COMPUTATIONAL MODELING OF THE FEAR CIRCUIT:
A SYSTEM APPROACH TO UNDERSTAND
ANXIETY AND STRESS DISORDER

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ABSTRACT

Computational models are becoming increasingly important to systems neuroscience. In fear learning, although there have been a few attempts at modeling emotional learning and memory in the past, most were limited to simplified connectionist or artificial neural network models which did not incorporate current knowledge about the biophysical properties of accurate neurons. This research focused on extending our understanding of the neural mechanisms underlying fear learning and extinction using biophysically realistic network models. Since disruption of the fear circuit is thought to underlie the pathology of post traumatic stress (PTSD) and other anxiety disorders, such models could potentially provide ideas and approaches for the development of new medications.

We initiated modeling of the overall fear circuit starting with the most critical component, the lateral amygdala (LA), and attempted to describe how a single structure (i.e., LA) can encode both acquisition and extinction memories learned during auditory fear conditioning. Next, we developed a biophysical model of another critical element of the fear circuit, the ITC (intercalated cells) to understand the role of ITC neurons in suppressing fear. After successful development of component model for the LA and ITC network, an overall amygdala network model was developed to investigate how conditioning-induced potentiation of LA response leads to activation of the central amgyala (CE) output, by inclusion of another important unit of the circuit – basal amydala (BA).