Modeling the Visual Processing in Toad

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The common toad (*Bufo bufo*) is an important neuroethological model since it was one of the first vertebrates used to study the predator-prey feature recognition system. Since the toads' visual system is "effectively blind to static scenes" (Ewert, 1980), toads can only discriminate prey from non-prey by certain spatiotemporal stimulus features. In a toad's brain, three crucial components are involved in this system. First is the retina involved in retinal processing. Second and third are the optic tectum and the thalamic pretectum, involved in feature recognition. In the optic tectum, T5.1 and T5.2 are feature detector neurons involved in signaling prey feature recognition. TH3 neurons play a role in recognizing threatening stimuli and initiating escape and avoidance behaviors in the thalamic pretectal area. Besides, TH3 neurons act as an inhibitor on T5.2 neurons to sharpen the prey-detecting properties' specificity. Together, these components form two parallel pathways, which is the retinotectal pathway, excited by prey visual stimuli, and the other one is the retinopretecto-tectal pathway, excited by non-prey stimuli and converge onto T5.2 neurons of the optic tectum (Keith T. Sillar, Laurence D. Picton and William J. Heitler, 2016).

Three exciting questions motivate me to delve into the prey recognition system. How are prey stimuli distinguished from non-prey stimuli? What are the visual features of prey? Do these features consist of a unique prey sign stimulus or a certain range within a stimulus continuum? These questions have been extensively studied from behavior to neuron. Thus, I aim to model this prey recognition system then study and compare its functioning and performance against animal behaviors.

Based on a simplified version for visual predation in toads, I divide my model into four layers: the retinal layer, in which different visual stimuli converge, the tectal optic layer that corresponds to feature detection, the pretectal layer, containing TH3 neurons, and a final layer of interactions among retina, tectum, and pretectum, releasing the main output of the whole model. In the retinal layer, the primary inputs are the movement and contrast of prey or non-prey stimuli. I will use matrices of the location to represent these inputs. In the tectal layer, the direct inputs are from retinal signaling. I describe these inputs as lateral interactions among tectal columns, in which cells of column receive afferents from cells of neighbor columns. In the pretectal layer, I will use a two-dimensional array of TH3 neurons to model the pretectum. In the interaction layer, the inputs for this layer are the outputs from the pretectal and tectal layers; I will use a binary classification to describe its outcome, in which 0 indicates an avoidance behavior, and 1 indicates an attack behavior. I will use Python to implement my model.

For simplicity, I will use three types of stimuli to test my model:

1. Rectangles whose longest axis moves in the direction of motion.
2. Rectangles whose longest axis moves perpendicular to the direction of movement.
3. Squares of different sizes.

Even though my model's primary purpose is to test the behavior responses under a single prey or non-prey stimulus, my model's expansion can also test the behavior responses under multiple stimuli.