Visual attention in the central vision: The effects of voluntary and involuntary shifts

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VISUAL ATTENTION IN THE CENTRAL VISION: THE EFFECTS OF VOLUNTARY AND INVOLUNTARY SHIFTS

By
OHASHI TOMOKI (大橋智樹)[1]
(*Tohoku University*)

The properties of the visual attention in the central vision were investigated. Seven subjects were participated in the reaction time task detecting the mean luminance change in the central vision. Two conditions were set up to examine the differences between voluntary and involuntary attentional shifts: the voluntary condition which had the dual task of the central and peripheral vision, and involuntary task was the single task which was ignoring the peripheral stimulus. Then, the delay between the central stimulus and the peripheral stimulus was changed for investigating the temporal properties of the visual attention in the central vision. The results showed the new finding that the visual attention affected the apart location by the backward manner. Furthermore, different from the findings from the peripheral vision, there was no "inhibition of return" in the central vision.

Key words: visual attention, central vision, perioheral vision.

INTRODUCTION

Many studies have revealed the various properties of visual attention using many kinds of the tasks or measures. The tasks in the most of these studies, however, were set up for the investigation of the peripheral vision only. For example, the spatial extension of the attention (Eriksen & Yeh, 1985; LaBerge, 1983), the possibility of splitting the attention (Posner, Snyder, & Davidson, 1980; Shaw & Shaw, 1977), the manner of shifting the attention (Remington & Pierce, 1984; Tsal, 1983), and so on.

On the other hand, there were only a few studies of the attention in the central vision. Using the cost-benefit method, Posner (1980) indicated that the detection rate for the stimuli presented in the fovea was lowered, and Sagi and Julesz (1986) found that the sensitivity of the central vision was declined after attentional shift, using the discrimination task. These studies indicated to decline the performance of the central vision, but there were no suggestion for the dynamic changes of the attention at the central vision during the task. In the work of Raymond, Kimron, Shapiro, and Arnell (1992), these dynamic changes of the performance at the central vision were investigated, but this examination aimed at the properties on the central vision only, that is, no peripheral stimuli were presented (Duncan et al. (1994) investigated similar phenomenon.).

1. Department of Psychology, Faculty and Arts and Letters, Tohoku University, Kawauchi Aobaku, Sendai 980-77, Japan. (E-mail: ohashi@sal.tohoku.ac.jp)

Thus, there may have been no studies about the dynamic temporal changes of the central visual attention, after shifting the attention to the peripheral. In another word, it is necessary to investigate the temporal variances in the central vision during disengagement[2].

The present report aims at the investigation of the properties of the visual attention on the central vision. For this purpose, I adopt the dual task, that consist of the detection task of the mean luminance change on the central vision and the discrimination task of the digit on peripheral vision. To measure the performances of the temporal properties on the central vision, the time interval between these tasks (I called this interval "delay.") was operated. Moreover, about the two characteristics of the visual attention, so called as voluntary and involuntary attention, the difference of the effect on the central vision task by each of characteristics was investigated, too.

METHOD

Subject: Seven volunteers participated in this experiment. They all had normal and corrected normal vision. All of them were the expert of this kind of task, because they were participated in some similar experiment, before.

Stimulus: The central stimulus, presented on the fixation point, was two kinds of the disk patch (0.17 degree in diameter), one was the filled pattern (mean luminance: 119.7 cd/m^2)

