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Short Communication

The neural substrates associated with inattentional blindness

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ABSTRACT

Inattentional blindness is the failure to perceive salient stimuli presented at unattended locations. Whereas the behavioral manifestation of inattentional blindness has been investigated, the neural basis of this phenomenon has remained elusive. In the current study, event-related fMRI was used to identify the neural substrates associated with inattentional blindness. During central fixation, participants named colored digits presented at a peripheral location. On a subset of trials, an unexpected checkerboard circle (the critical stimulus) was presented at the same eccentricity along with the colored digits (a post-scan questionnaire assessed participants' awareness of the critical stimulus). Neural activity during inattentional blindness was observed in the prefrontal cortex. Together with previous findings, these results call into question the widespread view that activity in the prefrontal cortex reflects conscious processing.

1. Introduction

Inattentional blindness is the failure to perceive salient visual stimuli presented at unattended locations (Mack & Rock, 1998). While several studies have focused on the behavioral manifestation of inattentional blindness (Cartwright-Finch & Lavie, 2007; Koivisto, Hyona, & Revonsuo, 2004; Koivisto & Revonsuo, 2008; Most, Scholl, Clifford, & Simons, 2005; Newby & Rock, 1998; Simons & Chabris, 1999; Thakral & Slotnick, 2010), the neural basis of inattentional blindness, to date, has remained elusive. During an inattentional blindness paradigm, only a single unaware trial can be acquired from each participant. This is due to the increased expectation of the unexpected salient stimulus presented after the first trial. Moreover, it is generally assumed that numerous trials must be averaged to extract a reliable neural signal, and thus the neural basis of inattentional blindness has not been evaluated. Nevertheless, robust functional magnetic resonance imaging (fMRI) activity has been reported based on few or even single trials (Blamire et al., 1992; Richter et al., 2000; for discussion see, Huettel & McCarthy, 2001). Based on this, the current aim was to investigate the neural basis of inattentional blindness using fMRI.

Of relevance, conventional theories have posited that neural activity in the prefrontal cortex is associated with conscious processing (Baars, 2003; Beck, Rees, Frith, & Lavie, 2001; Crick & Koch, 1995, 1998; Dehaene et al., 2001; Dehaene & Changeux, 2005; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Dehaene & Naccache, 2001; Jack & Shallice, 2001; Rees, 2007; Rees, Kreiman, & Koch, 2002). Crick and Koch (1995, 1998), for example, stated that the prefrontal cortex holds a privileged role in conscious processing, due to its association with planning, language production, and motivated behaviors (Fuster, 2001; Miller, 2000; Sakai, 2008). This stands in contrast to activity in striate cortex (visual cortical area V1) which is presumed to not necessarily lead to consciousness due to its distinct lack of direct connections to the prefrontal cortex (Crick & Koch, 1995, 1998). Similar to striate cortex, neural activation in the ventral and dorsal visual processing streams is presumed to be necessary but not entirely sufficient for conscious visual processing (Rees, 2007; Rees et al., 2002; Tong, 2003). For example, activation of the parahippocampal cortex in the ventral stream has been observed for visual

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scenes in the absence of awareness during attentional blink (Marois, Yi, & Chun, 2004). Dorsally, activation of the parietal lobe has been observed for objects rendered invisible through interocular suppression (Fang & He, 2005). For a review of evidence in support of the role of the ventral and dorsal visual streams (in addition to striate cortex) during unconscious processing see Rees (2007).

In opposition to the notion that the prefrontal cortex is directly involved with conscious processing, recent studies have reported evidence of neural activity occurring in this higher-cortical region during unconscious processing. Using behavioral paradigms such as change blindness (Beck et al., 2001), binocular fusion (Moutoussis & Zeki, 2002) and priming (Dehaene et al., 2001; Lau & Passingham, 2007), neural activity has been observed in the frontal cortex. To further this idea, experimental studies investigating the neural activity associated with previously seen but unrecognized items provides parallel findings for unconscious activity in this higher-cortical region (Henson, Hornberger, & Rugg, 2005).

