show that the probability of detecting displacement for near stimulus was higher than that for far stimulus in all four subjects in the disparity condition. This indicates that displacement perception during a saccade is affected by binocular disparity. On the other hand, MH and TT showed similar results for the disparity condition in the occlusion condition. However, TM and HM did not indicate similar tendency. The difference between the probability of displacement perception for near stimulus and that for far stimulus in the occlusion condition was generally smaller than that in the disparity condition. This might be caused by the characteristics of these two depth cues. Although binocular disparity has information of both depth order and amplitude, occlusion indicates only depth order. If subjects perceived a larger depth in the disparity condition, the far stimulus and the near one would strongly be recognized as the background and the object, respectively.

These results indicate that different depth cues, disparity and occlusion in this study, affect different ways on displacement perception during a saccade.

References

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3. Research achievement in perception region (2)

In this chapter, we show the second paper by Ryuma Ohkubo and Keizo Shinomori (NEINE '04) as shown below.

Relationship between the stimulus location and the stimulus-response compatibility effect

Ryuma Ohkubo and Keizo Shinomori

Abstract

The "stimulus-response compatibility effect (Simon effect)" is the phenomenon that reaction time is faster when the location of presented stimulus and the direction shown by the hand are relevant than the case when they are not. About this phenomenon, the general consensus is that the main factor which causes the Simon effect is a spatial code which is automatically generated by presentation of a stimulus. However, it is not clear yet how the spatial code causes the Simon effect, or what kind of other mechanism can cause it. In this research, we made a following hypothesis : the "Simon effect" is caused by reflecting response in the lower levels of visual information processing. The main factor of the effect is that the destination of the spatial code changes to right or left based on the stimulus location on the retina as a stimulus is presented to right or left visual field processed in the ipsilateral cerebral hemispheres. For verification of this, we set up the experiment as to let only right or left brain as work. There is no significant differences in the results and it suggests that there is no "Simon effect". Thus, this fact supports to the correctness of our hypothesis.

3.1 Introduction

The "stimulus-response compatibility effect (Simon effect)" is the phenomenon that reaction time is faster when the location of presented stimulus and the direction shown by the hand are relevant than the case when they are not. For example, when red or green stimulus is shown at the left or right side of a screen, subject click the left or right button depending on only color of the stimulus (red-left, green-right) without reference to the stimulus location; then, reaction time becomes shorter when the red stimulus is presented at the left side or green stimulus at the right side than the case the stimulus is presented on the other side. This is called "Simon effect."

About this phenomenon, the general consensus is that the main factor which causes the Simon effect is the spatial code that is automatically generated by presentation of

a stimulus. In this paper, "spatial code" is the electric signal that is automatically generated by presentation of a stimulus on the retina. That is, all information about stimulus (location, shape, color, etc.) will be included in spatial code. That detail is not clear yet, but we can think that the electric signal is carried to the brain, and each information which is included in signal is carried to the suitable place on the cortex, after that, the signal affect a part which decide on direction of response, so show up this phenomenon. However, the model that explains this phenomenon is not confirmed yet, and there're many unknown points.

The "Simon effect" was first reported in the field of psychology. In these days, this topic is also discussed in the field of cognitive science, but almost all studies are discussed with work of higher levels of human visual system. Since, a research which discussed

No.	Stimulus Configuration	Eye	Hand	Distance A	Distance B	No.	Stimulus Configurations	Eye	Hand	Distance A	Distance B
1-1		Both	Right	13.8		3-2		Left	Right	3.2	6.4 9.6
1-2		Right	Right	13.8		4-1		Right	Right	12.8	6.4
2-1		Right	Right	3.2	6.4 9.6	4-2		Left	Left	12.8	6.4
2-2		Right	Left	3.2	6.4 9.6	5-1		Right	Right	19.2	9.6
3-1		Left	Left	3.2	6.4 9.6	5-2		Left	Left	19.2	9.6

Figure 1: Conditions used in this experiment. The white circles denote the position of a stimulus, and the small black dots denote a fixation point. The column " Eye" indicates which eye looked at the stimulus. The column " Hand" indicates which hand respond. " Distance A" means distance between two stimulus presentation areas, and " Distance B" means distance between the stimulus and the fixation point by visual angle.

about this phenomenon in the lower levels have not much even as the spatial code is considered to be generated in the lower levels.

