Decoding The Neural Circuitry of Reward Behavior

Ernesto H. Bedoy, McNair Scholar, Psychology Major, Biology Minor
James M. Hyman, Faculty Mentor, Department of Psychology

Introduction

Classical conditioning demonstrates that rewards can be used to train behavior by pairing a stimulus, known as a prompt, with reinforced behavior. At a neuronal level, this association strengthens the connections between the neurons involved, making communication easier the next time. Enhanced communication is identified with learning, allowing an organism to anticipate a reward with a prompt so that it can perform the desired behavior to successfully obtain the reward (Noonan et al., 2011). In this study, we created a computational model to represent a neural circuit with synaptic plasticity during reward, no-reward and anticipation states. Our results confirmed our hypothesis that the model would be able to differentiate between reward and no-reward stimuli and subsequently anticipate the likelihood of reward and no-reward states on ensuing trials.

Methods

Using the Neuron software developed by professors at Yale and Duke Universities, a computational model of 8 neurons was created to represent a neural circuit in the anterior cingulate cortex (ACC). The neural pathway follows the arrows in the figure below.

The circuit received 3 input signals:
- A reward stimulus that simulated a feedback scent 100% predictive of a reward (reward trial)
- A no-reward stimulus that simulated a feedback scent 100% predictive of no reward (no-reward trial)
- A prompt for a prediction that simulated a visual cue indicating that a reward might be available at the nose port (behavior trial)

The simulation consisted of 31 trials, each separated by 1 second.

ACC(+/-)1 action potential amplitude peaks and time of peaks were collected only during behavior trails: during the control trial (C); after a reward trial (1); after a no-reward trial (0).

Results

The data were examined to note the differences in action potential amplitude peaks and peak times between ACC(+1) and ACC(-1). A correlation was found between these attributes and the predictability of this model.

- A higher amplitude correlates with the anticipated state
- A faster spike correlates with the anticipated state

Acknowledgements

I would like to thank the McNair Institute for their continued support in my research endeavors. I would also like to thank Dr. Hyman for his guidance and insight on this project. His expertise in neuroscience was an indispensable tool that enabled me to translate a biological system into a computational one.

References