

Object-Category Processing, Perceptual Awareness, and the Role of Attention during Motion-Induced Blindness

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INTRODUCTION

The extent of visual processing that occurs outside of awareness is an unresolved issue of broad importance to the field of cognitive neuroscience. Research examining this question is predicated on the notion that any information that is represented in the brain, whether an individual is aware of it or not, holds the potential to affect subsequent behavior in a relevant way. Identifying the information coded in the brain with or without explicit awareness therefore enhances our understanding of what determines or influences behavior.

One method of identifying perceptual processes that occur in the absence of awareness is through the dissociation paradigm, which is comprised of several essential components (Reingold & Merikle, 1988). In vision, for example, once a visual perceptual process of interest is identified, two measures of this process are obtained as a viewer is presented with images invoking this process. An explicit measure is derived from the viewer's behavioral output or report regarding the content of the images, which serves as an index of their level of awareness. A second measure is typically implicit in nature and reflects the processing of the image content of which the viewer may not be aware, as in the case of behavioral priming or neural responses. Through any number of possible manipulations of the presentation parameters

of relevant images (e.g., a manipulation using motion-induced blindness (MIB), for example, as described below), conditions are created in which images are present but not visible to the viewer, which is reflected in a marked decrease of the explicit measure (Kim & Blake, 2005). The implicit measure is then probed in these conditions of reduced awareness vs. those with full awareness. If the implicit measure of the perceptual process is shown to be intact, regardless of the viewer's ability to report relevant image content, then it is inferred that this process is occurring in the absence of awareness (Holender, 1986; Reingold & Merikle, 1988).

Discrimination of object category by the visual system is evident through multiple measures, behavioral and neural, and thus provides explicit and implicit indices that can be used to examine its relationship with visual awareness. A particularly well-studied and readily measured process reflecting such categorical discrimination is face-specific processing. Neural reflections of this process have been most directly observed as enhancements of specific neural responses to face images relative to images of any other object category that are observed in functional modules of the ventral extrastriate and ventral temporal cortices in human and nonhuman primates (Allison et al., 1994; Harries & Perrett, 1991; Perrett, Hietanen, Oram, & Benson, 1992). In normal human observers, for example, face-specific responses have been localized to

areas in the fusiform gyrus and lateral occipital cortex using functional magnetic resonance imaging (fMRI) measures (Kanwisher, McDermott, & Chun, 1997; Puce, Allison, Gore, & McCarthy, 1995), and in the occipitotemporal sulcus through intracranial recordings in patients (Puce, McCarthy, Bentin, & Allison, 1997). Using scalp-recorded event-related potential (ERP) measures, face-specific processing has been recorded as a negative-polarity amplitude enhancement over lateral-inferior temporal-occipital regions, peaking at ~170 ms after stimulus onset (Bentin, Allison, Puce, Perez, & McCarthy, 1996), often followed at longer latencies (~300–800 ms) by a smaller amplitude but longer duration negative wave with a very similar scalp distribution (Harris, Wu, & Woldorff, 2011; Philiastides, Ratcliff, & Sajda, 2006). These high temporal resolution electrophysiological measures of this process are especially useful indices of this relatively high-level of object-category discrimination that may not require an explicit report of image content, and thus can serve as an informative implicit measure of this process.

MIB is a relatively recently discovered experimental manipulation that can be used for disrupting visual awareness of target images. In MIB, parafoveally presented static targets are superimposed on a globally moving array of distractors. While maintaining fixation at a specific nontarget spatial position (typically centrally located) and covertly attending to these ever-present static targets, viewers periodically lose and regain awareness of them (Bonneh, Cooperman, & Sagi, 2001). This striking perceptual phenomenon provides a novel and robust manner by which to attenuate visual awareness experimentally and serves as an appealing method by which to examine face-processing in the absence of awareness. To this end, experimenters use MIB to gauge the extent of target-associated processing that occurs in the absence of awareness by probing target-specific processing within and outside of MIB episodes (Kim & Blake, 2005).

A number of behavioral studies have suggested that MIB acts through a high-level or late mechanism to disrupt visual awareness. For example, the formation of negative afterimages, a process likely mediated by a relatively low-level of visual processing, is uninterrupted by MIB (Hofstoetter, Koch, & Kiper, 2004). Similarly, orientation-specific aftereffects persist following exposure to a Gabor patch of a given angle, regardless of whether it was presented during or outside of MIB (Montaser-Kouhsari, Moradi, Zandvakili, & Esteky, 2004; Rajimehr, 2004). Also, higher-level processes of object representation and updating have been demonstrated to occur during MIB. For example, one experiment showed that the sudden physical offset of a perceptually suppressed target “breaks” the blindness episode, making the viewer aware of this transient change. This in turn suggested that changes in the gross physical properties of the target

(i.e., its presence or absence) were being processed during MIB episodes, despite the objects being invisible to the subject (Mitroff & Scholl, 2004). This group also showed that if two previously disparate objects are linked with a connecting line during a blindness episode, they tend to reemerge simultaneously as one object, suggesting that object-based representations can be updated during MIB (Mitroff & Scholl, 2005).

