NEURAL DYNAMICS OF HOW COGNITION AND EMOTION WORK TOGETHER TO CHOOSE AND EVALUATE REWARDS

Whether crossing traffic or selecting fruit from the produce aisle of a grocery store, humans are capable of evaluating multiple stimuli in parallel. Understanding how humans can recall past preferences and current metabolic needs to assess the value of competing options is a critical issue in cognitive neuroscience that has applications to robotics, obesity, and addiction. To clarify these issues, Daniel Bullock, Mark Dranias, and Stephen Grossberg, of CELEST Thrust 3 (Learning in Cognitive-Emotional Interactions and Learned Sequential Behaviors) have developed a biologically-based neural network model that can evaluate stimuli in parallel, assess whether these stimuli are associated with rewards that meet the current needs of the animal, and then use this information to select targets for action and suppress responses to irrelevant distractors. Distinguishing desirable from undesirable stimuli requires a process of valuation. Frequently experienced stimuli acquire emotional and motivational value from the specific rewards with which they have been associated. Learned internal connections allow stimuli to recall the current value of specific outcomes. The ability to recall outcome-specific value ensures that stimuli that signal the most needed rewards are most attractive and elicit approach. To model valuation and selection of stimuli, simulated brain regions are divided into four classes: (1) *Object Categories*: registering visual or gustatory inputs in inferotemporal and rhinal cortex; (2) *Value Categories*: calculating the value of anticipated outcomes in the amygdala and hypothalamus; (3) *Object-Value Categories*: resolving relative values of competing stimuli in orbitofrontal cortex; (4) *Reward Expectation Filter*: detecting delivery or omission of rewards in basal ganglia.

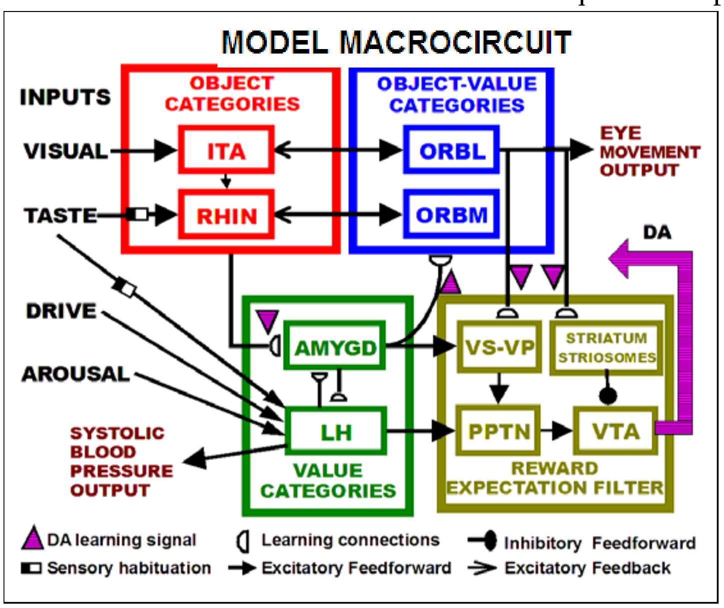

Figure. Model replicates electrophysiological data from ten brain areas. Eye movement and blood pressure signals are outputs.

The model simulates stimulus-outcome learning and evaluative visual discrimination, replicating behavioral, autonomic and electrophysiological data regarding the learning, reversal, and outcome-specific revaluation of stimuli. Simulations of the visual discrimination task reveal that both reinforcement learning and satiation for specific foods alters choice behavior. Simulated lesions of the modeled brain regions alter learning and decision-making, and provide critical insight into the functions of the amygdala and orbitofrontal cortex. Results show that amygdala lesions impair affective learning while orbitofrontal lesions disconnect affect from behavior, leaving emotional and habit learning systems intact but unable to interact.