The aim of the present study was to determine the neural underpinnings of inattentional blindness. Inattentional blindness related activity was defined as neural activity, independent of awareness (i.e., activity consistent across both conscious and unconscious processing of the unexpected critical stimulus). Awareness related activity was identified by contrasting trials where participants were aware versus unaware of the critical stimulus. To anticipate the results, inattentional blindness related activity independent of awareness was revealed to be significant in the prefrontal cortex, a region more traditionally associated with conscious processes.

2. Materials and methods

2.1. Participants

The experimental and imaging protocol was approved by the Massachusetts General Hospital Institutional Review Board. Informed consent was obtained before the experiment commenced. Twenty-eight participants (with normal or corrected-to-normal visual acuity) completed the study with nine participants included in the final analysis; nineteen participants were not included due to awareness of the critical stimulus in the *inattention* condition.

2.2. fMRI stimuli and tasks

As illustrated in Fig. 1, each trial began with a central fixation cross presented on a grey background (for 1500 ms), followed by two colored digits (each for 350 ms, ranging in value from 1 to 9, and subtending 0.5° of visual angle) located 11° of polar angle from the horizontal meridian and 3.2° of visual angle from fixation, and ended with a mask (for 500 ms, Koivisto et al., 2004; Thakral & Slotnick, 2010). Participants were instructed to maintain fixation and name each digit (ranging from 1 through 9) and its corresponding color (red, orange, green, purple, blue, pink, black, or yellow) requiring participants to focus attention at the location of the digits. Participants completed two non-critical trials (each followed by the mask) where only the colored digits were presented, and on the third trial, the critical trial, the critical stimulus – a black and white checkerboard circle – was presented along with the digits (for 700 ms; see Fig. 1). The critical stimulus subtended 1° of visual angle in diameter and was presented 1.5° of visual angle from the attended location at the same eccentricity as the digits.

Participants completed three attention conditions (*inattention*, *divided attention*, and, *full attention*; see also, Koivisto et al., 2004; Thakral & Slotnick, 2010). Each of these conditions included the three trials described above (*inattention* condition: trials 1–3; *divided attention* condition: trials 4–6; *full attention* condition: trials 7–9). The first condition was classified as the *inattention* condition because there was no expectation of the critical stimulus (trials 1–2, non-critical *inattention* trials and trial 3, critical *inattention* trial). The second condition was classified as the *divided attention* condition because the questions asked after the previous *inattention* condition signaled participants to the possibility that an extra stimulus might appear, even though there were no direct instructions to look for the critical stimulus (trials 4–5, non-critical *divided attention* trials and trial 6, critical *divided attention* trial). The third condition was classified as the *full attention* condition because participants were explicitly told to detect the occurrence of anything new appearing on the screen, and were thus expected to attend more diffusely, including the location of the critical stimulus (trials 7–8, non-critical *full attention* trials and trial 9, critical *full attention* trial). This *full attention* condition served as the control because observers were expected to perceive the critical stimulus. Across the three conditions, the digits and critical stimulus were always presented at the same location in the upper right quadrant as shown in Fig. 1 (Thakral & Slotnick, 2010). Each condition began and ended with a period of fixation (for 14 s).

After each of the three conditions (i.e., *inattention*, *divided attention*, and *full attention*), participants answered three questions to determine whether they had been aware of the critical stimulus (Koivisto et al., 2004; Thakral & Slotnick, 2010). The first question asked if the participant had detected something new that had not been previously presented. The second question asked participants to choose the critical stimulus from five possible shapes (square, circle, star, triangle, or diamond). The third question asked participants to select the quadrant in which the critical stimulus appeared. Participants were classified as aware of the critical stimulus if they answered yes to the first question and either correctly identified it, or correctly selected its spatial location (and were otherwise classified as unaware of the critical stimulus). Questions were administered visually in the scanner and participants responded via button box placed in their left hand. These behavioral responses along with the presence or absence of the critical stimulus yielded three event types: (1) 'no-critical stimulus', where only the