In addition to studies focusing on the visual processes that occur during MIB, research examining the more general dynamics of MIB has supported a mechanism of disruption that acts relatively late in terms of visual processing stages. Specifically, MIB episodes associated with specific static targets are shown to be enhanced (to occur more frequently and for greater durations) when those targets are covertly attended (Carter, Luedeman, Mitroff, & Nakayama, 2009). This is in contrast with a low-level mechanism of disruption, such as that seen in sandwich masking wherein visual mask stimuli occur immediately before and after a target image, which does not appear to be modulated by covert attention (Harris et al., 2011). In addition, the manner in which the visual system accounts for the static target location during blindness episodes is similar to the high-level mechanisms of perceptual filling-in observed for the retinal blindspot or scotomas (Hsu, Yeh, & Kramer, 2006). For example, superimposing a stationary grid over a static target and moving array results in the target being replaced by the stationary pattern, in what amounts to a perceptual filling-in effect based upon context (New & Scholl, 2008). In general, evidence has suggested a rivalrous relationship between the static target and array of moving distractor stimuli that is manifested in the temporal properties of MIB (Carter & Pettigrew, 2003). Although relatively few neural studies of MIB have been performed, this proposed rivalrous relationship has been supported by functional MRI measures that show a competitive relationship between ventral and dorsal visual regions associated with the static target and motion array, respectively, which track the perceptual state of the subject in their respective levels of activity (Donner, Sagi, Bonneh, & Heeger, 2008; Scholvinck & Rees, 2010). Nevertheless, a consensus on the neural mechanisms underlying MIB has yet to be reached.

In the present study, we employed the high temporal resolution measures of face-specific neural processing afforded by electroencephalogram (EEG) to examine the extent and nature of object-category processing that can occur during MIB. In addition, the possible mechanism by which MIB exerts disruption of awareness was investigated. These processes were probed by examining responses associated with the perceptual onset of a static target following a blindness episode. Specifically, two conditions were employed: one in which the disappearance and reappearance of target images was

physical in nature (a “static” condition in which a target image actually appeared or disappeared), and the other in which target objects only disappeared and reappeared perceptually due to MIB (“motion condition”). Face-specific neural responses were then tracked across these actual and perceptual onset conditions to gauge the extent of object-category processing in the brain during MIB, the assumption being that a lack of face-specific activity following a perceptual onset (following an MIB episode) would imply that face-processing had been ongoing and intact during the MIB. In addition, activity preceding the perceptual onset of a present image was compared to that preceding the reonset of an image that had actually physically disappeared, to extract an electrophysiological difference between perceptual “reentrance” after an MIB-induced perceptual disappearance and actual perceptual “entrance”. This comparison effectively extracts activity reflecting the emergence of awareness of a continually present image of which the viewer was previously unaware, thereby providing insight into the mechanism underlying MIB and, correspondingly, into the neural underpinnings of perceptual awareness.

METHODS

Subjects

Twenty-six neurologically intact subjects with normal or corrected-to-normal vision participated in the study. Before beginning the EEG portion of the study, each subject underwent a behavioral screening procedure to establish a minimal level of susceptibility to the MIB effect (described below). Four subjects were excluded on the basis of inadequate behavioral effects. Two additional subjects were excluded due to excessive eye blink artifacts in the acquired EEG data (trial rejection rate due to blink artifacts greater than 25%). This left 20 subjects with sufficient behavioral effects and viable EEG data for the final analysis (mean age 22.8 ± 2.4 years, eight female, all right-handed). All subjects completed informed consent procedures as approved by the Duke University Institutional Review Board and were paid for the period of time of their participation, even if only for the screening task.

Stimuli and Task

Prior to the EEG session, subjects were screened so as to only include those with a sufficiently robust MIB effect. Subjects were seated with their eyes 70 cm from the center of a 19 inch CRT stimulus presentation monitor with a 60 Hz refresh rate and were asked to covertly attend to a parafoveal static yellow disc (visual angle of 3.37° ; eccentricity of 7.46° , located in the upper left

quadrant of the screen). This target was superimposed on a full-screen array of blue-cross distractors on a black background, which rotated clockwise as a single surface with its origin at central fixation, at a speed of 15 rounds (360° rotation) per minute (Psychtoolbox, MATLAB). As per the typical MIB task, subjects were asked to press a response button associated with the static target when the target disappeared and to release this button when it reappeared (e.g., [Bonneh et al., 2001](#)). If subjects experienced MIB episodes at a rate of at least five disappearances per minute, and of a mean duration of at least 100 ms, they then proceeded to participate in the full experimental session, which differed from the standard MIB task in several ways, as described below.

