Edges and Lines minimally mask width discrimination of Rectangles

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Abstract

We studied the effect of various attributes of visual masking on width discrimination of rectangles. We found that masks even one tenth the width of the target were as effective as masks twice the width of the target. Masks were effective when they were shown from 30 milliseconds before the target was presented to 110 milliseconds after it. Masking was effective regardless of whether the mask overlapped the target area or not. Onset and offset of nearby edges were not necessarily effective as masks. Positive and negative luminance contrasts were equally effective for masking.

Summary

Measurements of visual masking phenomena may establish temporal constraints on possible mechanisms for processing a visual stimulus that any model would need to satisfy. Such measurements might also help determine the conditions under which recurrent processing of visual information might be more appropriate than a feed forward processing architecture. An excellent review of recent models and experimental findings in backward visual masking lists the positive contributions of the existing models as well as their limitations and inadequacies (1). Many attempts at understanding the backward masking effect have assumed that if a mask presented after the stimulus is effective, there must be some signal from the mask that seems to catch up to the target signal and degrades it. This was explicitly expressed in the dual-channel sustained-transient approach to visual masking introduced about two decades ago (1). Some of the more recent quantitative models emphasize modification of feed forward or feedback inhibition for spatial sharpening of the stimulus, which results in the erosion of stimulus boundaries over time as an explanation of backward masking.

We studied how visual masking affects our ability to discriminate the width of a 7 by 11 arc min. solid rectangle. We find that when the test rectangle is shown for 3 msec and is not followed by any other stimulus, observers are able to distinguish it reliably from a rectangle that is just 4% different in width (i.e. Weber fraction,Wf, of 4%). This performance improves incrementally to a Wf of

3% when the presentation time is extended to a full second. However, when the briefly presented test rectangle is masked by being preceded or followed by some other visual stimuli that are shown for an extended time (until the observer responds), the ability to discriminate size is degraded. We also found that the degradation could be fairly severe for naïve observers who were sometimes unable to see the test rectangle at all. However, with a little practice their performance improved dramatically. Here we report the results of trained observers whose performance on each set of stimuli had stabilized and did not appear to be changing with further training.

The mask was a pair of solidly filled rectangles 7 by 15 arc min in size with one rectangle 14 arc min above and the other 14 arc min below the test rectangle (See Fig 1). When the mask is presented 10 msec after the test rectangle (i.e. Interstimulus interval, ISI, was 10 msec) a Wf of 7.8% was measured. For an ISI of 110 msec we obtained a Wf of 6% and the largest Wf of 8.9% was obtained for an ISI of 42 msec. All of the following results are for an ISI of 42 msec. The test rectangle was always shown for 3 msec.

The Wf changed gradually from a maximum of 8.9% to 5.5% when the width of the masking rectangles wA increased from 15 arc min to 81 arc min. However, the Wf was 7.9% when the width of the masking rectangles was only 0.8 arc min (i.e. the mask was a 7 arc min long bar above and below the test rectangle). This might suggest that it is mainly the active edges of the mask that contribute to the masking effect as has been proposed in many of the existing models. However, when we widened the 7 by 15 arc min masking rectangles to 7 by 81 arc min and retained the vertical lines marking the ends of the original 7 by 15 arc min mask rectangles the Wf remained 5.5% as was found with the wider 7 by 81 arc min masks alone (See Fig 2). Apparently the vertical edges of the smaller mask were not contributing much to the masking effect. Interestingly when we used 5 by 2 arc min. vertical lines filling about 10 percent of a 65 by 81 arc area as the mask, thereby providing lots of edges at varying distances from the test rectangle's edges, the Wf was only 6%, barely different from the 5.5 % obtained with the solidly filled 7 by 81 arc min. mask. However, when this mask is modified so that no line is drawn in an area of 12 by 20 arc min concentric with the target rectangle, the Wf is now again greater than 8%. This result is unchanged when the luminance contrast of the lines is reversed. Since the density of the lines is low and no areas are demarcated explicitly there is no obvious real extended contour visible near the edges of the test rectangle. This is not predicted by models which rely upon active edges of the mask laterally inhibiting and eroding boundary formation of the target over time.

Fig 1

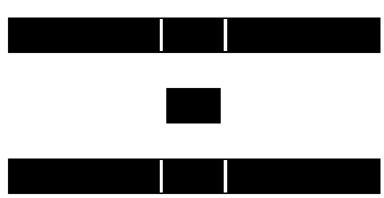

Fig 2.

1) Breitmeyer, B. G., Ogmen, H. Recent models and findings in visual backward masking: A comparison, review, and update. Perception & Psychophysics, 2000 Nov, Vol. 62 (8): 1572-1595.