

SSVEP approaches to studying visual attention in insects

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The University of Queensland

How do we study attention in humans?



- Verbal reports

Input



Response

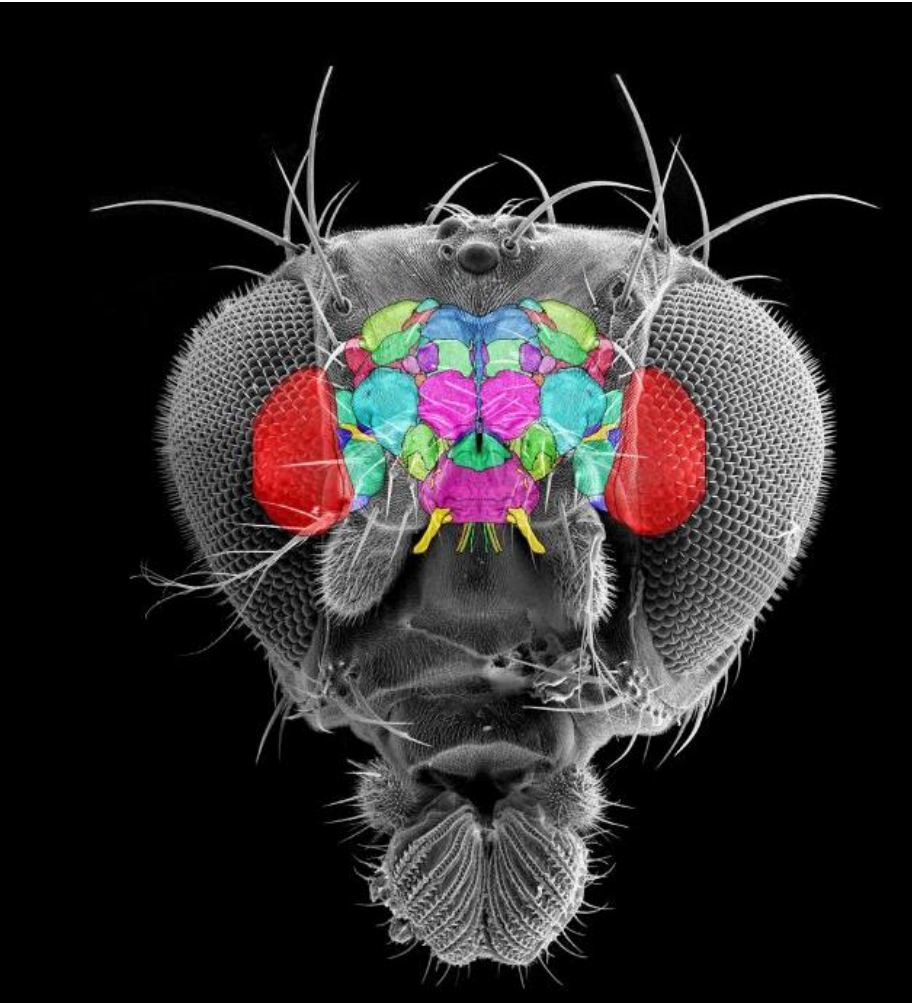


Brain activity



Direction of gaze

Why study insect attention?



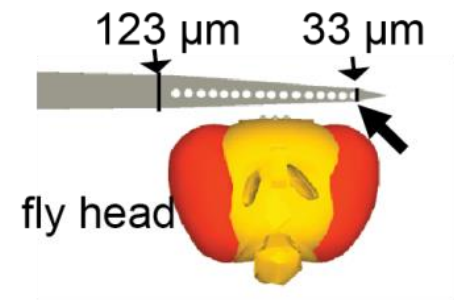
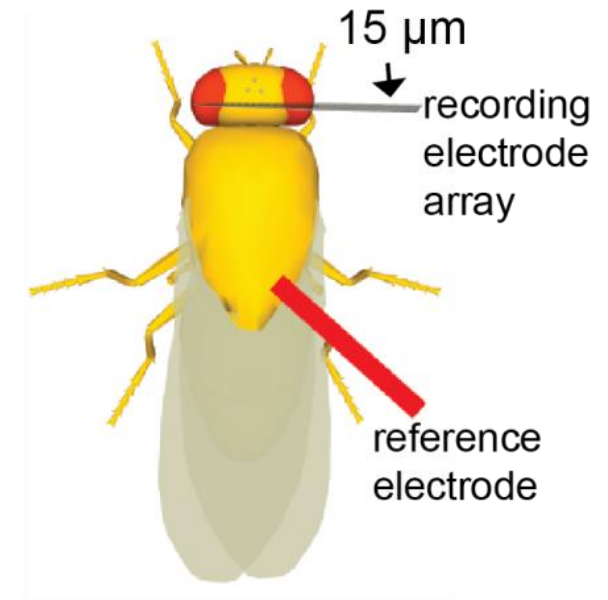
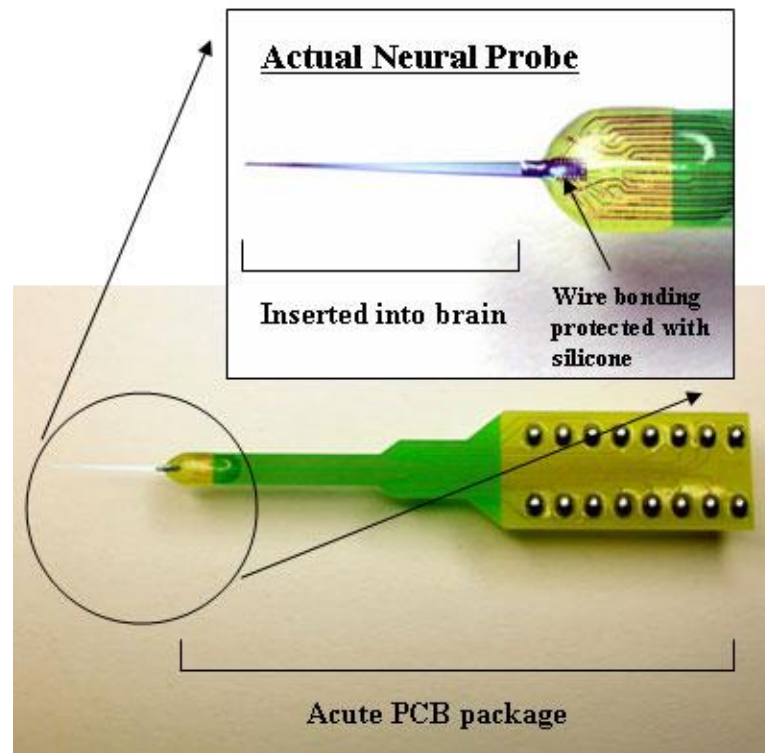
Insect brain