After applying the EEG cap, the experimental session began. This differed from the screening task in several ways. Static targets were selected randomly and equiprobably from a set of 80 grayscale circular cropped faces and houses, each of the same size and eccentricity as the static targets utilized in the screening task. The background array of distractors was adjusted to be comprised of black crosses over a gray background (rather than blue crosses on a black background), rendering all visual elements in the display grayscale. Two run types were included: a “static” type in which there was no motion of the distractor array, and another in which the distractor array rotated with the same parameters as in the screening task ([Figure 8.1](#)), alternating between clockwise and counter-clockwise rotation on each run. Regardless of the run type, subjects were instructed to covertly attend to the location of the static target, and to push a response key as quickly as possible upon the *reappearance* of the target after a disappearance period. Ultimately, this would enable the direct comparison of the brain responses to physical onsets to the responses to strictly perceptual onsets (following MIB), as a means of assessing the preceding processing during MIB. In the case of static runs, the target would physically disappear for a duration that was randomly jittered between 1200 and 1800 ms, and then reappear. Following the button press, a new image (face or house) would be presented at the target location and the sequence would repeat. In the case of the motion condition, the target image only perceptually disappeared (due to MIB) and, following the button press indicating the perceptual reappearance, would switch (after a random period between 800 and 1200 ms) to another selected face or house image that remained onscreen until the subsequent button press. This approach enabled a comparison between actual physical disappearances in which MIB could not occur (during the static condition) and perceptual disappearances in which the target never physically disappeared (during the motion condition). Regardless of the run type, subjects were instructed in an identical manner, namely to press the button upon the reappearance of an image that had previously disappeared.

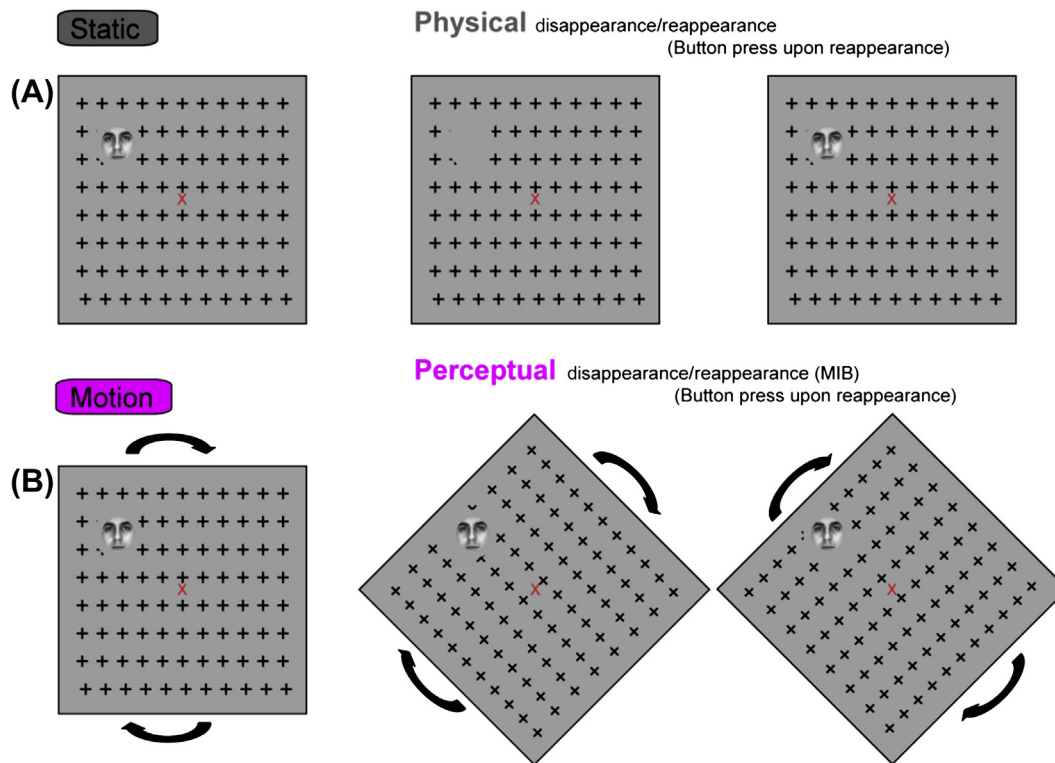


FIGURE 8.1 Stimuli and task: subjects performed the same task for two types of experimental runs. In the static condition (A), randomly selected face and house targets appeared parafoveally (upper left quadrant) for a variable period of time prior to disappearing and then reappearing, at which point subjects were instructed to press a response key as quickly as possible. In the motion condition (B), parafoveal targets superimposed on a coherently rotating array of distractors would perceptually disappear due to MIB (but would never actually physically disappear), with subjects being given the same instructions to press the response key as quickly as possible when observing a reappearance of the target image.

