How the brain produces behaviour: Connectomic analysis of aversive olfactory integration in the fruit fly

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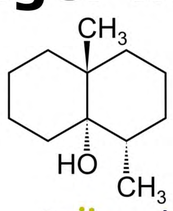
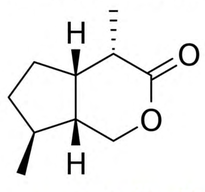
1 Flies rely on the olfactory system to detect danger in their environment

GEOSMIN
produced by toxic microbes that grow on yeast





IRIDOMYRMECIN
a pheromone produced by predatory wasps

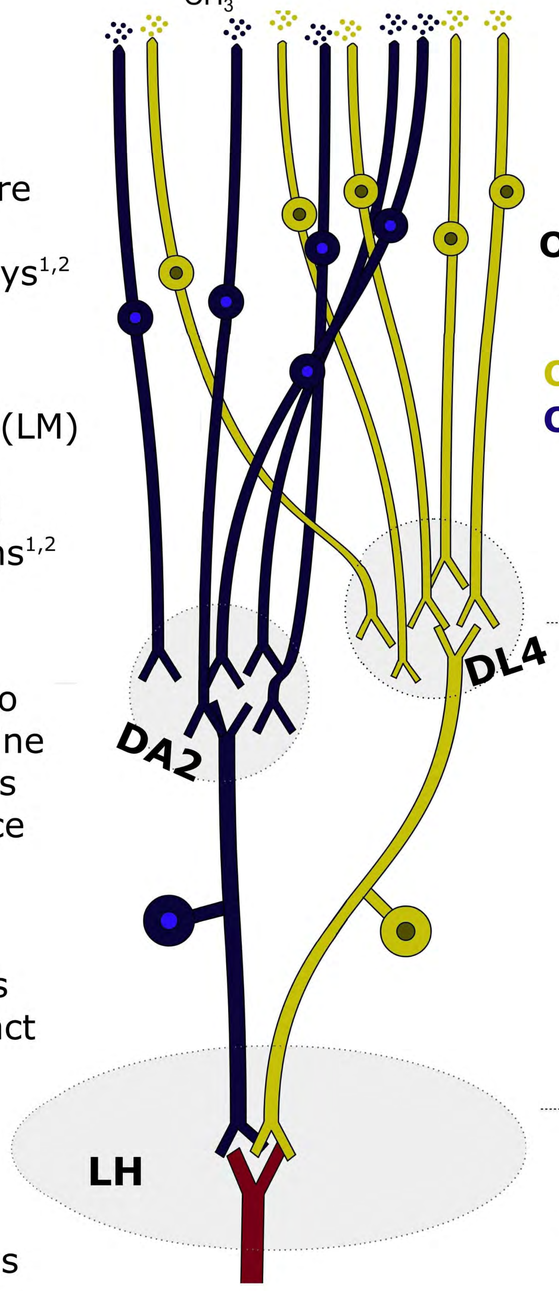
The two odours are processed by dedicated pathways[1,2]

Light microscopy (LM) indicates overlap between DA2 and DL4 PN projections[1,2]

Inactivation of two LHNs labelled in line R22D02[3] abolishes geosmin avoidance

The R22D02 LHNs run in the AV1 tract

The circuitry is fundamentally similar in fruit flies and mammals



Olfactory receptor neurons (ORNs)

Or49a ORNs x 20-50
Or56a ORNs x 20-50

Projection neurons (PNs)