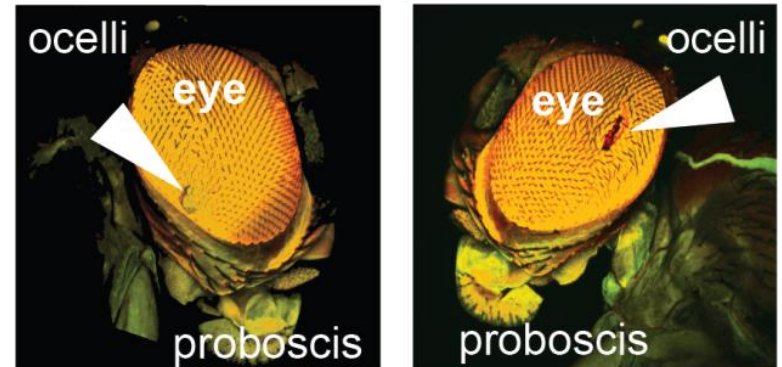
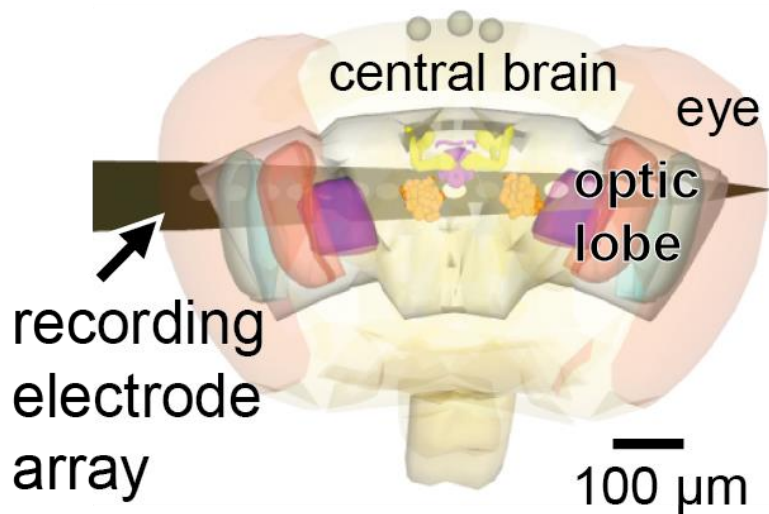
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How can we record from the fly brain?



How do we determine recording locations?



