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The effects of the global structure of the mask in visual backward masking ☆

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Abstract

The visibility of a target can be strongly affected by a trailing mask. Research on visual backward masking has typically focused on the temporal characteristics of masking, whereas non-basic spatial aspects have received much less attention. However, recently, it has been demonstrated that the spatial layout is an important determinant of the strength of a mask. Here, we show that not only local but also global aspects of the mask's spatial layout affect target processing. Particularly, it is the regularity of the mask that plays an important role. Our findings are of importance for theoretical research, as well as for applications of visual masking.

Keywords: Visual perception; Backward masking; Mask structure; Regularity

1. Introduction

In visual backward masking, a briefly presented target is followed by a mask, which impairs performance on the target. Whereas several studies in simultaneous masking have investigated spatial layout effects, most research in backward masking has been devoted to the temporal aspects of masking, such as the duration of the target and the mask, or the time between their onsets (the stimulus onset asynchrony; SOA). Surprisingly, relatively few studies have investigated the effect of the spatial layout of the backward mask. When spatial aspects were studied, typically low-level aspects were investigated, such as the spatial distance between target and mask (e.g., Alpern, 1953; Growney, 1977) and the size of the stimuli (Bridgeman & Leff, 1979; Kolers, 1962; Sturr, Frumkes, & Veneruso, 1965; Sturr & Frumkes, 1968). There are a few notable exceptions (Ramachandran & Cobb, 1995; Wehrhahn, Li, & Westheimer, 1996; Werner, 1935; Williams & Weisstein, 1981, 1984) in which the importance of the objectness of the mask was demonstrated. It was not until recently that the effects of the spatial layout of the mask started to be investigated *systematically* (Herzog, Dependahl, Schmonsees, & Fahle, 2004; Herzog & Fahle, 2002; Herzog, Fahle, & Koch, 2001; Herzog et al., 2003). These studies showed that small changes in the mask's layout, such as adding two small contextual lines (Herzog, Schmonsees, & Fahle, 2003), can strongly change the mask's effect on the target. These large effects induced by relatively minor modifications to the layout are hard to explain with low-level stimulus descriptions, such as the overall intensity of the mask (luminance × surface × duration), or the distance between target and mask.

The above experiments made use of the shine-through effect (Herzog et al., 2001; Herzog & Fahle, 2002; Herzog & Koch, 2001). If a bright vernier target (two vertical segments with a small horizontal offset) is followed by an array of 25 aligned vertical verniers, both presented on a dark background, the vernier target is clearly visible. However, if two elements are removed from the array of verniers such that two gaps arise in the grating at the same

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distance from the vernier target, masking becomes much stronger, and the preceding vernier is hardly visible. This is a surprising finding, because it shows that reducing the overall intensity of a mask can increase its masking strength.

The experiments with the shine-through effect have shown strong effects of the layout of the mask. However, all these effects were local in nature. For example, two lines were removed (Herzog et al., 2001) or two contextual lines were added to the mask (Herzog, Schmonsees et al., 2003). Here, we show that also the *global* spatial layout of the mask strongly affects its masking strength, by keeping the mask elements close to the target constant and varying the structure of the remainder of the mask. We found that masking was strongest when the mask elements were distributed in an irregular fashion, suggesting an important role of mask regularity in masking.

2. General materials and methods

2.1. Participants

The authors, members of the department, and undergraduate students participated in the experiments. The age of the participants ranged from 20 to 40 years. All participants had normal or corrected-to-normal vision, as determined by means of the Freiburg visal acuity test (Bach, 1996). Participants had to reach a value of at least 1.0 (corresponding to 20/20) in this test for at least one eye. The students were paid for their participation.

After being informed about the general purpose of the study, participants gave informed consent and were informed that they could quit the experiment at any time they wished. None of the participants used this possibility.

