Flavour

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"What" and "where" in sensory space: parallels between olfactory and visual perception

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The representation of odorants detected by ligand-specific olfactory receptor neurons targeting discrete anatomical units called olfactory glomeruli has been well document for two animal groups: vertebrates and insects. Odortypic maps have likewise been confirmed in specific second and third order brain centers in these taxa. However, there are two abiding problems that confront researchers studying olfactory processing and odor representation. The first pertains to marine crustaceans, in which any olfactory receptor neuron responds to a broad range of stimulants and supplies an olfactory lobe that is very differently organized from those of the sister group Insecta. The second relates, generally, to the question of how an odor source is located by an animal in its odor space: which circuits enable the coding of "where" as distinct from "what." Research on insects, suggests that two additional modalities are required to determine an odor source. Yet in insects, as in crustaceans, there are blind taxa living in still environments that efficiently locate odor cues. Comparative anatomical studies on arachnids and flightless insects also suggest that invoking casting behaviors within upstream wind currents may not be sufficient to account for odor source detection.

To fully appreciate the challenge offered by odor-locating systems we need to turn to visual processing where recent research has demonstrated that high order visual primitives are encoded in specific glomerular islets that together comprise the optic glomerular complex (OpGC). As in the antennal lobes of an insect, glomeruli of the OpGC are interconnected by elaborate arrangements of local interneurons. The outputs from the OpGC variously extend to premotor descending pathways, to the mushroom bodies, and to central brain areas. Neurons in visual neuropils that supply optic glomeruli are retinotopically organized; yet, because the axons of any one type of these neurons converge at a particular glomerulus, information about where the stimulus occurred in visual space is not represented. The OpGC therefore shares with antennal lobe's olfactory glomerular complex a representation of stimulus properties but not a representation of where those properties occur in sensory space. The visual system does, however, contain a simple parallel system of neurons distinct from the OpGC that encodes "where," not of any particular feature but of a salient feature. In my overview talk I will compare organization of olfactory representation across Arthopoda emphasizing similarities with the visual system, and consider how sensory representations may have evolved from a common ground pattern. I will ask whether a search image for a substrate, in which there is odortopic representation – as opposed to odortypic representation – might develop from the study of how other modalities are encoded in glomerular centers.

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