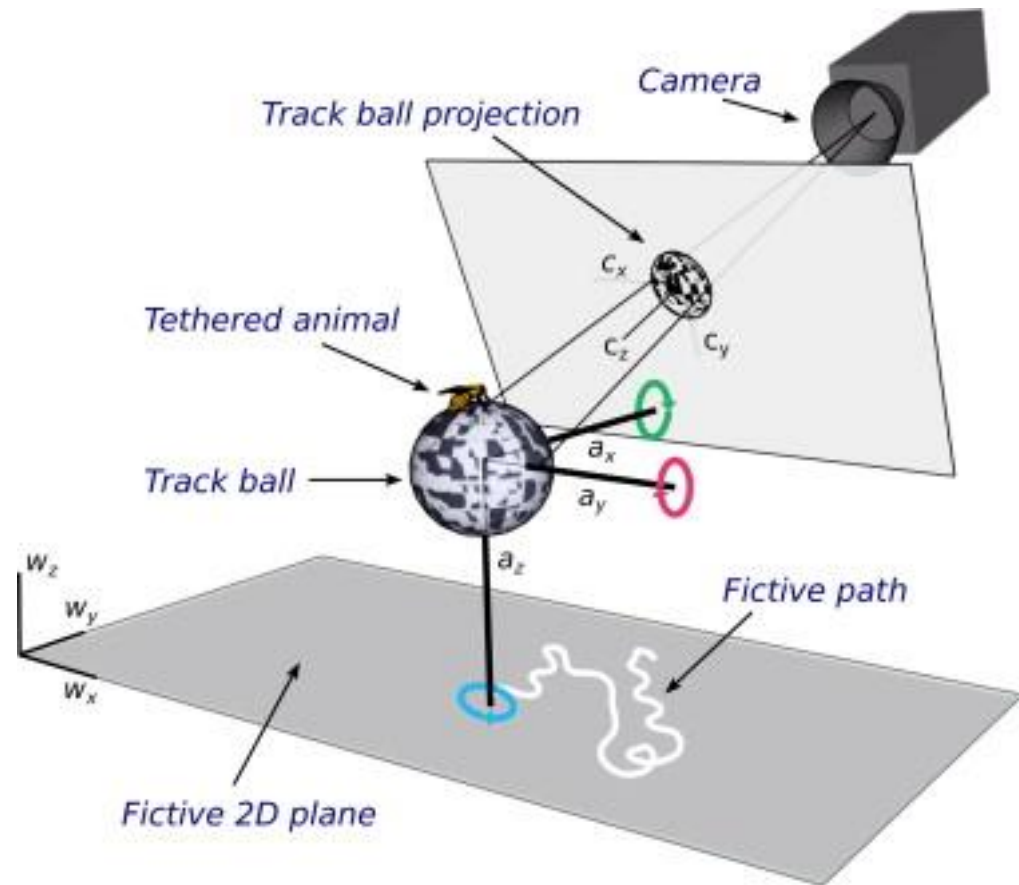
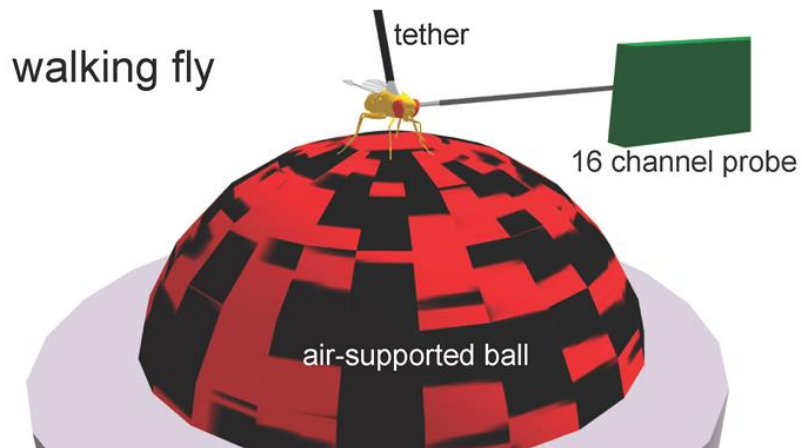
How can we get flies to report attention-like states while recording from their brain?



How can we get flies to report attention-like states while recording from their brain?

