

There is a lively interchange of ideas concerning empirical results and their philosophical implications, leading to radical changes in the philosophy of mind. Anyone interested should visit the annual meeting of the Association for the Scientific Study of Consciousness (<http://www.theassc.org/>), and witness this spirited exchange. Perhaps most importantly, these efforts lead to real and applicable results, with implications for both theoretical understanding and applied clinical settings.

Have we come to a fundamental understanding of consciousness yet? Of course not. But it is clear that the field is maturing and making significant progress, converging on approaches to understanding this most enigmatic phenomenon. The science of consciousness does not suffer from a lack of public engagement; on the contrary, it is often discussed in the popular press. However, as Paller and Suzuki [1] point out, the public should be made aware of the most recent developments in the field. Such engagement should strive to make clear the distinction between rigorous, testable scientific ideas and outlandish speculations on the nature of consciousness – such as the view that electrons are conscious – that may easily attract media attention but are not grounded in empirical research.

Consciousness science is here to stay. The great empirical strides made in recent years, the continuing development

of rigorous approaches, and the enthusiasm of new generations of researchers lend themselves to a feeling of optimism. We will, eventually, crack this natural phenomenon that is so fundamental to our very being.

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Response to Block *et al.*: first-person perspectives are both necessary and troublesome for consciousness science

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We are grateful to Ned Block and co-authors for their commentary piece, ‘Consciousness science: real progress and lingering misconceptions’ [1], which expands on the arguments we put forward in our earlier *Science and Society* article [2].

Because people are conscious, it is natural for them to have views about the basis of their own conscious experiences and, by extension, about the basis of consciousness generally. Block and colleagues open their piece by pointing out the ‘troubling state of affairs’ that this causes.

People can introspectively reach the conclusion that consciousness is a form of energy or something akin to it that arises in essence from a nonphysical source to generate their unique mental lives. Consequently, consciousness is believed to lie outside the realm of scientific investigation. This introspective conclusion may have an understandable basis in the way consciousness functions as a

vehicle for compartmentalizing the intentions of self and others [3] — but it can be seriously misleading.

Introspection can nevertheless yield helpful foundations for consciousness research. Consider that we routinely switch back and forth between conscious and unconscious modes of information processing. For instance, when you begin to write a paper, you consciously formulate ideas that you want to convey, and if you get lucky, appropriate sentences mysteriously emerge from your unconscious processing. If not, you consciously toy with the ideas in various ways, and if still no good sentences emerge, you may become flustered or decide to procrastinate.

Consciousness reflects a specific mode of information processing wherein information is explicitly available for intentional (goal-directed) control of attention, memory, and thoughts. By contrast, information can remain largely intangible to intentional control mechanisms via the unconscious mode of processing, but still automatically direct attention, evoke memory, and induce thoughts. A major scientific challenge is to understand the neurocomputational mechanisms of both conscious and unconscious processing, as well as their interactions.

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Three lines of research are promising for understanding these mechanisms. First, new methods are being developed for precisely measuring neural correlates of conscious and unconscious processing.

Second, multidisciplinary efforts are being made to integrate analyses of behavior, introspection, physiological constraints, and computational requirements (e.g., efficiency, stability, and adaptability), which will facilitate coherent theoretical frameworks to explicate the operation of and interplay between conscious and unconscious processing.

Third, methods to train expertise in introspection are being investigated in research contexts, some inspired by the long history of meditation practices [4,5]. This development is critical because when it comes to research on conscious experiences, our own perspective is not something to dissolve, but rather something to understand in itself.

We share the optimism that Block and colleagues expressed [1]. It is clear that recent progress has provided

new insights into neural mechanisms relevant for consciousness. However, an even better metric of the fruitfulness of these approaches is the extent to which new horizons have been opened for empirically testing proposals about consciousness and its neural underpinnings. In this sense, the record of research in this field leaves little doubt that consciousness is a valid topic for scientific inquiry.

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