In this research, as a first step for clarification of the mechanism of the "Simon effect", we made a following hypothesis and verified it: the "Simon effect" is caused by reflecting response in the lower levels. The main factor of the effect is that the destination of the spatial code changes to right or left based on the stimulus location on the retina as a stimulus is presented to right or left visual field.

3.2 Methods

We conducted an experiment under ten conditions to test the hypothesis. Fig. 1 shows each condition. Three subjects (only males, 21-32 years old, right-handed, one person is an author) participated in the experiment. The stimulus (diameter of 1.2 deg visual angle) was presented on CRT background is black. The diameter of fixation point is 0.5 deg visual angle. The experimental procedure was as follows.

The subject seated in the darkroom. First, the fixation point is presented except condition 1-1 and 1-2. The subject pushed a button to start the session. A red or green stimulus was shown at the either left or right stimulus presentation area. The subject had to push the left or right button as soon as possible depending on only color of the stimulus (red-left, green right) without reference to the stimulus location. If the subject pushed left or right button, the stimulus disappeared, and the red or green stimulus was shown at one of the area again after the 5 seconds interval. One session consisted of 105 trials for each

condition.

As shown in Figure 1, these ten conditions differed by location of presented stimulus, existence of fixation point, binocular or monocular viewing and which hands respond. Condition 1-1 was a replication of the conventional "Simon effect". Condition 1-2 was conducted in order to show that the "Simon effect" appeared even by monocular viewing. Condition 2-1, 2-2, 3-1 and 3-2 were conducted in order to verify our hypothesis; the "Simon effect" is not caused unless the location of presented stimulus changes to right or left visual field. Condition 4-1, 4-2, 5-1 and 5-2 were conducted in order to show that the "Simon effect" appeared irrespected of existence of the fixation point, and verify about the influence of the distance between location of the stimulus and fixation point used in condition 2-1, 2-2, 3-1 and 3-2.

3.3 Results

Fig. 2 shows the mean reaction time (RT) for each condition. The mean RT was calculated by dividing into "Relevant (white bar)" and "Irrelevant (black bar)" trials except for miss response (red - right, green - left). "Relevant" was the case which the location of presented stimulus and the direction shown by the hand were relevant (red stimulus was presented at the left side of screen or green stimulus was presented at the right side). "Irrelevant" is the other cases. If the "Simon effect" showed up, there is a significant difference between "Relevant" and "Irrelevant". But if difference of RT is not significant, the "Simon effect" did not appear in the condition. If our hypothesis, the main factor which causes the "Simon effect" is switching of visual field

of presented stimulus, is correct, there should be no significant difference in experiment 2-1, 2-2, 3-1 and 3-2, and there is it in other experiments.

As a result of T-test ($p < 0.05$), our hypothesis was not supported in these cases

(subject ST in exp.4-1 and 5-2, subject HM in exp.4-2). However, in experiment 2-1, 2-2, 3-1 and 3-2, in order to verify our hypothesis, difference of RT was not significant and this result supports our hypothesis.

