Attentional influences on the dynamics of motion-induced blindness

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Motion-induced blindness (MIB) is a visual phenomenon in which a highly salient, peripheral, visual target spontaneously disappears from visual awareness (and subsequently reappears) when superimposed on a globally moving background of distracters. Here, we investigated the influence of attention on these fluctuations in perception in two experiments. In the first experiment, directing spatial attention to the MIB target (and thus away from the distracters) led to an increased probability of disappearance of the target. This counter-intuitive effect of attention enhancing disappearance is nonetheless consistent with earlier reports that increased target salience enhances disappearance. Conversely, in a second experiment withdrawing attention from the entire MIB display (both target and distracters) led to a decrease in perceptual disappearances and reappearances, as well as prolonged periods of invisibility. Taken together these findings suggest that the global availability of attention facilitates competition between target and moving distracters, while the local direction of attention toward or away from the target can influence the outcome of that competition. Thus, in common with other related perceptual phenomena, attention has complex effects on the dynamics of target-distracter interactions associated with motion-induced blindness.

Keywords: motion-induced blindness, spatial attention, attentional load


Introduction

Motion-induced blindness (MIB) is a striking phenomenon in which a perceptually salient stationary visual target repeatedly disappears (and subsequently reappears) when superimposed on a field of moving distracters (Bonneh, Cooperman, & Sagi, 2001). Target disappearance in MIB is influenced by low-level sensory factors. For example, the target disappears more often at increased eccentricity (Hsu, Yeh, & Kramer, 2004) and when it is smaller (Bonneh et al., 2001). Importantly, the properties of the target in relation to the moving distracters are also important; reducing the contrast between the target and the distracters (Hsu et al., 2004) and placing the target behind the distracters (Graf, Adams, & Lages, 2002) both enhance disappearance of the target. Moreover, MIB is prone to the boundary adaptation effect, consisting of the fading of the boundaries of the target, followed by interpolation of the surrounding distracter elements (Hsu, Yeh, & Kramer, 2006).

In addition to these low-level sensory factors, higher-level factors also influence MIB. Disappearance of the target is subject to gestalt-like grouping effects; several targets tend to disappear together rather than separately when they form good gestalts (Bonneh et al., 2001). More specifically, when two Gabor patches are presented as targets, they tend to disappear together when they are collinear, and in alternation when their orientation is orthogonal (Bonneh et al., 2001). Finally, the perceptual decision-criterion (for detecting the target) is shifted upward during perceived invisibility of the target (Caetta, Gorea, & Bonneh, 2007). The influence of such higher-level factors on MIB has led to the proposal that disappearance of the target in MIB might reflect a disruption of attentional switching between target and distracters (Bonneh et al., 2001). In line with this proposal, it has been shown that focusing attention on one MIB target versus dividing attention among several targets facilitates MIB (HaiYan, QianLan, YunFeng, Shan, & Ying, 2007). This study, however, did not separate any spatial attention effects from general task...
difficulty differences (keeping track of only one target is easier and might have been reported more reliably than reporting disappearances of several targets simultaneously) and therefore the influence of attention on target disappearance and other aspects of MIB remains elusive.

To investigate this issue, we conducted two behavioral experiments to characterize how attention affects the dynamics of MIB. In the first experiment, we manipulated the voluntary allocation of spatial attention to one of two MIB targets placed on a field of moving distracters. This allowed us to examine how directing attention toward versus withdrawing attention away from one target might alter the competitive interactions between that target and the distracters believed to underlie MIB. In a second experiment, we manipulated attentional load in a task entirely unrelated to the MIB target or moving distracters (Lavie, 2005; Lavie, Hirst, de Fockert, & Viding, 2004). By increasing the attentional demands in an unrelated task, we could now examine the effects of withdrawing attentional resources from the entire MIB display, both targets and moving distracters. Briefly, we found that directing spatial attention to the MIB target led to an increased probability of its disappearance, while withdrawing attention from both target and distracters led to a decrease in perceptual switches and prolonged periods of target invisibility.

