CENTRL PERFORMANCE DROP BY NON-TEMPORAL MASKING

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Abstract

Central performance drop (CPD) refers to the phenomenon that, in some conditions, texture segmentation is inferior in near fovea compared with that in peripheral area. It is controversial whether temporal backward masking is necessary for CPD to occur or not. This study proposes that CPD could occur without temporal masking. The texture was a set of oblique lines distributed on the screen. The target area was defined by the direction of the lines which were orthogonal to the lines of the non-target area. The texture was masked by the oblique lines, each of which intersected orthogonally the lines of the texture and were less bright than the lines of the texture. The subjects were requested to identify the location of the target area. As a result, the rate of correct identification decreased when the target area was farther from the fixation point of view.

Generally, visual performance declines as the target stimulus is far from the fovea. In contrast, Kehrer (1987) reported that the detection of a texture comprising foreground in which oblique lines having a common orientation and a background in which the lines having the orthogonal orientation declined as the location of the foreground was nearer to fovea. Kehrer named 'central performance drop' (CPD) for the phenomenon that detection performance declines at fovea or near-fovea area. The similar results has been obtained in a number of studies (see Gurnsey, Lenardo, & Potechin, 2004). Therefore, this phenomenon is an unquestionable aspect of vision.

The question why CPD occurs has been controversial. Kehrer (1989) proposed a spatio-temporal account of CPD, by assuming that low frequencies are processed faster than high frequencies, and that foveal processing is more associated with high frequencies and peripheral vision more associated with low frequencies and that the processing speed is higher for low frequencies that for high frequencies. Many studies reporting CPD employed a backward mask following the texture to avoid ceiling effect. If Kehrer's assumption is true, texture segmentation based on high frequencies at fovea could be interfere with by the mask, while that based on low frequencies at peripheral vision would not be because of its faster processing. This spatio-temporal account has been supported by the finding of some studies (see Gurnsey et al., 2004). Against the spatio-temporal accout, Kehrer et al. (1996) proposed that CPD could be explained by spatial terms. They assumed that texture segmentation is based on the responses of small filters at fovea and large filters in the periphery. From this assumption, the segmentation mechanism at fovea may be too small relative to the texture, while that in periphery are too large. Some intermediate eccentricity are optimal for the texture and the mechanism, resulting in a performance peak. This spatial account has also been supported by some findings (see Gurnsey et al., 2004). Consequently, the critical point of controversy on the mechanism of CPD is whether temporal aspect are necessary for explaining the CPD. This study aimed to obtain CPD without backward masking, in order to argue this question. Performances of texture segmentations as a function of eccentricities were compared between the condition in which the mask was presented after the stimulus and the condition in which the mask and the stimulus were presented simultaneously.

Method

Observers

Six undergraduate students recruited from psychology course at Osaka University participated in the experiment. All of them had normal or corrected to normal vision. They all were naïve to the experimental hypothesis of this study. They were all male students and their ages ranged from 21 to 23.

Apparatus

Stimulus presentation and the recording of observers' responses were conducted by a personal computer operated by Windows, connected to a SONY 17-inches multiscan, flat, color CRT monitor. The refresh rate of the monitor was 100 Hz, and the resolution of it was 1240 × 1024 pixels. The observers viewed the monitor from a distance of 55 cm, with their head fixated by using a chin rest. The experiment was conducted in a dark chamber illuminated by a 100-W shielded fluorescent lamps.