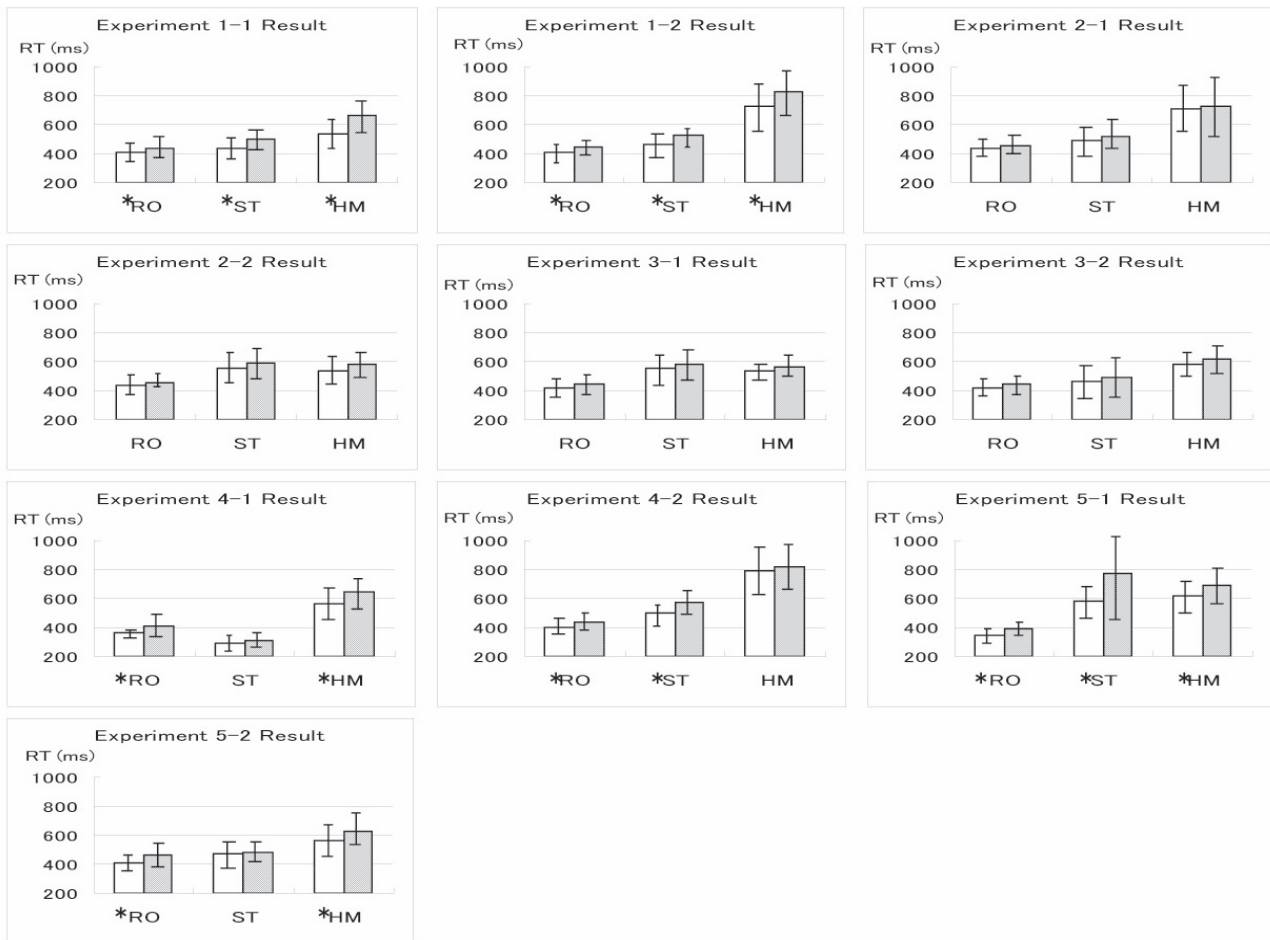


Figure 2: Mean reaction time for each condition white bars denote mean RT when the location of presented stimulus and the direction shown by the hand were congruent (Relevant), and a black bars denote mean RT in other cases (Irrelevant). Abscissa indicates the subject. Statistically-significant difference was denoted by an asterisk.

3.4 Discussion

As a result, although the mechanism was still unknown, we got results support to the correctness of our hypothesis. Three cases contrary to our hypothesis were same result such as no significant difference while that condition that should come. We think that the subject had adapted himself to the experiment. In the case of subject ST, experiment 4-1,

RT was very short. This is the evidence that he had adapted himself to the experiment temporarily as a result of conducting two or more experiments in a relatively short period of time. In fact, experiment 4-1 and 5-2 were conducted on the same day. However, session of condition 5-1 was conducted for ST after one week. Then RT increased again and statistically significant different between

"Relevant" and "Irrelevant" was appeared. It can be said that this consideration is right.

Moreover, we think that the result according to our hypothesis can be obtained if conducted a re-experiment as pay attention to adaptation to the experiment of the subject. Because there is no example which two or more subjects achieved result contrary to our hypothesis under the same conditions.

References

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4. Research achievement in operation region

We summarize the research achievement in operation region by the papers that are published by Jing Kong and Xiangshi Ren (NEINE '04) in this chapter.

Effective target width calculation and the effects on the speed and accuracy interaction in pointing task
Jing Kong and Xiangshi Ren

Abstract

Using effective target width in Fitts' law has been a widespread applied method for one dimensional pointing task evaluation. However, the feasibility of using it in different speed and accuracy instruction has not been

tested. Moreover, the concrete calculation method of effective target width has not been officially united. This paper concentrates on resolving these problems. The experiment and data analysis results show that the application of effective target width in pointing task evaluation should depend on different levels of speed and accuracy requests. Meanwhile, after comparing the two existed method of calculating effective target width, one method of using the target center is tested as a better selection for human computer interface design.

