and targets (e.g., androgyny; [14]). However, much of the work to date is exploratory and raises further questions about when and why people have less favorable attitudes toward gender diverse people as well as the downstream implications of these beliefs on the lives of gender minorities. We see a clear opportunity for more work in these areas, particularly with larger, well-powered studies to understand the causal mechanisms behind attitudes toward and beliefs about gender diverse people.

Concluding Remarks and Future Directions

A broad goal of cognitive science is to advance fundamental knowledge about human cognition and to generate theories about how humans perceive and conceptualize the world. Yet, in order to accurately do so, it is important to capture the full range of variation in human experience. Until recently, the focus of most studies of gender identity and gender roles was on the experiences of cisgender people. The resulting theories failed to account for the experiences of individuals who are transgender, nonbinary, or otherwise do not reside within discrete gender categories. Thus, a newer movement toward documenting basic descriptive information – such as how transgender and nonbinary people identify their gender – is an important first step to eventually developing more inclusive and up-to-date models about identity, categorization, and the mental representation of gender. In this process we encourage the increased inclusion of gender diverse people not only as participants, but as researchers.

In addition to advancing theory, research on human gender diversity is likely to lead to more applied contexts and policy prescriptions. For example, we can begin to investigate when and why transgender and nonbinary people of color experience disproportionate rates of discrimination and violence in their everyday lives [5] and intervene upon both the individual and structural factors contributing to these disparities. Furthermore, it is important to examine the impact of state and federal legislation on the health of gender-diverse people [15]. In the USA for example, state laws prohibit many gender-diverse people from using public restrooms that align with their gender identity. Future research should examine if these social environments contribute to negative health outcomes and heightened rates of mistreatment for gender diverse people.

Ultimately, our hope is that the work summarized here, as well as the future work in this area, can simultaneously enhance our understanding of gender diversity, lead to the development of better measures, inform our understanding of the mechanisms underlying prejudice and discrimination, and ultimately improve the lives of gender diverse people and their loved ones. We expect the findings of the last 5 years to be only the tip of a much larger iceberg in which our understandings of gender and related constructs continue to expand and improve.

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Supplementary Information

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Letter

The Fundamental Problem with No-Cognition Paradigms

Ian Phillips[1,*] and
Jorge Morales[2]

A central controversy in consciousness science concerns whether the neural correlates of consciousness (NCCs) exclusively reside posterior to the central sulcus or also include frontal regions [1–4]. In a recent *Trends in Cognitive Sciences* article, Block [5] contends that popular ‘no-report’ paradigms [6,7] cannot settle this dispute, since absence of report is consistent with extensive private cognition. To make progress, we instead require a ‘no-cognition’ (or more precisely, ‘no-post-perceptual cognition’) paradigm. According to Block, doubts about such approaches [8–10] are misplaced, since Brascamp *et al.* [11] have already developed precisely such a paradigm. Block is rightly dissatisfied with no-report methods. However, a fundamental difficulty faces no-cognition paradigms, as examination of Brascamp *et al.*’s study reveals.

Brascamp *et al.* exploit binocular rivalry: the presentation of different stimuli to each eye, leading to alternating percepts. Specifically, they presented each eye with a distinct pattern of quasi-randomly moving dots with 40% motion coherence. These dots changed direction every 300 ms, creating an impression of high-tempo jitter in their global motion. Average dot motion was orthogonal across patterns, creating two types of transition: objective transitions, where the dots physically changed direction every 300 ms, and rivalry transitions, where a switch in eye dominance changed the perceived motion direction every few seconds. When dots differed in color across eyes, rivalrous transitions were easily detectable. However, when dots were the same color, although rivalry transitions still occurred, observers detected them eight times less frequently, a level insignificantly different from chance. This is plausibly because such changes, while visible, could not be distinguished from objective changes in dot dynamics (i.e., the constant jitter in global motion). (In Box 1, we discuss the possibility that such transitions were in fact invisible.)

According to Block, what is theoretically important is that ‘this method avoids the systematic change of cognitive states… that can accompany rivalrous changes’. Thus, the methodology is ‘not just a no-report methodology: it is a no-differential-post-perceptual cognition methodology’. Yet, Brascamp *et al.*’s paradigm does not avoid systematic changes of cognitive states. All it avoids are thoughts specifically tied to rivalrous transitions as opposed to objective changes in dot dynamics. Nothing in Brascamp *et al.*’s methodology prevents observers engaging in extensive cognitive processing when transitions occur, so long as similar processing attends objective changes. Indeed, Brascamp *et al.* precisely designed their displays so that the appearance of objective change closely matched that of rivalry-driven change, so we should expect close similarities. Cognitive processing cannot be expected to distinguish the subjectively indistinguishable.

This fundamentally compromises Block’s interpretation of Brascamp *et al.*’s fMRI data. Brascamp *et al.* calculated blood-oxygen level-dependent (BOLD) contrasts between intervals inferred to contain a rivalry transition and intervals inferred to be transition free in three overlapping frontoparietal and temporoparietal attentional networks. No evidence was found that this activation differed from model predictions, which treated BOLD activation as a function of transition reportability. Thus, a large contrast was found in the different color condition and a much smaller contrast in the same color condition. However, this does not indicate an absence of activity in target regions accompanying transitions. It only shows that this activity does not significantly differ between intervals with and without transitions. Moreover, since both intervals contain multiple objective changes engineered to look just like rivalrous transitions, it is unsurprising if subjects respond to both intervals in very similar ways. Compared with the different color condition, where there is a dramatic difference in the type of change between intervals, there is effectively no detectable difference in the same color condition.

