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Motion-induced blindness is influenced by global properties of the moving mask

Erika T. Wells[1] and Andrew B. Leber[2]

[1]Department of Psychology, Union College, Schenectady, NY, USA
[2]Department of Psychology, The Ohio State University, Columbus, OH, USA

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Perceptual fluctuations experienced during motion-induced blindness (MIB) have been characterized as the result of a competition between representations of the moving mask and stationary (or slowly moving) targets (Bonneh, Cooperman, & Sagi, 2001). While there is evidence to support a local influence of the mask on target disappearance, what is not yet clear is whether the global properties of the mask can likewise impact disappearance. In the present study, we investigated the presence of a global effect of the mask on MIB by manipulating global motion properties of the mask while controlling its local motion properties surrounding the target. Results showed a significant impact of the global mask properties on the observed degree of disappearance. We also tested for a complementary local effect by comparing conditions in which we manipulated local mask properties while controlling global properties. This analysis did not yield evidence for a local effect, although this may have been due to our weaker manipulation of local mask properties compared to previous studies. Overall, the present results highlight a key role of global stimulus representations in producing the perceptual disappearances observed in MIB.

Keywords: Motion-induced blindness; Mask effects; Motion coherence; Awareness.

Motion-induced blindness (MIB), first reported in 2001 by Bonneh, Cooperman, and Sagi, describes a perceptual phenomenon whereby stationary, peripheral targets undergo cyclic periods of invisibility when surrounded by motion. Since the first report of the phenomenon, researchers have focused on understanding how the moving objects (collectively referred to as the *mask*) induce a stationary object to fade from perception. In their original report, Bonneh and colleagues

Please address all correspondence to Erika T. Wells, Department of Psychology, Union College, 313 Bailey Hall, Schenectady, NY 12308, USA. E-mail: wellse@union.edu

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suggested that the effect is driven by a competitive interaction between the online representations of the mask and target. What is not yet fully understood is the extent of influence of the mask–target interaction on disappearance. To shed light on this issue, we ask the following question in the present study: Is the scope of the interaction between the mask and target limited to the local area surrounding the target or is the influence much broader, encompassing the overall global nature of the mask?

Previous research provides good evidence that local interactions between the mask and target selectively drive perceived disappearance (Libedinsky, Savage, & Livingstone, 2009; Wallis & Arnold, 2008, 2009)—what we will henceforth refer to as the *local effect*. Libedinsky et al. (2009) reached this conclusion from an experiment in which they compared a mask containing a global array of coherently rotating elements to a mask with elements spatially limited to the area around the target. Their local mask was generated by superimposing a virtual (background coloured) occluder on the global mask, which covered all but a small region of the display. Results showed that disappearance was not significantly different between the two mask conditions, and one might thus conclude that competition between the mask and target is determined by local mask characteristics. The lack of an effective change in disappearance with an increasingly larger mask suggests that any global influences may be minor compared to spatially restricted, local suppressive mechanisms. To further bolster this idea, Libedinsky et al. manipulated the placement of the local mask such that only the left half of the mask was visible. Fixation was then systematically manipulated, allowing the mask and target to appear in the same or different visual hemifield. Libedinsky et al. found that disappearance favoured the same hemifield condition. They reasoned that the hemispheric organization of early visual cortex provides greater competition between the target and mask representations within the same hemifield, again suggesting a local effect on MIB.

Others have corroborated the local account by introducing subtle changes to the characteristics of the mask in close proximity to the target. For example, a small number of dots moving away from a target increase disappearance compared to when the dots move towards the target. This effect may be the result of local suppression due to motion traces produced following movement of the mask elements (Wallis & Arnold, 2009). Furthermore, local modulations in temporal frequency of mask elements appear to selectively impact target disappearance (Wallis & Arnold, 2008). Finally, local spatial interactions in MIB may also help to explain why increasing the density of items in the mask without any variation in its size results in an increase in target disappearance (Bonneh et al., 2001; Wells, Leber, & Sparrow, 2011); it is presumed that the greater the number of mask elements surrounding the target, the greater the likelihood of a local mask–target interaction.

There is clear evidence supporting the existence of the local effect, but this does not rule out an additional *global effect* (where global is defined as the summation of mask properties across the display). Although the global effect has not been investigated directly, previous research does provide some clues. For instance, global properties of depth ordering and surface completion of the mask impact disappearance. Graf, Adams, and Lages (2002) found that a mask sharing the same depth plane as the target produces less disappearance compared to a mask that is perceived to be in front of the target. With respect to surface completion, the same authors used Kanizsa elements to produce subjective contours and thus the perception of a completed surface. This completed surface produced greater disappearance compared to when the elements were rotated to prevent surface completion. These results demonstrate that mask components producing MIB need not be physically placed in close spatial proximity to produce disappearance and in some cases a distal mask (i.e., in depth) can be more effective.