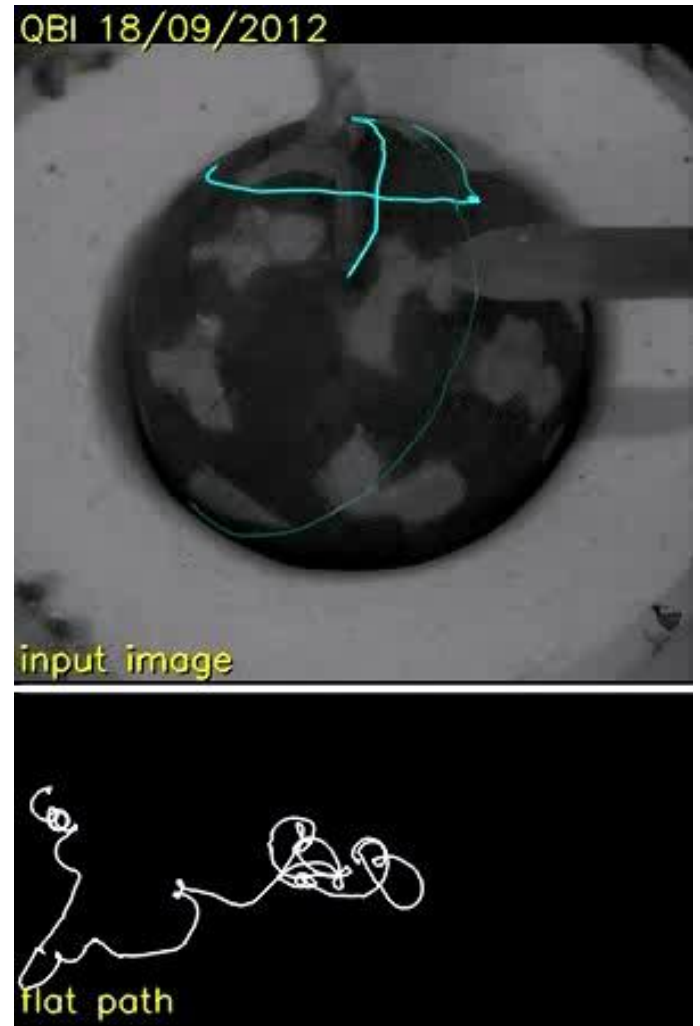
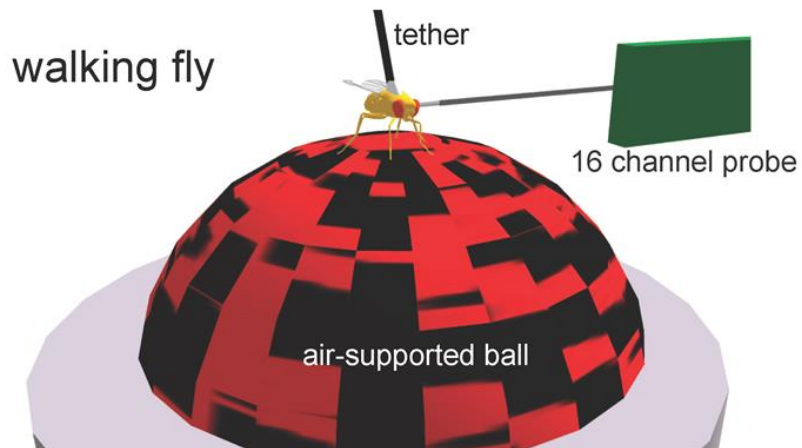


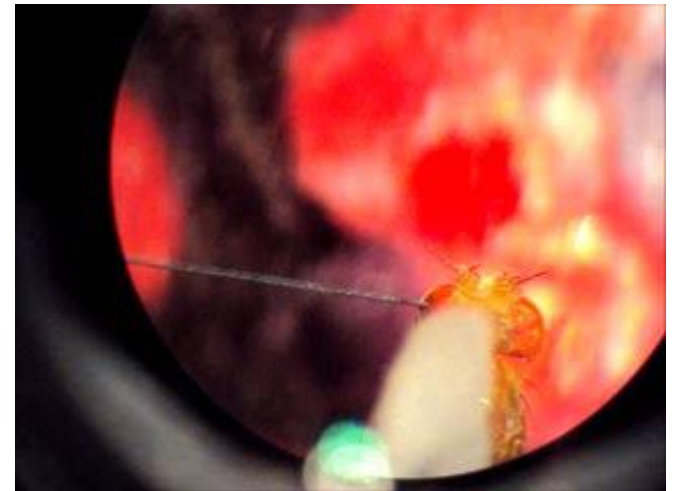
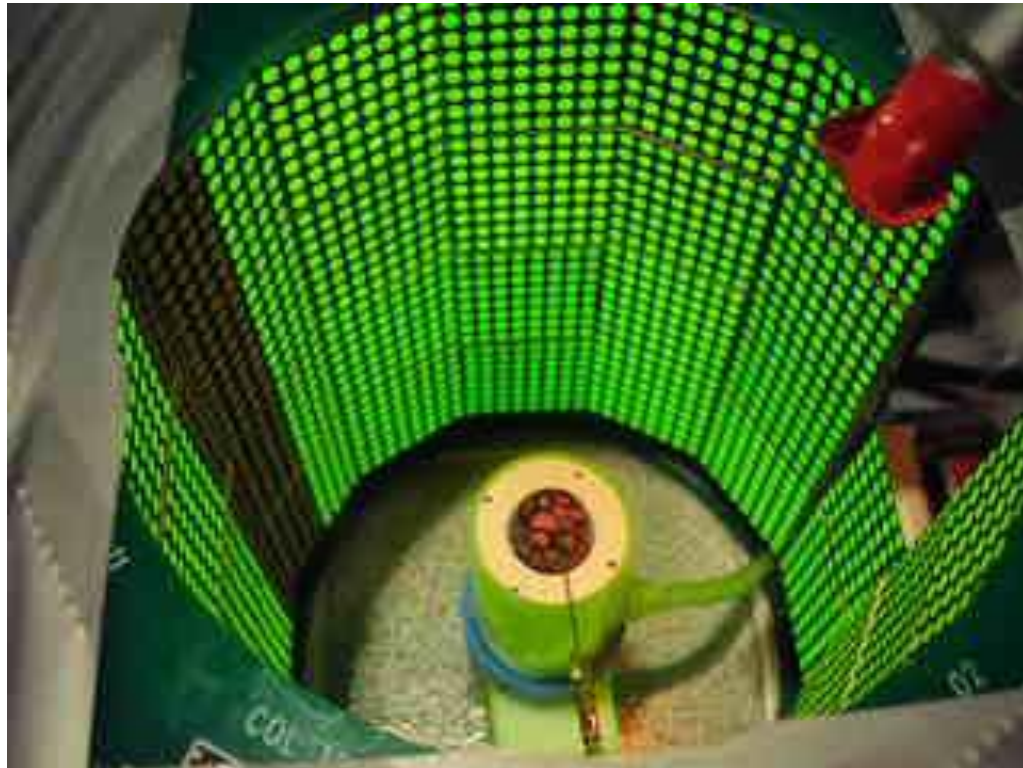
Direction of gaze