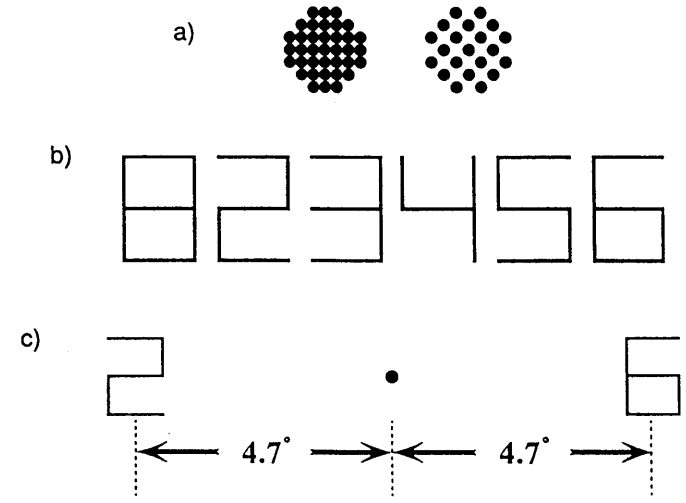

Fig. 1. a) pixel arrangement of the central stimulus. Left circle patch is the filled pattern, and right patch is the dot tiles pattern. To change the central stimulus from filled pattern to dot tiled pattern make brief decrement. b) digit pattern used in the experiment. c) CRT exhibition of the experiment. Digit was presented only left or right, in random.

2. The term "disengagement" was one of three processes that Posner, Peterson, Fox, and Raichle (1988) were proposed. They suggested that the visual attention was shifted from one location to another using a "disengage-shift-engage" strategy.

and another was the dot tiled pattern (mean luminance: 28.8 cd/m^2). The peripheral stimulus was the roman digit pattern (1.1 × 0.8 degree) that were five types varied from 2 to 5. The distance between central and peripheral stimulus is about 4.7 degree. Fig.1 shows the stimuli used in this experiment.

Apparatus: AV. tachistoscope (IWATSU ISEL IS-701A) controlled by NEC PC-9801 RX was used to present the stimuli and to measure the reaction time.

The experiment was done in the experimental room excluded the outside light and lighted normally. The subjects were observed the display from 130 cm distance, and subject's head rested on the chin-rest. The reactions were to press key on the reaction key box attached to the AV. tachistoscope.

Procedure: Each trial started by the key press. Following the central stimulus, peripheral stimulus was presented on the left or the right side randomly, and after a certain delay, mean luminance of the central stimulus was briefly decreased[3]. The subject's task was different in two conditions, named the recognize condition and the ignore condition. They were only different in whether subjects had to recognize the peripheral stimulus or not.

In the recognize condition, the subjects asked to recognize the peripheral digit and to detect whether the mean luminance at the central stimulus was decreased and to press one of two keys (the left key: decrement; the right key: not decrement) as fast and accurately as possible. If the peripheral stimulus, however, was "3," the subjects had to stop detecting the mean luminance change and press another key (this key pressing did not ask the quickness.). Using this procedure to find the digit "3" in the peripheral, it could confirm that the subjects certainly recognized the digit.

The ignore condition was same as the recognize condition except not to recognize the peripheral digit. In this condition, the only task was to detect the mean luminance decrement of the central disk, ignoring the peripheral stimuli. In the former condition, I examined the effects of the voluntary attention, and in the later condition that of the involuntary attention.

The delay, that the time interval between the onset of the peripheral stimuli and the decrement of the central stimuli, was 17 steps that varied from 5 msec to 85 msec at 5 msec regular interval. There were 2 experimental sessions (1020 trials in each session, 120 trials for each delay) in the recognize condition. The ignore condition was examined only 1 session (1020 trials, 60 trials for each delay). Therefore, the experiment was consisted of 3 sessions, and all subjects were participated in all sessions. Figure 2 provides an example of the trial events.

Eye movement was not monitored, because the main task was the detection in the central vision and the exposure duration of the peripheral stimuli was below the latency of the regular saccade.

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3. In the display of AV. tachistoscope used in this experiment, each pixel had 1-bit intensity levels, that is, a pixel, that formed the stimuli, could change only the on or off condition. Therefore, for the decrement of the luminance, the density of the stimulus was changed. In this experiment, for the decrement of the luminance, the stimulus changed from the filled pattern to the dot tiled pattern, which had same contour.

