The Unseen Influence: Investigating the Crucial Role of Consciousness in Visual Processing

Shreyashish Roy-Chowdhury[1]; John Christy Johnson[1,2]; Peter Anto Johnson[1,2]; and Austin Albert Mardon[1,2,3*]

[1]Antarctic Institute of Canada, Edmonton AB.
[2]Faculty of Medicine and Dentistry, University of Alberta, Edmonton AB.
[3]John Dossetor Health Ethics Centre, Edmonton AB.

E-mail: aamardon@yahoo.ca*

ABSTRACT

Research has shown that various aspects of perception, such as attention, sensory processing, and cognitive interpretation, significantly impact our conscious awareness. Additionally, the way our senses process information, such as through visual, auditory, or somatosensory pathways, can affect the quality and content of our conscious experiences. To investigate the role of consciousness on visual processing, this review assesses scientific evidence regarding (a) the capacity of visual processing in the absence of conscious awareness and (b) how visual task performance differs depending on whether visual stimuli are processed unconsciously and consciously.

(Keywords: consciousness, visual perception, cognitive interpretation, visual, auditory, and somatosensory pathways, task performance)

INTRODUCTION

Consciousness and perception are intrinsically intertwined, forming a complex and dynamic relationship that has been extensively explored in the scientific literature. Our current understanding suggests that perception, which refers to the process of interpreting and making sense of sensory information from the external world, plays a fundamental role in shaping our conscious experiences (Raccah, *et al.*, 2021). Research has shown that various aspects of perception, such as attention, sensory processing, and cognitive interpretation, significantly impact our conscious awareness (van Boxtel, *et al.*, 2010). For instance, the attentional spotlight, which allows us to selectively focus on certain stimuli while filtering out others, influences what we consciously perceive.

Additionally, the way our senses process information, such as through visual, auditory, or somatosensory pathways, can affect the quality and content of our conscious experiences. Given the reliance on vision in shaping perception, what role does consciousness have on visual processing?

Research on visual perception has been successful due to the precise control of visual stimuli using current technology. This manipulation of visual stimuli makes visual perception ideal for studying processes ranging from unconscious stimuli to conscious perception. There are different lines of research in this field, with one focusing on the neuro-cognitive mechanisms of unconscious visual stimuli (subliminal perception). This research investigates how unconsciously perceived stimuli can influence information processing and perception (Kiefer, *et al.*, 2011).

The ability to perceive unconsciously presented visual stimuli has been attributed to visual processing pathways that bypass the primary visual cortex (V1) and therefore avoid conscious perception. Specifically, direct projections from the lateral geniculate nucleus to extra-striate areas including the middle temporal visual area, the secondary visual cortex, and the mid-tier visual cortical areas in the ventral visual pathway have been discussed (Bullier and Kennedy, 1983; Sincich, *et al.*, 2004; Yukie and Iwai, 1981).

To investigate the role of consciousness on visual processing, this review assesses scientific evidence regarding (a) the capacity of visual processing in the absence of conscious awareness and (b) how visual task performance differs depending on whether visual stimuli are processed unconsciously and consciously.

What is the Capacity of Unconscious Visual Processing?

Unconscious Orientation and Color Processing in the Absence of Primary Visual Cortex: A significant body of literature suggests that area V1 in the human brain is crucial for conscious visual perception (Silvanto and Rees, 2011). When a portion of V1 is damaged, patients may not be aware of stimuli presented in the corresponding region of their visual field. However, some patients with V1 damage can still discriminate and localize these stimuli at above-chance levels, even though they are not consciously aware of them.

An example of their abilities includes the capacity to respond to such stimuli through eye movements and manual actions, as well as to distinguish between line orientations, wavelengths, motion direction, and fundamental shapes (Ajina and Bridge, 2018).

Using Transcranial Magnetic Stimulation (TMS), Boyer and colleagues (2005) disrupted V1 processing while presenting stimuli to examine orientation and color processing in the absence of V1 functioning and awareness. In experiment 1, line orientations were presented to investigate orientation processing (Figure 1).

In experiment 2, red or green disks were presented to investigate color processing, both without V1 functioning and awareness (Figure 2). If orientation and color processing do not solely rely on conscious visual processes, then orientation and color discrimination should be at above-chance levels despite a lack of conscious awareness.