4.1 Introduction

Today the need for a reliable prediction model for computer input tasks is stronger than ever. HCI designers are eager to find a useful model to predict people's performance using different devices and to test the feasibility and efficiency of the devices on interfaces of different systems. In some situations certain devices are not convenient. Before we can decide an input device or design an interface for a system, we must first predict the performance of users. Fitts' law, which was proposed in 1954 by Fitts, is a famous model used to predict the performance of rapid and aimed movements. It had already been applied to computer input device evaluation a lot [4]. However, its adequacy remains debatable.

One widely accepted version of it is in the following form:

$$MT = a + bID \quad (1)$$

where MT is the movement time in which the subject move a pointing device from one target's center to another target's center. a and b are empirically determined constants. ID is

the difficulty index of the pointing task, which can be expressed as following:

$$ID = \log_2(A/W + 1) \quad (2)$$

Here W is the target width and A is the distance between the centers of two targets.

Fitts' law formulations (equations 1 and 2) are based on the analogy to the information capacity formulation, movement amplitudes are analogous to "signals" and target widths are analogous to "noise" [2]. This analogy requires that in motor tasks the input hits should follow a normal distribution [5]. According to Mackenzie, to keep target width analogous to noise, 96% of the hits must fall inside the target width. Obviously, during the factual experiment, the hits falling into the target width may not follow the normal distribution so accurately and subjects cannot be expected to maintain a 96% successful rate while working under a command mentioned in the Fitts' law paradigm experiment: "as fast and accurately as possible".

Therefore, a great deal of work has been done to revise Fitts' law. One solution is to use effective target width instead of the normal target width [1]. It has been accepted by ISO standards 9241-9 [3].

The equation for the effective target width method is:

$$MT = a + b \log_2\left(\frac{A}{W_e} + 1\right) \quad (3)$$

where W_e is the effective target width. Correspondingly, ID should be revised as ID_e :

$$ID_e = \log_2(A/W_e + 1) \quad (4)$$

We call this version of Fitts' law as W_e model.

Although W_e model has been used widely

in HCI, it is far from a piece of untenable theory. One problem is that the calculation of the W_e has not been decided or united.

There are two methods to determine the effective target width: using standard deviation or using percentage errors. In the early studies, due to the lack of powerful calculation tools, such as computers, there was no record of the endpoint coordinates, and thus the standard deviation of the distribution cannot be calculated. Researchers would use a trickier method to retrieve the effective target width through the percentage errors [5]. There is no much theoretic support for this method. Thanks for the wide application of the computers, the endpoint coordinates of the input hits of recent studies can be easily and clearly recorded, therefore, in most cases, the effective target width is calculated by the first method.

Even with the first method, there are two concrete ways to calculate the standard deviation and thereafter the effective target width. One is using the target center to calculate the average of the x coordinates to get the standard deviation. The other is using the distribution center to calculate the average of the x coordinates to get the standard deviation. By both of the two ways the averages of the x coordinates needs to be calculated according to the relative abscise.

One dilemma of the present situation is that no study has shown any comparison of these two calculation method. Researchers just select one method that they regard as reasonable. Isokoski and Raisamo [4] have mentioned that they used the second method and they thought that method was suitable for big size target. However, no accurate

calculation method in Fitts' law related researches. The data and result afforded here may be of great help for the further application of Fitts' law to HCI field.

4.2 Experiment

4.2.1 Subject

Ten volunteers, eight male and two female (average 24.2 years old), participated in this experiment.

4.2.2 Apparatus

The experiment was conducted on a tablet computer (FUJITSU FMV Stylistic) with a screen size of 21 cm x 15.6 cm. Each pixel on the screen was 0.2055 mm wide.

4.2.3 Procedure

The experiment consisted three parts: part A, part B and part C. In all the three parts, similar to Fitts' paradigm experiment [2], participants reciprocally pointed on a pair of vertical strips with a fixed distance D of 400 pixels with a stylus pen. If the outside region of the target was tapped, an auditory signal would be played as warning signal. Nevertheless, there is great difference of the three parts both in experimental form and purposes.