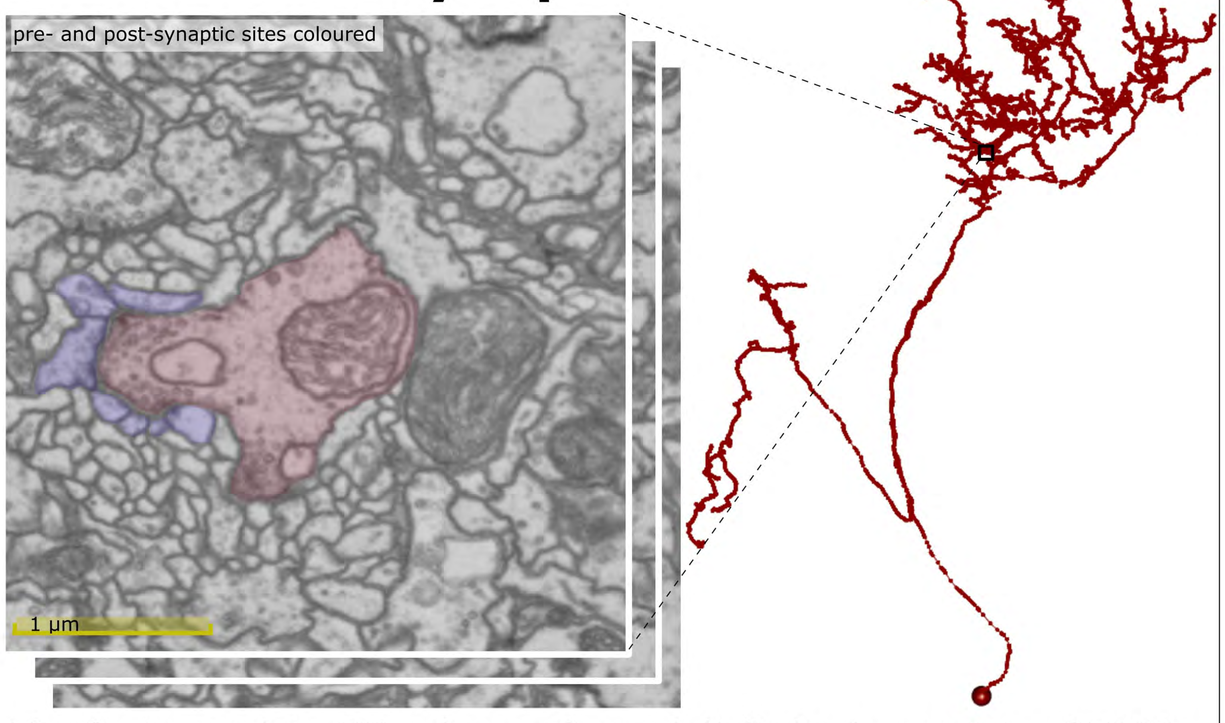
DL4 PN x 1
DA2 PNs x 5

Lateral horn neurons (LHNs)

LHNs x 2 ?

Are there lateral horn neurons which integrate the two different danger signals?

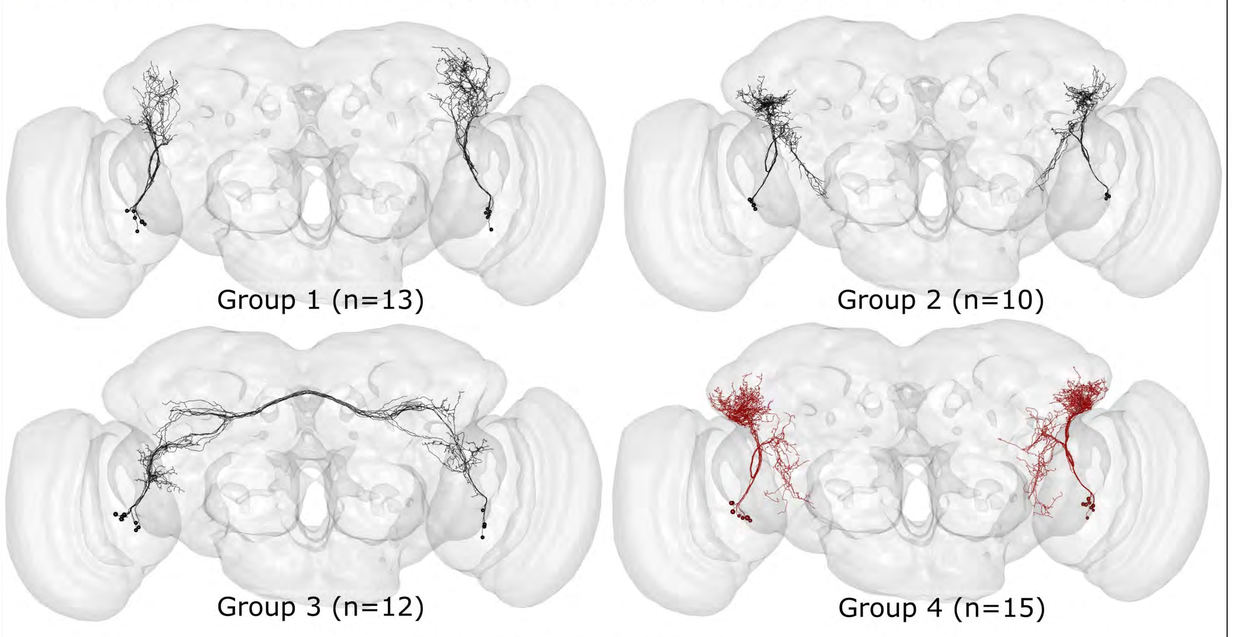
2 EM connectomics – an approach to study neuronal connectivity at the synapse level



The first complete EM volume of an adult fly brain consists of 7060 serial sections[4], each 2000x thinner than an average human hair