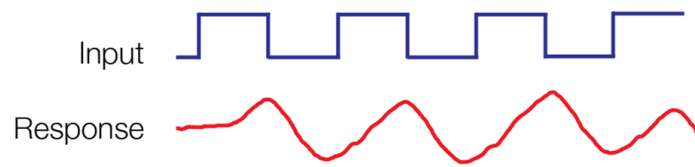




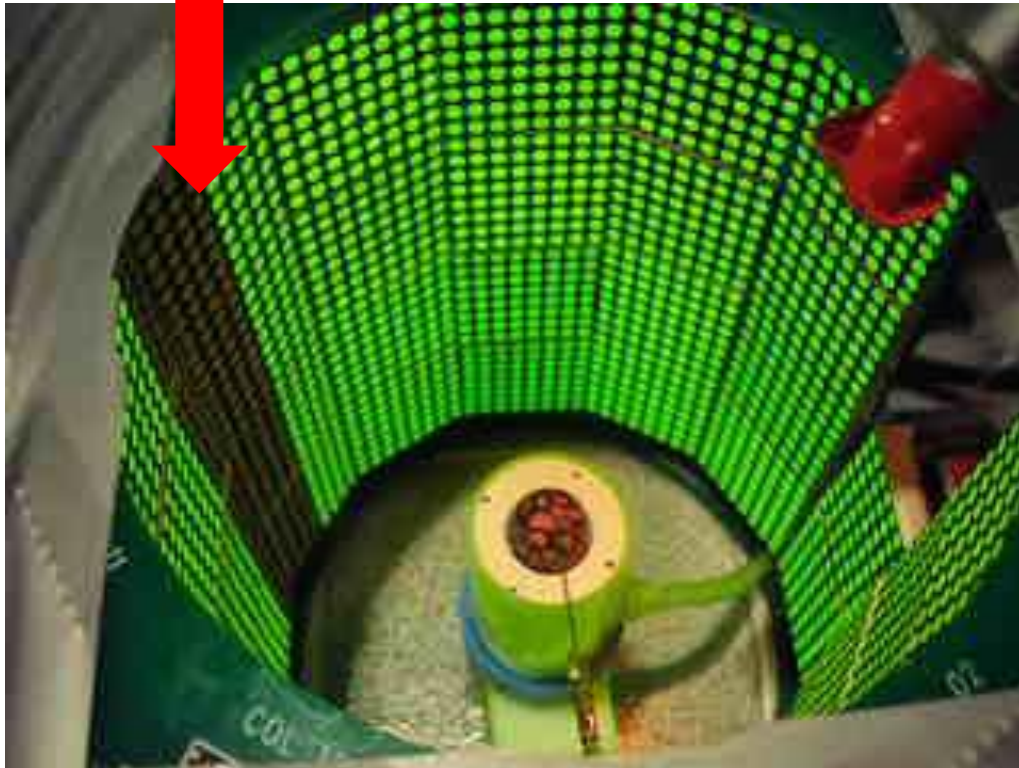
Direction of gaze



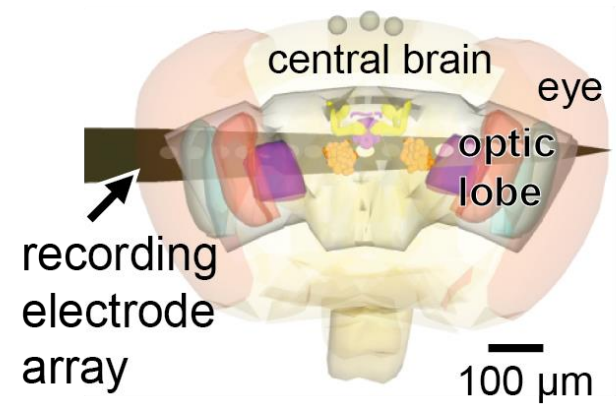
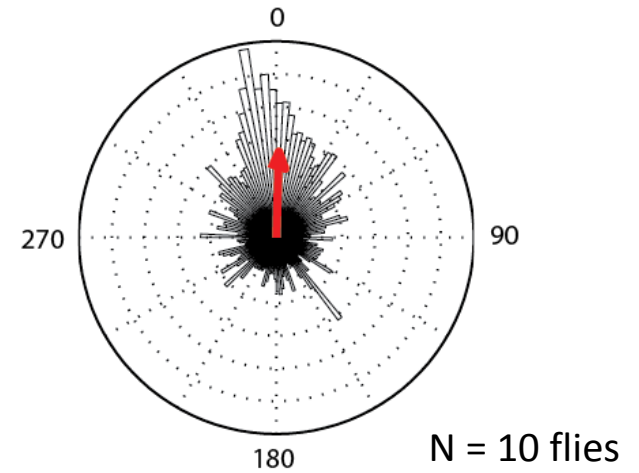




