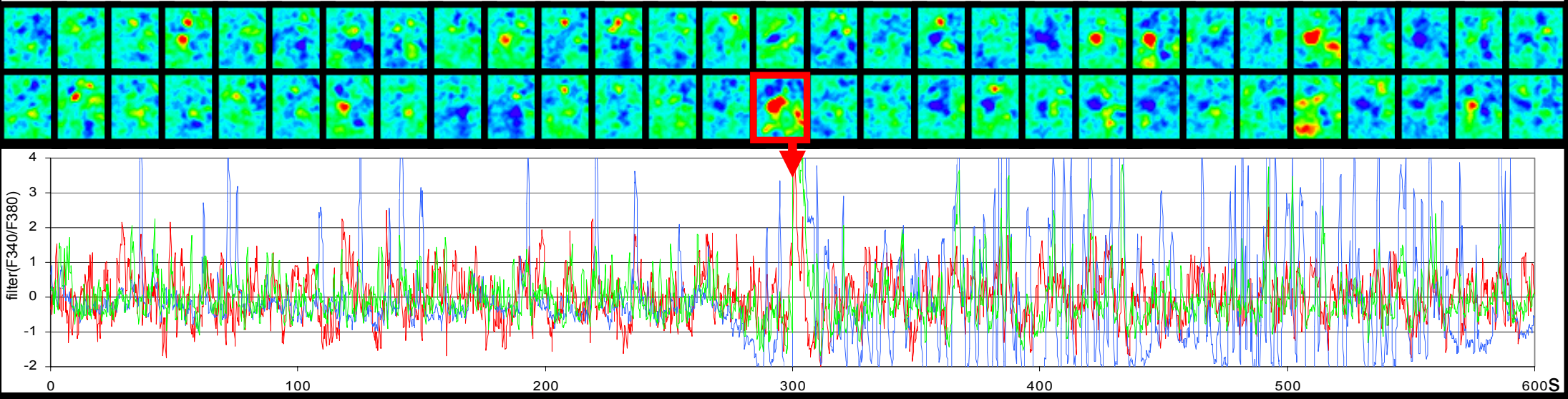


Dissecting the olfactory code: a working memory trace in the bee antennal lobe

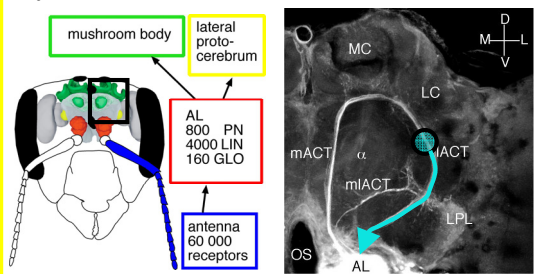
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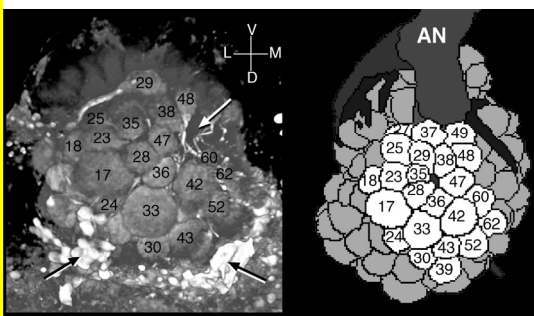
Spontaneous activity: False-color coded images of a recording of spontaneous activity in the bee AL. Frames are 10 s apart. The trace shows activity in three glomeruli. Note the correlated activity in the blue and green trace after odor delivery, but not before. Odor at 300 secs. Some 'inhibitory' events are due to high-pass filtering (30s kernel).