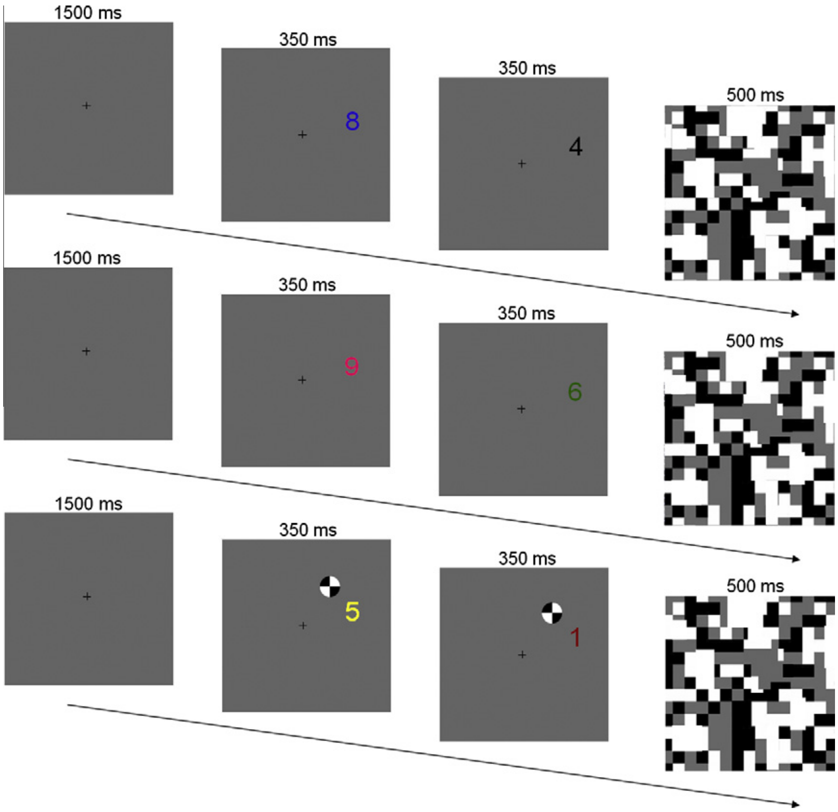

Fig. 1. Depiction of the inattentional blindness paradigm with the unexpected checkerboard circle (i.e., critical stimulus). Each trial began with a central fixation cross presented on a grey background with the addition of to-be-recited colored digits presented in the periphery. There were two non-critical trials of digit naming without the critical stimulus. A subsequent trial of colored digits was accompanied by a black and white checkerboard circle which served as the unexpected critical stimulus (critical trial). Participants were instructed to maintain central fixation and say each color/digit aloud, thus requiring attention at that location. Each participant completed three such attention conditions (*inattention*, *divided attention*, and *full attention*) either with no expectation or varying expectation that the critical stimulus might be present (based on task instructions). Each of these conditions included three trials (two non-critical trials and one critical trial). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

colored digits were presented, (2) 'unaware', where the critical stimulus was presented (in addition to the colored digits) but participants did not perceive it, and (3) 'aware', where the critical stimulus was presented and perceived by the participants.

2.3. fMRI acquisition and data analysis

A 3 Tesla Siemens Trio scanner was used to acquire imaging data. Anatomic images were acquired using a multiplanar rapidly acquired gradient echo sequence (TR = 30 ms, TE = 3.3 ms, 128 sagittal slices, resolution = 1 mm $\times$ 1 mm $\times$ 1.33 mm). Functional images were acquired using an echo-planar imaging (EPI) sequence (TR = 2 s, TE = 30 ms, 64 $\times$ 64 acquisition matrix, 33 axial slices, 4 mm isotropic resolution). Analysis was conducted using BrainVoyager QX (Brain Innovation, Maastricht, The Netherlands). Preprocessing for functional data included slice-time correction, motion correction, and linear trend removal (no spatial smoothing was applied). Functional and anatomic images were transformed into Talairach space (which included resampling at 3 mm isotropic resolution). Twenty EPI images were collected for each individual inattentional blindness condition (i.e., *inattention*, *divided attention*, and *full attention*; 18 EPI images were collected for one participant).