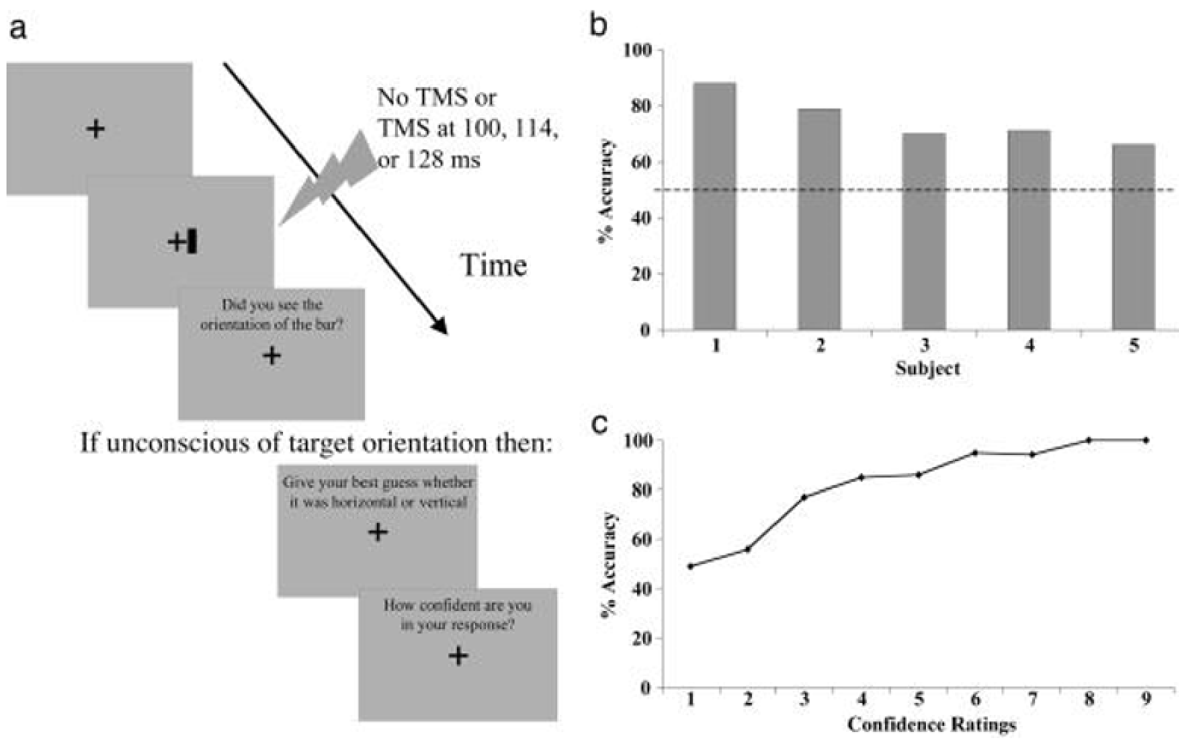

Figure 1: The study investigated unconscious processing of orientation by using transcranial magnetic stimulation to suppress activity in the primary visual cortex. During the experiment, subjects were presented with a horizontally or vertically oriented line and asked to guess its orientation and provide a confidence rating when they were unaware of the stimulus. The mean accuracy of their guesses was found to be significantly above chance, despite their lack of awareness. Additionally, there was a correlation between the accuracy of their guesses and the confidence ratings they provided (Boyer, *et al.*, 2005).

