A new discovery published in PNAS, from researchers at Dartmouth College and the Barrow Neurological Institute offers new insight into the localization of visual awareness of simple unattended targets in the visual system.

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Press release

Tse PU, Martinez-Conde S, Schlegel AA, Macknik SL, (2005), “Visibility and visual masking of simple targets are confined to areas in the occipital cortex beyond human V1/V2”, Proceedings of the National Academy of Sciences (USA), 102 (47), pp.17178-17183. Download

Visual awareness is the feeling that makes the world seem visible. In contrast to a visual reflex, as in when our eyes change their focus, visual awareness describes the conscious experience of recognizing a stimulus as visible, rather than invisible. This function is perhaps the most fundamental job of the visual system and it may be critical to understanding all visual processing: a target is not seen as moving unless it is visible, a target is not seen as red unless it is visible, and perception of higher cognitive processing of visual objects requires that the stimulus be visible.

We have discovered that awareness of simple and unattended visual targets is maintained in a small portion of the occipital lobes of the brain, downstream of cortical area V2. Previous studies by two of us had already ruled out the first stages of the visual system, such as the retina, lateral geniculate and V1, as capable of generating visual awareness (Macknik & Martinez-Conde, Journal of Cognitive Neuroscience, 2004). However, these previous studies, in addition to other of the many studies that have attempted to localize visual awareness, have served only to place a lower bound in the visual hierarchy for processing that leads to awareness. Some studies place the lower bound for awareness in the thalamus, V1, V2 or even later, but all of these studies leave the upstream brain areas (i.e. the vast majority of the brain) as potential candidates to maintain awareness. The present study places, for the first time, both lower and upper boundaries within the visual system for circuits that maintain the awareness of simple unattended targets, thereby localizing the brain circuits sufficient to generate awareness of simple objects to a small area of the brain.

The study used functional Magnetic Resonance Imaging (fMRI) technology to scan the brains of 17 volunteers while they were exposed to simple unattended visual targets that appeared either more visible or less visible. Functional MRI measures the position of deoxygenated blood within the brain, which indicates areas where energy is being used (this is called the BOLD signal). When study participants saw the stimuli as more visible, the energy required to create the awareness was detected by fMRI, which led
We addressed several potential concerns in our study. To ensure that our conclusions were not the result of having missed activity outside the occipital lobe, we performed a crucial control which has not been used before in conjunction with a localization experiment in fMRI, to our knowledge. In all of the target-responsive parts of cerebral cortex, we tested how well they respond to non-illusory visual stimuli: we found that occipital lobe measurements were weaker than non-occipital lobe measurements, which suggests that rather than having missed non-occipital activity, we may have instead missed activity in the occipital lobe (and thus underestimated the strength of our conclusions). Some previous theories of awareness have stated that only the frontal lobes are capable of “reporting” conscious perception. However, we are not convinced that the circuits purported to lie in the frontal lobes for the purpose of reporting conscious perception may not lie in many places in the brain, which would mean that many possible locations in the brain could “report” consciousness. Until we understand more about the circuits that “report” consciousness, it is not possible to know either way.

Visibility, visual awareness, and visual masking of simple unattended targets are confined to areas in the occipital cortex beyond human V1/V2

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Abstract

In visual masking, visible targets are rendered invisible by modifying the context in which they are presented, but not by modifying the targets themselves. Here, we localize the neuronal correlates of visual awareness in the human brain by using visual masking illusions. We compare monoptic visual masking activation, which we find within all retinotopic visual areas, with dichoptic masking activation, which we find only in those retinotopic areas downstream of V2. Because monoptic and dichoptic masking are equivalent in magnitude perceptually, the present results establish a lower bound for maintenance of visual awareness of simple unattended targets. Moreover, we find that awareness correlated circuits for simple targets are restricted to the occipital lobe. This finding provides evidence of an upper boundary in the visual hierarchy for visual awareness of simple unattended targets, thus constraining the location of circuits that maintain the visibility of simple targets to occipital areas beyond V1/V2.

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