Trends in Cognitive Sciences

Letter

Prefrontal Cortex and Consciousness: Beware of the Signals

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During binocular rivalry (BR), incongruent, unchanged visual stimulation induces intrinsically generated transitions in conscious content. Due to this astonishing property, BR is commonly combined with functional magnetic resonance imaging (fMRI) or single neuron recordings to identify the neural correlates of consciousness (NCCs); namely, brain activity reflecting conscious contents and spontaneous transitions between them. No-report BR versions, where the perceived stimulus is decoded from objective markers like reflexive eye movements instead of active behavioral reports, can be used to discard activity related to motor and postperceptual processes that might contaminate the pure NCC. This is especially relevant for resolving an ongoing theoretical debate about the role of the prefrontal cortex (PFC) and posterior cortical areas in consciousness. Block recently suggested that no-report might still fail to eliminate postperceptual cognitive processes accompanying BR [1,2]. This could result in neural signals being incorrectly interpreted as reflecting conscious contents, under the strong assumption that postperceptual processes are systematically aligned to each of the competing percepts. He therefore calls for the development of no-post perceptual cognition paradigms and highlights the BR paradigm of Brascamp et al. [3], that uses unreportable transitions, to address this problem. We agree with Block that dissociating the NCCs from cognition is necessary. However, we caution against (i) Block’s interpretation of the Brascamp et al. findings; and (ii) the criticism that our recent recordings during no-report BR in the PFC reflect postperceptual cognitive processing and show no evidence of transition processes.

Block’s interpretation of the Brascamp et al. results relies on the assumption that the unnoticed and unreportable BR transitions in this elegant experiment are transitions in conscious perception. The validity of this interpretation depends on accepting the phenomenal consciousness concept, in which a stimulus can be consciously perceived without triggering the ability to report it. This view is opposed to the framework of access consciousness which would suggest that unreportable transitions fall into the category of unconscious perception, since consciousness is accompanied by the ability to report [4,5]. Indeed, transitions in phenomenal consciousness are more likely to reflect unconscious transitions, shown to induce neural activity fluctuations correlated with rivalry dynamics in primary visual cortex (V1) [6,7]. Similarly, alternating activation of V1 ocular dominance columns is observed even when BR is presented during loss of consciousness induced by general anesthesia [8]. Unconscious BR transitions could therefore activate sensory visual cortex but are not access conscious, and therefore do not activate PFC. In other words, if no conscious transitions, and therefore changes in the consciously perceived content, occur, then PFC and other associational cortical areas will remain silent, as shown in the Brascamp et al. study.

Block also argues that our results [9,10], showing decoding of conscious contents from prefrontal neural ensembles using no-report BR are problematic due to the ‘bored monkey problem’: macaques participating in passive, no-report BR are bored during the experiment and therefore engage in postperceptual, higher-order thoughts reliably aligned to the rivaling stimuli and therefore decodable in cognitive brain areas such as the PFC. In this case, prefrontal populations could reflect postperceptual thinking rather than pure conscious representations. However, this would suggest that postperceptual thinking is reproducible, and stimulus aligned across trials. This seems an unlikely combination of events in the brains of bored macaques, given also the absence of active reports that could associate stimuli with specific actions (e.g., button presses) and thoughts. It is unclear why the macaques would engage in such reliable postperceptual cognitive thinking to fight or due to boredom.

Block further argues that the absence of differences in content representations between externally induced stimulus alternations and endogenously driven BR transitions in the PFC suggests that this cognitively critical region does not causally initiate transitions, under the assumption that the neural bases of transitions and contents are linked. Therefore, failure to find differences between rivalrous and real transitions in cognitive areas disconfirms cognitive theories of conscious contents. Although we agree that PFC alone, most likely, does not cause the transitions and rather network interactions are necessary, Block’s assumption is flawed (Box 1). Although the correlates of transitions in the PFC interact with conscious contents, it is likely that they are not the same. In our no-report experiments, we found that a spontaneous transition in the activity of feature specific neural ensembles reflecting conscious content representations is preceded by fluctuations in the PFC state, measured in the local field potential signals [10,11]. Similarly, conscious reports require a nonlinear ignition process that depends on ongoing neural activity in the PFC [12]. These findings, showing that spontaneous fluctuations precede conscious access, suggest a possible dissociation between the neural correlates of conscious contents and transitions in conscious perception.
We believe that current empirical findings from fMRI and electrophysiological BR studies may have a different interpretation and suggest that two mechanisms of intrinsically generated transitions might exist in the cortex. One mediating unconscious switches in sensory cortical areas, and another in association cortical areas that gates conscious access and therefore transitions between consciously perceived contents.

References