### Methods

#### Observers and stimuli

Six healthy volunteers (27–31 years old) with normal or corrected-to-normal vision gave informed consent to take part in Experiment 1, nine other healthy volunteers (26–36 years old) with normal vision agreed to take part in Experiment 2. Participants fixated centrally while viewing an MIB display consisting of yellow dots (the targets) of 0.6 degrees in diameter, underneath a grid of blue crosses (the distracters) rotating at 5.5 deg/s round a central fixation dot (Bonneh et al., 2001; Caetta et al., 2007; Graf et al., 2002). In Experiment 1, two targets were shown, which were placed in the left and right upper visual quadrants at 5.8 degrees eccentricity (5 degrees lateral and 3 degrees superior to central fixation) (Figure 1a); in Experiment 2, only the left upper target was shown (Figure 2a). The upper visual fields were chosen for target placement as MIB is most robust at this location (Bonneh et al., 2001). The blue distracter grid (luminance 8.81 cd/m^2) and yellow targets (luminance 11.23 cd/m^2) were displayed on a black background (luminance 0.10 cd/m^2). In Experiment 2, a continuous stream of colored crosses (0.250 degrees wide and 0.375 degrees high) was presented.
presented at fixation, with each cross appearing for 250 ms with a 500 ms blank period between subsequent crosses. Each individual cross could appear in any of six colors (red, green, yellow, blue, cyan, and purple) and two orientations (upright or inverted; the horizontal line of the cross was placed 0.25 degrees above or below the center of the vertical line) (Figure 2a). Stimuli were created in Cogent 2000 (http://www.vislab.ucl.ac.uk/cogent.php) under Matlab 7.1.0 (Mathworks Inc.) and presented on a CRT display (21” Sony GDM-F520) that was set at 600 by 800 pixel resolution and an 88 Hz refresh rate.

**General procedure**

Both experiments lasted about an hour, including practice trials and breaks, and were carried out in a darkened room. Participants were tested extensively before the experiments to ensure they could experience MIB and assign consistent responses to the different perceptual states. To ensure a fixed viewing distance of 57 cm, a chin rest supported their head. They responded by use of a keyboard. Eye position and pupil diameter were continually sampled at 300 Hz using a CRS infrared video-based eye tracker (Cambridge Research Systems Ltd., Kent, England). Eye position was defined as the mean horizontal and vertical position of the eye, eye movements were defined as variance round the eye position, and eye blinks as an absence of signal. Statistical analyses were performed to examine differences in eye movements and blinks between the various experimental conditions. For one (Experiment 1) and four (Experiment 2) participants, eye data could not be analyzed due to technical difficulties. Procedures specific to each experiment are described below.

Figure 2. **Experiment 2**. Participants viewed an MIB display of one yellow dot in their left upper visual field underneath a grid of rotating blue crosses (a), while maintaining fixation at a central stream of crosses of different color and orientation (enlargement of center). They indicated by pressing or releasing a button when the target dot was visible or invisible, while simultaneously performing an attentional task involving the central crosses (see Methods). The average number of perceptual disappearances and reappearances of the target (taken together as perceptual switches per second) are plotted in b; the average durations of the target invisibility are shown in c. Since invisibility durations were highly variable across participants (2616 ± 2724 ms, 2894 ± 2391 ms, and 3526 ± 4298 ms for the no, low, and high load conditions) and the difference between the conditions within participants was the variable of importance, durations were mean-corrected to the average of the three conditions. White bars represent the no load condition, gray bars the low load condition, and black bars the high load condition in both graphs. Error bars represent the standard error of the mean-corrected average of participants. Significant differences are indicated by asterisks.
Experiment 1 procedure

Experiment 1 tested the effect of directed spatial attention on MIB. In separate blocks, participants were instructed to fixate centrally while attending either the left or the right yellow target. Each target subtly changed hue between reddish-yellow and greenish-yellow at random intervals every 1–3 seconds. Both dots changed hue at random times (though never simultaneously), so changes to the attended and unattended target were perceptually equivalent. Participants were required to report hue changes of the attended target while ignoring hue changes of the unattended target by pressing either the left or the right arrow on the keyboard with their right index finger, depending which side was attended. At the same time as reporting hue changes for the attended side, observers monitored both target dots for perceptual disappearance. As soon as they saw either target disappear, they were required to press the up arrow, upon which the screen turned completely black. They then had 3 seconds to indicate which target (left, right, or both) had disappeared using a key press (left, right, or up arrow respectively). This second key press signaled the start of the next trial, which was preceded by an arrow on the screen pointing leftward or rightward to remind participants whether they were required to attend the left or right visual field target. Each visual field target was attended for 8 blocks of 3 minutes; thus, there were 16 blocks in total, each block consisting of a variable number of trials (depending on the time it took for a target to disappear), but always with the same attended side throughout. Participants could take breaks in between the blocks.

