Boundaries of brain information processing

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The nature of reality is experienced as determined by the information-processing capabilities of our brains. While the processing of sensory inputs at the level of the sensory organs operates near optimal performance and the response properties of sensory neurons are optimal for the encoding of stimuli, the processing at later stages within the brain may lose that optimality. Limitations exist at several levels, imposed by neurophysiology as well as psychology, from the unreliability of cell-to-cell contact through synapses to the restrictions of the mental functions derived from their own logical features. It is a fundamental goal of neuroscience to understand the limitations of information processing in nervous systems and particularly in the mammalian brain, not only to better comprehend cognitive functions and the perception of reality but also to characterize pathological mental/brain states. Equally important is another of the main goals of contemporary neuroscience, the understanding of self-consciousness, that is, that the brain is not only aware of its surroundings but also of its own functioning. This scheme contains the implicit assumption that brain states like the “self” can be comprehended by the brain itself. The constraints imposed by autonomous neural/mental activity and internal brain architecture have to be acknowledged as much as those imposed by the environment. In addition to the limits imposed by the intricacy of the brain’s cellular circuitry, other logical limitations may also play a role, specifically the highly debatable issue of whether the fundamental limitative theorems in mathematical logic can also apply or are relevant to the mind as a formal system.

This special issue contains works that deal with different aspects of brain and machine information processing and from distinct perspectives: mathematical, physical, and philosophical, as the examination of these queries requires a multidisciplinary approach. We hope that these contributions will stimulate readers to further explore the complexities of the mental world that brains create.

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