The Graf et al. (2002) study opens the door to the possibility of a global effect, and in our present work we aim to test this directly. Here, we systematically manipulate global mask properties while holding local properties constant. We adopted a new approach, guided by our recent findings that a change in motion coherence precipitates a change in target disappearance. We found that as the motion coherence of the mask increased (i.e., from dots moving with 0% coherence to dots moving with 100% coherence), target disappearance decreased. This differential effect of mask coherence on target disappearance allows a unique opportunity to investigate locations where motion coherence would significantly impact disappearance. By selectively manipulating the degree of motion coherence within spatially confined regions of the mask, we could compare stimulus conditions where global mask properties were manipulated while local properties surrounding the target were held constant, thereby isolating the global effect. For instance, imagine the following two example stimulus conditions: The first stimulus condition could contain one column of coherent downward motion surrounding the target paired with a column in the opposite hemifield that also contains coherent downward motion (Figure 1a). In contrast, the second stimulus condition could again contain one column of coherent downward motion surrounding the target but now paired with a column of incoherent motion in the opposite column (Figure 1c). When comparing the two conditions, the former condition is more globally coherent than the latter. At the same time, the local properties are controlled for and thus do not confound any inferences to be made about a global effect on MIB. Thus, if MIB is at least partly determined by a global effect, then a decrease in overall mask coherence should produce greater disappearance; the direction of this effect is predicted by our previous study manipulating coherence (Wells et al., 2011). However, if there is no global effect (i.e., only local mask properties drive MIB), then observed disappearance should be the same in these two conditions.

Beyond our main pursuit of testing the global effect, we also took the opportunity to isolate and investigate the local effect. Here, we examined conditions where the local mask properties surrounding the target were manipulated but the

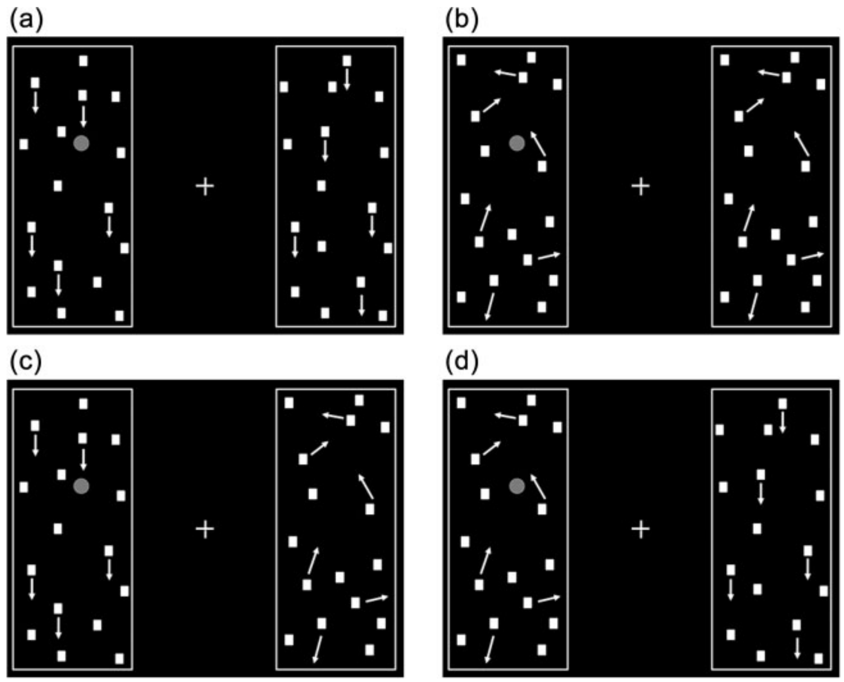

Figure 1. Stimulus conditions 1–4 used in Experiment 1 (see text for detail). Each stimulus had two columns of motion on the left and the right of fixation. (a) Stimulus 1: $T_{Coh}O_{Coh}$, (b) Stimulus 2: $T_{Incoh}O_{Incoh}$, (c) Stimulus 3: $T_{Coh}O_{Incoh}$, (d) Stimulus 4: $T_{Incoh}O_{Coh}$. In all experiments, the moving square dots were blue and the peripheral, circular target was yellow. A visible, grey frame outlined the two outer columns. Arrows, here depicting the overall motion in each column, were not present in the actual stimulus.

global properties were held constant. For instance, in one stimulus condition the target column could contain coherent dot motion, while the opposite column could contain incoherent motion (Figure 1c). In another condition, the columns could be switched such that the target column now has incoherent motion and the opposite column coherent motion (Figure 1d). Across these two conditions, the global properties are identical but the local properties surrounding the target diverge. Thus, if a local effect at least partly determines MIB—outside of any global contribution—then greater disappearance should be observed in the condition containing local incoherent motion compared to the condition with local coherent motion.

