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Looming-Sensitivity in Hummingbird Hawkmoths: Neurons and Models.

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Intracellular recordings in *Manduca sexta* (Sphingidae, Lepidoptera) identified a class of wide-field neuron that responded selectively to looming or receding stimuli. Clockwise and counter-clockwise rotating spirals and expanding or contracting discs simulated looming and anti-looming. Both spirals and discs provide the eye with outwardly or inwardly moving edges, while the spiral simulates looming or anti-looming maintaining a constant area, perimeter length, and luminance on the retina. Type 1 cells are activated only by the disc and not the spiral, effectively distinguishing expansion from contraction by measuring perimeter length. The cell class is further divided: Type 1a neurons responded to looming and were inhibited by image size decrease (anti-looming) whereas type 1b neurons were activated by anti-looming and inhibited by looming.

The proposed model for type 1 neurons requires them to be mutually inhibited, while being fed by two systems of retinotopically organized directional insensitive and motion sensitive edge-detectors through an intermediate level of elements that either preserve or invert the signal. The first of the two systems provides an excitatory output on the type 1a neuron, the latter inhibits the type 1b neuron. As the edge of the looming stimulus expands on the retina there is a recruitment of sequentially stimulated edge detectors increasing the depolarization of the class 1a cell and increasing the inhibition of the class 1b cell. The opposite occurs with reversed stimulus: excitation of the class 1a cell diminishes, while the class 1b cell is gradually released from inhibition. Reciprocal inhibition occurs between the class 1a and class 1b neurons to provide the observed responses of excitation to looming and inhibition to anti-looming or the reverse. We implemented the proposed model comparing the performance of the real circuit with the model. The model proves to be able to simulate the essential features of the neuronal circuit.

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