Subjects completed 16 experimental runs, each of which ran for 4 min, with the majority (12) being of the motion run type (in order to obtain comparable numbers of trials across conditions). Button presses were recorded throughout both run types to assess reaction time (RT) in the case of the static condition (relative to the actual reappearance of an actual target), as well as the susceptibility of faces and houses to MIB during the motion condition.

EEG Acquisition and Analysis

EEG data was continuously recorded during static and motion run types from a 64-channel custom cap (Electrocap, Inc., Eaton, OH) with extended scalp coverage, using a right-mastoid reference, a bandpass filter of 0.01–100 Hz, a sampling rate of 500 Hz, and a gain of 1000 (Neuroscan Inc., Charlotte, NC). Eye movements and blinks were monitored and recorded using two horizontal electro-oculogram (EOG) channels referenced to one another and placed on the outer canthi, and two vertical EOG channels placed below the eyes and referenced to frontal electrodes Fp1 and Fp2. Subject behavior was also monitored using a closed circuit video camera.

Following the experimental session, acquired data was analyzed offline using ERPSS, a Linux-based ERP data-analysis software package (University of California at San Diego, La Jolla, CA). Extracted epochs containing eye blinks, eye movements, muscle activity, and slow drift artifacts were rejected offline prior to selective averaging. Artifact-free data were time-locked averaged selectively for the different stimulus types, both to the onset of the stimuli, as well as to button presses indicating the reappearance of images (following physical disappearances in the case of the static condition, and following MIB-induced perceptual disappearances in the motion condition). Averages were low-pass filtered offline using a nine-point running average filter, which attenuates external electrical noise of ~56 Hz frequency content and higher. ERP averages were algebraically rereferenced to the average of all electrodes (common reference) and baseline corrected to the 200 ms preceding stimulus onset in the case of image-locked responses, and to the period of –1000 to –800 ms preceding the button press in the case of response-locked trials. Face-selective effects were extracted by comparing responses to faces to those associated with houses, separately within the static and motion conditions.

In order to examine the extent of face-specific processing that occurred during MIB, ERP activity time-locked to the button presses in response to the reappearance of a face was compared to the corresponding activity associated with the reappearance of a house for the static (physical onset) and motion (perceptual onset) conditions. The extent to which the face-specific effect for these reappearances differed between the static and motion conditions was used to infer the extent of face-specific processing that occurs during MIB. Specifically, in the case of the static condition, a face or house stimulus reappeared after having actually disappeared, meaning that no face-specific processing was possibly occurring during the intervening period. In the case of the motion condition, the targets were always present during the preceding MIB episode, but the extent of face-specific processing during that episode is unknown. Accordingly, if the face-specific ERP responses for the reappearances were identical for perceptual onsets after an MIB as for actual physical onsets, it would suggest that during the preceding MIB no face-specific processing had been ongoing, similar to how there would have been no face-specific processing prior to an actual physical onset because there had been no image present. If however, the extracted face-specific activity surrounding the reappearance button press differed significantly between physical and perceptual onsets of targets, it would not only differentiate the neural processes triggered by those onset events, but it would also differentiate between the ongoing object-related processes preceding those onset events. In particular, if no face-specific activity was observed surrounding a button press in the post-MIB reappearance condition, it would suggest that face-specific processing had been uninterrupted during the preceding MIB, thereby dissociating face-specific processing activity from awareness during the MIB. Finally, to examine more general differences between perceptual and physical onsets, the response-locked data was collapsed across image type (i.e. collapsed across faces and houses), and compared between the static and motion conditions. This comparison was made for assessing whether activity patterns for an image of any type (i.e. not specific to any object category) differed for perceptual vs physical onsets, which would also speak to the mechanisms by which MIB disrupts awareness.

