Editorial Focus

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Fish Smell. Focus on "Odorant Specificity of Single Olfactory Bulb Neurons to Amino Acids in the Channel Catfish"

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Olfactory systems serve a crucial role in kin recognition, mate selection, finding food and avoiding predators, and navigation and homing in a large proportion of invertebrate and vertebrate species. It is increasingly apparent that for many chemical cues, the olfactory system begins the process of encoding olfactory stimuli through recognition and discrimination of specific physicochemical features of the stimulus. These features are initially extracted by specific olfactory receptors in the nose or antenna and contrast enhanced through circuitry within the first central relay of the olfactory system, the olfactory bulb, or antennal lobe. The precise nature of these odor features is yet to be determined for the most part, but may range from submolecular functional groups to particular classes of whole molecules. In their paper in this issue, Nikonov and Caprio (p. 123–134) demonstrate, in the most complete study to date of this type in the fish, precise subclasses of olfactory bulb neurons for coding biologically significant amino acids in channel catfish (*Ictalurus punctatus*). Given the wealth of behavioral, neuroanatomical, and sensory physiological data on this species, these data can form a keystone between our understanding of how chemosensory stimuli are encoded and specific odor-guided behaviors in catfish.

One of the remarkable features of olfactory systems is the highly conserved anatomy of the first central olfactory relay across the animal kingdom. Thus terrestrial invertebrates and vertebrates and aquatic vertebrates display a roughly laminar olfactory bulb (vertebrates) or antennal lobe (invertebrates) wherein olfactory receptor neurons coalesce into small regions of dense neuropil called glomeruli within which the receptor neurons synapse with olfactory second-order projection neurons. There is variation in the size and complexity of the glomerular structure as well as the number of glomeruli innervated by the dendritic trees of olfactory bulb/lobe projection neurons across species. However, this basic anatomy is often a defining characteristic of olfactory systems. The glomeruli and their associated neurons appear to function as odorant feature detectors and are spatially arranged across the olfactory bulb to create a unique spatial pattern of glomerular and projection neuron activity for each odorant. Thus second-order projection neuron molecular receptive ranges/odorant receptive fields are believed to reflect the selectivity of the olfactory receptor neurons impinging on them as well as local circuit interactions. Previous work examining catfish olfactory bulb single-unit molecular receptor ranges has demonstrated, for example, odor-selective response zones (odotopy) across the olfactory bulb including relatively discrete amino acid, nucleotide, and bile-salt-sensitive zones (Nikonov and Caprio 2001). Each of these stimulus classes has been shown to have behavior-specific significance for the catfish, for example, with amino acids important for food detection and bile salts involved in conspecific recognition. The spatial organization of these odorant-sensitive zones in the catfish roughly mirrors similar zones in other teleosts (Friedrich and Korsching 1997). Interestingly in catfish, these zones appear to be innervated by different morphological classes of olfactory receptor neurons, which each express different transduction mechanisms and thus presumably shape the differential stimulus selectivity (Hansen et al. 2003).

In this issue, Nikonov and Caprio demonstrate that neurons within the amino-acid-responsive zone have tuning properties that may directly contribute to the catfish's ability to make fine discriminations between these biologically important stimuli (Valentinic et al., 1994). Their results demonstrate that catfish olfactory bulb neurons can be subdivided into classes of neurons selective for basic, neutral, and acidic amino acids. Importantly, these classes can be further subdivided based on the characteristics of the amino acid side chains. For example, the subclass of neurons selective for neutral amino acids can be further subdivided into neurons selectively responsive to neutral amino acids with linear side chains and neutral amino acids with branched side chains. By varying stimulus concentrations over wide ranges, the authors demonstrated that receptive ranges could be broadened at higher concentrations but remained within the original subclass (e.g., neutral amino acids). These results imply the existence of olfactory receptors selective for these different forms of amino acids, indirect evidence for some of which already exists (Caprio and Byrd 1984; Rhein and Cagan 1983). Given the diversity of receptor morphology and transduction mechanisms in the catfish, the present results may be a crucial guide to further identification of olfactory receptor mechanisms in teleosts.

This paper is an excellent example of the power of exploring a model system at multiple levels of analysis and using biologically relevant stimuli. The results bear out what has been implied by work on olfactory receptor neuron function and provide a potential mechanism contributing to known behavioral olfactory acuity in the catfish. Given the conserved nature of olfactory systems across species, these studies can serve as a template for understanding general properties of olfaction.

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