In part A, W was fixed at 20 pixels based on the consideration of the size of usual targets in human computer interfaces. Each participant was instructed to repeat the experiment five times with different operational strategies: extremely accurate (EA), accurate (A), neutral (N), fast (F) and extremely fast (EF). The following verbal instructions corresponding to each task were given by the experimenter to the participants:

"Perform as accurately as possible and don't worry about time or speed, try to avoid any error" in Condition EA; "As accurately as possible but keep some speed" in Condition A; "As accurately as possible and as fast as possible" in Condition N; "As fast as possible but keep some accuracy" in Condition F; and "As fast as possible and some errors are acceptable" in Condition EF. There were a total of 700 trials collected (= 5 instructions x 14 trials x 10 participant s). No accidental trials(*) were observed. The goal of part A was to produce a set of time measurements under the same appointed target width but different effective target width due to different instructions.

(* Usually we excluded the accidental trials (for example, target appears on the left, but the point fell into the right region of the screen) from further analysis to prevent their disproportional impact on modeling.)

To test which of the two effective target width calculation methods can describe the reality more reasonable, we set W at 10, 14, 20, 28 and 40 pixels in part B and C, supposing they are corresponding to the expected W values produced by the five different instructions (EA, A, N, F, EF) in part A. Then Part B and C could produce a set of time measurements when participants obediently complied with the given target widths to an (almost) ideal extent (W_e matches W within 7% margin). To achieve that, we used a target width enforcement method inspired by and refined from the verbal feedback method of Zhai and colleagues [6]. During the experiment (after the first 5 trials in each block), if $W_e > 1.07W$, which meant that the participant took too much risk, a yellow sign appeared in the

middle of the two target strips to remind the performer to slow down. In contrast, if $We < 0.93W$, a red sign appeared in the middle of the two strips to remind the participant to speed-up. If no sign was displayed, it meant the participant's current endpoints dispersion corresponded to W within 7% margin so the participant could keep his or her current pace. According to these regulations, the concrete scope of the limitation of We used in the program to do the comparison can be listed in table 1.

Appointed target width (pixels)	10	14	20	28	40
Lower limit	9.33	13.06	18.66	26.12	37.32
Upper limit	10.72	15.00	21.44	30.01	42.87

Table 1 The limits of the effective target width and the corresponding appointed target width

The method of measuring the running We value was as follows: Before the participant performed the 15th trial in a W condition, the program calculated the standard deviation of the end points distribution based on all of the past trials (from 1 to 14). From the 15th trial the program calculated the standard deviation of the end points based on the most recent 14 trials (i.e. a 14 trial moving window was used). The experiment program stopped the current W condition and began the next one once a block of a 14 trials whose We matches W by a less than a 7% margin. These 14 trials were used in later analysis. The program would have also aborted the current W condition

if the participant had performed 30 trials without reaching a 14 trial block that met the requirement. In the actual experiment none of the participants needed to use up the maximum 30 trials. We analyzed the end points of the last 14 trials and confirmed that they were normally distributed.

The difference between part B and part C is that the calculation method of standard deviation was different. In part B, the program calculated the standard deviation based on the distance of the endpoints to the center of the targets. This is the first method introduced in the Introduction. In part C, the program calculated the standard deviation based on the distance of the endpoints to the center of their distribution [4]. This is the second method introduced in the Introduction.

Therefore, through part A, we could observe the relationship between mean trial completion time and the effective target widths under different levels of speed-accuracy instructions that caused the participants to disrespect the nominal target width to varying direction and extent. Through part B and C, we could observe the relationship between mean trial completion time and the nominal target width when the participants obediently and effectively complied with the accuracy tolerance specified by the target. Comparing the curve of time and We may help us to see whether the We method models the pointing task accurately and which calculation method is better.

4.3 Results and Discussion

After experiment, we collected data and made the Fitts' law regression lines in figure 1 and 2. The difference between the two regression

lines in figures 1 and 2 demonstrates that in fact, when special enforcement upon the distribution is not exerted, and with different subjective or objective request on speed and accuracy, the movement time cannot be modeled by the Fitts' law completely.