2.2. Apparatus

Stimuli were presented on an X–Y display (HP 1334 A or Tektronix 608) controlled by a PC (Pentium 4 or Power Macintosh) via fast 16 bit D/A converters (1 MHz pixel rate).

Depending on the target duration, which was selected individually for each participant, the refresh time of the display was set to 5 or 6 ms. The luminance of the stimuli was set to approximately 80 cd/m^2 as determined with a Minolta LS-100 luminance meter. A background light illuminated the room at about 0.5 lux.

2.3. Stimuli

In all experiments, the target stimulus consisted of a vertical vernier of which the segments were horizontally offset (as illustrated in the small inset of Fig. 1). Segments were 10′ long and separated by a small vertical gap of 1′. Hence, the total length of the vernier was 21′. The vernier duration was determined individually for each observer and ranged from 10 to 30 ms.

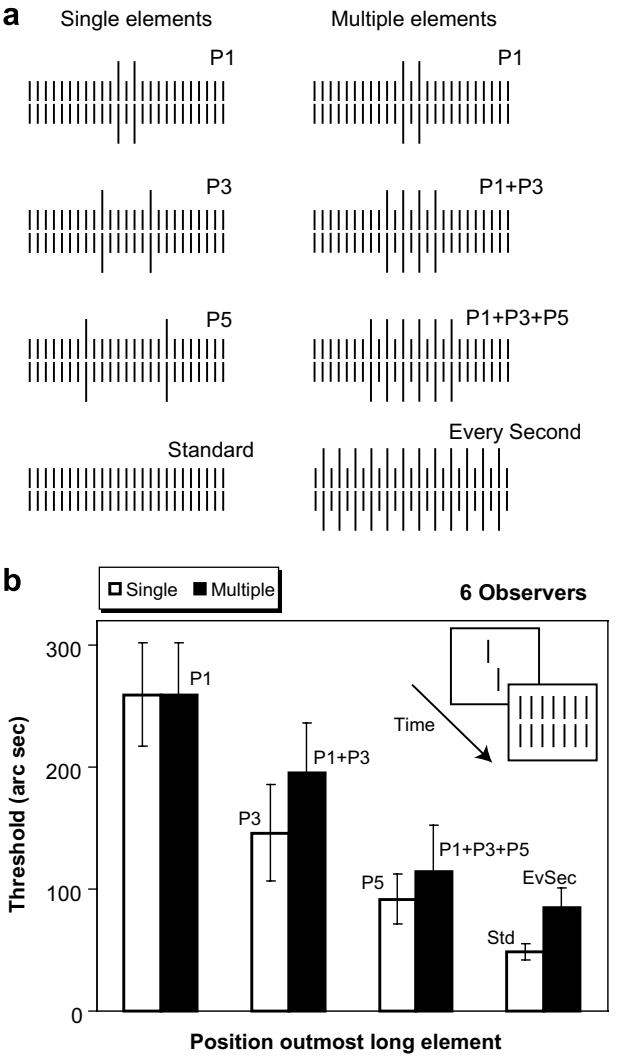

Fig. 1. Masks (a, in reverse contrast) and mean thresholds across observers (b) of Experiment 1. In the 'single element' conditions, we find that placing the longer lines further away from the center results in lower thresholds, indicating weaker masking (white bars). In the 'multiple elements' conditions, adding more lines to the mask resulted in a decrease of the threshold (black bars). Error bars show the standard error of the mean. The small inset in the data plot illustrates the sequence of target and mask (in reverse contrast).

A mask immediately followed the target vernier. The standard mask consisted of an array of 25 aligned verniers (see left of Fig. 1, 'Standard' grating). Additional grating masks were constructed from this standard grating by changing the length of some of the standard grating elements. The spacing between grating elements was 200″ in all conditions. Masks were presented for 300 ms.

The target vernier and the grating mask were both presented in the middle of the screen, and were preceded by a fixation screen consisting of a small cross in the center of the screen and four line elements in each of the corners for 1 s, followed by a blank screen presented for 400 ms.