EXPERIMENT 1

Method

Participants. Sixteen participants (12 females, four males; aged 18–29) with normal or corrected-to-normal visual acuity took part in the experiment. All were students from the University of New Hampshire and received partial course credit. Informed consent was obtained from each participant.

Stimuli. Stimuli were viewed from an approximate distance of 50 cm. on a 19-inch CRT display (ViewSonic G90fb) powered by an Apple G4 desktop computer with a refresh rate of 85 Hz. The design and implementation of the stimuli were achieved using Matlab (Mathworks, Natick, MA) with PsychToolbox extensions (Brainard, 1997; Pelli, 1997). The stimuli consisted of a mask composed of two distinct, evenly spaced, columns of 49 blue moving dots, each subtending 0.20 degrees with a dot density of 0.91 dots/deg^2 and maintaining a speed of 8.51 deg/s. Each column subtended 3.98 deg × 13.60 degrees, was surrounded by a grey aperture, and positioned on a black background. A fixation cross was placed at the centre of the display and the distance from the fixation cross to the centre of each column was 5.56 deg. The intensities of the background and mask were 0.05 and 10 cd/m^2, respectively.

Each dot in a column had a limited lifetime of 235 ms at which point it was replaced by another dot in a randomly determined position. Incoherent motion was achieved by assigning each dot a random angle of trajectory from one to 360 degrees with a new angle and position being randomly determined for each new dot "birth". When a dot reached the edge of the column aperture, it was replaced by another dot in an equivalent location on the opposite side. Coherent dots followed a predictable linear downward trajectory. We specifically eliminated the use of horizontal coherent motion to avoid the perception of motion colliding with the columns but it should be noted that our earlier study (Wells et al., 2011) revealed no difference in target disappearance between coherent motion in any of the four cardinal directions, i.e., up, down, left, or right.

While maintaining gaze on the fixation cross in the centre column, observers were instructed to report the perceived disappearance of a yellow (95 cd/m^2), stationary peripheral 0.55 deg diameter circular target. The location of the target appeared either in the left or right column with the centre of the target positioned at 5.56 deg horizontally from fixation and 3.29 deg vertically from fixation for an angular eccentricity of 6.46 deg. The eccentricity of the target was far enough to ensure placement in the centre of the column. A protection zone measuring 1 deg in width surrounded the target. This prevented any mask dots from entering the area in close proximity to the target.

The variables of motion coherence (coherent, incoherent) and target location (left, right column) were manipulated to produce the following four stimulus conditions, each accounting for 25% of the total number of trials (the abbreviations of "T" and "O" are used to indicate target column or opposite column):

1. $T_{Coh}O_{Coh}$: Both target column and opposite column contained coherent motion moving in the same downward direction (Figure 1a). On half of

the trials, the target was presented in the left column, and on the remaining trials the target appeared in the right column.

2. $T_{Incoh}O_{Incoh}$: Both target column and opposite column contained incoherent motion (Figure 1b). Target side (left or right) was manipulated as in stimulus condition 1.
3. $T_{Coh}O_{Incoh}$: The target column contained coherent motion and the opposite column contained incoherent motion (Figure 1c). Target side was manipulated as in stimulus condition 1.
4. $T_{Incoh}O_{Coh}$: The target column contained incoherent motion and the opposite column contained coherent motion (Figure 1d). Target side was manipulated as in stimulus condition 1.

Design and procedure. Participants were instructed to press the right shift key when they saw the target disappear and release it upon target reappearance. The time recorded in between the button press signalling a target disappearance and the button release signalling target reappearance was defined as an MIB episode (in seconds). The mean length of an MIB episode constituted the average of all the MIB episodes in a trial. Finally, the percentage of time the target was perceived to disappear across the trial (percentage disappearance) was calculated as the ratio of the pooled MIB episodes within a trial as a function of the 30 s trial. These two measures of disappearance were normalized for each participant in an effort to minimize variability in disappearance. Normalization for each condition was calculated as a ratio of the pooled data across trials divided by the average across all conditions. The majority of MIB studies have used only one of these two measures, but we employed both to allow a broader ability to determine how MIB changes across different conditions, an approach that has been used with other rivalry phenomena (e.g., Sobel & Blake, 2002). Note that additional measures could be used, such as gamma fits, which can be useful in modelling stochastic fluctuations of rivalry phenomena (Carter & Pettigrew, 2003); however, we did not feel the present study warranted this measure.

Each participant completed a minimum practice session of six trials, each lasting 30 s. Following the practice trials, participants completed a total of 96 trials, divided into six blocks of 16 trials, each trial also lasting 30 s. Each mask type was presented four times in random order within a block, for a total of 24 trials for each stimulus condition per session. A self-timed break after each block was provided.

