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Masking with faces in central visual field under a variety of temporal schedules

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ABSTRACT

With a few exceptions, previous studies have explored masking using either a backward mask or a common onset trailing mask, but not both. In a series of experiments, we demonstrate the use of faces in central visual field as a viable method to study the relationship between these two types of mask schedule. We tested observers in a two alternative forced choice face identification task, where both target and mask comprised synthetic faces, and show that a simple model can successfully predict masking across a variety of masking schedules ranging from a backward mask to a common onset trailing mask and a number of intermediate variations. Our data are well accounted for by a window of sensitivity to mask interference that is centered at around 100 ms.

1. Introduction

The use of visual masking as a means to study the nature of visual perception has a long and rich history (Breitmeyer & Ogmen, 2006). By measuring the effect that varying spatiotemporal relationships between target and mask have upon visual processing of the target, valuable insights can be gained about the time course of visual perception (Bacon-Macé, Macé, Fabre-Thorpe, & Thorpe, 2005; Bar et al., 2006; Reeves, 1982), as well as spatial properties of vision (Ghose, Hermens, & Herzog, 2012; Habak, Wilkinson, & Wilson, 2006). While masking continues to remain a popular tool in the study of vision (Breitmeyer, 2007), the general temporal character of the mask has been limited to two broad classes: those involving a briefly flashed (pulsed) mask (e.g. Burr, 1984) and those involving a common onset trailing mask (e.g. Di Lollo, Enns, & Rensink, 2000). In the former case, the primary temporal property of the mask that is studied is the stimulus onset asynchrony (SOA), where the onset of the mask is varied relative to the onset of the target (although there have been systematic investigations of the effect of changing the duration of target and mask pulses, e.g. Breitmeyer, 1978; Macknik & Livingstone, 1998). In the latter, the duration of the trailing mask is varied. The use of these classes of mask schedules has also led to the development of unique *spatial* relationships between target and mask structure. In most modern studies involving a pulsed mask, the contours of the mask and target are closely aligned, while studies involving a trailing mask typically use a sparse mask (Fig. 1). Furthermore, pulsed contour masks are often studied in central visual field, while sparse masks are usually studied in peripheral visual field.

This packaging of stimulus properties is not accidental. The discovery that a sparse, four dot mask can produce powerful masking supports the idea that the mechanisms of masking here involve interference with feedback from higher to lower areas of visual processing, as it is difficult to account for such masking with local feedforward effects such as lateral inhibition (although see Bridgeman, 2007). For example, the finding that robust masking can be obtained with non-foveal stimuli using large target-mask separations is difficult to explain with lateral inhibition (e.g. Growney, Weisstein, & Cox, 1977, although see Breitmeyer, Rudd, & Dunn, 1981). Accordingly, while a contour mask may derive its effectiveness through lateral inhibition and feedback (Enns, 2004), a sparse mask may be effective through feedback alone. Furthermore, the finding that it was, until recently (Filmer, Mattingley, & Dux, 2015), challenging to produce masking using a sparse mask with a single target in central visual field means that object substitution/updating studies often use multiple simultaneous targets arranged in the peripheral visual field. However, the fact that a sparse, trailing mask is effective primarily in peripheral visual field does not mean, ipso facto, that the basic properties of object processing are not shared between peripheral and central visual field. Object substitution masking (OSM) is thought to

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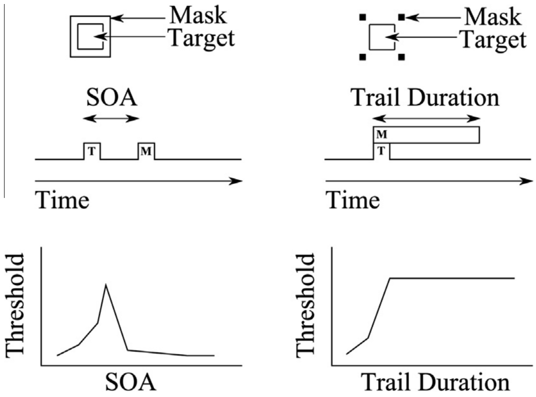

Fig. 1. Two broad classes of masking schedules. Left: a pulsed backward contour mask. Right: a sparse four dot common onset trailing mask. Typical masking functions for each are shown at bottom.

involve the interference of a masking pattern with feedback which, under normal (non masked) viewing, would serve to consolidate the target into conscious visual processing. The fact that OSM is not as effective in central visual field does not mean that feedback is not used to consolidate visual processing in central visual field; rather, this more likely means that these sparse masks are not powerful enough relative to the robust representation of information in central visual field (Enns & Di Lollo, 1997). Accordingly, the effectiveness of a contour mask in central visual field may be at least partially due to object substitution mechanisms (Enns, 2004). Notably, a common onset contour mask in central visual field was found to produce powerful masking (Bischof & Di Lollo, 1995), showing that contour masking can occur without a delayed onset, and recent accounts of metacontrast masking include feedback mechanisms (Breitmeyer, 2007; Silverstein, 2015; Tapia & Breitmeyer, 2011).