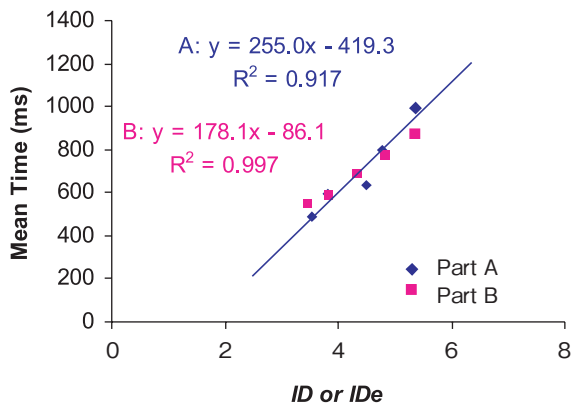


Figure 1 Time~ID and Time~IDe regressions in part A and B

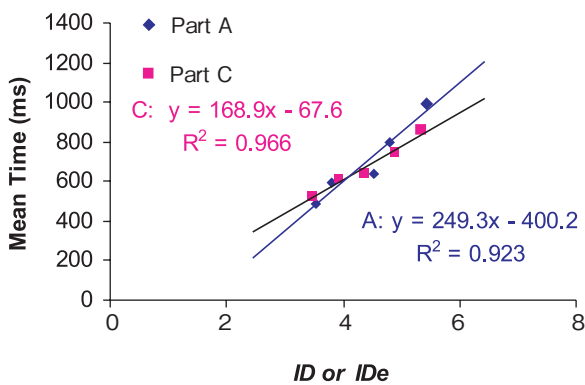


Figure 2 Time~ID and Time~IDe regressions in part A and C

R square value of the regression line got from part B is near to 1 (0.997), which means by using the first effective target width calculation method with experiment data of part B, the regression of Fitts' law is ideal and strong. Comparing with figure 1, the regression of Fitts' law regression line got from Part C in figure 2 is still big (0.966), but not as great as indicated by figure 1.

Combining the regression lines with part A experimental data, although the difference between the regression lines of different experimental control strategies can be observed clearly, the discrepancy between the two regression lines in figure 1 is less than that in figure 2 (also shown in table 2).

	<i>a</i>	<i>b</i>	Δa	Δb	R^2
Part	-419.3	255.0			0.917
A	-400.2	249.3			0.923
Part	-86.1	178.1	387.0%	43.2%	0.997
B	-67.6	168.9	492.0%	47.6%	0.966
Part					
C					

Table 2 Comparison and Regressions of the data got from part A, B and C.

The Fitts' law regression lines help to observe the effects of using the two calculation method. From figure 1 and 2, it is not difficult to conclude that using the first calculation method may bring a more reliable description of the pointing performance.

In Fitts' law, no matter what derivation version we used, the relationship between movement time and target width is a logarithm relationship. Therefore, a logarithm relation curve between movement time and *W* will be more helpful to compare the effect of the two calculation methods.

Figure 3 shows that with the first calculation method, the logarithm relationship between movement time and target width is obvious and all the five dots are dwelling on the curve restrictedly. However, in figure 4, the dots scatter around the logarithm curve and the dot with target width near to 20 pixels obviously escapes from the curve. From these

two figures, it is natural to conclude that the first method can afford an accurate calculation of the relationship between movement time and target width.

At last, the comparison of the concrete values of the effective target widths got from the two calculation method can also help to show the effects. With the first method, the results do not deviate from the aiming target size far. The difference is less than 1 pixel. All the effective target widths are in the acceptable range defined by table 1 except in case of 28 pixel nominal target size.

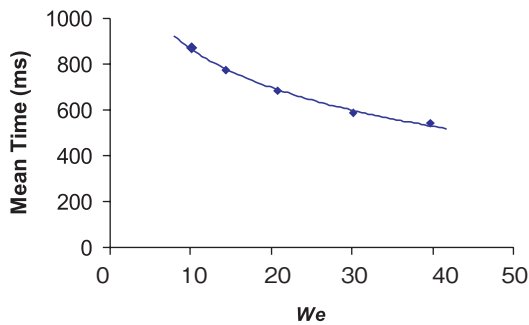


Figure 3 The match between Time and We in part B

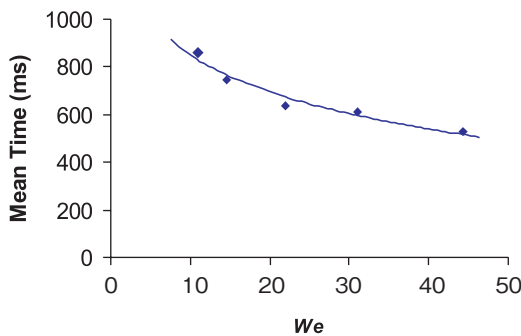


Figure 4 The match between Time and We in part C

However, although the effective target width with 30.07 is bigger than the limitation, the difference is rather tiny. On the other hand, with the second calculation method, the final results deviate from the aiming

target size. All the effective target widths are beyond the limitations set in table 1 and the differences are all bigger than 0.1 pixel. The actual effective target widths are shown in table 3.