Results and discussion

Group means from the four stimulus conditions are plotted for both normalized percentage disappearance (Figure 2a) and for normalized length of an MIB episode (Figure 2b). A one-way, repeated measures ANOVA was conducted on

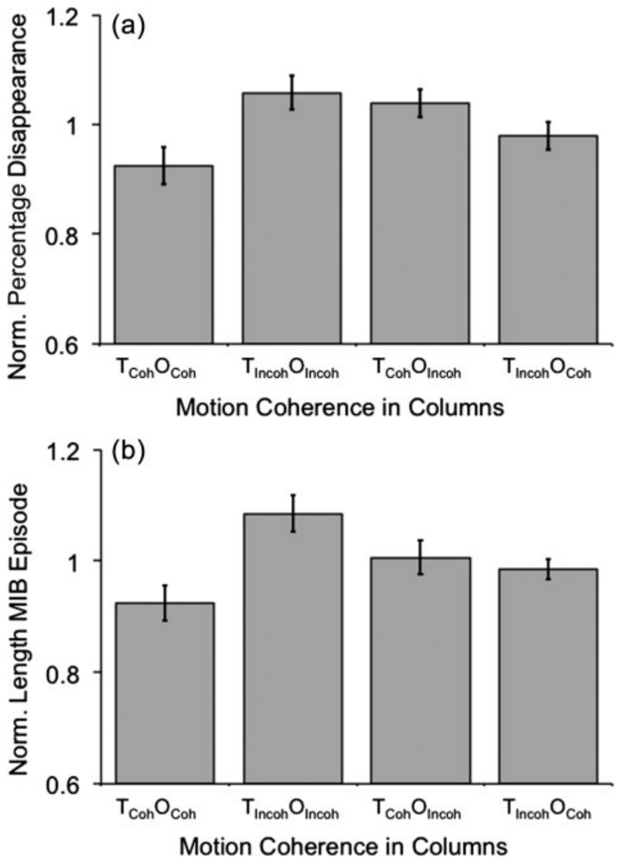

Figure 2. Results of Experiment 1: Means for each stimulus condition are plotted for (a) Normalized percentage disappearance and for (b) normalized length of an MIB episode. Error bars indicate within-subject variability (±1 SEM).

the four different mask conditions. When Mauchly's test determined the data violated the assumption of homogeneity of variance, we used a Greenhouse-Geisser correction applied to the degrees of freedom. We found a main effect of mask type for normalized percentage disappearance, $F(3, 45) = 3.27$, $p = .03$, $\eta^2 = .18$, and a main effect for normalized length of an MIB episode, $F(3, 45) = 4.01$, $p = .01$, $\eta^2 = .21$. In the following paragraphs, we present the results of several a priori contrasts between these conditions. For each a priori pairwise comparison we report the means for each mask condition, uncorrected *p*-values and effect sizes (Cohen's *d*).

First, to ensure that our manipulation of mask coherence replicated our previous work (Wells et al., 2011) and successfully influenced MIB, we compared MIB measures for coherent motion in both columns versus incoherent motion in both columns ($T_{Coh}O_{Coh}$ and $T_{Incoh}O_{Incoh}$). In line with our previous results, a planned comparison found greater disappearance with incoherent motion across the display compared to coherent motion for normalized percentage disappearance (1.06 vs. 0.93, p = .04, d = 0.55). A similar result was found for normalized length of an MIB episode (1.09 vs. 0.92, p = .01, d = 0.75).

Next, we pursued our primary question, which concerned the contribution of global mask properties to MIB (i.e., the global effect). Specifically, we compared conditions in which the local motion at the target remained constant but the global motion properties summed across the display varied. This resulted in two comparisons: (1) $T_{Incoh}O_{Incoh}$ versus $T_{Incoh}O_{Coh,}$ and (2) $T_{Coh}O_{Coh}$ versus $T_{Coh}O_{Incoh}$. Planned pairwise comparisons revealed a significant difference for normalized percentage disappearance between $T_{Incoh}O_{Incoh}$ and $T_{Incoh}O_{Coh}$, 1.06 versus 0.98, p = .03, d = 0.60 and for $T_{Coh}O_{Coh}$ and $T_{Coh}O_{Incoh}$, 0.93 versus 1.04, p = .008, d = 0.76. This shows that when global incoherence increased, disappearance increased, supporting a global effect.

The same set of pairwise comparisons was carried out for the normalized length of an MIB episode. These showed a significant difference between $T_{Incoh}O_{Incoh}$ and $T_{Incoh}O_{Coh}$, 1.09 versus 0.99, p = .01, d = 0.74. Although the difference between $T_{Coh}O_{Coh}$ and $T_{Coh}O_{Incoh}$ was numerically in the predicted direction, the difference did not reach significance, 0.92 versus 1.01, p = .11. As in the normalized percentage disappearance analysis, when global incoherence increased, MIB increased, again supporting a global effect.