RESULTS

Behavior

In the static condition, whether a disappearing/reappearing stimulus was a face or house had no bearing on the RT of the subjects. Specifically, subjects responded to faces and houses with approximately equal speed, as

the mean RT across stimulus type (403 ms for faces and 409 ms for houses) did not differ ($t_{19} = 0.96, p = 0.34$). In addition, results showed that MIB was equally effective in diminishing subjects' awareness of faces and houses. In particular, an average of ~10 blindness episodes per stimulus type (mean \pm SD: 10.0 ± 4.1 for faces; 9.9 ± 3.5 for houses) per run was observed, with no difference in the mean number of episodes across image type ($t_{19} = 0.13, p = 0.90$).

Electrophysiology

Electrophysiological data time-locked to the onset of face and house targets (appearance of a new object in the static condition and a switch to a new object image in the motion condition) showed robust face-specific processing in both the static and motion condition. In both the static and motion conditions, face-specific activity elicited by a new image was characterized by an increased negative-polarity response to faces relative to houses across the poststimulus time window of 150–800 ms over the relevant ventrolateral temporal–occipital scalp area, thus displaying the hallmark face-selective ventrolateral N170 response ($F(1, 19) = 21.6, p < 0.001$ for the static condition; $F(1, 19) = 30.2, p < 0.0001$ in the motion condition; site TO2; [Figure 8.2](#)). This extracted face-specific activity (face minus house) did not differ between the static and motion conditions ($F(1, 19) = 1.0, p = 0.33$; [Figure 8.2](#)), though some small differences in onset latency and early amplitude, particularly of the raw ERPs to the face and house stimuli, were present. These differences were likely due to the responses in one case (the static condition) being to an image onset following an offset (giving a sharper and earlier deflection) and in the other case (the motion condition) being that of a switch from one image to another (giving less of a raw onset potential). The overall result demonstrates that, despite the various physical differences across the static and motion condition (actual visual offsets occurring in the static but not in the motion condition, as well as constant rotational motion of a distractor array only in the motion condition only), stimulus-locked face-specific processing to actual image onsets was present and equally robust in both conditions, with relatively minor differences.

To investigate the extent of face-specific processing that occurs during MIB, *response-locked face-specific activity* associated with the reappearance of target images was compared across the static and motion condition ([Figure 8.3](#)). This peri-response face-specific activity differed significantly between the static and motion conditions during the time period surrounding the button press by the subject indicating reappearance (–150 to +300 ms) ($F(1, 19) = 24.0, p < 0.001$; [Figure 8.3](#)). This effect was driven by the presence of robust face-specific ERP activity in the static condition ($F(1, 19) = 22.6, p < 0.001$)