In addition, during one trial in each block, one of the targets (the attended targets in half these trials) was physically removed from the screen after 5 seconds. The latency with which observers responded to the physical disappearance of this target served as an estimate of their reaction times to the perceptual disappearance of the targets. After the experiment, trials were divided into those where the attended target perceptually disappeared first, and those where the unattended target perceptually disappeared first. These trial ‘categories’ were used to arrive at an estimate of the probability with which a target disappeared; for instance, the probability that the left target disappeared while being attended was defined as the number of trials the left target disappeared while attending to the left side, divided by the number of trials that any target disappeared while attending to the left side.

Experiment 2 procedure

Experiment 2 tested the effect of attentional load in an unrelated task at fixation on MIB in three different conditions; no, low, and high attentional load. For each condition, identical physical stimuli were presented at fixation while an MIB target was presented in the periphery; but the nature of the central task changed. The central task has been extensively described elsewhere (e.g. Schwartz et al., 2005).

Under no attentional load, participants fixated the central stream of crosses but were not required to perform any task on these stimuli. To avoid involuntary responses to the stimuli, all crosses in this condition were of the same color which was random, though not one of the target colors in the other two conditions (red, green, or yellow). At the same time, participants were required to monitor the peripheral MIB target and indicated its disappearance by pressing a key down with their right index finger when it was invisible, and releasing the key when it was visible. In the low attentional load condition, in addition to monitoring the peripheral MIB target for disappearances and reappearances, participants performed a simple feature-detection task on the stream of crosses presented at fixation. Specifically, they were required to monitor the stream of crosses and press a key with their left index finger whenever they saw a red cross. In the high attentional load condition, in addition to monitoring the peripheral MIB target for disappearances and reappearances, participants performed a more challenging conjunction-detection task on the stream of crosses presented at fixation. Specifically, they were required to monitor the stream of crosses and press a key with their left index finger when either an upright yellow or an inverted green cross was displayed.

In all three conditions, participants were encouraged to respond as quickly and accurately as possible. Each condition was tested in 8 blocks of 2 minutes, giving 24 blocks in total; their order was randomized and they were preceded by a written instruction specifying the load condition beforehand. Participants could take a break after every fourth block.

In addition, during each block, the yellow target was physically removed from the screen once for 7.5 seconds approximately halfway through the block, yet always at a time when it was being reported by the participants as perceptually visible. Upon debriefing, participants declared they could not distinguish between instances where the target disappeared due to MIB or due to physical removal. Their key presses to the physical disappearance and reappearance of the target in these instances served as an estimate of their reaction times to the switches in perception.

Results

Experiment 1

Spatial attention was directed toward one of two targets by requiring participants to report hue changes of this target; they also reported perceptual disappearances of
both targets. The first disappearance of either target signaled the end of the trial. Trials where both targets disappeared simultaneously were excluded from the analysis. On average, participants completed 154 and 146 trials while attending to the left and the right visual field target, respectively. Their reaction times to the hue change of the attended target did not differ significantly between visual field (t(5) = .135, p = .898; 961 ms and 968 ms for the left and right target, respectively).

Directing attention to the left visual field target strongly increased the probability of that left target disappearing first (compared to the unattended right visual field target), and vice versa (Figure 1b). This striking effect of attention was confirmed by the significant interaction between perceptually disappearing target (right or left) and attended side (right or left) (F(1,5) = 58.357, p = .001), as revealed by repeated-measures ANOVA. There were no main effects of target (F(1,5) = 2.853, p = .152) or attended side (F(1,5) = 1.107, p = .319). A χ² test on the probability of the attended target disappearing first showed that this effect was highly significant across all 6 participants (all p values below 0.0001). In contrast, the direction of attention had no effect on the time from the start of a trial until a target perceptually disappeared (Figure 1c). The interaction between required time and attended side was not significant (F(1,5) = 2.679, p = .163) and there was no main effect of attended side (F(1,5) = .036, p = .857). There was a main effect of target (F(1,5) = 23.432, p = .005), with the right target perceptually disappearing quicker than the left target, regardless of whether it was attended to or not.

