Hybrid artificial neural network modelling predicts behaviour and neural activity in a solution for Buridan's ass

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Abstract

Decision-making often requires balancing information gathering with action, yet the neural mechanisms governing this trade-off remain an active area of research. Here, we combine ultra-high field (7T) fMRI with a novel hybrid artificial neural network model to investigate how the brain computes the value of information during decision-making. Twenty participants performed an information-sampling task where they gathered evidence about two options with varying levels of uncertainty before making a choice. Our hybrid model, which integrated established cognitive principles with data-driven neural network components, predicted participants' sampling behavior better than conventional approaches. The model revealed a non-linear relationship between uncertainty and information value, which we captured through symbolic regression into an interpretable mathematical expression. Using high-resolution imaging, we simultaneously recorded activity from key neuromodulatory nuclei (VTA, SN, DRN, LC, BF) and cortical regions (AI, ACC), revealing distinct patterns of activity associated with different aspects of information valuation and evidence accumulation. These findings advance our understanding of how the brain arbitrates between gathering more information and acting on available evidence, providing a computational framework for resolving the fundamental trade-off between deliberation and action.

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