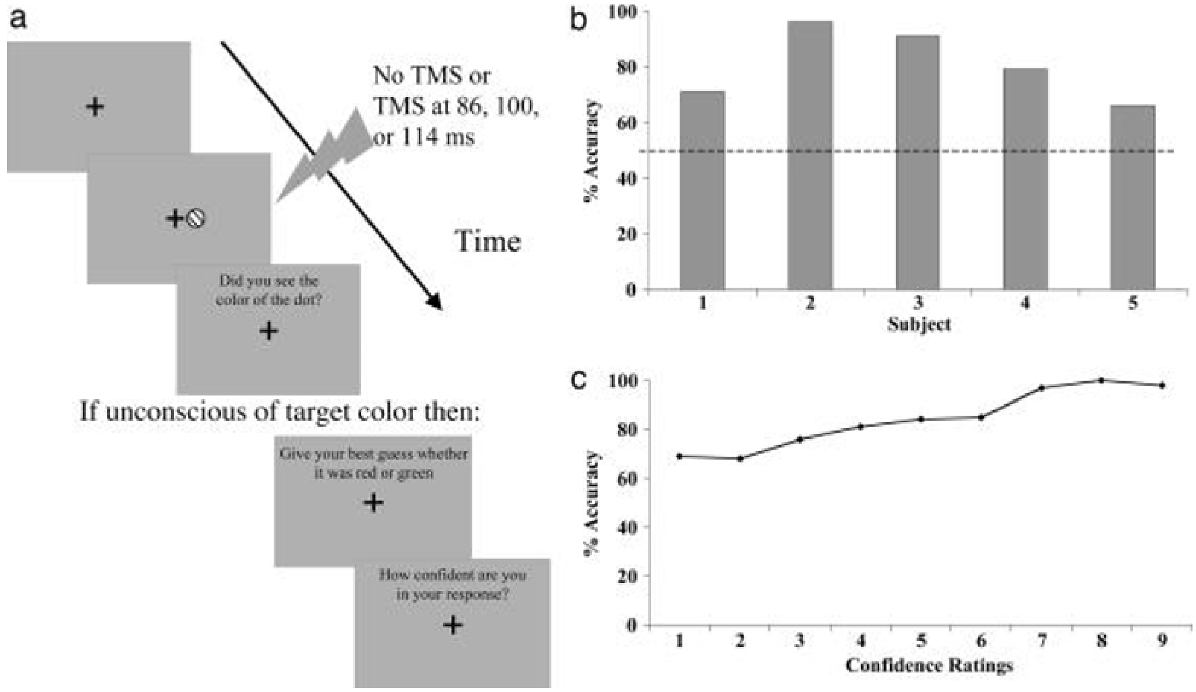

Figure 2: This study looked at how people process color without being consciously aware of it. Participants were shown a red or green disk while their primary visual cortex was suppressed using TMS. They were then asked to guess the color and rate their confidence in their guess. Despite not being aware of the color, participants were able to guess the color correctly with significant accuracy above chance. The study also found a correlation between accuracy and confidence in the guesses (Boyer, *et al.*, 2005).

In experiment 1, despite being unaware of the stimulus orientation on most trials, subjects still performed significantly above chance levels, indicating that an alternative visual pathway may be involved in processing orientation even in the absence of normal V1 functioning and conscious visual perception. Similarly in experiment 2, even when subjects reported being unaware of the target color on most trials, they still accurately guessed the color significantly above chance levels, indicating color processing in the absence of normal V1 functioning and conscious visual perception. The results of experiments 1 and 2 indicate preserved orientation and color processing in the absence of conscious awareness.

The Influence of Unconscious Information on Saccades in Neurologically Healthy Humans: Humans use saccadic eye movements to orient themselves towards stimuli, which can be initiated unconsciously. The visual pathway mediated by V1 is believed to be responsible for the conscious perception of visual stimuli, while phylogenetically older pathways through the pulvinar and superior colliculus (SC) can trigger behavioral responses toward visual stimuli that are not consciously registered (Kragel, *et al*., 2021).

Saccades are initiated by neurons in the SC, making them prime candidates for actions triggered by unconscious stimuli (Gandhi and Katnani, 2011). V1 lesions in non-human primates lead to spatially more imprecise saccades but do not affect the reflexive behavior of saccades (Yoshida, *et al*., 2008). In humans, V1 lesions typically cause blindness in the corresponding visual field but stimuli presented in the affected visual field can still influence the behavior of these patients, a phenomenon known as blindsight. Oculomotor responses to stimuli in the blind visual field have been studied in blindsight patients, and it has been observed that some patients can fixate targets presented in their blind visual field.

In an experiment by Olkoniemi and colleagues (2023), participants were shown visual targets on a gray background and instructed to indicate the target location by eye movement or not moving their eyes if they didn't see it. The TMS pulse was given 100ms after the onset of visual targets, which is known to suppress conscious perception. The participants rated their subjective visibility of the target on a scale of 0 to 3. Figure 3 section illustrates this experiment.

The researchers reported the participants were able to initiate saccades toward targets they reported not seeing. Specifically, participants made more saccadic reactions towards a stimulus that was presented (but they reported not seeing it), compared to catch trials where no target stimulus was presented. This finding indicates that the unconscious target influenced their behavior.

Unconscious Vision and Affective Emotions

Modulating Eating Behavior: The feelings and reactions that people have towards food can be both advantageous and disadvantageous. Emotions have helped us find food when resources were scarce. However, in modern societies with high-calorie foods and food advertisements, emotions can lead to overeating and related health issues. Previous studies have shown that positive emotions can increase food intake, and these emotions are triggered in the brain's affective regions.

