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著者	OHASHI Tomoki, KIYONOBU Kazuyoshi
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EFFECTIVE FIELD OF VIEW AND VISUAL ATTENTION

By

OHASHI TOMOKI (大橋智樹)[1] and KIYONOBU KAZUYOSHI (清信一芳)[1]

(*Tohoku University*)

The purpose of this study was to reveal the relationship between the extent of the effective field of view (EFV) and the load of the task, and to investigate the characteristics underlying the EFV. In most of previous studies using the dual task method, the tasks conducted in the central and peripheral fields were independent from each other and the magnitude of task load had not been defined clearly. Considering about these points, symmetry-discrimination was used as dual tasks for the central and peripheral vision, while the magnitude of the task load was measured by a discrimination reaction time. It was found that there was a close relationship between the task load and the extent of the EFV, and that a spotlight analogy was appropriate for interpreting the characteristics of the EFV. The obtained shape of the EFV was inconsistent with those revealed in the previous studies. It is suggested that the property of the task is influential in determining the extent and the shape of the EFV.

Key words: effective field of view, spotlight metaphor, visual attention.

INTRODUCTION

When we perform a particular behavior, such as reading a book or driving a car, our eyes go on moving for getting the neccesary information. This kind of moving the eyes is called saccadic movement, in which the fixation point moves in a discrete manner in every 300 msec. The distance of fixation between one point and the next is changed by the task required to the subject. The visual field in which one can get the information to need for the ongoing behavior is called the effective field of view (EFV). There were a lot of studies that investigated the extent of the EFV, and many discussions were conducted for that size.

The investigations of EFV can be classified into two groups, the studies by the restricted visual field method and those by the dual task method. The restricted visual field method examined the performance by narrowing the subject's visible area. Saida and Ikeda (1979) moved a mask that had a window in the center, synchronizing with the eye movements, so that the subjects could view only the small area through the window. The subjects were requested to read Japanese sentences. The results showed that the time needed for the reading was prolonged when the window was narrowed less than 10 degree in visual angle. They defined this area as the EFV for the Japanese reading. McConkie and Rayner (1975) used the similar task and showed that the EFV corresponding 12 to 15 letters was necessary for the English reading.

In the dual task method, the stimuli were presented on the central and the peripheral visual field. By measuring the performance for the peripheral stimuli, the EFV for the central task was

1. Department of Psychology, Faculty of Art and Letters, Tohoku University, 980-8576, Japan. Electric mail may be sent via Internet to ohashi@sal.tohoku.ac.jp.

estimated. Ikeda and Takeuchi (1975) provided three magnitudes of load for the central task, and showed that the high load reduced the correct answers on the location identification task in the peripheral vision. Williams (1982) presented two letters in the central, and requested subjects to make a same/different judgement for the letters or to classify the letters into vowels or consonants. The peripheral task was the orientation discrimination of a short line. The results showed that the EFV for the orientation disctimination task was more narrowed at the classifying task than at the same/different judgement task.

However, these investigations seem to have some procedural problems. At first, the load was defined by the researchers without any experiments for checking the magnitudes of load. Another problem is the relationships between the central and the peripheral task. The EFV is considered to be an area in which the subjects get the useful information for the ongoing behavior, therefore, the central task must be closely related to the peripheral task. However, in the previous studies, there were no relationships between the central task and the peripheral one, for instance, the identifying task used in the central vision and the orientation detection task in the peripheral.

In the present research, we investigated the EFV in consideration of the problems mentioned above. The load for the central task was defined by the discrimination reaction time, and the same task was adopted for the peripheral task. These improvements would reveal more precise and meaningfull characteristics of the EFV.

Experiment 1

In Experiment 1, we measured the magnitude of the task load. For this purpose, we adopted the task discriminating whether the presented dot-patterns were symmetric or not. Manupulating the numbers of correlated dots in asymmetric patterns, reaction times were measured as indicating the load of the discrimination task.

Method

Subjects: Ten college students were participated in the experiment. They had normal and corrected-to-normal vision and no knowledge about the experiment.

Stimuli and Apparatus: The stimuli were presented on a display (MAG DX-15T), and controlled by a personal computer (NEC PC-9801 RA). The stimulus was a square (2.3×2.3 degree in visual angle), having 16 dots in each side, and the density of the dots was 50%. The symmetric or asymmetric patterns were made by arranging the dots (Fig. 1). The degree of symmetry was defined by the percentages of correlated dots plotted on the right and left side of the pattern. These percentages were changed in 16 steps from 0% to 93.75%, every 6.25%.