The observed differences in probability of disappearance between the attended and the unattended target could be caused by a failure to notice disappearance of the unattended target. In order to account for this, the targets were periodically removed from the screen and reaction times to these disappearances were measured. Surprisingly, the reaction times to report physical disappearance of the unattended target were slightly shorter compared to the reaction times to the attended target (1126 ms and 1267 ms respectively; t(5) = 2.319, p = .068, values more than 2 std. from the mean excluded). Our results can therefore not be explained by a failure to keep track of the unattended target. The peripheral location of the targets, participants’ division of attention between the two targets, and their engagement in the hue change detection task are all consistent with these relatively long reaction times. The probability of disappearance might also be influenced by small eye movements or blinks round the time of the perceptual switch (Martinez-Conde, Macknik, Troncoso, & Dyar, 2006).

However, paired t-tests of eye position, eye movements and average number of eye blinks/sec (see Methods) showed that these did not differ significantly in the 1.5 s leading up to the button press signaling the disappearance of the attended or unattended target (t(4) = .885, p = .426, t(4) = 1.716, p = .161, and t(4) = 2.152, p = .098, respectively). Thus, the increased probability of disappearance of the target can reliably be attributed to an attentional effect.

One possible attentional mechanism which could have contributed to the increased probability of disappearance for the attended target is prior entry into awareness, which is the notion that an attended stimulus or event will be perceived sooner than a physically simultaneous unattended stimulus or event (Schneider & Bavelier, 2003). Thus, maybe the targets disappeared simultaneously, but the disappearance of the target on the attended side was detected first. In order to control for this possibility, we conducted a control experiment in three subjects who had also participated in the original experiment. We introduced a short delay of 750 ms between the time of the first button press (indicating that one of the targets had disappeared) to erasing the stimulus from the screen, thus allowing the detection of a possible disappearance of the unattended target as well. If there had been a prior entry effect of attention, more ‘simultaneous disappearance’ button presses would be expected in this manipulation than when the stimulus was removed immediately. However, the number of ‘simultaneous disappearance’ button presses did not increase (1 vs. 0, 7 vs. 5, and 26 vs. 14 for the previous vs. present number of button presses, respectively) as compared to the condition where the stimulus was removed from the screen immediately. We therefore conclude that the increased probability of the attended target to disappear first was not due to a prior entry of this target into awareness.

**Experiment 2**

Participants’ performance on the central task showed that the manipulation of attentional load was successful. Mean reaction times were shorter and the percentage of correctly detected central targets higher in the low load compared to the high load condition (623 and 753 ms, 96% and 85%, respectively). These differences were significant (t(8) = 9.118, p < .001 for RTs; t(8) = 5.004, p = .001 for accuracy). This replicates previous findings (e.g. Schwartz et al., 2005) and confirms that attentional demands were indeed higher under high compared to low attentional load.

Behavior on the motion-induced blindness task was captured by two variables: the average number of disappearances and reappearances of the target (together called ‘perceptual switches’) and the average duration that the MIB target was invisible. Assessing the probability and time it took for the target to disappear, as calculated in Experiment 1, was not possible due to the use of a continuous MIB display instead of discrete trials. To assess the influence of the unrelated attentional task on the normal MIB behavior of our participants, we first computed an attention index (AI), using the formula AI = (average of the number of perceptual switches under low and high load conditions together) / (average number...
of perceptual switches under the no load condition). This AI for switches equaled .81, corresponding to a significant decrease in number of perceptual switches under the load (versus the no load) conditions ($t(8) = 3.664, p = .007$). Using the same attentional index formula but now using average durations that the target was invisible rather than switches, the attention index for durations equaled 1.23 for the load (versus the no load) conditions, corresponding to a small but significant increase in duration of the invisible periods ($t(8) = 2.340, p = .047$). Thus while the duration that the target was invisible increased with attentional load, the number of switches decreased. Independent of this, the percentage of total time of the experiment that the target was invisible slightly decreased as a function of load (38.5%, 36.8%, and 35.6% for the no, low, and high load conditions respectively), though this measure did not reach significance ($F(1,8) = .334, p = .645$). Thus, adding an unrelated task to MIB reporting decreases the number of perceptual switches and increases the duration that the target is invisible, while not significantly influencing the total proportion of invisibility.

