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What Type of Awareness Does Binocular Rivalry Assess?

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Abstract

Recent experiments demonstrate that invisible stimulus features can induce binocular rivalry, indicating the phenomenon may be caused by differences in perceptual signal strength rather than conscious selection processes. Here, we clarify binocular rivalry's role in consciousness research by highlighting a critical difference between two distinct types of visual awareness.

Keywords

Binocular Rivalry; Awareness; Consciousness; Blindsight

Among neuroscience researchers interested in determining the neural correlates of consciousness, binocular rivalry has been heralded as a gold standard since Crick & Koch's endorsement of the paradigm [1]. In binocular rivalry, two monocular images are simultaneously presented to a participant whose subjective perceptual experience alternates between each image. This "switching" between image percepts is of particular interest to researchers investigating the neural correlates of consciousness, as it demonstrates fluctuating conscious experience despite fixed physical stimulation. Evidence of a brain region's involvement in such percept switching has been taken to mean that the relevant activity should be considered a neural correlate of consciousness [2]. However, a recent study by Zou et al. [3] challenges this assumption.

In a series of elegant experiments, Zou et al. investigated whether binocular rivalry could be induced by invisible gratings. Results showed that participants were less likely to perceive a monocular low contrast (but visible) grating when it was paired with an invisible flickering grating with an orthogonal orientation, compared to when it was paired with a yellow disk or a uniform color flickering disk; participants were also less likely to correctly identify a monocular test probe's orientation when the other eye was given the invisible flickering grating than the other stimulus types. Interestingly, while visible stimuli activated visual, parietal, and frontal cortices, invisible stimuli only activated early-level visual areas, highlighting the possible role of lower-level visual regions in producing unconscious

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binocular rivalry. Combined, these results provide convincing evidence that invisible stimuli can induce binocular rivalry, and support the idea that binocular rivalry may be caused by a low-level ocular selection mechanism.

The findings from Zou et al. cast doubt on the supposed link between binocular rivalry and conscious perception. These findings are reminiscent of previous arguments in the literature regarding similar effects [4–6]. As noted by Blake et al., “What one ideally would want in the experimental search for [neural correlates of consciousness] is a procedure that not only leaves physical stimulation intact while perception fluctuates, but that also leaves all neural processing intact apart from that which is part of the [neural correlates of consciousness] for the particular perceptual states experienced by the observer. But the evidence indicates that binocular rivalry does not quite allow this idealized experimental approach” [4]. In other words, the changing percepts in binocular rivalry may simply be the result of fluctuating strengths of perceptual signals from early visual areas, rather than changes in conscious perception per se. Does this imply that binocular rivalry has nothing to do with consciousness?

While binocular rivalry may not be **uniquely** linked to consciousness in terms of subjective experience, it is clear the paradigm is still related to awareness in some important sense, as the brain regions responsible for percept switching directly influence the information represented by the visual system. To clarify how binocular rivalry is related to awareness, a conceptual distinction should be made between two types of awareness. **Perceptual awareness** constitutes the visual system’s ability to process, detect, or distinguish among stimuli, in order to perform (i.e., give responses to) a visual task. On the other hand, **subjective awareness** constitutes the visual system’s ability to generate a subjective conscious experience. While the two may seem conceptually highly related, operationally they are assessed by comparing different task conditions (see Fig. 1): to specifically assess subjective awareness but not perceptual awareness, one needs to make sure that perceptual performance is matched across conditions. One example of this type of contrast can be seen by comparing normal conscious vision against **blindsight** [7].

This distinction between perceptual and subjective awareness is congruent with Zou et al.’s interpretation of the neural mechanisms associated with invisible binocular rivalry. They note that binocular rivalry could be caused by one of two processes: (1) higher-level regions (e.g., in frontal and parietal areas) that interpret perceptual signals and resolve interocular conflict may suppress one of the ocular representations, or (2) lower-level visual areas could automatically resolve interocular conflict regardless of higher-order perceptual interpretations by suppressing one eye’s signal. According to the results of Zou et al., it would appear that percept switching in binocular rivalry happens at the lower level, and may reflect perceptual awareness (i.e., fluctuation of perceptual signal) rather than subjective awareness or conscious experience per se.

This is not at all to say that binocular rivalry should be abandoned in research regarding conscious awareness. The fact that binocular rivalry tracks perceptual awareness rather than subjective conscious experience per se may be no different from other common paradigms such as masking, inattentional blindness, and attentional blink paradigms, which compare

task conditions of different perceptual signal strengths or task performance levels. And indeed, there is a sense in which having good perceptual capacity is an important aspect of awareness; when driving a car, this is exactly the notion of awareness that one needs. Encouragingly, recent results have shown that it is possible to track the signal strength in binocular rivalry even without engaging a task, allowing for a clean readout of the strength of the perceptual signal [8]. Thus, the study of binocular rivalry is far from irrelevant.

However, the results of Zou et al. highlight that to specifically assess the phenomenological aspects of conscious perception, we may need a different kind of paradigm - those that allow us to isolate differences in subjective experiences apart from differences in perceptual capacities (e.g., comparison between normal conscious vision and blindsight). This points to the special status of blindsight (and its variants) in consciousness research. Blindsight is not just another case of unconscious vision, but rather one of the few instances where one can isolate subjective experience from objective perceptual signal strength, and as such, it is fundamentally different from binocular rivalry. As in other areas of neuroscience research such as attention [9] and memory [10], careful taxonomy of task paradigms and concepts, as is stimulated by the results of Zou et al here, may prove crucial in fostering future research.

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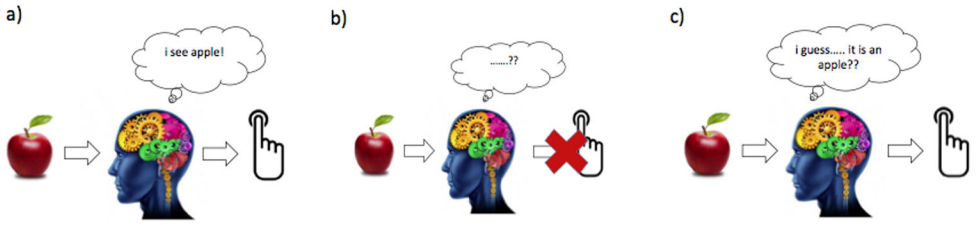

Figure 1. Perceptual awareness vs. subjective awareness

The two notions of consciousness can be assessed by comparing the following conditions: a) **Normal conscious perception** - a participant receives visual input, experiences a conscious representation of the stimulus, and reports their experience via a motor response. b) **Subliminal/No perception** - visual input is identical to a) but the information fails to get through perceptual processing, such that neither a conscious percept nor an explicit response is generated. c) **Blindsight** - the same visual input gets through perceptual processing roughly as effectively as in a) and a similar motor response is produced, yet the participant does not subjectively experience seeing the stimulus. Whereas comparison between a) and b) reveals mechanisms for perceptual awareness, to isolate and assess subjective awareness, one needs to make sure that task performance capacity is matched, as in the comparison between a) and c).