On an individual participant basis, a standard general linear model analysis was conducted where the three event types ('no-critical stimulus', 'unaware', and 'aware') were modeled as square waves based on their respective onsets, durations, and behavioral responses of the participant (i.e., being aware or unaware of the critical stimulus). For each participant, each condition was divided into two parts, the first part being the two non-critical trials where the critical stimulus was not presented (the 'no critical-stimulus' event type; trials, 1–2, 4–5, and 7–8), and the second part being the critical trial where the critical stimulus was presented (either the 'aware' or 'unaware' event type; trials, 3, 6, and 9). The square wave model for each event-type included the initial digit presentation for a total of 700 ms, the mask for 500 ms, and the ending fixation for 1500 ms. The fixation periods that began each condition were not modeled. Each event-type ('no-critical stimulus' and 'unaware' or 'aware') had with an approximate duration of 5.4, 2.7, and 2.7 s, respectively (for two participants the length of the events were approximately 7.6, 3.8, and 3.8 s, due to technical difficulty). Given that the 'no-critical stimulus' event-type was twice as long as the ‘unaware’ and ‘aware’ event-type, it could be argued that this could bias the results. An additional fMRI analysis was conducted where only the first non-critical trial was modeled (as oppose to both non-critical trials) and a largely similar pattern of results was observed.

A canonical hemodynamic response was convolved with the square waves resulting in hemodynamic response models. These response models were fit to each voxel’s timecourse activity yielding estimated beta-weights for each event type. To identify voxels significantly active across participants, a random-effects analysis was conducted. For each contrast, only those voxels classified as active were those where the respective beta-weights were significantly positive across participants using a one-tailed *t*-test. Four participants were classified as unaware in the *divided attention* condition. To avoid an expectancy confound, these were not included in the current analysis (i.e., both the non-critical and critical trials that comprised the *divided attention* condition were excluded). If participants were classified as aware in the *divided attention* condition, both the non-critical and critical trials were included. Across all nine participants, there were 9 ‘unaware’ events, 14 ‘aware’ events, and 23 trials where no critical stimulus appeared. Of those 9 unaware events, four participants correctly guessed the shape and/or location (with two of those participants only correctly guessing the spatial location).

To isolate the neural regions associated with inattentional blindness, common activity (Caplan & Moo, 2004) across events where participants were aware of the critical stimulus versus when the critical stimulus was not present and another where participants were unaware of the critical stimulus versus when the critical stimulus was not present was identified; activity common across (aware > no-critical stimulus) and (unaware > no-critical stimulus). The assumption was that neural regions associated with both awareness and unawareness of the critical stimulus would be reflective of activity independent of awareness and thus unconscious (i.e., automatic neural processing associated with the critical stimulus but not correlated with awareness; Rugg et al., 1998; Slotnick & Schacter, 2004). To identify neural regions associated with awareness of the critical stimulus, a comparison was done for trials where participants were aware of the critical stimulus versus those trials for which they were unaware (aware > unaware).