The average number of perceptual switches decreased even more for the high attentional load compared to the low attentional load condition ($t(8) = 4.458, p = .002$) (Figure 2b). Also the effect of attention on duration was further increased; the target was invisible for longer under higher attentional load compared to low attentional load (Figure 2c). This effect trended toward significance ($t(8) = 2.080, p = .071$); the pattern could be observed in 6 out of 9 participants. These observed duration differences between the three conditions could be due to shorter reaction times to a disappearance of the target, or longer reaction times to a reappearance of the target under high attentional load. To examine this possibility, we examined RTs to the periodic physical removals and reappearances of the target. Mean reaction times to these target disappearances were 780 ms, 771 ms, and 1067 ms for the no, low, and high attentional load condition, respectively; for the reappearances of the target on the screen the mean RTs were 814 ms, 1497 ms, and 1190 ms. In both subjects, the effect of load (no, low, and high) was not significant for either physical disappearances or reappearances ($F(1,7) = 3.293, p = .100$ and $F(1,7) = 0.566, p = .503$). Also their reaction times did not differ significantly from their reaction times in the original experiment in any condition ($t(5) < 2.184, p > .065$). We therefore conclude that the regularity in duration of the physical removal of the target in the original experiment cannot account for our findings.

The observed differences in number of perceptual switches and average duration of MIB can therefore not be attributed to differences in reaction times. Alternatively, the differences in duration might have been due to differences in small eye movements or blinks (Martinez-Conde et al., 2006). Repeated measures ANOVA of eye position, eye movements, and average number of eye blinks/sec (see Methods) revealed no significant differences between the three conditions ($F(1,4) = 1.141, p = .352, F(1,4) = 2.762, p = .155, and F(1,4) = 3.497, p = .129, respectively). Hence, the differences we observed in number of perceptual switches and duration cannot be caused by differences in eye movements (although the precision of our eye tracker does not rule out potential differences in microsaccades). We therefore conclude it is likely that placing attentional demands on an unrelated central task decreases the number of perceptual switches and increases the duration of perceptual invisibility of the target.

**Discussion**

The influence of high-level factors (such as endogenous attention) on the dynamics of motion-induced blindness has not been studied extensively. Here we report that directing spatial attention to an MIB target directly increased its probability of disappearance (compared to an unattended MIB target), while not interfering with the time it took the target to disappear. Conversely, increasing the attentional load in a central task unrelated to MIB decreased the number of disappearances and reappearances of the target and prolonged the periods of its perceived visibility and invisibility.

It is well established that spatial attention can modify processing in local regions of the visual field, and this is associated with corresponding retinotopically specific modulations of activity in primary and extrastriate visual cortex (e.g. Brefczynski & DeYoe, 1999; Gandhi, Heeger, & Boynton, 1999; Somers, Dale, Seiffert, & Tootell, 1999). Typically, the effect of spatial attention is characterized as strengthening the representation of a
stimulus, enhancing its salience and potency in competitive interactions with cortical representations of other stimuli in the visual environment (Kastner, De Weerdt, Desimone, & Ungerleider, 1998). Here, we found that spatial attention directed to an MIB target increased the probability of it disappearing. This appears counterintuitive given the characterization of spatial attention as increasing the salience of a target; why should a more salient target be more likely to disappear? However, previous behavioral work suggests that increasing target salience increases the duration of MIB (Bonneh et al., 2001). Specifically, disappearance of the target occurs for longer when the contrast between target and distracters is greater, presumably hampering the grouping of target and distracters (Hsu et al., 2004). These findings have led to the proposal that MIB is unlikely to be caused by local adaptation, but rather that higher level attentional and grouping mechanisms play a role (Bonneh et al., 2001). Thus, our findings of increased probability of disappearance with spatial attention are consistent with the notion that increased salience of the target (relative to distracters) is associated with enhanced disappearance. Moreover, this effect of attention might be different from a facilitation of adaptation, which is assumed to underlie perceptual filling-in (De Weerd, Smith, & Greenberg, 2006).

While Experiment 1 tested the effects of increasing attention directed specifically to the MIB target, Experiment 2 tested the effects of globally withdrawing attention from both MIB target and MIB distracters using attentional load in an unrelated central task. Attentional load theory (Lavie, 2005) proposes that at any one time the attentional capacity of participants is limited. After capacity is voluntarily allocated to the task at hand, any spare capacity results in processing of task-irrelevant stimuli. Thus, the extent to which task-irrelevant stimuli are processed depends on the degree to which attentional load in the relevant task has withdrawn resources from processing them. Processing of irrelevant distracters can be inferred indirectly either by measuring brain activity associated with their presence (Rees, Frith, & Lavie, 1997; Rees, Russell, Frith, & Driver, 1999), or their behavioral interference on the central task (Lavie, 2005). Here, we explicitly required participants to monitor the peripheral MIB target at all times and so even under high load in the central task, attention by definition was not fully withdrawn but always remained to some extent divided. Nevertheless, the changes in performance in the central task replicate previous findings (Schwartz et al., 2005) and suggest that attention was progressively withdrawn from the MIB display under no, low and high load respectively. We found that such allocation of attention to the central task leads to a decrease in number of perceptual switches reported. Following load theory, this implies that perceptual alternations require some allocation of attentional resources.