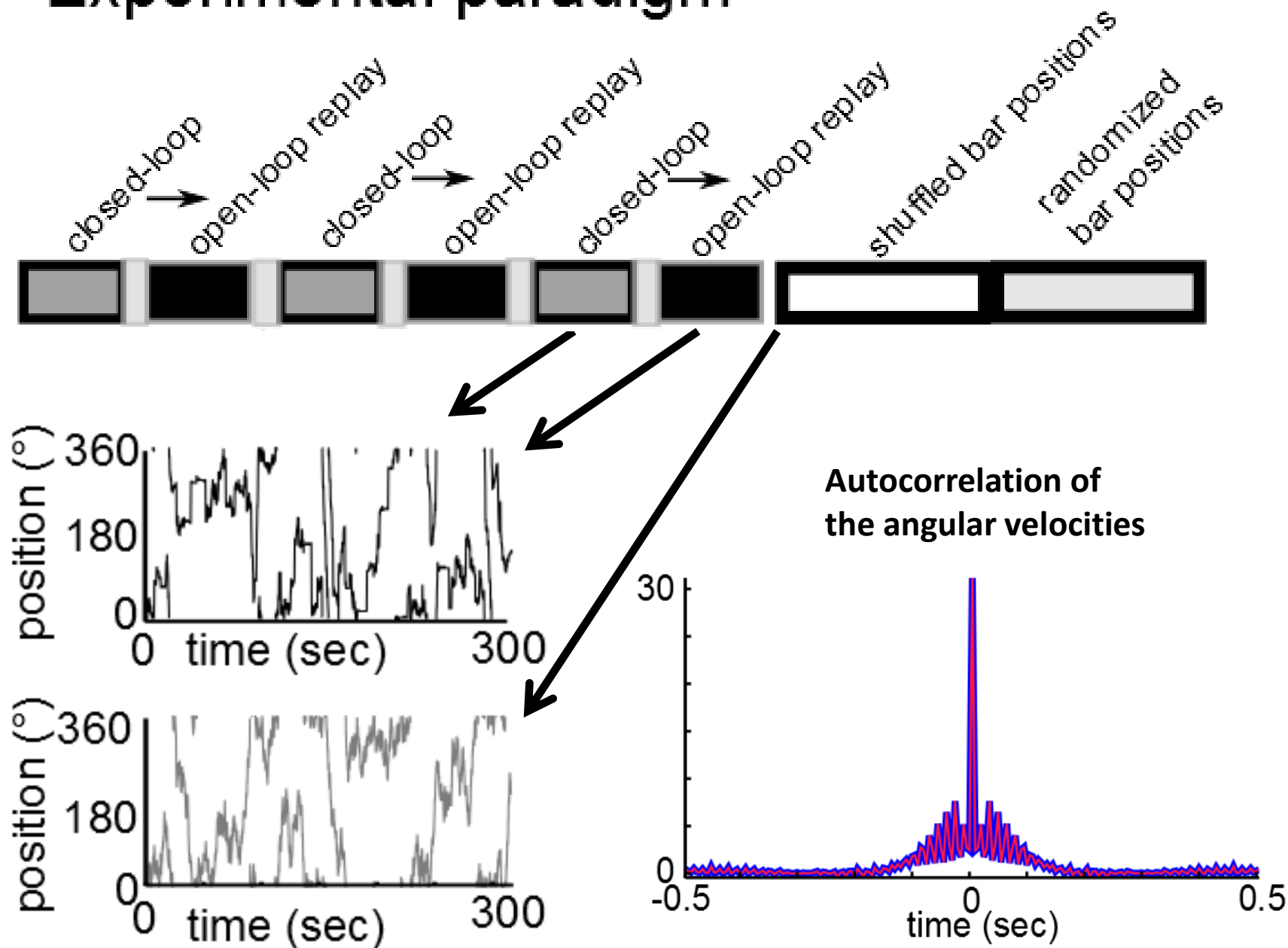
7 Hz

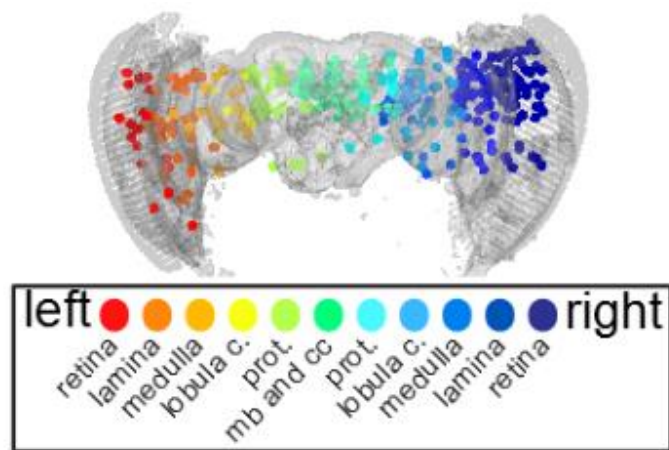


Front of fly

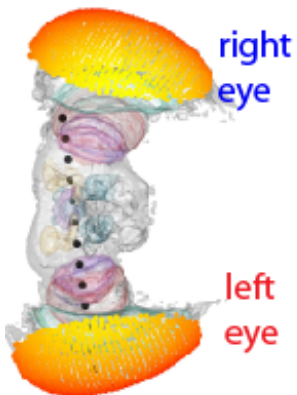
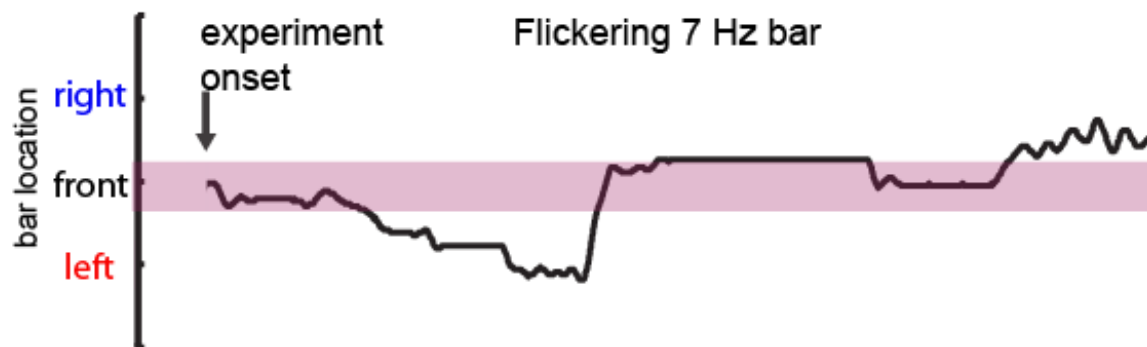