When identifying common activity associated with both awareness and unawareness of the critical stimulus, the individual voxel threshold for each contrast of (aware > no-critical stimulus) and (unaware > no-critical stimulus), was set to $p < 0.01$, corresponding to a joint p-value of $p = 0.001$ (computed using the Fisher technique, Fisher, 1973). In order to correct for multiple comparisons, a minimum cluster extent threshold (Forman et al., 1995; Ledberg, Åkerman, & Roland, 1998) of 10 resampled voxels was implemented correcting to a whole-brain threshold of $p < 0.05$. This was computed using a Monte Carlo simulation of 1000 iterations (Slotnick & Schacter, 2004, 2006; Thomspon, Slotnick, Burrage, & Kosslyn, 2009) using custom software written in MATLAB (The Mathworks, Natick, MA; Slotnick 2008a). To model smoothness, three-dimensional spatial autocorrelation was estimated for the random-effects image using custom software written in MATLAB (The Mathworks, Natick, MA; Slotnick 2008b). This was computed to be 4.5 mm full-width-half-maximum (FWHM) and implemented as part of the Monte Carlo simulation. The cluster extent was chosen such that the probability of observing 10 contiguous voxels or larger was less than 0.05. For all other contrasts, an individual voxel threshold was set to $p < 0.001$, corrected to $p < 0.05$ by enforcing a similar cluster extent of 10 voxels (computed using the same Monte Carlo procedure with an estimated spatial autocorrelation of 4.5 mm FWHM).

As stated in the Introduction, a severe drawback of the present inattentional blindness paradigm is that it only produces a single unaware trial per participant. Thus, the statistical power to detect a significant effect is very small at the outset. Moreover, data from only nine participants was used in the analysis, which is a small number for a fMRI experiment. All these reasons work against the possibility of finding any significant effects in the present experiment. However, null results were not observed and thus, these were not major concerns.

3. Results

The percent detection for each of three conditions, *inattention*, *divided attention*, and *full attention,* was 67.86%, 85.71%, and 100%, respectively. The nine participants who were unaware in the *inattention* condition were included in the fMRI analysis.

Inattentional blindness related activity, independent of awareness, identified by common activity across (aware > no-critical stimulus) and (unaware > no critical stimulus), was observed within the prefrontal cortex, including bilateral medial prefrontal cortex (BA 10/11/32; Fig. 2A, Table 1) and bilateral anterior cingulate cortex (BA 24 and 32; Fig. 2A, Table 1). Although these higher processing regions have been traditionally associated with conscious processing (Baars, 2003; Beck et al., 2001; Crick & Koch, 1995, 1998; Dehaene et al., 2001, 2006; Dehaene & Changeux, 2005; Dehaene & Naccache, 2001; Jack & Shallice, 2001; Rees, 2007; Rees et al., 2002), the current results provide evidence that these cortical regions are also associated with unconscious processing. Neural activity was also evidenced in the right cerebellum.

In an effort to further characterize the nature of activity during inattentional blindness, ‘unaware’ events were directly compared to ‘no-critical stimulus’ events (unaware > no-critical stimulus). Given that the presence of the critical stimulus is different but the participants’ awareness is identical, this contrast would isolate stimulus-driven but unconscious processing of the critical stimulus during inattentional blindness (Beck et al., 2001). Identical to activity independent awareness during inattentional blindness, significant activations were observed in the medial prefrontal cortex and anterior cingulate cortex (BA 10/32; Fig. 2B, Table 1). Novel neural activity was observed in the orbitofrontal cortex (BA 10/11/12; Table 1). These results support the fact that unconscious processing of the critical stimulus alone can drive activity in the prefrontal cortex during inattentional blindness.