Research has also shown that people can unconsciously process information related to food, which suggests that unconscious emotions may be involved in eating habits. However, whether unconscious emotions can be elicited by unconsciously viewed food remains unknown.

Sato and colleagues (2016) aimed to investigate whether unconscious emotions could be triggered by unconsciously perceived food stimuli and whether these emotions would be related to eating behaviors. The study used the subliminal affective priming paradigm to test whether unconscious emotions could be elicited by food stimuli presented unconsciously (Figure 4).

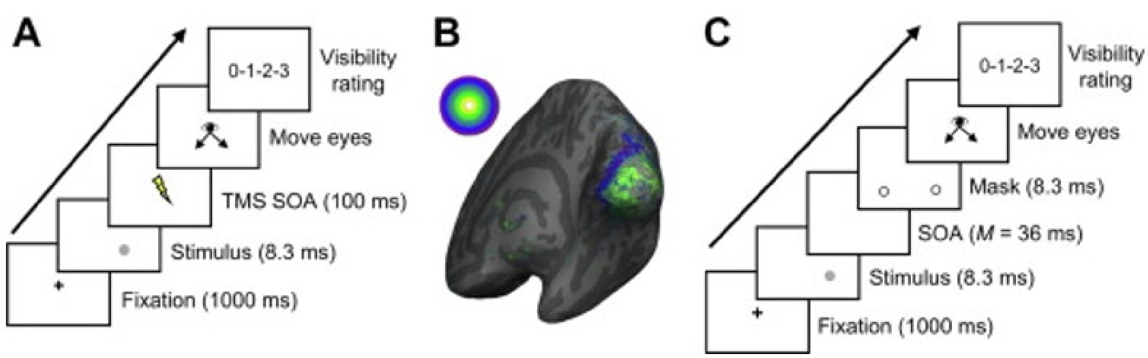

Figure 3: Participants were asked to quickly move their eyes to where they saw a target appear and rate their confidence in their decision. The visibility of the target was changed using TMS, and retinotopically mapped visual cortical areas were used to determine the stimulated area. The participants were instructed to quickly move their eyes to the location of the target if they perceived it, or keep their eyes fixed on the central location if they didn't see any target, and then indicate their confidence level in their decision (Olkoniemi, *et al.*, 2023).