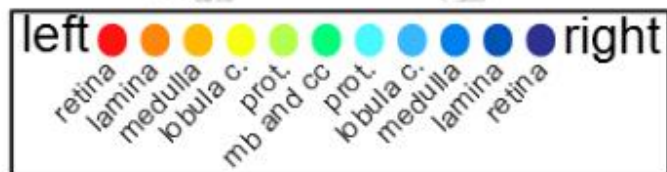
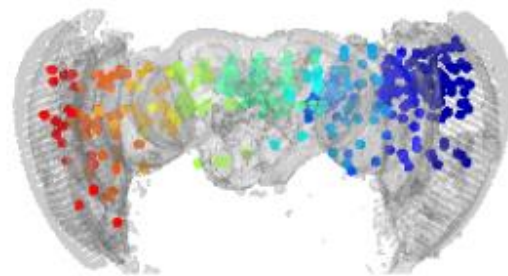


Experimental paradigm



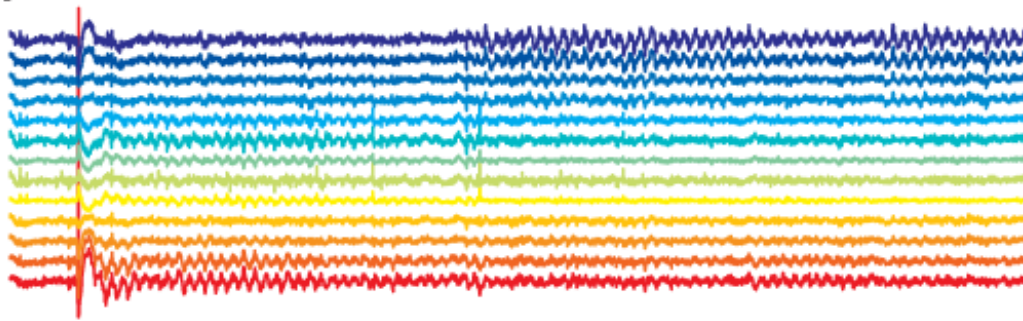


How are different brain regions responding during fixation?