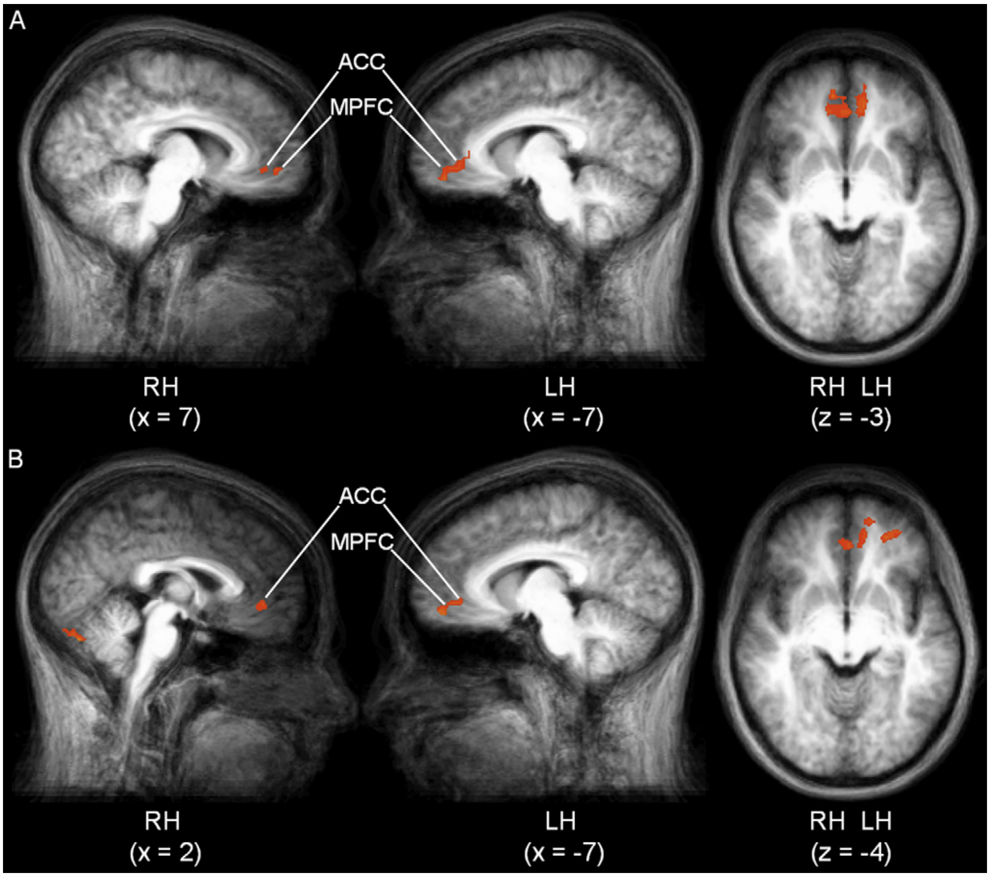

Fig. 2. (A) Inattentional blindness related activity, independent of awareness, identified as common activity across (aware > no-critical stimulus) and (unaware > no-critical stimulus). (B) Stimulus-driven unconscious processing of the critical stimulus during inattentional blindness identified using the contrast of (unaware > no-critical stimulus). Significant group activity (shown in orange) was overlayed onto a group averaged anatomic normalized image. Activations within the prefrontal cortex are labeled with medial sagittal views of each hemisphere on the left and a tranverse image on the right; ACC = anterior cingulate cortex, MPFC = medial prefrontal cortex). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Neural regions associated with inattentional blindness independent of awareness (common activity across (aware > no-critical stimulus) and (unaware > no-critical stimulus)), stimulus-driven unconscious processing of the critical stimulus (unaware > no-critical stimulus), and awareness of the critical stimulus (aware > unaware).

Region	BA	*x*	*y*	*z*
(Aware > No-critical stimulus) and (Unaware > No-critical stimulus)				
Anterior cingulate cortex (L)	24/32	−8	37	−2
Anterior cingulate cortex (R)	32	4	38	−3
Medial prefrontal cortex (L)	10	−11	51	−3
Medial prefrontal cortex (L)	11/12	−7	47	−9
Medial prefrontal cortex (R)	10/32	7	46	−4
Cerebellum (R)		41	−68	−23
Unaware > No-critical stimulus				
Anterior cingulate cortex (L)	32	−7	40	−3
Anterior cingulate cortex (R)	32	2	39	−3
Medial prefrontal cortex (L)	10/32	−9	46	−5
Orbitofrontal cortex (L)	11/12	−28	44	−5
Orbitofrontal cortex (L)	10/11	−13	52	−5
Cerebellum (R)		40	−70	−23
Aware > Unaware				
Orbitofrontal cortex (L)	11/12	−14	20	−9

Note: L = left hemisphere, R = right hemisphere. BA refers to Brodmann area. Talairach coordinates (*x*, *y*, *z*) correspond to the center of each activation.