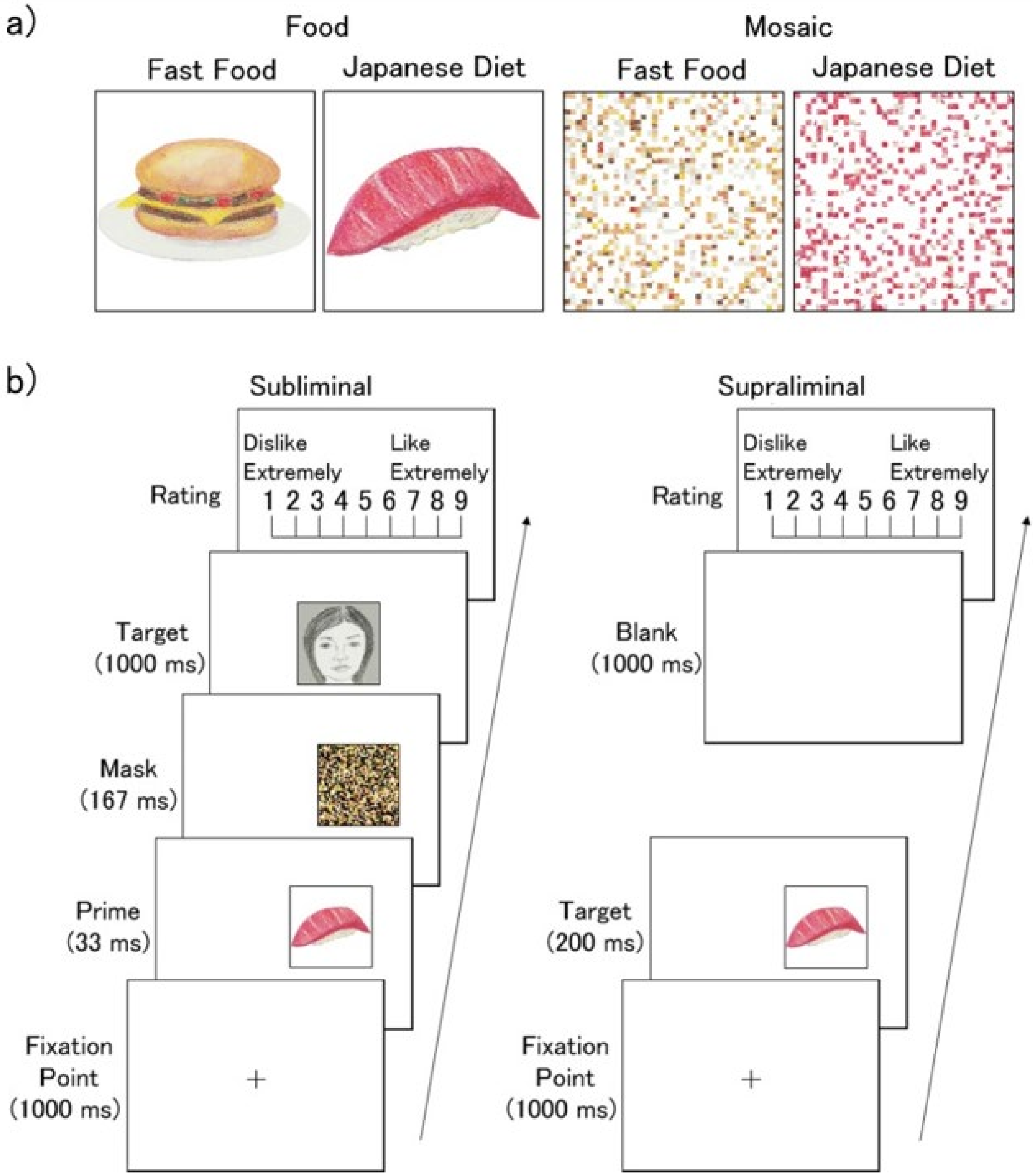

Figure 4: Panel (a) displays depictions of food and mosaic stimuli, while Panel (b) presents the trial sequences for the subliminal and supraliminal presentation conditions (Koivisto, *et al.*, 2013).

Sato and colleagues (2016) demonstrated that unconsciously viewing food images led to a higher preference for subsequent target faces compared to unconsciously viewing mosaic images. These results suggest that unconsciously perceived food primes heighten participants' preferences for subsequent stimuli. The study also found that people with a higher external eating tendency were more likely to unconsciously prefer food stimuli over mosaics, indicating that affective reactions play an important role in triggering externally driven eating habits. Interestingly, unconscious food preference scores were negatively correlated with the restrained eating tendency, suggesting that people who have weak unconscious affective responses to food may be more successful in restricting their food intake.

How Does Consciousness Facilitate Performance on Semantic Tasks?

Koivisto and colleagues (2013) use object substitution masking to explore the ability to categorize visual stimuli when conscious or unconscious. In this model, the target and a mask (e.g., four dots surrounding the target) appear simultaneously, but the mask persists after the offset of the target.

The time delay between the target and the mask allows for the initial processing of the target through feedforward processing. Feedforward processing results in coarse low-resolution representation. The mask is thought to mainly disrupt the subsequent stage of processing known as recurrent processing which provides a vivid and detailed conscious perception with high resolution through feedback with higher-level visual areas enhancing neural activity in lower-level areas. Therefore, masking impairs the perception of the target, as compared with a condition in which the target and mask offset simultaneously.

The experiment involved the presentation of two images at the same time, with the target image identified by the surrounding dots. In masked trials, the dots remained visible after the images disappeared. The participants were instructed to quickly and accurately release the response button when they identified an animal in the target image. Following each trial, the participants were asked to rate how clearly they perceived the target image.

The results showed that masking reduced the clarity of perceptual awareness but did not affect categorization accuracy at a superordinate level. However, categorization speed was slower in trials with low perceptual awareness. Recurrent processing played a role in categorization and awareness under suboptimal conditions, such as when the target animal was difficult to segregate from the background. The study also found that the clarity of visual awareness depended on recurrent processing. Altogether, Koivisto and colleagues (2013) suggest that fast categorization is limited to scenes in which the target animal is easily segregated, and recurrent processing contributes to categorization and awareness when figure-ground segregation is more demanding.