Our final comparisons tested for the local MIB effect. We compared the stimulus conditions in which global properties were held constant but the local motion properties surrounding the target varied ($T_{Coh}O_{Incoh}$ vs. $T_{Incoh}O_{Coh}$). Results of pairwise comparisons revealed no significant difference between the two conditions for normalized percentage disappearance, 1.04 versus 0.98, p = .22, or for normalized length of an MIB episode, 1.01 versus 0.99, p = .54. Thus, by varying the local motion coherence around the target while keeping the global motion properties of the mask the same, we did not observe a reliable local effect.

To summarize the results thus far, we tentatively find support for the global effect. However, there is one possible limitation in this experiment that could undermine such an inference. Consider that, overall, presenting incoherent motion in the opposite column increased target disappearance compared to coherent motion in the opposite column. The incoherent motion in the opposite column could be congruent with the motion at the target ($T_{Incoh}O_{Incoh}$) or incongruent with the motion at the target ($T_{Coh}O_{Incoh}$). It is possible that what we have termed the global effect here arises because incoherent motion creates more noise for the visual system (Barlow & Tripathy, 1997). Some might consider this still to be a global effect, but it is not the same as what we initially conceptualized with respect to overall summation of motion signals across the display. To address this concern in a second experiment, we created an additional stimulus that still allowed for manipulation of the global mask properties but did not rely on the use of incoherent motion. Specifically, we created two columns of coherent motion and then manipulated the congruency of the motion direction in the two columns. This generated a globally congruent or globally incongruent motion display, while holding local mask properties constant (i.e., always coherent). If MIB is at least partially determined by global motion signals irrespective of incoherent motion, then we should observe greater disappearance in the incongruent condition than the congruent condition.

EXPERIMENT 2

Method

The methods were similar to Experiment 1 except where indicated.

Participants. Nineteen participants (nine females, 10 males; aged 18–41) with normal or corrected-to-normal visual acuity took part in Experiment 2.

Stimuli. Stimuli were similar to those used in Experiment 1. Motion in the display was once again restricted to the two outside columns: the column containing the target and the column opposite to the target. Motion coherence (coherent, incoherent), target location (left, right column), and motion direction (up, down) were manipulated to produce five stimulus conditions, each accounting for 20% of the total number of trials. Four of the stimuli were similar to the stimulus conditions in Experiment 1. A fifth stimulus condition was created to address the question of motion incongruence:

1. $T_{Coh}O_{Coh}$ *(congruent)*: Although the stimulus was the same as Stimulus 1 in Experiment 1 (Figure 3a), we provided a new "congruent" label for clarity, to indicate that both columns contained motion in the same direction. Additionally, overall motion direction was now manipulated such that half of the trials contained upward motion in both columns and the remaining trials contained downward motion in both columns. Target side was factorially crossed with motion direction, with a target in the left column on half of the trials and the right column in the remaining trials.
2. $T_{Incoh}O_{Incoh}$: The stimulus was identical to Stimulus 2 in Experiment 1.
3. $T_{Coh}O_{Incoh}$: The stimulus was similar to Stimulus 3 in Experiment 1. Now, motion direction in the target side column was manipulated such that 50% of the trials contained upward motion while the remaining trials contained downward motion. The column opposite to the target

