This Week in The Journal

Salamanders Predict Future Fly Positions

Bart G. Borghuis and Anthony Leonardo

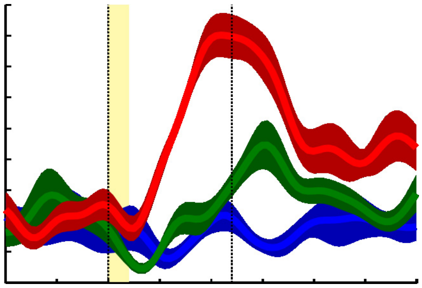
(see pages 15430–15441)

When prey enters a predator's visual field and an image forms on the retina, it excites retinal ganglion cells, which transmit the information to the CNS. Based on this information, central circuits generate a motor command that is transmitted to muscles. These contract, producing a movement aimed to capture the prey. All this takes time, however, allowing the prey to move before the predator strikes. To avoid wasting energy on unsuccessful attempts, predators must therefore incorporate a prediction of prey's future position when planning an attack.

Borghuis and Leonardo have investigated this prediction process in three-lined salamanders. When a fruit fly entered a salamander's visual field, the salamander turned its head in a saccade-like motion, then rapidly projected its tongue toward the fly. The head turn and tongue projection took ~130 ms, which together with a retinal processing latency of 100 ms (reported previously), gave flies ~230 ms to move before being struck by the tongue. Flies typically moved at least one body length during this period, yet 91% of strikes resulted in capture. If salamanders did not account for neural delays, the tongue would miss the center of the fly by an average of 8°, but the error was only 3°. This suggests that salamanders target the place they expect a fly to be after the sensorimotor delay.

How do salamanders predict a fly's future position? Because flies typically moved in straight lines at fairly constant speeds, the authors reasoned that simple linear extrapolation from a fly's prior movement could be used to predict where the fly would be when the tongue was fully extended. Indeed, a model in which fly movement was assessed over a 175 ms period ending 100–250 ms before the onset of prey capture accurately predicted tongue position at peak extension. In fact, in the few cases where a fly stopped or turned and the salamander missed, the tongue's strike point was usually as close or closer to the position predicted by the model as to the actual position of the fly.

These results demonstrate that salamanders incorporate predictions about the future state of the world when planning actions. Future investigations of these animals may therefore deepen our understanding of how neural circuits generate such predictions.



Average firing rates (solid lines) and standard deviation (shaded areas) of a neuron over the course of 10 trials in which a man imagined hand shapes representing rock (blue), paper (green), or scissors (red). The neuron fires most when the scissors hand shape is imagined. Vertical lines indicate the onset of the cue and response phases. See Klaes et al. for details.

Neurons in Human AIP Are Selective for Hand Shapes

Christian Klaes, Spencer Kellis, Tyson Aflalo, Brian Lee, Kelsie Pejsa, et al.

(see pages 15466–15476)

Primates can make a wide range of hand movements to grasp objects of different shapes and sizes. To grasp a particular object, one must first determine the appropriate hand shape to use and then coordinate movements of the wrist and fingers to form that shape. While the latter task is performed by primary motor cortex (M1), the former is achieved by higher-order brain areas, including the premotor cortex and the anterior intraparietal area (AIP).

Single-unit recordings in monkeys suggest that neurons in M1, AIP, and premotor cortex are tuned to different hand shapes or movements. Based on the pooled activity of neurons in each area, researchers can determine which of several grasps an animal was preparing to perform. In such experiments, however, monkeys typically reach for and grasp visually presented objects, making it difficult to disentangle neural components related to motor imaging, planning, execution, and sensory feedback. Furthermore, whether AIP is involved in forming non-grasp hand movements, such as those used in sign language, is unknown.

Klaes et al. show that human AIP also encodes hand shapes unrelated to grasping. To do so, they recorded single units in a tetraplegic man who was learning to control a robotic limb. The subject imagined making hand shapes for the game rock-paper-scissors, as well as two additional hand shapes. Approximately one-third of recorded neurons showed selectivity for one of the hand shapes. Some neurons' firing rates were highest when a visual cue indicating which hand shape should be imagined was presented, whereas other neurons were most active when the cued hand shape was actually imagined. The activity of either population could be used to decode which hand shape was imagined.

These results suggest that AIP contains separate populations of neurons that encode visual cues related to hand shaping and the hand shapes themselves, regardless of whether grasping an object is involved. Thus, they confirm and extend results from single-unit recordings in monkeys. More importantly, they show that single-unit recordings from human AIP can be used to accurately control neural prostheses.

This Week in The Journal is written by Teresa Esch, Ph.D.