How do the findings from both experiments relate to existing explanations of motion-induced blindness? Bonneh et al. (2001) speculated that MIB might be caused by a disruption of usually unnoticed, fast attentional switching. This disruption might result from an inability to divide attention between dissociated elements (i.e. the target and distracters) of the visual scene. By such an account, directing attention toward the target location would predict increased disappearance of the target since it is incompatible with the distracters. This is in line with our first experiment. However, directing attention away from the target would predict diminished attentional disruption and therefore more, naturally occurring, perceptual switches. This is not in agreement with our findings of a ‘slow-down’ of perceptual fluctuations. MIB has more recently been described in terms of a process of completion of the distracters into one homogeneous field, thus hiding the target from view (Graf et al., 2002). Such a completion process implies neuronal competition between target and distracters. This process might be likely to occur locally in regions in early visual cortex, corresponding retinotopically to the target location, in common with other completion processes such as perceptual filling-in (Mendola, Conner, Sharma, Bahekar, & Lemieux, 2006; Weil, Watkins, & Rees, 2008), neon color spreading (Sasaki & Watanabe, 2004), and filling-in of a visual phantom (Meng, Remus, & Tong, 2005). It can also occur at a more global level; neural competition between an MIB target and the distracters has recently been shown to occur between ventral and dorsal visual cortex (Donner, Sagi, Bonneh, & Heeger, 2008). Such neural interpolation mechanisms are facilitated by attention (De Weerd et al., 2006; Hol, Koene, & van Ee, 2003). Thus, directing attention to the MIB target should favor the distracters in the neural competition by enhancing distracter field completion and inducing target disappearance, which agrees with our findings. Conversely, directing attention away from both target and distracters should hamper the competition between target and distracters, thus slowing down the alternations of target visibility and invisibility.

Most studies investigating the effect of attention on bistable perception have focused on voluntary control over the perceptual alternation rate of the bistable stimuli. For example, voluntary attention can influence the rate of alternations in perception of apparent motion (Kohler, Haddad, Singer, & Muckli, 2008). Attentional control over perceptual reversals of ambiguous figures seems to be associated with activity in both frontal (Windmann, Wehrmann, Calabrese, & Güntürkün, 2006) and posterior parietal (Pitts, Gavin, & Nerger, 2008; Slotnick & Yantis, 2005) areas. Selective attentional control over perceptual alternations in binocular rivalry is considerably weaker than control over alternations in other forms of bistable perception, such as Necker cube or face/house reversals (Meng & Tong, 2004; van Ee, van Dam, & Brouwer, 2005).

More relevant to the present findings are several recent studies that have begun to investigate the effects of...
directing attention toward versus away from the bistable stimulus. In one study employing a continuous MIB display with two targets, attention to a target was manipulated by asking subjects to respond to the two targets simultaneously versus to only one of them (HaiYan et al., 2007). When attention is focused on one target only, it disappears more frequently and for longer than in the divided attention condition. Similar enhancement of disappearance by attention has also been reported for Troxler fading (Lou, 1999), and perceptual filling-in, a phenomenon related to MIB (Hsu et al., 2004, 2006), is likewise affected by attention (De Weerd et al., 2006). All these results are consistent with our findings from Experiment 1. Another study showed that disengaging attention from a binocular rivalry stimulus by using a demanding, unrelated task reduces the rate of rivalry alternations (Paffen, Alais, & Verstraten, 2006), and recently less disappearance of an MIB target has been reported under similar conditions (Carter, Luedeman, Mitroff, & Nakayama, 2008). Thus, the results from both our experiments seem to be in agreement with the emerging literature on spatial attention and bistable perception.

Conclusions

We have shown that appearances and disappearances of the target in motion-induced blindness are influenced by higher level factors such as attention. It has been hypothesized that the neural processes underlying motion-induced blindness reflect the completion of the distracters into a homogeneous field (Graf et al., 2002). Our present results support this account, by demonstrating that directing attention away from the target (and distracters) by an unrelated task elsewhere hampers this process, by impeding competition between target and distracters, while directing attention toward the MIB target enhances such a process, by enhancing competition between MIB target and MIB distracters.

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References