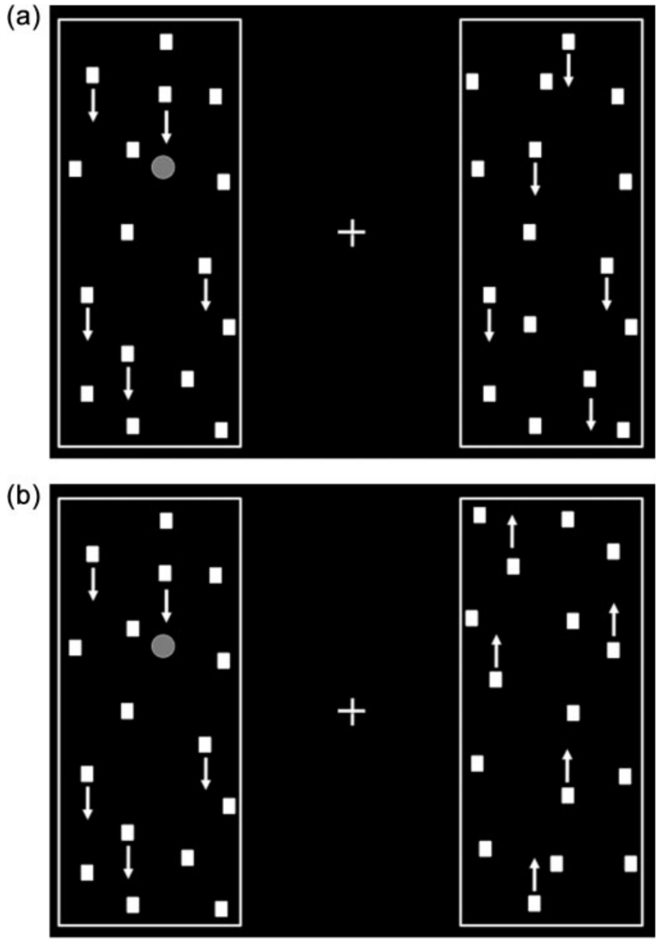

Figure 3. Stimulus conditions used in Experiment 2 (see text for details). Stimulus conditions 1–4 were the same as in Experiment 1, and condition 5 was new. (a) Stimulus 1: $T_{Coh}O_{Coh}$ (congruent) and (b) Stimulus 5: $T_{Coh}O_{Coh}$ (incongruent). Again, arrows depicting the overall motion in each column were not present in the actual stimulus.

contained incoherent motion. Target side was factorially crossed with motion direction.

4. $T_{Incoh}O_{Coh}$: The stimulus was similar to Stimulus 4 in Experiment 1. Motion direction and target side were manipulated as in the third stimulus condition, except now the coherent motion was in the column opposite to the target.
5. $T_{Coh}O_{Coh}$ *(incongruent)*: Both target column and opposite column contained coherent motion moving in opposite motion directions (Figure 3b). Motion direction was manipulated such that half of the trials contained upward

motion in the target column and downward motion in the opposite column; the motion directions were reversed in the remaining trials. As in all the conditions, target side was crossed with motion direction.

Design and procedure. Each participant completed a minimum practice session of six trials, each lasting 30 s. Following the practice trials, participants completed a total of 100 trials, divided into five blocks of 20 trials, each trial also lasting 30 s. Each mask type was presented four times in random order within a block, for a total of 20 trials for each mask across a session. A self-timed break after each block was provided.

Results and discussion

Group means for the five stimulus conditions are plotted for both normalized percentage disappearance (Figure 4a) and for normalized length of an MIB episode (Figure 4b). For both dependent measures, we conducted a one-way, repeated measures ANOVA on the five different mask conditions. When Mauchly's test determined the data violated the assumption of homogeneity of variance, we used a Greenhouse-Geisser correction. For the dependent measure of normalized percentage disappearance, we found a significant difference among the mask conditions, $F(2.76, 49.63) = 5.06$, $p = .005$, $\eta^2 = .22$. A similar effect was found for the dependent measure of normalized length of an MIB episode, $F(4, 72) = 3.61$, $p = .01$, $\eta^2 = .17$. In the following paragraphs, we report the individual, uncorrected pairwise comparisons central to our hypotheses, as well as means and effect sizes (Cohen's *d*).

As in the first experiment, we tested the mask coherence manipulation. We conducted pairwise comparisons on the dependent measures of MIB for the stimulus condition containing coherent motion in both columns versus incoherent motion in both columns, $T_{Coh}O_{Coh}$ (congruent) versus $T_{Incoh}O_{Incoh}$. We found a significant difference between these two conditions for normalized percentage disappearance, 0.91 versus 1.06, $p = .02$, $d = 0.60$, and for normalized length of an MIB episode, 0.92 versus 1.08, $p = .02$, $d = 0.60$. Consistent with Experiment 1, greater disappearance was observed for the stimulus containing incoherent motion across the display compared to coherent motion.

Next, we addressed our primary goal of investigating the possibility of a global effect on MIB. First we examined the two stimulus conditions (Stimulus 1 and Stimulus 5, see Figure 3) in which both columns contained coherent motion but the directions of the coherent motion were congruent, $T_{Coh}O_{Coh}$ (congruent), or incongruent, $T_{Coh}O_{Coh}$ (incongruent). Pairwise comparisons revealed a significant difference between the stimulus conditions for both normalized percentage