One approach in exploring the extent to which mechanisms in backward masking and common onset masking overlap is to create a paradigm where the schedules of masking can be arbitrarily varied between the two extremes (pulse and common onset trail), while keeping constant both the spatial relationships between target and mask, and the location of presentation in visual field. In the current study, we use centrally presented synthetic faces (Wilson, Loffler, & Wilkinson, 2002) for both target and mask, and explore the effects of varying mask schedule upon performance in a face identification task. The parametric generation of our faces allows us to titrate the difficulty of each testing condition to avoid ceiling and floor effects (Argyropoulos, Gellatly, Pilling, & Carter, 2013). Our particular faces are also interesting in that they contain elements of contour masking, as well as masking by structure (Fig. 2).

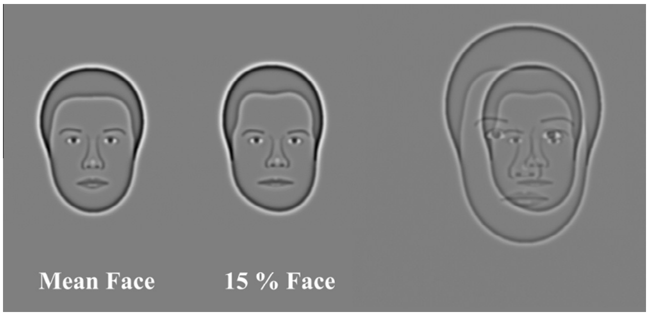

Fig. 2. Target and mask stimuli. Left: mean face. Middle: face whose identity differs from the mean by 15%. Right: 15% face is masked by the mean face. In any given trial, the target face would be either the mean face, or one of a number of identities of various strengths. The mask, which was 50% larger than the target face, was always the mean face. Note that the head outlines of the mask and target face serve to function as contour masks, while the features serve as a structure mask.

Our study is divided into three sets of experiments. The first set is designed to assess whether our stimuli can produce effective masking using both pulsed and trailing masking schedules, and to probe what effect, if any, briefly interrupting a trailing mask has upon performance. The second set follows up on this in order to determine if and when mask energy, across the duration of a single trial, has an additive effect upon performance. The third experiment follows up on the previous ones and explores the role of transients. Our results demonstrate the effectiveness of using faces in central visual field, both as a pulsed and trailing mask. Our results also suggest that additivity of mask energy across time depends upon the temporal window in question, and we have developed a model that suggests there is a distinct moment in time when the mask can interfere with target processing.

2. Experiment 1a

In this first experiment, we tested the effectiveness of our stimuli under two masking conditions: as a backward mask, and as a common onset trailing mask (Fig. 3).

2.1. Stimuli

Synthetic faces (Wilson et al., 2002) were used for both target and mask patterns (see Fig. 2). The target face was either the mean of a set of 41 male faces, or a face whose distance from the mean was determined by a staircase procedure (two-down-one-up). On each trial, the identity of this latter face was randomly chosen from one of four orthogonal identities. On each run, four new identities were randomly chosen from the set of the 41 faces and then orthogonalized. The mean face was used as the mask, and was 50% larger than the target face. Our stimuli were presented on a VIEWPixx display, which has the advantage of a scanning backlight coupled with a fast pixel response time (black to white rise time = 1 ms, and white to black fall time = 1 ms). The display was set to a refresh rate of 120 Hz (8.3 ms per frame). We took advantage of these properties, and used an interleaved frame approach to present our stimuli. Presenting the target and mask in alternating frames is perceptually equivalent to the two stimuli being presented simultaneously at 60 Hz at half contrast. At a viewing distance of 1.28 m, the screen subtended 23 by 13 degrees of visual angle, horizontally and vertically. The target faces subtended an average of 3.5 by 5.0 degrees, and the mask face subtended 5.25 by 7.5 degrees. The display was calibrated to linear light (gamma = 1), and the mean luminance of the screen, measured with a Konica-Minolta LS-110, was 59.8 cd/m^2.

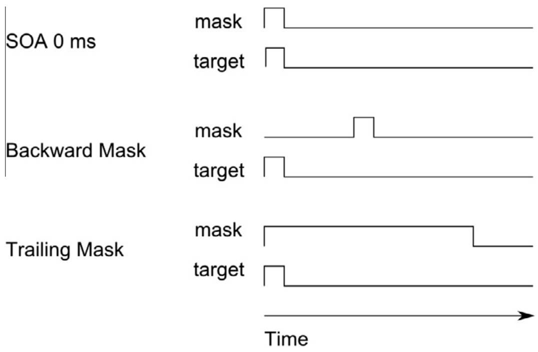

Fig. 3. General schematic of backward and trailing mask conditions in experiment 1a. The zero SOA condition is also shown.