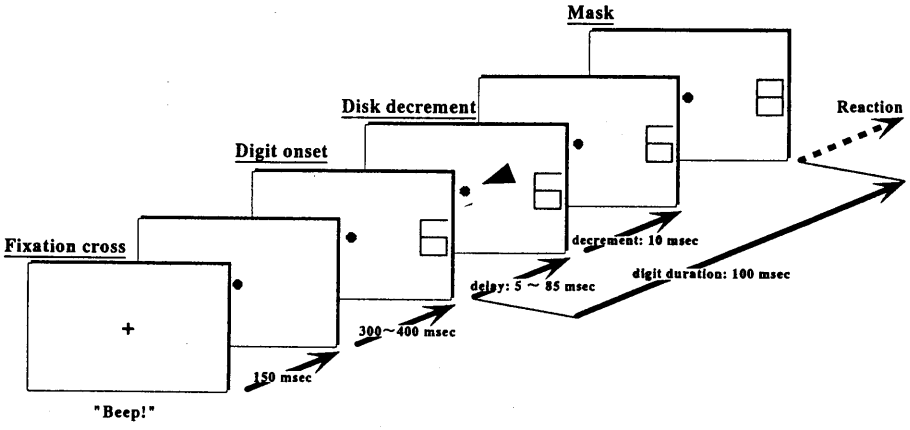

Fig. 2. Events on a single trial. In this case, digit "6" was presented on the right side, and disk patch was decrement (indicating by arrow).

RESULTS

In the recognize condition, the detection rates of the digit "3," that was used to confirm that the subjects recognized the peripheral stimuli, was more than 90% in all the subjects. Thus, it was ascertained that the subjects recognized the peripheral stimuli.

Figure 3 shows the mean detection rates of the central stimuli's luminance change. A two factor (condition × delay) ANOVA performed on arcsine-transformed responses showed that

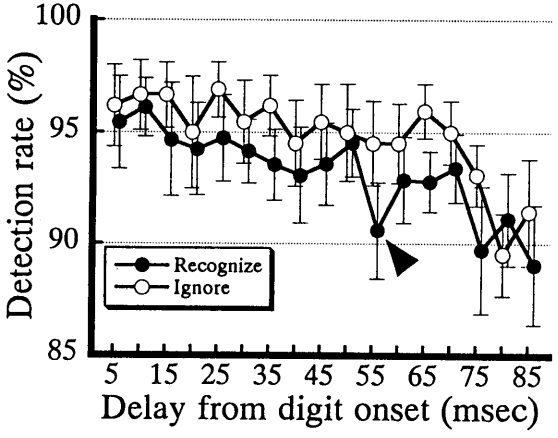

Fig. 3. Mean detection rate of detecting decrement. The detection rate was lowered with extending delay, and brief gap at the delay 55 msec (indicating by arrow). (vertical line shows standard error)

the main effects of only the condition factor was significant (F (16, 96) = 3.89, $p < .01$). Further comparisons by LSD tests for the delay factor showed that the longer the delay extended, the lower the detection rate decreased, and that there was a temporal gap at 55 msec Consequently, detection rate of the central stimuli was affected by the delay factor, and recognize condition showed the less accurate than the ignore condition.

Next, Fig. 4 shows the mean reaction time of the mean luminance decrement of the central stimuli. A two factors (condition × delay) ANOVA of the mean reaction times demonstrated that there were significant main effect to both the condition and delay factor ($F(1, 16) = 57.57, p < .01$; $F(16, 96) = 2.27, p < .05$, respectively), and the interaction was significant, too ($F(16, 96) = 1.88, p < .05$). Further comparisons tests for the interaction showed that the simple main effects of the condition factor at the all delay.

Moreover, to get hold of changing tendencies on the each condition, the recognize and the ignore condition, those data were fitted by the function. Akaike's Information Criterion (Akaike, 1976; AIC) was performed on the each data and the best function was selected (Fig. 5).

