FILLING-IN OF DOTS ON THE BLIND SPOT

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Abstract

We examined whether filling-in of dots occurred in the blind spot, when dots were presented either on one side or on opposite sides of the blind spot. Stimuli consisted of dots and a probe. The observers' task was to judge whether the number of dots on the blind spot side against the probe increased or not. When dots were presented on one side, the probabilities that more dots than one on the blind spot side against the probe were perceived were higher in vertical configurations than in horizontal configurations. However, when dots were presented on opposite sides of the blind spot, the probability was higher in horizontal configuration than in vertical configuration, and was lower in the 2.8 degree diameter condition than in the other diameter conditions. The results suggest that filling-in of dots in the blind spot is affected by the orientation and size of dots.

The blind spot is a visual field corresponding to the optic disc (Tripathy, Levi, Ogmen, & Harden, 1995). Since the optic disc has no receptors, visual information in the blind spot does not trasmit to the visual system. However, one seldomly perceives holes or defects in the visual field.

There are two hypotheses that explain this phenomenon. One is that visual system simply ignores the blind spot. The other is that visual system fills in the blind spot with visual information around the blind spot. Recently, most of the psychophysical and physiological studies support the latter hypothesis (for example, He & Davis, 2001).

Although previous studies showed that filling-in of texture and dots occurred in the blind spot, the spatial properties of filling-in of texture and dots were unclear yet. Brown and Thurmond (1993) reported that observers perceived dot patterns with the same color and distribution density as stimuli, that is, filling-in of dots occurred. Spillmann, Otte, Hamburger, and Magnussen (2007) reported that filling-in occurred when an annulus of 0.35 degree in width consisting of dots with a 0.17 or 0.25 degree diameter covered the blind spot. Kawabata (1982) showed that two dotted lines on the horizontal axis of the blind spot were perceived as continuous. On the other hand, Ramachandran (1992) reported that two vertical dotted lines consisting of large dots were not perceived as continuous. The difference might be due to the orientaiton or size of dots.

The pupose of the present study was to examine whether the orientation and size of dots affect filling-in of dots. In order to discriminate whether the blind spot was ignored or filled in, the number of dots inside of a probe was considered as an index of whether filling-in occurred or not. Experiment 1 examined filling-in of dots when dots were presented on one side of the blind spot. Experiment 2 examined filling-in of dots and perceptual completion of a dotted line when dots were presented on opposite sides of the blind spot.

Method

Observers were three graduate students and the first author. Stimuli were presented on the horizontal or vertical axis as shown in Figure 1. In Experiment 1, dots were presented on one side of the blind spot (Figure 1a). The configuration of dots was nasal, temporal, superior, or inferior. In Experiment 2, dots were presented on opposite sides of the blind spot (Figure 1b). The configuration of dots was horizontal or vertical. The diameter of dots was 0.7, 1.4, 2.1, or 2.8 degree. The gap between dots was 0.3 degree. The distance between the first dot and the border of the blind spot was 0.3 degree. The initial number of dots was one in first presentation on a trial, and the number of dots was increased when observers pressed a key. The probe, an aqua line, was presented between first and second dot from the border of the blind spot. Dots and the probe were presented for 600 ms by each key press. A red ellipse, whose radius was 0.3 degree shorter than the radius of the blind spot, was presented in the blind spot during the experiment. The stimuli were presented on a 19-inch color monitor (RDF193H, MITSUBISHI). A computer (DIMENSION9150, DELL) controlled the presentation of the stimuli and recorded the responses that were made by pressing assigned keys. The observers' head was fixed with a bite-board.

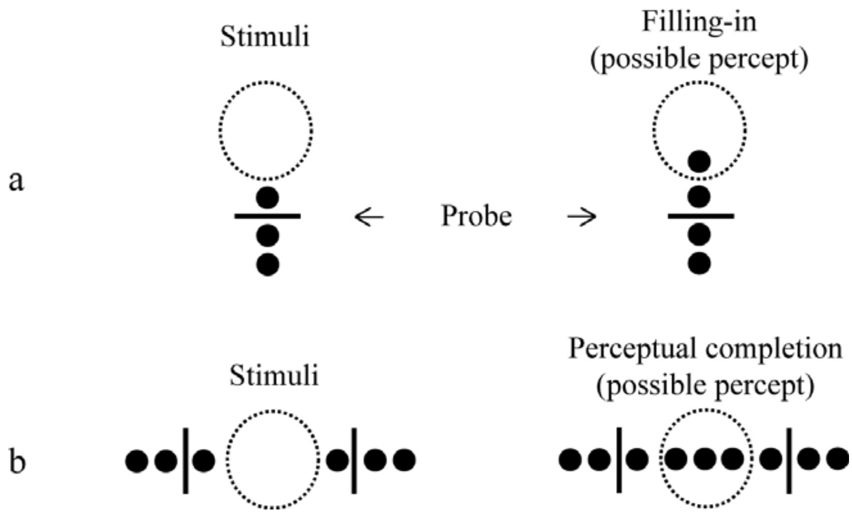

Figure 1. Example of the stimuli used in the experments and the possible percept. a. Examples of dots presented in the inferior cofiguration and the possible percept after filling-in. b. Examples of the horizontal dotted line presented on opposite sides of the blind spot and the possible percept after perceptual completion. The dotted ellipses and solid lines represent the border of the blind spot and the probe, respectively.