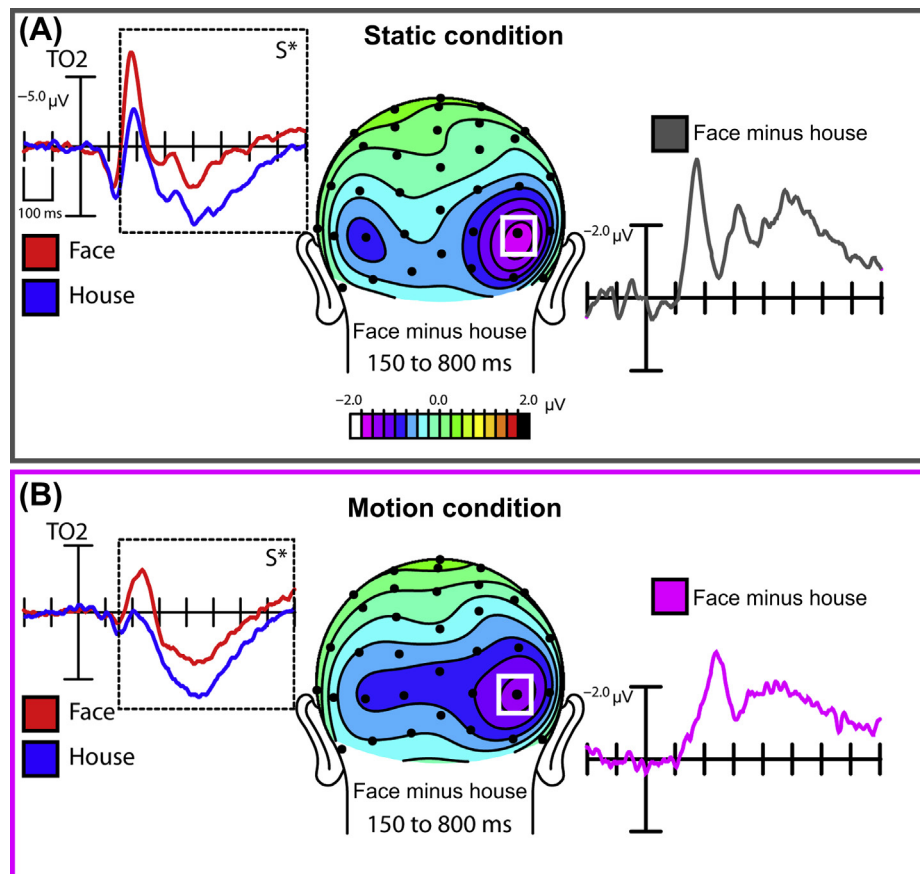


FIGURE 8.2 Face-specific activity to new-image target onsets: face-specific activations were extracted over right temporal–occipital scalp sites in response to new-image target onsets in the static (A) and motion (B) conditions during the poststimulus time window of 150–800 ms. These face-specific responses did not differ across conditions, as shown in a comparison of the face-specific difference waves in the same time window (right side of panel).

and an absence of this activity in the motion condition ($F(1, 19) = 0.02$, $p = 0.90$) during the same time period. For the static condition, this button-press-locked response would reflect the convolution of the stimulus-onset-driven face-specific negativity with the response time distribution associated with the button press. If the strictly perceptual onset had actually triggered a comparable face-specific response, a similar activation pattern would be expected in the response-locked averages for the motion condition. Because no discernible face-specific processing was observed for these perceptual onsets, it suggests that face-specific processing had continued uninterrupted during MIB, and that the perceptual onset marked only reentrance of the target into awareness and not the coming online of face-specific processing anew.

Additional analyses collapsing across the face and house object types further examined activity preceding button press responses in the static and motion conditions. This analysis sought to uncover differences in activity preceding the emergence of awareness of an image of any type that had been continuously present (motion

condition) to activity preceding the awareness of a physically reappearing image (static condition). This comparison uncovered a significant positive-polarity voltage deflection over parietal scalp sites during the 700 ms preceding a button press in the motion condition, but not in the static condition ($F(1, 19) = 47.5$, $p < 0.0001$; Figure 8.4). In the present context, this establishes such activation as distinguishing two types of perceptual reappearances: one in which the object was present but not within awareness, for which this parietal response was present (following MIB), and another in which no object was present and for which no such response was observed.

DISCUSSION

The present results provide electrophysiological evidence that face-specific processing continues relatively intact during MIB, thus supporting the view that MIB disrupts visual awareness through a higher-level mechanism that acts at a relatively late visual processing stage. With

