Book Reviews/Comptes rendus

Surfing Uncertainty: Prediction, Action, and the Embodied Mind

ANDY CLARK

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How does the human brain give rise to dreaming, imagining, thinking, and reasoning? How does it enable human animals to acquire knowledge about the world and act on the basis of this knowledge? Andy Clark addresses these questions in *Surfing Uncertainty: Prediction, Action, and the Embodied Mind*, via a framework that rejects the traditional view of the human brain as passive and stimulus-driven and portrays it instead as an active, predictive machine. In advancing this understanding of the brain, Clark draws on empirical studies from multiple disciplines, including machine learning, psychophysics, cognitive science, and cognitive and computational neuroscience. He synthesizes the findings from these studies into a unified framework that he uses as a basis for answering these questions about how humans know and act in the world.

Prediction lies at the heart of this framework; specifically, it is the brain's capacity to predict incoming sensory signals as they occur, using what it already knows about the world from previous experience. Failed predictions issue *prediction errors*—this occurs when the incoming sensory signal does not match the prediction—which may be used either to issue better predictions or to inform the slower process of learning (doing so allows the brain to make better predictions in the future, thus perceiving better). Prediction errors are taken to be more or less reliable depending on the context; the goal is always to reduce uncertainty (enabling the animal to better navigate and act in the world). The traditional, bottom-up view of perception holds that brains passively await stimuli; once such stimuli occur (e.g., I see a dog at my foot), the brain processes the sensory input and then constructs a concept (e.g., dog). Clark's framework suggests that the brain is active, constantly trying to stay 'ahead of the game' by predicting its own inner states and those of the world around it (e.g., predicting the location of the dog *before* receiving stimuli from the dog's presence). Instead of a bottom-up, feed-forward model, the brain is multilayered and involves a bidirectional flow, where predictions move from the higher cortical layers to the lower layers, and prediction errors move bottom-up and laterally in each layer. Brains are therefore not so much geared towards input *processing* as they are for *predicting* inputs. The conceptual shift from the passive

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brain to the active brain requires a reconceptualization of perception and action; this is Clark's main task in this book.

Clark depicts perception as an ongoing process whereby the brain makes use of stored knowledge to make predictions about its inner and outer environments; but this process is by no means independent of action. In fact, action and perception emerge as inextricably bound in a mutually-supportive, self-fueling loop. That is, prediction errors cause us to sample the world around us (by acting in the world) in ways that either match or test the hypotheses that create the predictions that motivate our actions. Since action does not occur in a vacuum, but requires a body that navigates the world, Clark's predictive processing view fits well with the literature on embodiment. Perception, action and cognition emerge as part and parcel of *a single mechanism* whose job is to reduce prediction errors. Crucially, this picture dissolves previously crisp boundaries between action and perception, instead depicting them as co-emergent and grounded in a bidirectional flow of predictions that enable us to test and sustain our understandings of the world. Perception and action, so conceived, yield a vision of cognition that is deeply bound up in the brain, body, and world.

Armed with this predictive processing framework, Clark works through and explains various types of cognitive processes (e.g., dreaming, imagining, mental time travel, etc.), what happens when things go awry (e.g., making mistakes and illusions, such as the hollow mask illusion), and various pathologies (e.g., schizophrenia, etc.). After this explanatory work, Clark situates the brain within its broader, embodied and socio-cultural context.

If Clark's story is right, a plethora of implications and research opportunities emerge. For example, if it is the case that a single mechanism underlies our abilities to know the world and act in it, research using Clark's framework may yield new insights about the nature of certain learning disabilities (e.g., dyslexia, dyscalculia, aphasia/dysphasia, etc.) and thus lead to the development of new pedagogical approaches for treating them. It might also prompt a new understanding of psychopathologies like schizophrenia and autism as caused by disruptions in the predictive processing mechanism, which may in turn revolutionize current treatment strategies (e.g., the use of anti-psychotics, cognitive behavioural therapy, etc.).

Another exciting research opportunity that emerges from Clark's book is the potential for the development of a unified science of the embodied mind. While it remains an open question as to whether such unification is possible, Clark's framework opens up a space to explore and bring together previously disparate bodies of literature (e.g., embodiment, predictive processing, and emotion).

Clark's book is captivating, stimulating, and compellingly written. It offers a novel theory of action and perception whereby neither should be conceived of independently but instead as co-emergent, bound together in a causal self-fueling loop that allows us to continuously test and sustain our knowledge of the world. Given the integrative and multidisciplinary dimension of his theory, should Clark's story turn out to be correct, there will be deep implications and rich research opportunities spanning a large domain of disciplines. Clark's book would thus be of great interest to philosophers and scientists alike. While there remain numerous points of controversy, and many open questions concerning the scope of Clark's framework and its extension into higher levels of cognition, such as long-term planning and social cognition, Clark's book is rife with thought-provoking ideas worthy of engagement.

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