

Conscious and Nonconscious Processes: Distinct Forms of Evidence Accumulation?

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Abstract. Among the many brain events evoked by a visual stimulus, which ones are associated specifically with conscious perception, and which merely reflect nonconscious processing? Understanding the neuronal mechanisms of consciousness is a major challenge for cognitive neuroscience. Recently, progress has been achieved by contrasting behavior and brain activation in minimally different experimental conditions, one of which leads to conscious perception whereas the other does not. This chapter reviews briefly this line of research and speculates on its theoretical interpretation. I propose to draw links between evidence accumulation models, which are highly successful in capturing elementary psychophysical decisions, and the conscious/nonconscious dichotomy. In this framework, conscious access would correspond to the crossing of a threshold in evidence accumulation within a distributed *global workspace*, a set of recurrently connected neurons with long axons that is able to integrate and broadcast back evidence from multiple brain processors. During nonconscious processing, evidence would be accumulated locally within specialized subcircuits, but would fail to reach the threshold needed for global ignition and, therefore, conscious reportability.

An experimental strategy for exploring consciousness

Although the nature of consciousness remains a formidable problem, Lionel Naccache and I argue that it can be approached through behavioral and brain-imaging methods:

The cognitive neuroscience of consciousness aims at determining whether there is a systematic form of information processing and a reproducible class of neuronal activation patterns that systematically distinguish mental states that subjects label as *conscious* from other states (Dehaene and Naccache 2001).

In that respect, identifying the neural bases of consciousness need not be any more difficult than, say, identifying that of other states of mind (e.g., face percep-

tion or anger). Bernard Baars (1989) outlined a simple *contrastive method* which, in his own terms, consists simply in contrasting pairs of similar events, where one is conscious but the other is not. Baars noted that in the last forty years, experimental psychology and neuropsychology have identified dozens of contrasts relevant to consciousness. Examples include normal vision versus blindsight; extinguished versus seen stimuli in patients with hemineglect; masked versus nonmasked visual stimuli; habituated versus novel stimuli; accessed versus nonaccessed meanings of ambiguous stimuli; distinctions within states of consciousness (sleep, coma, wakefulness, arousal); voluntary versus involuntary actions; or even explicit problem solving versus implicit *incubation*.

In this chapter, I focus on the masking paradigm, perhaps the simplest and most productive situation in which to study conscious access in normal subjects. During masking, a target visual stimulus is flashed briefly on a computer screen. It can be followed or preceded by a *mask*: another visual stimulus is presented at the same screen location or just nearby. Under the right conditions, presentation of the mask erases the perception of the target stimulus, and subjects report that they are no longer able to see it. Yet the target stimulus still induces behavioral priming effects and brain activation patterns which correspond to nonconscious or *subliminal* (below threshold) processing. Focusing on what types of processing can occur under subliminal masking conditions, and what additional processes unfold once the stimulus is unmasked, can thus shed considerable light on the nature of conscious access.

How do we measure whether conscious access occurred?

As mentioned above, once an appropriate paradigm such as masking is available, studying the cerebral correlates of conscious access need not be more difficult than, say, studying face perception. In both cases, one correlates brain activity with the presence or absence of the relevant aspect of the stimulus (face vs. nonface stimulus, or conscious vs. nonconscious perception). What is special about conscious access, however, is that it is defined solely in subjective terms. Thus, Lionel Naccache and I have argued:

The first crucial step is *to take seriously introspective phenomenological reports*. Subjective reports are the key phenomena that a cognitive neuroscience of consciousness purports to study. As such, they constitute primary data that need to be measured and recorded along with other psychophysiological observations (Dehaene and Naccache 2001).

Increasingly, therefore, consciousness research relies on subjective reports as a defining criterion. Ideally, one should measure the extent of conscious perception on every single trial, possibly using a graded scale to capture even fine nuances of the percept (Del Cul et al. 2007; Sergent et al. 2005; Sergent and Dehaene 2004). For an identical objective stimulus, one may then contrast the brain activation observed when it is or is not subjectively seen.