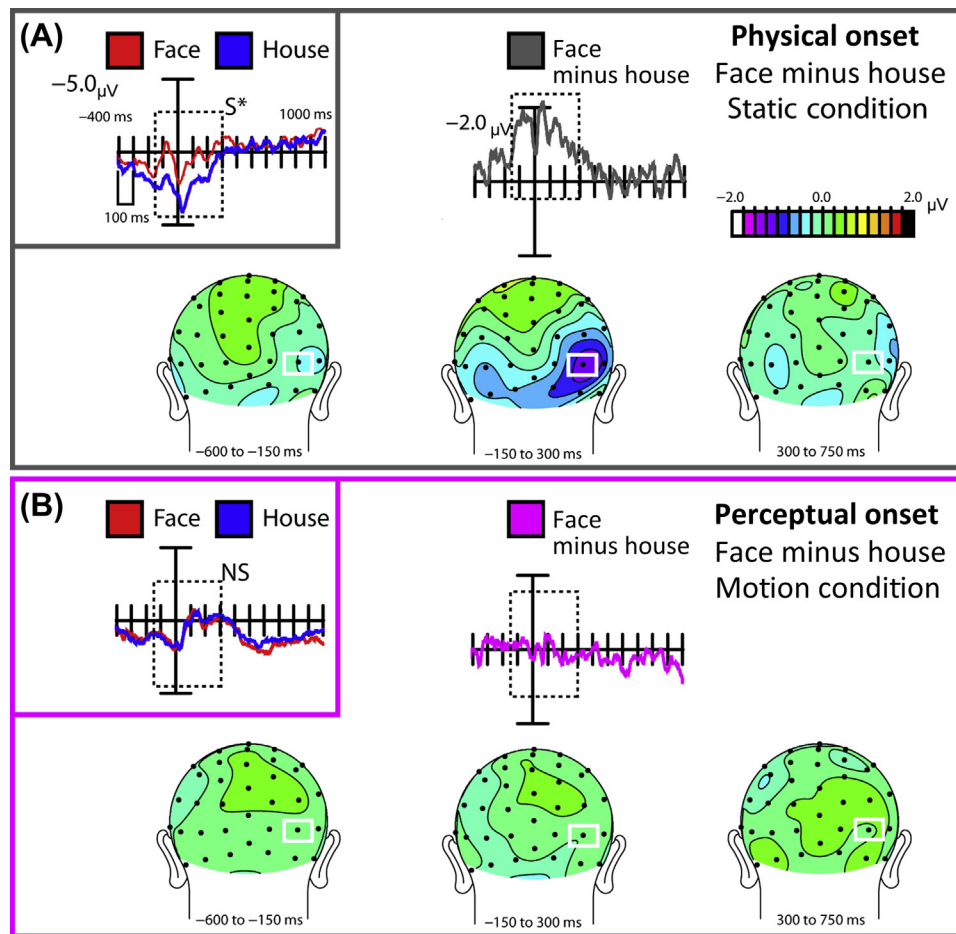


FIGURE 8.3 Response-locked face-specific activations: physical reappearances of faces and houses (static condition) triggered face-specific activations visible in the response-locked averages temporally surrounding the button press (A). In the case of the purely perceptual onsets of faces and houses (motion condition) following MIB episodes, there was no face-specific activation (B). These activations differed significantly across physical and perceptual onsets, during the time window of -150 to 300 ms (surrounding the button press in time).

regard to object-category processing, face-specific neural activity was present in the case of physical onsets, but not in the case of the strictly perceptual onsets that follow MIB episodes. This means that although the disappearance and reappearance of the targets were perceptually similar during the two conditions, the neural processing related to the perceptual appearance and reappearance of targets in the MIB condition was rather unlike that for targets that actually appear or reappear (i.e., in the static condition).

More specifically, the present pattern of results suggests that there was substantial ongoing visual-object processing happening during MIB than during an actual physical absence. In particular, it is clear that in the case of a physical stimulus absence, no face-specific processing could have been happening during that time, given that there was nothing on the screen, and thus the physical reappearance of the stimulus would be expected to trigger a full face-specific response. Thus, by analogy, if there were a complete lack of face-specific processing

during MIB (similar to that seen in the case of a physical absence), a similar face-specific signal would have been expected to occur when the image reentered awareness. The fact that no face-specific activity was actually observed following perceptual reappearance of an image suggests that this activity had been ongoing and intact during MIB. This perseverance of visual neural processing during an MIB despite an absence of awareness is consistent with behavioral MIB studies that suggest that low-level visual perceptual processes intact during MIB. For example, as mentioned earlier, orientation-specific processing (Kouhsari, Moradi, Zand-Vakili, & Esteki, 2002), the formation of negative afterimages (Hofstoetter et al., 2004), the unified nature of an object formed during MIB (Mitroff & Scholl, 2005), and the state of an object following its disappearance during MIB (Mitroff & Scholl, 2004) have all been shown behaviorally to persist during episodes of MIB. The present study, by employing measures of specific neural activity responses, adds

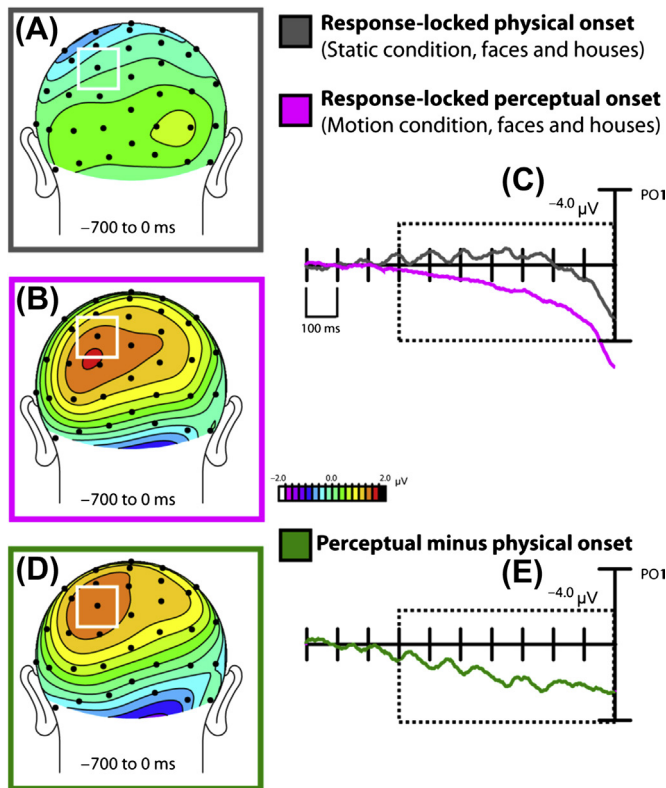


FIGURE 8.4 Perceptual vs physical target onsets: comparisons of physical (A) and perceptual (B) onsets of targets time-locked to the button press, regardless of object category, revealed a positive-polarity voltage deflection over parietal scalp regions during the 700 ms leading up to the button press in the case of perceptual onsets but not physical onsets.

visual object-category discrimination to that list of visual processes that appear to proceed intact during MIB.