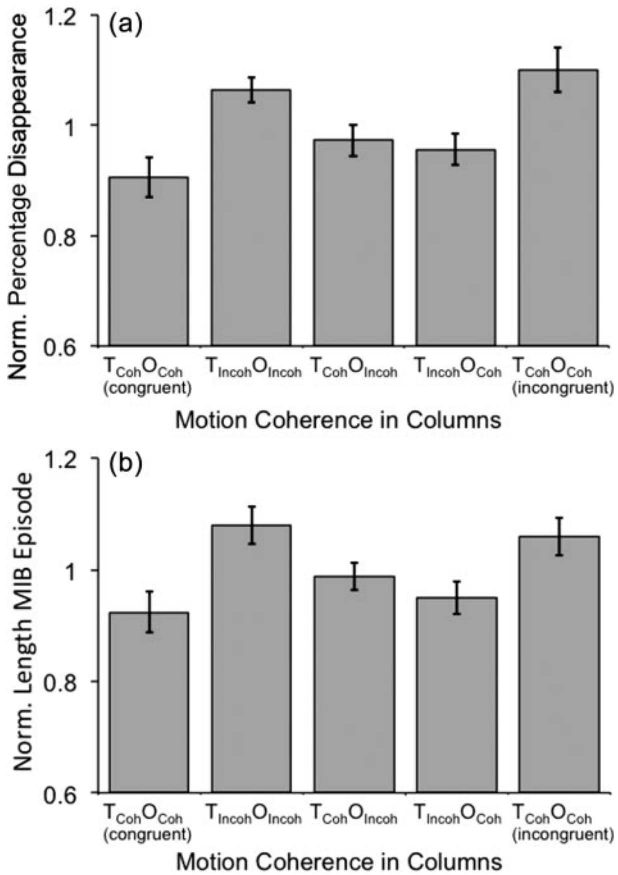

Figure 4. Results of Experiment 2: Means for each stimulus condition are plotted for (a) Normalized percentage disappearance and for (b) normalized length of an MIB episode. Error bars indicate within-subject variability (±1 SEM).

disappearance, 0.91 versus 1.10, p = .001, d = 0.89, and normalized length of an MIB episode, 0.92 versus 1.06, p = .008, d = 0.68. Specifically, when the local motion coherence around the target was held constant, disappearance was greater when the mask was globally incongruent than when it was globally congruent.

The next comparisons replicate the global effect found in Experiment 1. In particular, we compared the remaining stimuli pairs in which target motion was held constant and the global motion properties were manipulated. Specifically, we compared (1) $T_{Incoh}O_{Incoh}$ versus $T_{Incoh}O_{Coh}$ and (2) $T_{Coh}O_{Coh}$ versus $T_{Coh}O_{Incoh}$. The results of the pairwise comparisons for normalized percentage disappearance showed a significant difference between $T_{Incoh}O_{Incoh}$ and $T_{Incoh}O_{Coh}$, 1.06 versus 0.96, p = .04, d = 0.51. Although we did not find a significant difference between $T_{Coh}O_{Coh}$ and $T_{Coh}O_{Incoh}$ (0.91 vs. 0.97, p = .14), the difference was in the predicted direction. A pairwise comparison conducted on the normalized length of an MIB episode found a significant difference between $T_{Incoh}O_{Incoh}$ and $T_{Incoh}O_{Coh}$ (1.08 vs. 0.95, p = .006, d = 0.71). However, the comparison between $T_{Coh}O_{Coh}$ and $T_{Coh}O_{Incoh}$ did not reach significance (0.92 vs. 0.99, p = .22), although the difference was in the predicted direction. All of the comparisons in Experiment 2 replicated the direction of the effects in Experiment 1; however, it is possible that some were less reliable. In Experiment 2 there were fewer trials per condition to accommodate the additional fifth mask condition, thus yielding less statistical power.

As in Experiment 1, we again tested for the presence of a local effect. We conducted paired samples t-tests for the stimulus conditions in which global motion properties were held constant and local motion properties were varied ($T_{Coh}O_{Incoh}$ vs. $T_{Incoh}O_{Coh}$). Again, we failed to find a significant difference for normalized percentage disappearance, 0.97 versus 0.96, p = .63, and for normalized length of an MIB episode, 0.99 versus 0.95, p = .28.

Overall, results from this experiment were consistent with the global effect we observed in Experiment 1. Moreover, we show that the effect was not the result of an increase in visual noise due to the presence of incoherent motion but more likely the influence of a change in the motion characteristics of the mask across the entire display. Specifically, when the coherent motion in both columns was varied from moving in the same direction to moving in opposing directions, disappearance increased. Finally, similar to the results obtained in Experiment 1, we did not find evidence for a local effect of the mask.

GENERAL DISCUSSION

The main finding of this study was that MIB is influenced by global motion properties of the mask, when local properties are held constant. Although it was previously not known whether MIB had a global determinant, we find it interesting that several other visual phenomena are thought to have global determinants. Binocular rivalry, a phenomenon that has similar characteristics to MIB (Carter & Pettigrew, 2003) is also influenced by global characteristics. When participants were shown two competing stimuli in each eye formed by intermixing parts of two coherent images, they tended to perceive the rivalling stimuli not as the ungrouped (i.e., intermixed), incoherent representations but as two perceptually coherent, grouped images (Kovacs, Papathomas, Yang, & Feher, 1996). Similar effects have been observed for a number of individual grating patches presented to different areas in each eye (Sobel & Blake, 2002). In their study, Sobel et al. (2002) found that when each local patch in one eye had a corresponding orthogonal patch in the other eye, perception fluctuated randomly between the two eyes and the different patches. However, when the local patches could be grouped together by context or motion then dominance became more predictable and favoured a global percept.