What is evidenced by the absence of contrast is that frontal areas do not causally initiate transitions. This was the purpose of Brascamp *et al.*’s study. However, we should not conflate the property of causing transitions with the property of being an NCC of rivalrous changes or contents. Sensory circuits may determine when changes between contents occur, even though prefrontal circuits are constitutively involved in our awareness of them. This hypothesis is consistent with the finding that invisible stimuli elicit switches detectable in sensory cortex but not in frontal regions [12].

This methodological point generalizes to all studies that subtract activity during rivalry from activity during a ‘replay’ condition, designed to mimic observers’ percepts during rivalry using a single external stimulus (e.g., [6]). Such subtraction methods help determine the etiology of transitions. However, they are not suitable for establishing NCCs [10]. Although Block partially acknowledges this point about ‘replay’ subtraction, he does not appreciate that the issue represents an in-principle problem for rivalry-based ‘no-cognition’ paradigms. As

Box 1. Completely Unconscious Rivalry Transitions

It is possible (albeit unlikely in our view) that rivalrous changes are genuinely invisible in the same color condition, not merely indiscriminable from objective changes. However, this does not avoid our concerns. If rivalrous changes are invisible, we will not predict any contrast in frontal activity due to differences in consciously perceived change: there are no such differences. However, since rivalry still occurs, one interval could contain at most one extra change in perceptual contents. Yet, since there are multiple matching objective content changes in both intervals, we again will not predict a measurable difference in BOLD activity. Even more sensitive analyses of the data (e.g., multivoxel pattern analysis) or more sensitive methods (e.g., electrocorticography), which Brascamp *et al.* did not use [11], may well still fail to detect such subtle differences.

Block remarks, we cannot stop subjects thinking. At most, we can match their thinking across conditions (or intervals). However, to match thinking requires conditions that are indiscriminable in some relevant respect. Yet, indiscriminable stimuli look the same. Consequently, all sides will predict matching frontal activity between conditions with and without transitions. Thus, such paradigms cannot discriminate rival hypotheses concerning NCCs.

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Letter

Finessing the Bored Monkey Problem

Ned Block[1,*]

By recording from microelectrodes in monkey prefrontal cortex (PFC), researchers have decoded the contents of conscious perception in cognitive areas (lateral prefrontal cortex) in conditions in which perceptions are not determined by the stimulus, binocular rivalry, and flash suppression [1–4]. As I noted in my recent *Trends in Cognitive Sciences* article [5], such results cannot be taken to support cognitive theories of consciousness because of the ‘bored monkey problem’: the idea that subjects whose only task is fixating a dot may have thoughts about the noticeably different stimuli, causing prefrontal differences that do not reflect prefrontal consciousness. This was the negative point of my article, and in their commentary Phillips and Morales (P&M) [6] do not dispute it.

What they do dispute is my positive point: that Brascamp *et al.* [7] have evaded the bored monkey problem. One innovation introduced by Brascamp *et al.* is to use stimuli that have two related useful properties. The first is that the stimuli do not afford any ready-to-hand cognitive categories for characterizing them other than as moving dots. Subjects cannot say to themselves: ‘There is the face again.’ P&M say ‘Nothing in Brascamp *et al.*'s methodology prevents observers engaging in extensive cognitive processing’, both in the rivalry transitions and the similar real (objective) transitions. However, P&M are neglecting the fact that the stimuli do not naturally draw cognitive processing in either the rivalry case or the real case. P&M focus on the distinguishability of the rivalrous transitions from the nonrivalrous real (objective) transitions, emphasizing replay subtraction. However, the aforementioned monkey experiments [1–4] do not use any form of replay subtraction. This research does involve comparisons between perception of the rivalrous stimuli and perception of real stimuli, but the purpose is to ascertain which neurons respond to the percept rather than to the stimulus.

The second useful property of these stimuli is that they are subjectively different from each other without being conspicuously different. P&M [6] say: ‘Yet indiscriminable stimuli look the same.’ However, although the stimuli are not noticeably different, they are subjectively different: they differ from each other in the directions of movement of each dot and in the overall directions of motion of the dots. Indeed, they are sufficiently subjectively different to trigger conscious rivalry.

I mentioned [5] that rivalry occurs in fruit flies and can occur in unconscious perception. P&M conclude that the rivalry in Brascamp *et al.* might be invisible. However, one cannot generalize in this way from rivalry when subjects do not consciously see the stimuli. Rivalry involves the dominance of one whole neural coalition over another. I know of no evidence that rivalry in the case of consciously seen stimuli can somehow slice off the conscious part of the coalition. The competing stimuli are subjectively but not noticeably different. Not being noticeably different, rivalry transitions are less likely to draw more attention than real transitions – as confirmed by Brascamp *et al*.

Would the differences between the neural representations of such stimuli be decodable in the brain at all given how similar they are? Recall that the explanation of binocular rivalry is that pools of neurons that represent each of the stimuli are mutually inhibitory. In the presence of neural