The intactness of object-specific processing during MIB is also consistent with some of the proposed mechanisms of MIB. Although a consensus concerning such mechanisms has yet to be reached, one explanation posits that MIB occurs as a result of competing representations of the distractor array and the static target within the visual system (Bonneh et al., 2001). According to this theory, these competing representations are manifested as alternating dominance of the mask display and the static target in terms of what is consciously perceived. This account has been supported neurally by functional imaging studies tracking the relative levels of activity in ventral and dorsal visual regions during and outside of MIB episodes (Donner et al., 2008; Scholvinck & Rees, 2010). In particular, these studies uncovered a pattern of relative levels of activity that seemed to track the subjects' perceptual state, with ventral regions showing higher activity when the static target was within awareness, and dorsal regions showing higher activity during MIB.

The present study speaks to the neural activation patterns that are observed during MIB by measuring

the neural correlates of the perceptual events immediately preceding the reemergence of the awareness of an object. Specifically, the perceptual onset, relative to a physical onset, was characterized by a significant increase in parietal activity (during the 700 ms leading to the button press indicating reappearance). This signal could reflect a higher-level process of attentional capture by the continually present target, which would not be observed in the case of a physically absent target, and may mediate its reentrance into visual awareness. This idea of attention breaking an episode of MIB may be distinguished from that put forth in a previous study in which increased endogenous attention to a target enhanced its susceptibility to MIB (Scholvinck & Rees, 2009). In the present case, it may be *exogenous* capture of attention by a present but perceptually suppressed target that appears to facilitate its overcoming of MIB. It makes sense that such an effect would only be seen in the perceptual onset condition, as such attentional switching to the target could underlie its regaining of perceptual dominance in the competitive context of the MIB condition.

Although the neural origin and functional nature of such a parietal scalp signal is not clear as yet, other potentially related effects have implicated a role for parietal processes in the emergence of awareness. For example, disruption of parietal activity has been found to be associated with mediating perceptual switches. When transcranial magnetic stimulation was used to cause transient disruption to left inferior parietal cortex, it facilitated a switch to the subsequent perceptual state, shortened blindness episodes when applied at their onset, and shortened intervals of target awareness when applied with the reemergence of target awareness (Funk & Pettigrew, 2003). The present results thus offer a compelling addition to the body of literature concerning MIB, as well as to that concerning visual processing during the absence of awareness more generally. It must be noted, however, that the interpretation of these results is somewhat constrained by the assumption that the response time distribution in the case of perceptual onsets is reasonably comparable to that of the physical onsets. This assumption is necessary because of the indeterminate nature of the timing of perceptual target onsets in the motion condition, of which the only marker is the button press executed as quickly as possible by the subjects. However, it seems rather unlikely that the total absence of a face-specific effect in the post-MIB case and the presence of a parietal positivity for any object just prior to the button press in that condition could have derived from differences in RT distributions. With regard to face-specific processing, if it were actually present in the motion condition, the RT distribution would have had to be so

spread out relative to that of the static condition as to effectively wash out this effect, which seems unlikely. In addition, the observed parietal effect reflecting perceptual onset of a present image is simply not present in the case of static onsets, and cannot be explained by a difference resulting from the convolution of an RT distribution with the same stimulus-locked voltage deflections. Specifically, the parietal difference resulted solely from its presence in the motion condition and complete absence in the static condition. It seems rather unlikely that there was such a variable RT distribution in the motion condition that it could wash out a face-specific ventrolateral-occipital effect in that comparison, while also resulting in an enhanced effect over parietal scalp in another comparison.

CONCLUSIONS

MIB represents a useful tool in disrupting visual awareness while at the same time maintaining low-level visual stimulation. A variety of behavioral studies have suggested that substantial amounts of visual perceptual processing occurs during MIB, and others have proposed high-level mechanisms of competition to account for the effect. The present study adds to the understanding of MIB and visual processing in the absence of awareness in two main ways. First, it shows that although salient images of faces and other objects are susceptible to the effects of MIB, neural activity reflecting object-category discrimination is unaffected as images go in and out of perceptual awareness. Second, it extracts a pattern of parietally distributed activity just prior to the perceptual reappearance of an image (following an MIB episode) that suggests a process of attentional capture by an already present target as it reestablishes its dominance in an MIB setting. Such an attentional process might then constitute a key component of the set of mechanisms mediating MIB.

Acknowledgments

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