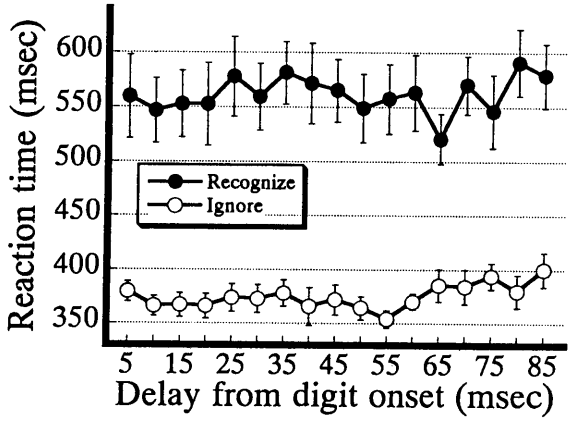

Fig. 4. Mean reaction time of detecting decrement. There were significant difference between condition factors. (vertical line shows standard error)

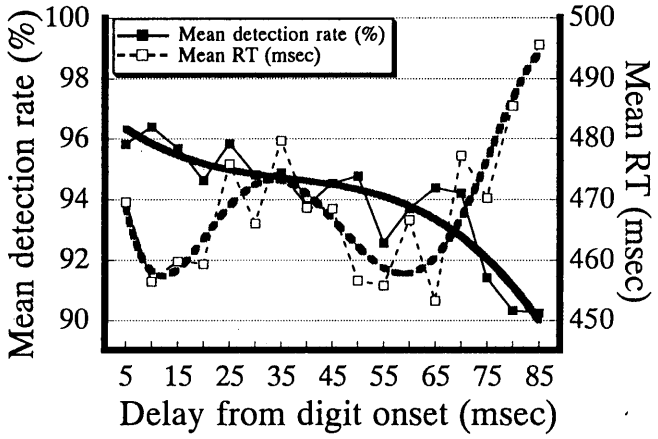

Fig. 5. AIC was performed on the each data and the best function was fitted. Wide solid line is the function of the detection rate, and wide dotted line is of the reaction time. The result shows that the mean reaction time had the periodicity. This periodicity might indicates that the attentional distribution increased and decreased in the central vision during task doing.

Discussion

In the results of the detection rates of the luminance decrement at the central stimuli, two major findings were indicated. One was the tendency that the detection rate was lowered with extending the delay. This might be occurred by "hasty conclusion" of the subjects, that is, because of the instruction to press key as fast and accurately as possible, at the long delay trials, the subjects judged that there did not changed before the decrement of the mean luminance of the central stimuli. It endorsed this confection to analyze the correct answers as below. The correct answers were divided into two elements, hit and correct-rejection, and a two-way ANOVA performed on the detection rates of the central stimuli's decrements (If the delay was lowered because of "hasty conclusion," the correct-rejection would lower round the long delays). This analysis showed that main effects of both the elements of the answers and the delays were significant ($F(1, 16) = 11.86$, $p < .05$; $F(16, 96) = 3.90$, $p < .01$, respectively;), and the interaction of the two main effects was also significant ($F(16, 96) = 3.43$, $p < .01$). Further comparisons by LSD tests for the interaction showed there were the temporal gap between the hit and the correct-rejection around the delay 55 msec, and the differences after the delay 65 msec. These results indicated that the correct-rejection shifted horizontally, but the hit gradually dropped on the later half. Thus, the phenomenon that the detection rates lowered with extending the delay was not the effects of "hasty conclusion" of the subjects.

If so, why did the detection rates was lowered? I regarded this phenomenon as the

backward effects by the abrupt onset of the peripheral stimulus. That is, a mask pattern was presented after 100 msec duration of the peripheral stimulus in order to break iconic memory. The change from the digit to the mask was to be the abrupt onset, and this abrupt onset capture the attention, and then this attentional capture was affected the task in the central vision. This result was the new finding that the visual attention had an effect on the separated location by the backward manner.