For the contrast of (aware > unaware), no activity was observed. However, when the cluster extent was loosened to seven voxels, significant activity was observed in the left orbitofrontal cortex (BA 11/12; Table 1).

4. Discussion

In the present study, inattentional blindness related activity, independent of awareness, was observed in the prefrontal cortex. This evidence bolsters recent findings reporting similar unconscious processing occurring in this higher-cortical region. Beck et al. (2001) observed unconscious frontal cortex activity in the inferior frontal gyrus when participants were unaware of a salient change as compared to when there was no change at all (i.e., change blindness). Similarly, Lau and Passingham (2007) observed effects of priming in the dorsolateral prefrontal cortex, an area commonly associated with cognitive control, a conscious process (see also, van Gaal, Ridderinkhof, Scholte, & Lamme, 2010). Using masked repeated words, a similar frontal cortex priming effect was also observed by Dehaene et al. (2001) in the precentral gyrus. Moreover, using a binocular fusion paradigm, Moutoussis and Zeki (2002) reported results of robust prefrontal activity for visual stimuli not perceived. While presenting each eye with differing visual inputs and having the binocular stimulus invisible (i.e., dichoptic color fusion), their study revealed how an unconscious monocular stimulus can be preserved in higher cortical processing regions (i.e., non-monocular regions of cortex). These findings in consideration with the current results provide evidence that unconscious activity can occur in a number of anterior cortical regions. More importantly, this unconscious related activity occurred in a region conventionally associated with conscious processes (Baars, 2003; Beck et al., 2001; Crick & Koch, 1995, 1998; Dehaene et al., 2001, 2006; Dehaene & Changeux, 2005; Dehaene & Naccache, 2001; Jack & Shallice, 2001; Rees, 2007; Rees et al., 2002).

Parallel findings for unconscious activity in the prefrontal cortex have also been observed in experimental studies investigating the neural basis of previously seen but unrecognized items. Activations have been reported in the medial superior frontal gyrus and the frontopolar cortex, for participants unaware of a previously seen item versus when a new item is correctly classified as new (i.e., a new correct rejection; Henson et al., 2005). As suggested by this parallel finding, the neural activity observed during inattentional blindness may be representative of the implicit memorial encoding of the unconscious critical stimulus during inattentional blindness (e.g., priming, Mack & Rock, 1998; but see Lamme, 2003, and for a related discussion, Scholte, Witteveen, Spekreijsei, & Lamme, 2006).

Two recent studies have presented suggestive data on the neural mechanisms of inattentional blindness (Matsuyoshi et al., 2010; Todd, Fougnie, & Marois, 2005). These studies probed awareness of an unexpected stimulus (i.e., inattentional blindness) during the delay period of a visual short-term memory task. Inattentional blindness was significantly greater under high versus low visual short-term memory load. In separate imaging studies, Todd et al. (2005) showed that activity in the temporo-parietal junction is negatively correlated with visual short-term memory load and Matsuyoshi et al. (2010) showed that activity in the intraparietal sulcus is positively correlated with visual short-term memory load. These researchers claimed that the likelihood of inattentional blindness may be mediated, in part, by suppression of the temporo-parietal junction or facilitation of the intraparietal sulcus, regions known to be involved in the capture of attention or goal-directed attention, respectively (Corbetta & Shulman, 2002). In the present study no activity was observed in either the temporo-parietal junction or intraparietal sulcus. This null-finding could be due, in part, to low statistical power. However, it will be important for future studies to manipulate task load experimentally and identify whether these same neural regions are true as oppose to suggestive neural correlates of inattentional blindness.

