

A Computational Neuroscience Approach to Visual Cognition

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Cognitive behaviour requires complex context-dependent processing of information that emerges from the links between attentional perceptual processes, working memory and reward-based evaluation of the performed actions. We describe a computational neuroscience theoretical framework which shows how an attentional state held in a short term memory in the prefrontal cortex can by top-down processing influence ventral and dorsal stream cortical areas using biased competition to account for many aspects of visual attention. We also show how within the prefrontal cortex an attentional bias can influence the mapping of sensory inputs to motor outputs, and thus play an important role in decision making. We also show how the absence of expected rewards can switch the attentional bias signal, and thus rapidly and flexibly alter cognitive performance. This theoretical framework incorporates spiking and synaptic dynamics which enable single neuron responses, fMRI activations, psychophysical results, the effects of pharmacological agents, and the effects of damage to parts of the system, to be explicitly simulated and predicted. This computational neuroscience framework provides an approach for integrating different levels of investigation of brain function, and for understanding the relations between them. The models also directly address how bottom-up and top-down processes interact in visual cognition, and show how some apparently serial processes reflect the operation of interacting parallel distributed systems.