The second major finding from the experiment was that the temporal gap at the 55 msec delay. Now, I mentioned that this gap did not appear on the ignore condition, but appeared on the recognize condition. This delay of 55 msec was consistent with the time that the involuntary attention started to have its effects. However, in this experiment, there was no effect on the condition that the involuntary attention was manipulated (ignore condition). This gap might be the evidence supporting the idea of Folk, Remington, and Jonstone (1992) that not only the abrupt onset of the stimuli, but also the set of the subjects for shifting attention was needed for the visual attentional capture. However, because the duration of this gap was only 10 msec, it appears a little weak as an evidence.

On the analysis of the reaction time, there was a significant difference between both the conditions, voluntary and involuntary attention. This was consistent with the findings of Jonides (1981) that the voluntary attention was influenced by the dual tasks, but involuntary attention was not. There was opposite evidence, however, that the detection rate was influenced by the abrupt onset on the peripheral, the dual tasks would have the influence to the reaction time only.

Furthermore, from the result of the fitting the function, the reaction time was dropped after about the delay 70 msec, and this was the backward effect of changing the peripheral stimulus, as describe above. Besides this, the reaction time also moved gradually up and down having about 30 msec per cycle. This gradual movement was the implication that the attentional distribution increased and decreased in the central vision. That is, when the distribution increased the RT shortened, and when the distribution decreased the RT lengthened. Moreover, this result indicated that there was no "inhibition of return[4]" in the central vision. In another word, it may indicate that the central vision does not allow the attention to maintain shifting to the peripheral vision.

References

Akaike, H. **1976** Canomical correlation analysis of time series and the use of an information criterion. In P. R. Krishnaiar (Ed.), *Application of statistics*. Amsterdam: North-Holland, pp.27-41.

Duncan, J., Ward, R., & Shapiro, K. **1994** Direct mesurement of attentional dwell time in human vision, *Nature*, **369**, 313-315.

Eriksen, C. W., & Yeh, Y-Y. **1985** Allocation of attention in the visual field. *Journal of Experimental Psychology: Human Perception and Performance*, **11**, 583-597.

4. The inhibition of return is a property that protects from re-orienting the attention to the area searched already (Posner & Cohen, 1984).

Folk, C. L., Remington, R., & Johnstone, J. C. **1992** Involuntary covert orientating is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perceprion and Performance*, **18**, 1030-1044.

Jonides, J. **1981** Voluntary and automatic control over the mind's eye's moment. In J. B. Long & A. D. Baddeley (Eds.), *Attention and performance* **IX**. Hillsdale, NJ: Lawrence Erlbaum. pp.187-203.

LaBerge, D. **1983** Spatial extent of attention to letters and words. *Journal of Experimental Psychology: Human Perception and Performance*, **9**, 371-379.

Posner, M. I., & Cohen, S. E. **1984**. Components of visual orienting. In H. Bouma & D. G. Bouwhuis (Eds.), *Attention and Performance*, **XIII**, pp.25-42.

Posner, M. I. **1980** Orienting attention. *The Quarterly Journal of Experimental Psychology*, **32**, 3-25.

Posner, M. I., Peterson, S. E., Fox, P. T., & Raichle, M. E. **1988** Localization of cognitive operative operations in the human brain. *Science*, **240**, 1627-1631.

Posner, M. I., Snyder, C. R. R., & Davidson, B. J. **1980** Attention and the detection of signals. *Journal of Experimental Psychology: General*, **109**, 160-174.

Raymond, E., Shapiro, L., & Arnell, M. **1992** Temporary supression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception & Performance*, **18**, 849-860.

Remington, R. W., & Pierce, L. **1984**. Moving attention: Evidence for timeinvarariant shifts of visual selective attention. *Perception & Psychophysics*, **35**, 393-399.

Sagi, D., & Julesz, B. **1985b** "Where" and "what" in vision. *Science*, **228**, 1217-1219.

Shaw, M. L., & Shaw, P. **1977**. Optimal allocation of cognitive resources to spatial location. *Journal of Experimental Psychology: Human Perception & Performance*, **3**, 201-211.

Tsal, Y. **1983** Movement of attention across the visual field. *Journal of Experimental Psychology: Human Perception and Performance*, **9**, 523-530.

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