Stimuli

Fig. 1 illustrates the parts of the stimuli in the three experimental conditions. Actually in the experiment, the stimuli and the mask were drawn by white on black background. In the first condition, the stimuli were drawn by oblique lines and the mask was lines that intersected the stimulus lines orthogonally, which appeared after the stimuli disappeared. This condition will be referred as the *backward-mask condition* hereafter. Each micro pattern was drawn within a 28 × 28 pixel grid, and each left and right oblique line was 18 pixels in length along a diagonal direction. The position of each line was randomly jittered by 2 pixels from the center of the grid. In the second condition, the stimuli and the mask were presented simultaneously. The stimuli were the same texture as in the *Backward-mask condition.* The mask was random dots pattern, having 6 % density of white dots overdrawn on the stimulus pattern. This condition will be referred as the *random-dots condition* hereafter. In the third condition, the stimuli and the mask were presented simultaneously. The stimuli were identical to those of the *backward-mask-* and the *random-dots conditions.* The mask was the same as in the *backward-mask condition* with the exception that the oblique lines were drawn not by full white but by gray with high brightness. This condition will be referred as the *reduced-brightness condition*. All stimuli comprised of 36 rows and 36 columns of micropatterns. The vertical and horizontal visual angles of this whole pattern were 23.0 degrees. A 3 × 3 disparate region, namely foreground region, was embedded in the whole background. The direction of the lines of the foreground region was 90 degrees different from those in the background. The center of the foreground region was distant from the center of the whole pattern by eight eccentricities (1.4, 2.3, 3.3, 5.1, 7.0, 8.8, 10.7, and 12.5 degrees) per quadrant along the two oblique axes (45 degrees from vertical) that intersect the center of the whole pattern. The orientations of the foreground and background elements were randomly varied through trials to counterbalance the effect of the orientation of lines on the texture segregation performance.

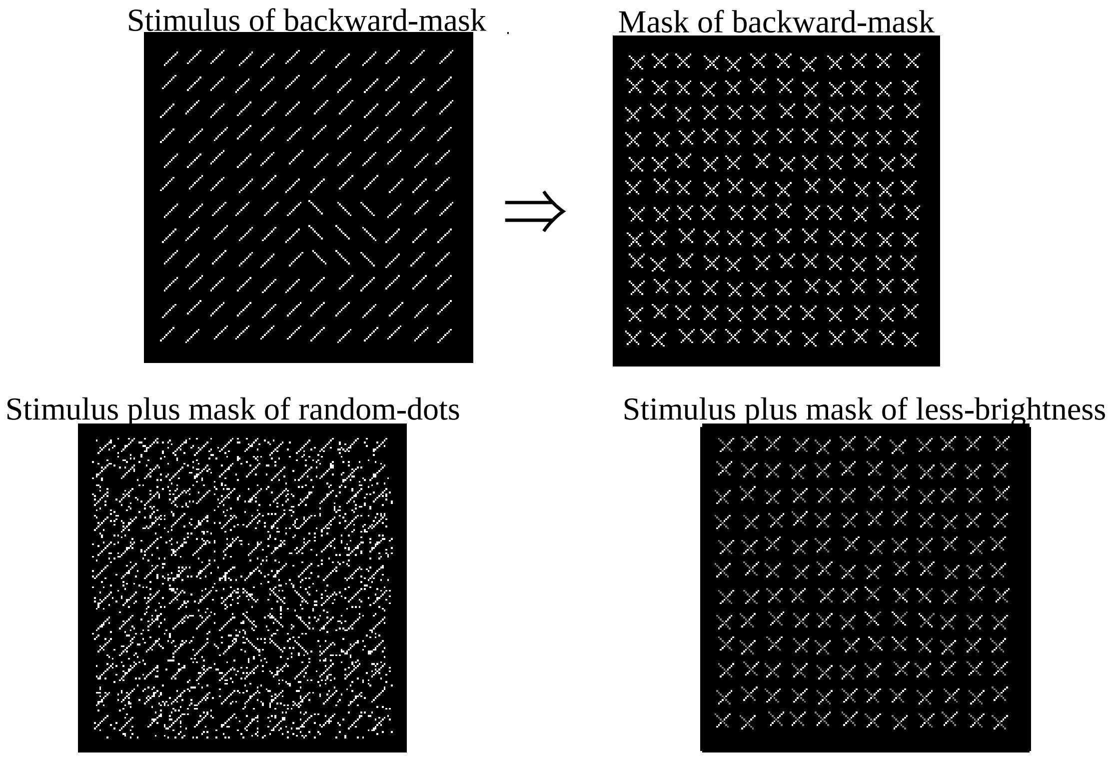

Fig. 1. Examples of stimuli used in the three conditions.