Procedure: The task of the subject was to discriminate whether the stimuli presented at the centrer of the display were symmmetric or not, and the reaction times for the discrimination were measured by pressing one of two keys. If the subject made an error, a short beep signal was presented. Trials were blocked by the percentages of correlated dots, and the order of the blocks were counterbalanced between subjects. The trial was started presenting the fixation mark that

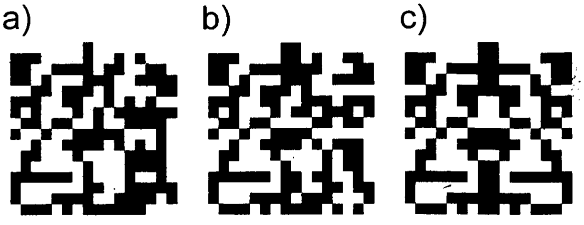

Fig. 1 Samples of the stimuli. a), b), c) show 0 %, 50%, and 100% dot-correlated pattern, respe ctively. The 100% dot-corre lated pattern is a complete symmetric patten.

was a square of the same size as the dot-pattern, and a randomforeperiod from 150 to 250 msec was given. Then, the symmetric or asymmetric pattern was presented on the fixation mark. This pattern was presented until the subject pressed the key.

Results and Discussion

Figure 2 shows the mean discrimination reaction times and the mean percentage of correct answers as a function of the percentages of correlated dots. The reaction time increased and the correct answer decreased with the increase in percentages of correlated dots. Therefore, we can consider the discrimination became more difficult in the higher percentages of correlated dots, and the load of the present task changed monotomically by the manupulation of dot-correlation. Therefore, 6.25%, 56.25% and 75% correlation conditions were chosen for Experiment 2, because they had almost the same intervals in reaction times and the percentages of correct responses for them were all above 80% (Fig. 3)

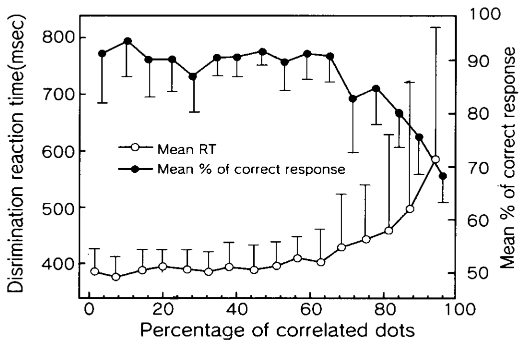

Fig. 2. Mean discrimination reaction times and mean percentages of correct answers as a function of the percentages of correlated dots. Vertical line shows standard diviation.

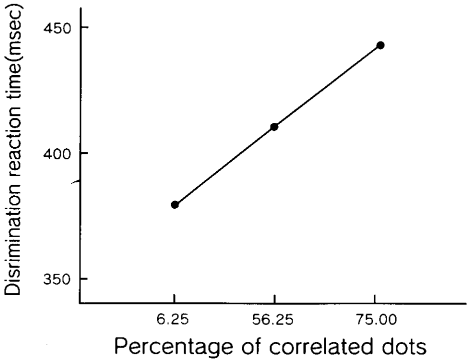

Fig. 3. Three degrees of the percentages correlated dots chosen from the data obtained in experiment I. They had almost the same intervals in reaction times. The percentages of correct responses for them were all above 80%. These degrees were used in Experiment 2 as a load of tasks.

EXPERIMENT 2

In Experiment 2, we examined the relationships between the load in the central task and the size of the EFV, utilizing the magnitude of the task load measured in Experiment 1.

METHOD

Subjects: Ten college students participated in the experiment. Seven of them had participated in Experiment 1. All subjects had normal or corrected-to-normal vision and no knowledge of the experiment.

Stimuli and Apparatus: The stimuli and apparatus used in Experiment 2 was the same as those in Experiment 1. The asymmetric patterns used in this experiment were chosen based on the results of Experiment 1. The stimuli were presented in the center and peripheral visual field, simultaneously. The center stimulus had also a role of fixation point. The display was divided in 7 × 7 matrix, in which the possible positions of the peripheral stimuli were 48, except the center stimulus.

Procedure: The central and peripheral task were to answer whether the presented stimuli were symmetry or not. The trial was started with presenting the fixation mark, and a foreperiod about 450 msec was given. Then, the central and peripheral stimuli were presented simultaniously for 200 msec. The subject was required to answer by pressing the keys for the central stimulus, then for peripheral one successively.

