This Week in The Journal

Heterogeneous Hair Cells of the Lateral Line

Paul Pichler and Leon Lagnado

(see pages 112–124)

Fish use information about water pressure and movement to help orient their bodies in currents, evade predators, and track prey. They gather this information using the lateral line system, which consists of numerous mechanosensory structures called neuromasts that are distributed over the fish's body. Each neuromast houses 10–20 hair cells similar to those found in the inner ear. The stereocilia atop these hair cells are encapsulated by a flexible cupula structure that is deflected by changes in water pressure. Deflection of the cupula bends the stereocilia, causing mechanosensory transduction channels to open or close, depending on the direction of deflection. This leads to hair-cell depolarization or hyperpolarization and increases or decreases in glutamate release.

To investigate how mechanical stimuli are converted into neural signals in the lateral line system, Pichler and Lagnado used the fluorescent glutamate sensor iGluSnFR to quantify glutamate release from individual hair cells in response to various degrees of cupula deflection. The transfer characteristics varied across cells within single neuromasts. As previously shown, some hair cells released more glutamate when the cupula was deflected toward the head, and others responded more strongly to deflections toward the tail; consequently, deflections in either direction elicited depolarization of some hair cells. Importantly, the sensitivity and working range (the difference in deflection angles eliciting minimal and maximal responses) varied across hair cells. The extent to which glutamate release was decreased by deflections in the non-preferred direction also varied across cells, and some cells exhibited only depolarizing responses. Hair cells also differed in how long glutamate release remained elevated during prolonged stimulation: some showed transient responses at stimulus onset while others showed sustained release. Finally, some hair cells exhibited transient increases in glutamate

release at the offset of deflections in their non-preferred direction.

The heterogeneity in transfer characteristics across hair cells likely benefits fish by enabling accurate encoding of both small and large changes in water pressure, as well as signaling onset, offset, and duration of these changes. Future work should examine the downstream connectivity of hair cells with different properties and determine how the cells contribute to various behaviors. In addition, the cellular and molecular bases of the heterogeneity should be examined.

Lateral line neuromasts contain several hair cells (green) whose stereocilia are ensheathed by a cupula (edges shown in blue). See Pichler and Lagnado for details.

Integration of Quality and Quantity in the Brain

Archy O. de Berker, Zeb Kurth-Nelson, Robb B Rutledge, Sven Bestmann, and Raymond J. Dolan

(see pages 163–176)

When making decisions, the brain is thought to calculate the value of each option, compare these values, and then choose the option with the highest subjective value. Often, multiple attributes of each option must be evaluated; for exam-

ple, when choosing a restaurant, one must consider the type of food, the quality, and the cost. Previous work has identified multiple brain areas involved in computing and comparing the values of options during decision-making tasks, but if, how, and where in the brain a single value is calculated for objects whose desirability varies along multiple dimensions remains a matter of debate.

To address this question, de Berker et al. used fMRI to identify brain areas activated when people considered the value of gift cards based on quantity (monetary value of the card) and quality (the subjective value of the retailer, determined separately for each participant). General linear modeling indicated that gift card quality, but not quantity, was correlated with activity in the inferior frontal gyrus (IFG), whereas quantity, but not quality, was reflected in activity in bilateral intraparietal sulcus (IPS).

To identify regions that might combine quality and quantity, the authors looked for regions whose activity increased more steeply with quantity for high-quality than for low-quality cards. They reasoned that this pattern would reflect the fact that a unit increase in quantity would be worth more for high-quality than for low-quality cards. They found such a pattern in the posterior cingulate cortex and superior temporal lobe. Finally, activity in the anterior cingulate cortex (ACC) varied with quality, quantity, and their interaction, suggesting that activity in this area represents integrated value.

These results are consistent with the hypothesis that the brain evaluates individual attributes of options and integrates these values into an overall value. Notably, the ACC has previously been implicated in tasks in which subjects evaluate objects sequentially, as was done in this study, and the IPS is involved in numerical processing. Few studies have implicated the IFG, which is involved in semantic processing, in value encoding, however. This suggests that different brain regions are involved in valuation depending on the attributes to be considered and how options are presented.

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