DISCUSSION

This review highlights previous research demonstrating crude, unconscious visual processing abilities. Unconscious vision has shown the ability to influence our perception. The ability to unconsciously perceive fundamental properties of visual stimuli is exemplified in the work of Boyer and colleagues (2005) who demonstrated orientation and color discrimination in the absence of conscious awareness of the visual stimuli.

Accurate shape and numerical discrimination of visual stimuli have also been reported in studies assessing unconscious visual capacities (Dineen and Keating, 1981; Lucero, *et al.*, 2020; Marcel, 1998). Beyond perception, unconscious visual processing has been shown to modulate motor responses in humans. This phenomenon was seen in the study done by Olkoniemi and colleagues (2023) where participants, at levels greater than chance, made accurate saccades toward visual stimuli that were not consciously perceived.

Automatic visuomotor response preparation triggered by the unconsciously perceived masked prime results in response priming - that is, faster responses to targets when the prime indicates the same response rather than a different one. Behavior has also been shown to be modulated by unconscious visual processes. Sato and colleagues (2016) found that unconsciously perceiving food images increased participants' preference for subsequent target faces compared to mosaic images.

They also reported a positive correlation between unconscious food preference and the external eating tendency, suggesting that unconscious affective reactions without consciously viewing food are important in triggering such habits. Altogether, this review provides evidence for the multifaceted capacity of unconscious visual processing. Although the accuracy and quality of visual processing may decrease in the absence of consciousness, unconscious visual processing shows the ability to modulate human perception, actions, and behavior.

The work of Koivisto and colleagues (2013) revealed that when masking interferes with recurrent processing and stimuli remain outside conscious perception, rapid categorization can still take place. However, if the stimuli are unmasked and recurrent processing is established and maintained, several changes occur. The visual categorization becomes clearer and more precise; categorization speed and accuracy improve for unclear images. This evidence is striking when coupled with studies demonstrating low-frequency representations through feedforward (and presumably unconscious) visual processing (Diano, *et al.,* 2017). Altogether, these findings suggest visual processing is possible even when individuals are not consciously aware of the visual stimuli, however consciousness at the time of visual processing facilitates greater quality in perception.

In considering the evidence for studies assessing the capacity of unconscious vision processing, there needs to be a refinement in the distinction between consciousness and awareness. Consciousness is a complex construct that encompasses both awareness and the mind (Kotchoubey, 2018). It is imperative to recognize that while consciousness is closely linked to the brain, it is not synonymous with awareness. The term awareness refers to a state that precedes our comprehension of the things around us. It comprises what we can confidently assert to be true, representing the only certainty in our understanding of the world.

In the Boyer, *et al*. (2005) and Olkoniemi, *et al*. (2023) studies, they simply ask whether you were perceptually aware of the stimulus presented where a lack of awareness constitutes unconscious visual processing. The operationalization of consciousness through whether an individual was perceptually aware of a stimulus neglects the state of being and mindfulness that comprises consciousness. It is crucial to note that awareness does not constitute the entirety of our consciousness. While we may be aware of our experiences (i.e., aware of seeing and not seeing a stimulus), are we aware of the nature of that experience (Goodale, 2023)?

Koivisto and colleagues (2013) demonstrated the ability to categorize animal images at a superordinate level when participants reported not being perceptually aware of the image. However, if a person, through masking studies or continuous flash suppression, is unconsciously presented with a threatening image of an animal, do they show a fear response?

The fear response here serves as a marker for the contents of the experience. People, through life, learn about what a threatening animal looks like and therefore may experience a fear response when they see the animal or quickly see something that resembles the animal. This fearful experience can constitute the state of being, where the emotion represents the content of experience when you see something threatening. Therefore, if participants show a fear response (i.e., through amygdala activation) to threatening images of animals presented without perceptual awareness, perhaps they are still consciously viewing that image (Cheng, *et al.*, 2006). The fear they experience without knowing the source, since the visual stimuli were masked, may then be serving as the “feeling” or experience that allows participants to make accurate responses to the stimuli they had seen above chance level.

CONCLUSION

The goal of this review was to investigate the role of consciousness in visual processing by assessing the capacity of visual processing in the absence of conscious awareness and how visual task performance differs depending on whether visual stimuli are processed unconsciously and consciously. Unconscious visual processing has been shown to discriminate rudimentary properties of visual stimuli, as well as facilitate motor responses and behavior. Intact consciousness at the time of visual processing demonstrates a modulatory function which enhances visual processing and allows for high-quality visual perception.

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