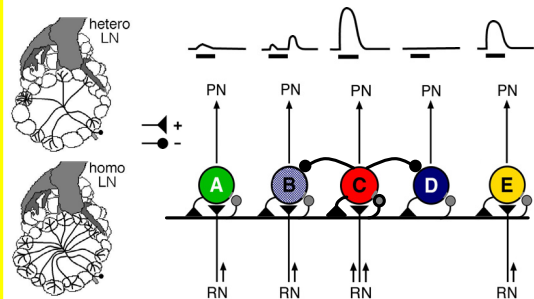
Introduction: Bees can learn to associate an odor with a sugar water reward. The antennal lobe (AL) is the first neuropil in the bee brain to process olfactory information. We recorded from the projection neurons (PN) of the AL (corresponding to mitral cells) for long periods (several minutes), and observed the changes in spontaneous activity induced by an odor stimulus.



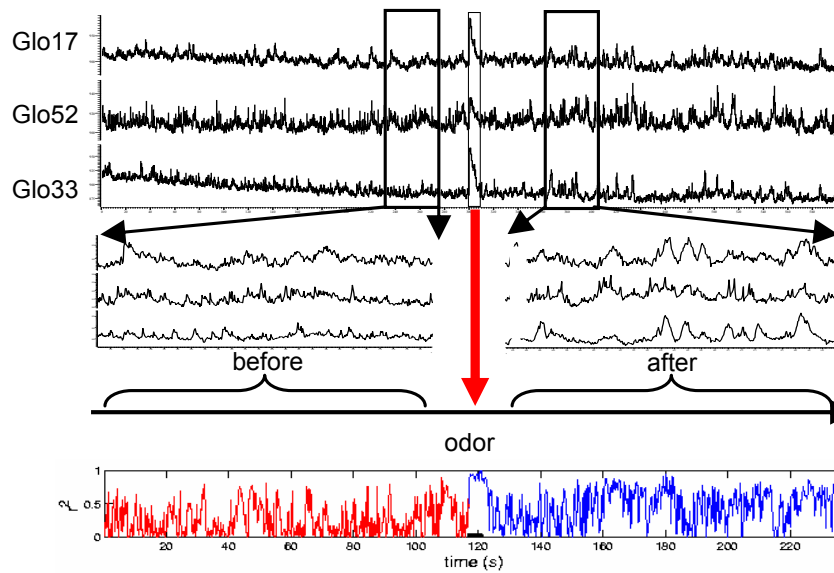
The olfactory system of the honeybee, and the injection site for FURA-dextran.



Left: projection neurons in olfactory glomeruli labeled with FURA. The individual glomeruli are identified. Right: a schematic view of the AL, with labeled glomeruli.

