OLFACTION

Converging inputs

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During olfactory processing, odours usually activate multiple glomeruli — structures in the olfactory bulb that are each associated with a specific odorant receptor — and, in turn, signals from glomeruli reach higher brain areas. The signals from different glomeruli often converge in these areas, but which signals converge, and which do not, is not well understood. A new study in flies shows that projections from some combinations of glomerular neurons converge on certain types of lateral horn neurons (LHNs) to process combinations of salient odours for certain behaviours.

In *Drosophila melanogaster*, olfactory projection neurons (PNs) in the glomeruli project to the Kenyon cells in the mushroom body or to the LH. Although Kenyon cells show unbiased sampling of the PN inputs, little was known about how LHNs sample the PN signals.

The authors first mapped functional connections between the PNs and the LHNs. To do so, they expressed a variant of channelrhodopsin in most of the glomeruli, and then used two-photon excitation to optogenetically activate PNs in individual glomeruli in slices while conducting whole-cell recordings in LHNs.

Stimulation of PNs led to mostly excitatory responses in LHNs, although very little spiking was seen in the latter, suggesting that most connections from PNs to LHNs are monosynaptic. Moreover, stimulation of glomeruli containing one PN versus stimulation of glomeruli containing multiple PNs elicited similarly strong responses, indicating that the strength of glomerular-to-LH connections is not a product of the number of PNs activated.

In the sample of cells assessed, the authors found that, on average, each glomerulus sent projections to 13% of the LHNs. However, there was considerable variation between glomeruli in terms of their connectivity to the LH, with some glomeruli making few connections and others making ~30. These highly connected glomeruli showed narrow tuning to odours.

Before assessing the connectivity data more thoroughly, the authors classified some of the LHNs into different types based on their morphology and their odour-tuning, such that there was greater variation in odour tuning between morphological types than between LHNs of one type. They then applied this method to their whole LHN data set, yielding 39 types of these cells.

The authors noticed that LHNs of the same morphological group often showed similar, but rarely the same, connectivity patterns, and that different glomeruli connected to non-independent sets of LHN groups. Moreover, through generating a glomerulus–glomerulus correlation matrix that showed how often pairs of glomeruli shared patterns of connectivity, the authors found that some combinations of glomeruli send projections to multiple LHN types.

The authors next compared how these overrepresented glomeruli were related to odour responses, derived from previously published data sets. Some glomeruli targeting the similar LHN types were similarly tuned to odours; however, many converging glomeruli had dissimilar odour tuning. Further analysis, however, revealed that some of these dissimilar odours were, together, relevant to certain behaviours (for example, aspects of feeding as well as seeking food).

In the final part of the study, the authors examined the importance of the connections between PNs and LHNs, given that LHNs also receive inputs from other cell types. Based on the connectivity data, they were able to predict the majority of the odour responses that they sampled, highlighting the importance of this circuit.

Together, these data reveal the organization of the connectivity between the glomeruli and higher-order olfactory brain areas in flies, and show that combinations of glomeruli are co-activated by odour combinations that are relevant to behaviour.

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