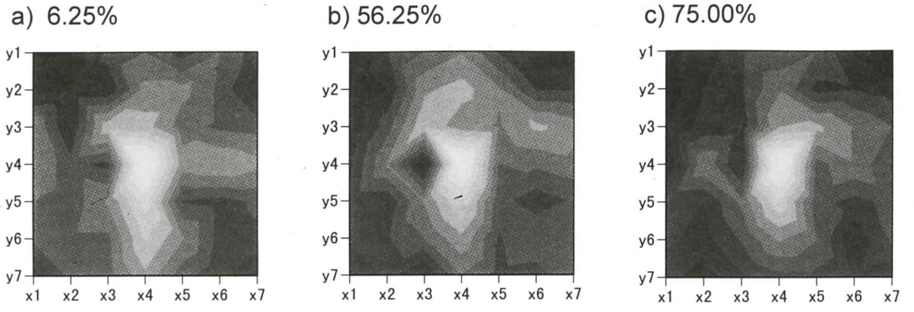

Fig. 4. Maps of the mean percentages of correct judgements for the peripheral stimuli for each dot-correlation condition; (a; 6.25%, b; 56.25%, c; 75.00%). Darker areas show more difficult areas in discriminating whether the presented stimuli were symmetric or not. These maps indicate that the higher load for the central task narrows the EFV.

RESULTS AND DISCUSSION

Figure 4 shows the maps of the mean percentage correct judgement for the peripheral stimuli in each dot-correlation condition. These results show that the higher task loads provided by the central stimuli decreased the correct answers. This deterioration reflects the reduction of the EFV size.

In another analysis for peripheral stimuli, the numbers of peripheral cells, which were correctly reported with accuracy more than 75%, were counted in each dot-correlation condition (Fig. 5). The obtained function clearly reveals that the EFV size reduces monotonically with the increase of the load for the central task.

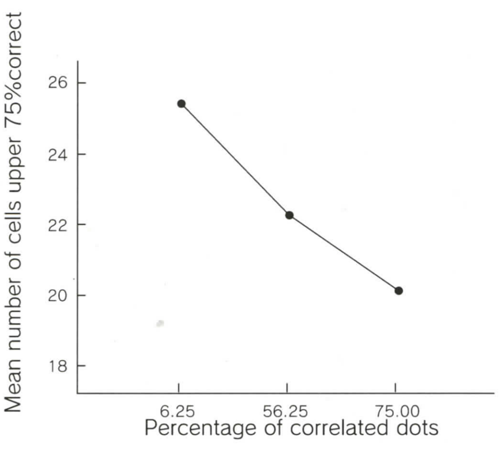

Fig. 5. Numbers of peripheral cells, which were correctly reported with accuracy more than 75%, were counted in each dot-correlation condition.

These results can be interpreted in terms of the characteristics of visual attention. There is a popular metaphor of the visual attention called 'spotlight analogy' (Jonides, 1980; Posner, 1980). This metaphor assumes a spotlight like beam in the visual field, and this beam can be controlled independent from the eye movement. The spotlight moves to the consciously focused area and the objects in that area take precedence over the other area. Many theories adopted the spotlight metaphor to explain the human attentional performances (e.g., Treisman & Gelade, 1980).

We considered that this metaphor could also explain the EFV. The obtained EFV can be regarded as an accumulation of the moving spotlight during the required tasks. More precisely, the spotlight might stay in the central vision before beginning the trial, and when the peripheral stimuli presented, subject might move the spotlight to the peripheral position after processing the central stimulus, because they were required to answer both the stimuli. At this point, if the central stimulus was difficult to judge, in the high load condition, more attentional resources might be spent for the central task and it became difficult to move the spotlight to far positions. As a result, the EFV would be formed reflecting the mobility of the spotlight during the task.

The shape of the EFV has been reported to be a horizontally elongated ellipse in many articles (e.g., Engel, 1971). However, in the present study, the obtained shape of the EFV was a vertically elongated ellipse. This inconsistency indicates that the shape of the EFV is influenced by the interaction between the characteristics of the stimuli and those of the tasks. The stimuli used in this study had vertical axis of symmetry, and the tasks were to judge whether the presented patterns were symmetric or not. In this sort of stimuli, when the peripheral pattern presented at the upper/or below position against the central stimulus, it might be much easy to judge their symmetry. Accordingly, if the symmetric patterns have a horizontal axis, the shape of the EVF would spread widely in the horizontal direction. This possibility should be investigated in futher study.

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