Pattern rivalry, a monocular form of perceptual rivalry, is likewise affected by global context (Maier, Logothetis, & Leopold, 2005). In the phenomenon described by Maier et al. (2005), two low contrast circular orthogonal gratings that were superimposed, eventually succumbed to rivalry periods in which one of the circular gratings was visible while the other one faded from perception. Maier et al. found that when they removed one of the patterns from a small central area (thereby creating two rivalling annuli and a central rivalry-free zone), the overlapping patterns would continue to rival. One feature of the Maier et al. study that we find particularly relevant to our present study is that the authors controlled for local properties and manipulated global characteristics. Specifically they maintained the features of the annuli but manipulated what was present in the rivalry-free zone. They reasoned that, if local competing features of the stimuli determine rivalry, then perception should alternate only between the two annuli, irrespective of the features of the central pattern. However, Maier et al. found that the orientation of the pattern at the centre would group with its appropriate annulus, producing a situation where a completed stimulus would alternate with the competing annulus (now devoid of the central pattern). These results suggest that global determinants play a role in pattern rivalry.

Global effects extend beyond binocular and pattern rivalry and include motion related phenomena such as the motion aftereffect (MAE). For instance, extended viewing of motion produces a motion aftereffect in remote locations not subjected to motion adaptation (von Grünau & Dubé, 1992). Participants who were adapted to a moving vertical grating and then shown a test stimulus in the same location (composed of two overlapping gratings moving in opposite directions and having no specific motion direction) were more prone to perceive the stimulus as moving in the direction opposite to adaptation. However, the same effect was observed when the adapting and test stimulus occupied different hemifields. These findings suggest that global motion processes, possibly through long-range neural connections, account for some of the motion aftereffect.

The extensive neural interconnectivity for motion processing in visual areas reveal the interplay between lower visual processing areas believed to be responsible for the local summation of signals and higher visual areas responsible for processing global context (Angelucci et al., 2002; Harrison, Stephan, Rees, & Friston, 2007). Cortical feedback mechanisms arising in higher visual areas are important in determining the global motion percept (Muckli, Kohler, Kriegeskorte, & Singer, 2005), as well as enhancing figure–ground segregation (Hupé et al., 1998). In the case of MIB, researchers have found evidence suggesting that motion sensitive areas in the brain, including the intermediate visual area V3AB and the middle temporal visual area (V5/MT), are selectively linked to target disappearance (Donner, Sagi, Bonneh, & Heeger, 2008; Schölvinck & Rees, 2010). Using functional MRI, these studies found that during intervals of time in which observers reported the target to disappear, the hemodynamic response associated with the target was relatively low while the response associated with the mask was relatively high. The present results, along with evidence from neuroimaging studies, support the notion that global motion processing exerts a key influence on MIB.

We found evidence for a global effect, but we did not observe a local effect. How can we reconcile the latter finding with the work of others, especially Libedinsky et al. (2009) who found clear evidence of a local effect? We suggest that the divergent results may be due to the fact that MIB supports both a local and a global effect but that the global effect masks the presence of a local effect in certain situations. In fact, Libedinsky et al., as well as Gorea and Caetta (2009), suggest that MIB may not be limited to one cortical visual processing region but may arise in different brain areas responsible for either suppression through local interactions or suppression originating from the global context of the surround. Therefore, it is possible that certain stimulus conditions may reveal a global effect but not a local effect and vice versa.

In order to see the local effect of the mask, one may have to make a more dramatic change to the interaction between the mask and target than what we did. For instance, if a few mask elements are removed directly around the target (originally termed a *protection zone* by Bonneh et al., 2001), no change in disappearance is observed. However, excluding a larger portion of the mask directly around the target (> 2 deg) causes disappearance to decline (Bonneh et al., 2001). Libedinsky et al. (2009) found that disappearance was significantly reduced when the mask was completely removed from around the target (i.e., in the same hemifield), indicating a local effect on MIB. In our experiments, we only *manipulated* the local characteristics of the mask, rather than fully removing it. Thus, it is possible that our more subtle manipulation may have obscured a local effect. That is, as long as the mask occupies both hemifields, a local effect may not be observable.

CONCLUSIONS

In summary, we found evidence for a distinct contribution from the global characteristics of the mask on MIB. We found MIB changed significantly when the global motion was varied while maintaining constant local motion coherence. Conversely, our manipulations of local mask characteristics did not produce changes in MIB, although this result does not necessarily contradict previous reports of local effects (e.g., Libedinsky et al., 2009). We suggest that global stimulus representations contribute to MIB in a manner consistent with the hierarchical nature of motion processing.

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