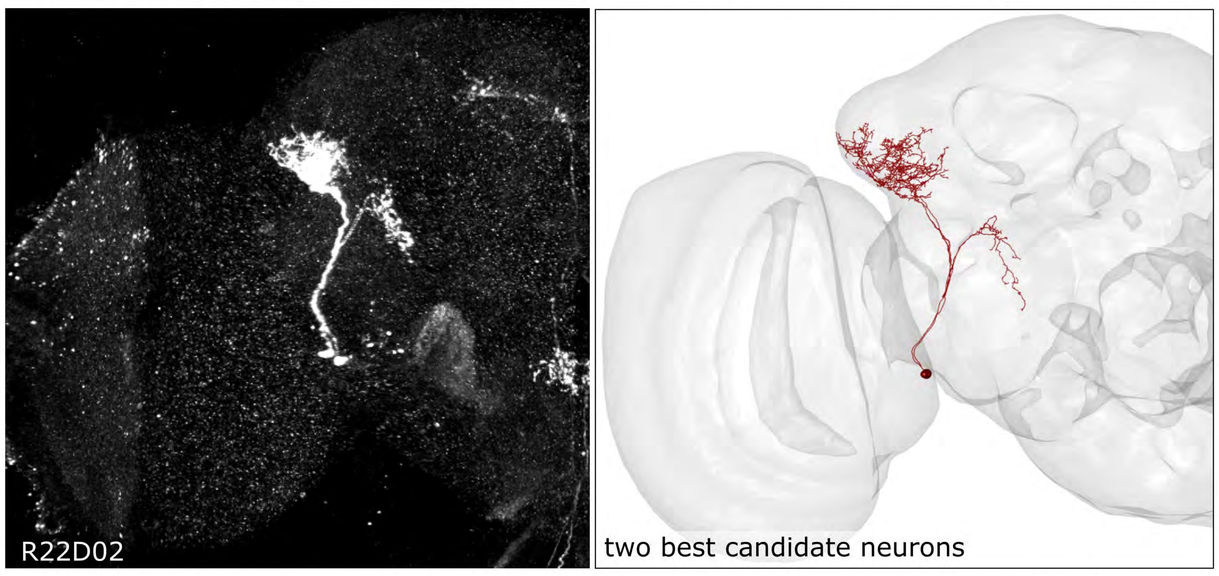
Neurons are reconstructed in CATMAID[5,6], a web-based collaborative tracing and analysis software

3 LHNs of interest run in the AV1 tract



EM reconstruction of the AV1 tract reveals FOUR distinct neuronal classes based on morphological clustering

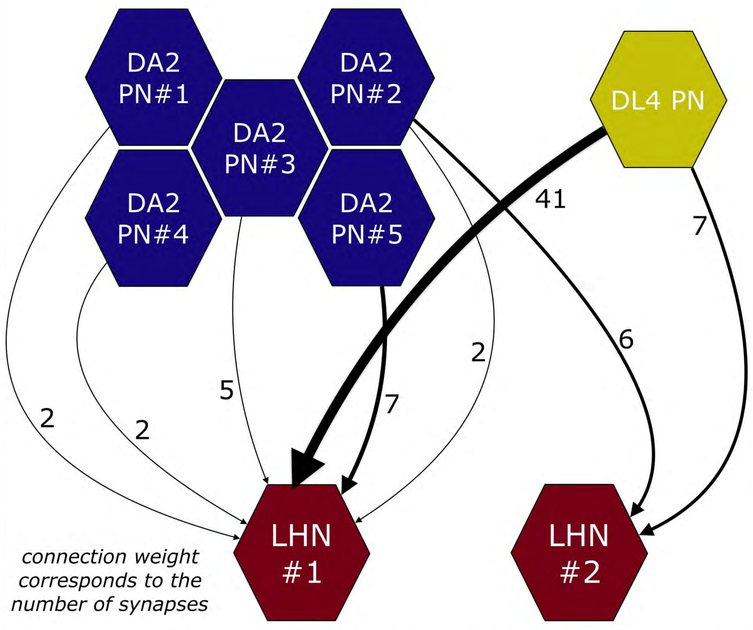
4 Two LHNs share the R02D22 morphology



Morphological comparison of LM neurons and reconstructed EM neurons identifies two R22D02 LHN candidates in each hemisphere

(only the right hemisphere shown here)

5 Connectivity reveals DA2 & DL4 inputs



Each of the two LHNs receives input from both DA2 and DL4 PNs

Thus, geosmin and iridomyrmecin signals indeed seem to be integrated by two LHNs as part of the avoidance circuit

The stronger DL4-to-LHN connectivity possibly compensates for the smaller number of DL4 PNs compared to DA2

Both LHNs also receive input from other, not necessarily repellent, glomeruli so further tracing is required to fully understand their role

References

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