Procedure

In the backward-mask condition, each trial consisted of the presentation of a fixation point, the stimulus, and the mask. In the random-dots- and the less-brightness conditions, each trial consisted of the presentation of fixation point and the mixed pattern of the stimulus and the mask. The fixation point was presented for 500 ms prior to the onset of the stimulus presentation and the remained on through the presentation of the stimuli and the mask. The fixation point was green circle with a diameter of 3 pixels presented at the center of the whole pattern. In the backward-mask condition, the stimulus was presented for 30 ms. A mask followed immediately after that for 300 ms. In the random-dots- and the less-bright conditions, the mixed pattern of the stimulus and the mask was followed by the fixation point, for 330 ms. Following the offset of the mask in the first condition and of the mixed pattern in the last two conditions, the fixation point changed to red and remained until the observers made their response. The task required to the observers was to find the disparate region and to answer the quadrant containing that region by pressing the valid keys on the keyboard to indicate their choice. In each condition, the observers conducted 192 trials, 8 eccentricities $\times$ 4 quadrants $\times$ 6 replications. Prior to the experimental trials, the observers were provided with 32 practice trials, comprising of 8 eccentricities $\times$ 4 quadrants, each once. All observers conducted all of the three conditions. The order of the conditions was counterbalanced across the observers.

Results and Discussion

For each of the 8 eccentricities within each condition, 24 responses were collected. From these data, the percentage of the correct responses was calculated in each cell. Fig. 2

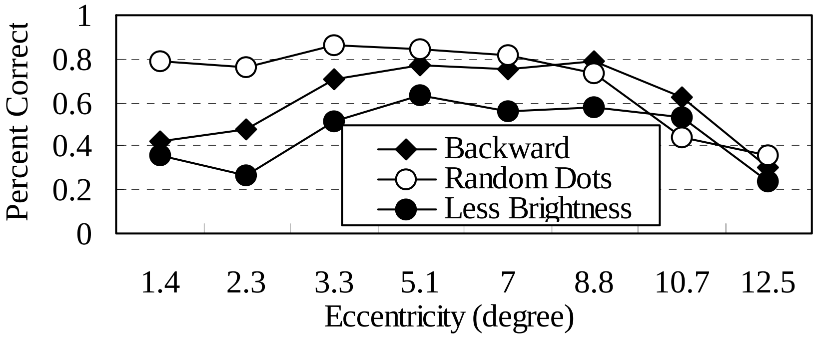

Fig. 2. Percentage of correct responses as a function of eccentricity in each conditions.

illustrates the mean percentage of the correct responses as a function of eccentricity across all observers for each condition. The purpose of this study was to investigate whether CPD could occur without backward masking. In the result of the backward-mask condition, CPD with backward masking was replicated as reported in the previous studies. Also in the result of the less-brightness condition in which no backward mask was used, CPD occurred. However, CPD did not occur in the random-dots condition. The finding that CPD occurred in the less-brightness condition implies that CPD can occur without backward masking. Potechin and Gurnsey (2003) also reported a finding consistent with that of the present study. In their study, no mask was used. Despite, they reduced the angle constructed by the orientations of the lines in the foreground and that in the background to make texture segmentation more difficult. CPD was obtained in such a pattern. Both of this study and the present study show that CPD can occur without backward masking. If the detector of line orientation is related to CPD, the structure of stimulus is more parallel to the original stimulus generating CPD that employs orthogonal oblique lines both in stimulus and mask. In random-dots condition, CPD did not occur, as is found by an experiment of Morikawa (2000). From this fact, Morikawa argued that temporal factor is necessary to obtain CPD. The difference between random-dots mask and less-bright oblique line mask may lie in the difference in the special frequencies masked by the two types of masks. From the previous and the present studies, it can be concluded that CPD can occur without temporal factors like backward masking at least in stimulus structure itself. However, it can be never been denied that the temporal factors in texture segmentation mechanisms are related to CPD.

References

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