All experiments were conducted in a bright room. The distance between the CRT display and the observers' eye was 30 cm. The observers saw the stimuli only with the right eye, while the left eye was occluded. Before experimental trials, the blind spot of the observers' right eye was individually mapped. Hence, stimuli were presented at slightly different positions for each observer, depending on the individual areas of the blind spot.

The task of obeservers was to judge whether the number of dots on the blind spot side against the probe was perceived as more than one. In addition to the task, in Experiment 2, the obeservers judged whether two dotted lines were perceived as a continuous dotted line or not.

Results and Discussion

The probability that the number of dots on the blind spot side against the probe was perceived more than one was regarded as the probability of filling-in of dots. The results of three observers in Experiment 1 show that filling-in of dots occurs when dots are presented on one side of the blind spot. (Since an observer did not perceive dots in the blind spot in all conditions on practice trials, the observer's data were not used.) Figure 2a shows the means of the probability of filling-in of dots, averaged over the three observers, and plotted as a function of the diameter of dots separately for each configuration. When dots were presented on one side of the blind spot, filling-in occurred more in vertical configurations than in horizontal configurations. Futhermore, filling-in occurred less in the 2.8 degree diameter condition than in the other diameter conditions. These results show that the configuration and size of dots affect filling-in of dots.

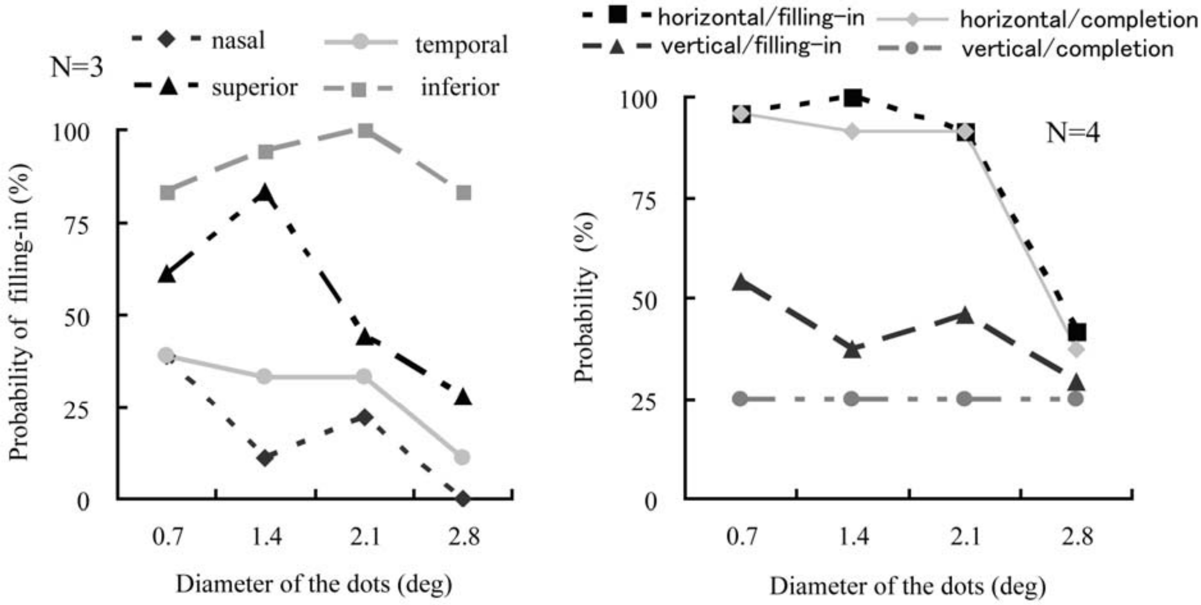

Figure 2. Results of the two experments. a. The means of the probability of filling-in of dots averaged over the three observers, and plotted as a function of the diameter of dots separately for each configuration. b. The means of the probability averaged over the four observers, and plotted as a function of the diameter of dots separately for each configuration and filling-in of dots or perceptual completion of the dotted line.

The probability that the two dotted line on opposite sides of the blind spot were perceived as a dotted line was regarded as the probability of perceptual completion of the dotted line. The results of four observers in Experiment 2 show that filling-in of dots occurs when dots are presented on opposite sides of the blind spot. Figure 2b shows the means of the probability averaged over the four observers, and plotted as a function of the diameter of dots separately for each configuration and filling-in of dots or perceptual completion of the dotted line. When dots were presented on opposite sides of the blind spot, filling-in and perceptual completion occurred more in the horizontal configuration than in the vertical configuration. Futhermore, filling-in and perceptual completion occurred less in the 2.8 degree diameter condition than in the other diameter conditions. These results show that the configuration and size of dots affect filling-in of dots and perceptual completion of the dotted line.

In summary, the results of the two experiments show that the configuration and size of dots affect filling-in of dots and perceptual completion of the dotted line. This supports the hypothesis that the blind spot is filled in by the visual information around the blind spot.

The finding of the present study can explain the difference between the previous studies about perceptual completion of the dotted line. Kawabata (1982) used the horizontal dotted line consisting of small dots, the two dotted line were perceived as a continuous line. On the other hand, Ramachandran (1992) used the vertical dotted line consisting of the large dots, the two dotted line were not perceived as a continuous line. Therefore, the difference was due to the configuration and size of dots.

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