Appointed target width	10	14	20	28	40
Part B We	10.05	14.39	20.73	30.07	39.66
Part C We	11.04	14.55	21.90	30.97	44.37

Table 3 The effective target widths of Part B and Par C

In figure 1, 2, 3 and 4, the scatter plots (and regression lines and curves) show that the relationship between completion time and We in part A and the relationship between completion time and W in part B and C were consistent in direction but different in extent. When the instruction is near to neuter (A, N, F), the difference was relatively small. When the instruction is inclined to the two extreme (EA and EF), this difference increased rapidly. The results of this experiment shed more lights on the effect that using We only partially compensates for time variance caused by different levels of speed-accuracy instruction: while the $Time \sim We$ relationship was similar to $Time \sim W$ relationship when the performers obediently complied with the target size specification, they did not exactly match in extent. The impact of We adjustment lagged behind the impact of W changes of the same amount.

4.4 Conclusion

The results of the experiment show two points in Fitts' law relative researches. First, using effective target width, or We , Fitts'

law model can almost model the pointing task. However, when some special instruction or there is special purpose of the subjects, experimental data will deviate from the regression line further.

Secondly, for different target width, using different methods to calculate the effective target width has different effects. With the first method, the logarithm relationship of movement time and target width can be described accurately in the experimental range of 10 to 40 pixels. With the second method, the logarithm relationship of movement time and target width can be described accurately in the case of bigger target size (in our experiment the range is from 30 to 45 pixels). For smaller target size, it is not accurate to use this method to calculate the standard deviation or the effective target width.

This result contradicts with the hypothesis of Isokoski and Raisamo. However, it is reasonable. The main reason for Isokoski and Raisamo to use the second method to calculate the standard deviation is that with bigger targets the users tend to click near the nearest edge of the target rectangle rather than near the middle. Then they argued that the problem caused by the off-center click distributions is that they inflate the standard deviation measured if it is calculated in relation to the target center.

However, during the actual experiment, the hits made by all the subjects almost follow normal distribution. Only if we consider the distribution of one person, the inclination could be clearly observed. Then if we use the distribution center to calculate the standard deviation, it means the request for the individual subject will become looser than

using the target center. Nevertheless, when we analyze the data, we must mix all the subjects data together, the standard deviation of the complete dots will be inflated. That is the reason for the effective target width in part C is bigger than expected (table 3). Therefore, in Fitts' law, it is a better way to calculate the standard deviation or effective target width based on target center, not distribution center.

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5. Research achievement in communication region

In this chapter, we summarize the research achievement in communication region by the abstracts by Tomohiko Kawachi and Akio Sakamoto (SJCIEE 2004), and Yutaka Kikuchi and Keizo Shinomori (in preparation), respectively.

*A genetic approach for graph coloring problems**Tomohiko Kawachi and Akio Sakamoto*

Genetic algorithm is a kind of optimization methods based on natural selection and genetics. It finds near optimal solutions of optimization problems by means of coding feasible solutions as chromosomes and applying genetic operations to chromosomes in each generation.

Multi-decode is a method of finding mutually prime independent sets from a permutation of vertex set of a graph.

This research paper reports an application of genetic algorithm to graph coloring problem using multi-decode method. Some improvements for multi-decoding and reproduction of genetic algorithm are also described. It is confirmed that the improvements are efficient by some experiments with DIMACS benchmark graphs for graph coloring problems. However, the superiority of genetic algorithm cannot be found by comparison with simulated annealing which is a kind of metaheuristics like genetic algorithm.

It is especially important to control and calibrate colors on images sent through WWW, if they are used for serious situations like net-shopping. So, we conducted the research to control colors through WWW. In 2004, we worked the program that will be used for individual calibration of luminance on the screen. By this data, the program controls the color on the screen for one user.