The reported pattern of inattentional blindness results was based on the assumption that neural regions associated with both awareness and unawareness of the critical stimulus would be reflective of activity independent of awareness, and thus unconscious (Rugg et al., 1998; Slotnick & Schacter, 2004). However, identifying common activity across (aware > no-critical stimulus) and (unaware > no-critical stimulus) limits the ability to detect only quantitative differences between 'aware' and 'unaware' events, whereas it is quite possible that there are qualitative differences between conscious and unconscious processing. Thus, neural regions labeled unconscious could, (1) Contain two populations of neurons one associated with conscious processing and another with unconscious processing or (2) Contain a single population of neurons that differ for conscious and unconscious processing. The latter possibility has been observed in numerous studies showing stimulus and category-specific ventral visual cortical activity when stimuli are processed unconsciously and also when the same stimuli are processed consciously (for review see, Rees 2007). The current inattentional blindness activity, specifically in higher-cortical regions, suggests that these regions may behave similarly to ventral visual cortex and participate in both conscious and unconscious processing. However, future research will need to determine whether the neural regions commonly involved with both conscious and unconscious processing elicit qualitatively different patterns of neural activity during these processes (e.g., using fMRI pattern-based decoding approaches; for review see, Rees, 2007).

Recently, a distinction has been made between different concepts of consciousness (i.e., phenomenal consciousness versus access/reflective consciousness; Block, 2007; Lamme, 2003, 2004; Revonsuo, 2006). Phenomenal consciousness refers to the mere presence of qualitative experiences, for example in the visual modality, to the subjective experience of seeing (e.g., differentiating the colors red from green; Block, 2005). Access/reflective consciousness consists of only those contents of phenomenal consciousness that have been attentionally selected for further cognitive processing in working memory (with the possibility of a later report of that selected content). In the present experiment, in order to be considered aware of the critical stimulus, participants were required to report/remember that stimulus. Therefore, it remains possible that it was the access/reflective consciousness that failed during inattentional blindness, although the stimulus was briefly experienced in phenomenal consciousness (e.g., as a disappearing and transient iconic memory trace, Revonsuo, 2006, see also, Wolfe, 1999). Therefore, according to this view, the prefrontal cortex activity during inattentional blindness may indeed reflect consciousness (i.e., phenomenal consciousness).

It should also be noted that the current pattern of neural activity associated with inattentional blindness was deemed unconscious based solely on the commonly used forced-choice identification and localization task used to assess subjective awareness in this paradigm (Koivisto et al., 2004; Koivisto & Revonsuo, 2008; Mack & Rock, 1998; Thakral & Slotnick, 2010). As such, participants may have been conservative in reporting the critical stimulus, and the inattentional blindness activity currently reported may be contaminated with some conscious processing (for a related discussion see, Slotnick & Schacter, 2006). As previously stated, Beck et al. (2001) and Dehaene et al. (2001) report unconscious frontal activity. However, these researchers argue for a privileged role of the frontal cortex in conscious processing given that stronger and more extensive frontal activity was observed during conscious processing. The former weak unconscious activation may thus reflect some form of low confidence awareness. To asses the degree to which neural activity is not contaminated with conscious processing, future research will need to use paradigms that better characterize unconscious processing during inattentional blindness (e.g., comparing activity for inattentionally blind stimuli at low and high confidence, see also, Slotnick & Schacter, 2004). Nevertheless, the present findings do replicate previous studies reporting unconscious neural activity occurring in similar cortical regions.

Of relevance to the aim of the study, inattentional blindness activity was observed in the prefrontal cortex. Whereas, the prefrontal has been traditionally associated with conscious processing (Baars, 2003; Beck et al., 2001; Crick & Koch, 1995, 1998; Dehaene et al., 2001, 2006; Dehaene & Changeux, 2005; Dehaene & Naccache, 2001; Jack & Shallice, 2001; Rees, 2007; Rees et al., 2002), the present results, together with previous findings, suggest that unconscious processing occurs in this higher-cortical region as well.

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