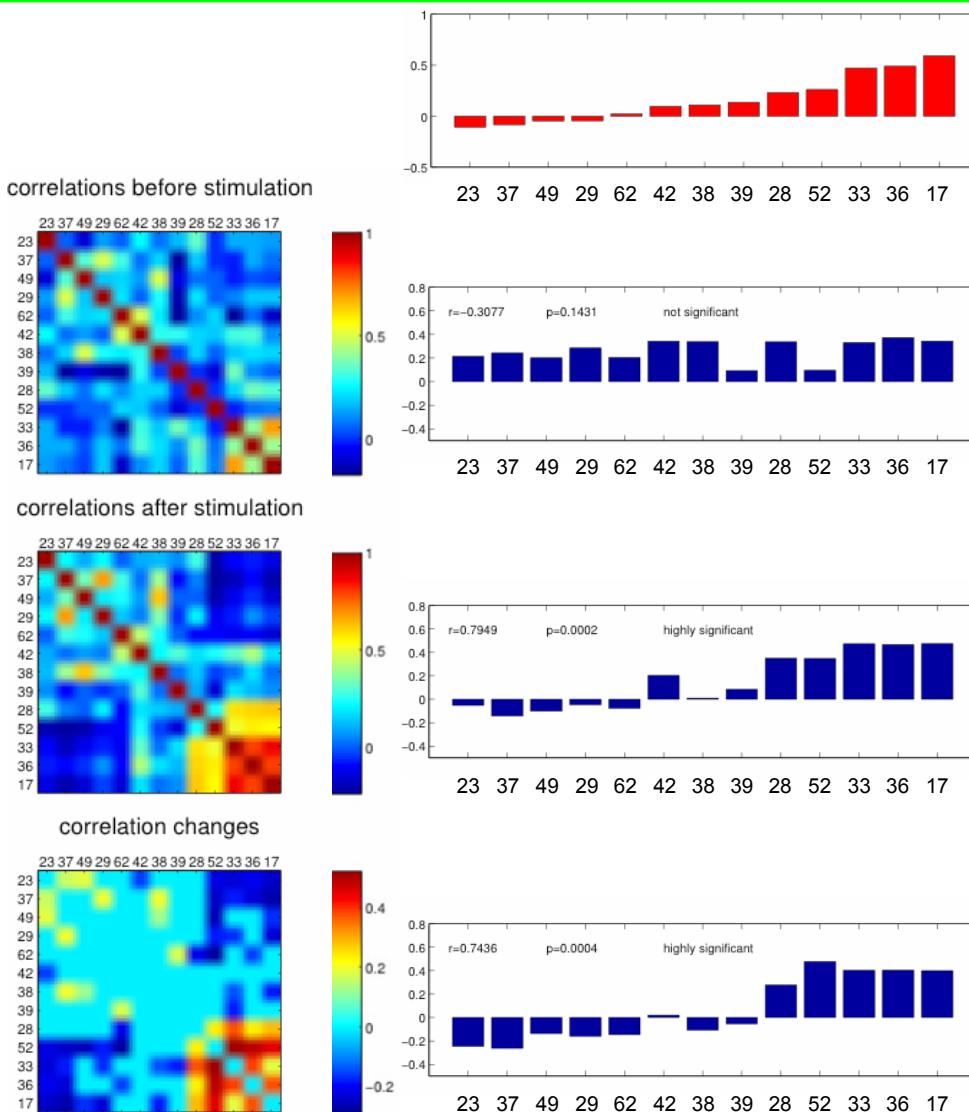


The AL gets input from receptor neurons (RN), and sends output to other brain areas (PN). Within the AL a network consisting of at least two types of local neurons (left) shapes both olfactory responses and spontaneous activity. The analysis of spontaneous activity therefore should allow to infer the connectivity patterns within the AL. Schematic view: responses to a particular odor, from Sachse&Galizia, 2002.



Working memory: Shown here are the activity traces for 3 glomeruli, with a detailed view for two time windows. An odor was given half-way through the recording (red arrow – note the strong calcium increase as compared to the spontaneous activity). After odor-delivery occurrences of spontaneous coactivity of those glomeruli that were activated by the odor are most frequent. This can be shown by calculating the similarity between the activity pattern of all identified glomeruli at any point in time against the odor-response pattern (below). After odor delivery the similarity increases (blue trace).

After a single odor exposure the network is dynamically 'tuned' into the pattern of the odor. This memory is purely olfactory, without any reward, and may represent the trace of olfactory working memory.



Correlation analysis:

Red histogram: Quantification of across-glomeruli responses to an odor (1-octanol) for identified glomeruli.

Correlations before stimulation: From the spontaneous activity before stimulation we calculated a correlation matrix across all identified glomeruli. The first eigenvector of this matrix shows that activity is fairly uniformly distributed across glomeruli (blue histogram). There is no significant correlation between this vector and the odor response itself ($p=0.1431$, Kendall's coefficient rank test).

Correlation after stimulation: However, when taking the spontaneous activity after stimulation, the relationship between the intrinsic activity and the odor response pattern becomes highly significant ($p=0.0002$, Kendall's coefficient rank test). Note that in the correlation matrix the correlation between glomeruli 17, 36 and 33 is very strong, while the correlation of these glomeruli with glomeruli 23, 37 and 49 is negative (to name but a few examples).

Correlation changes: This pattern becomes even clearer when looking at the changes in the correlation matrix.

The correlation analysis confirms that the odor is stored in dynamically coactive glomeruli well after stimulus onset. Which are the plastic synapses in the AL network?