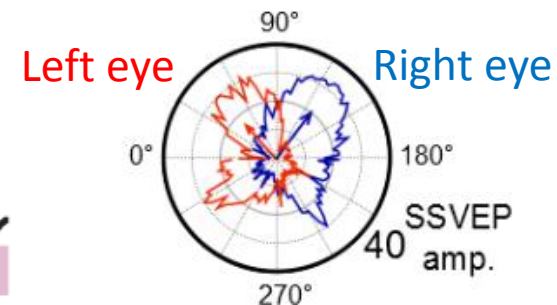
right eye

left eye

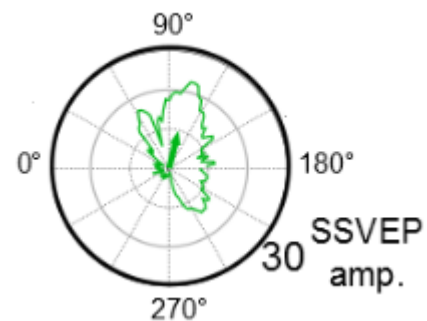


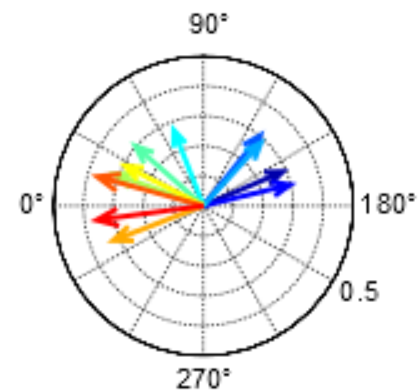
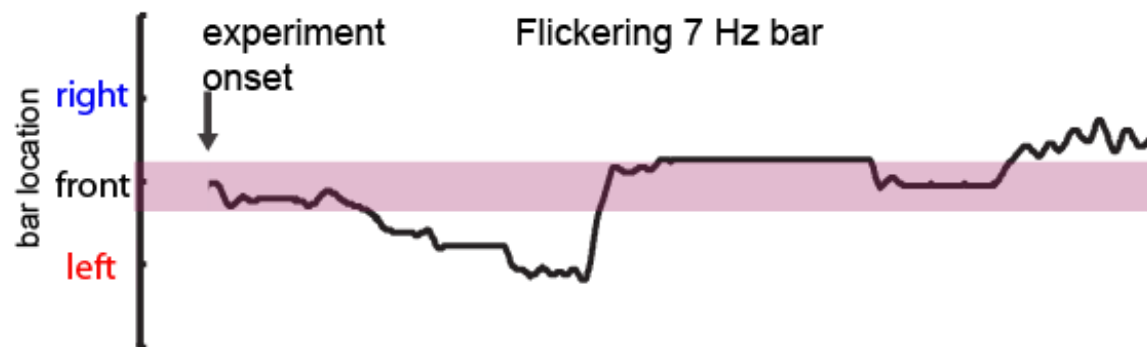
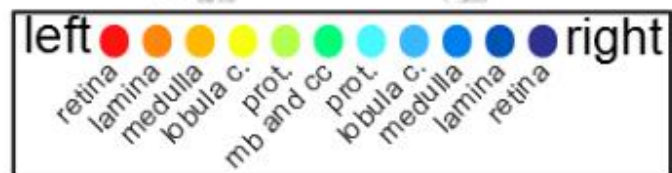
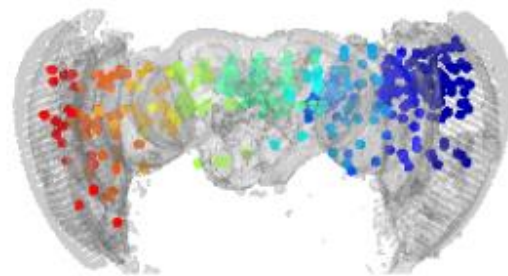
600 μ V

2 sec

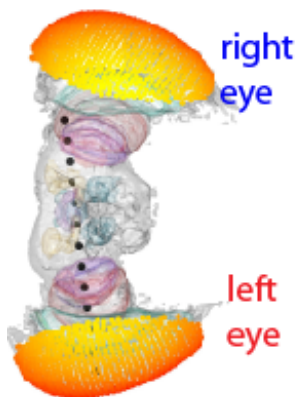


Central brain

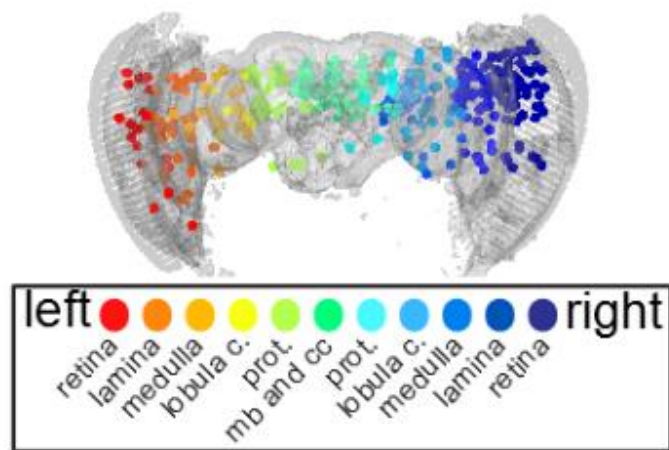




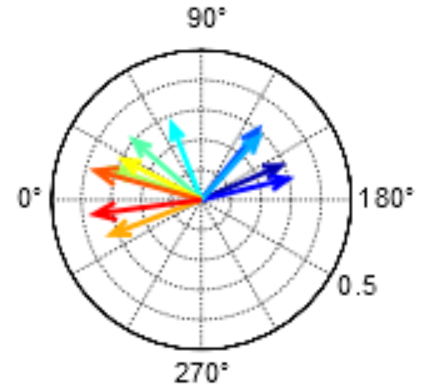
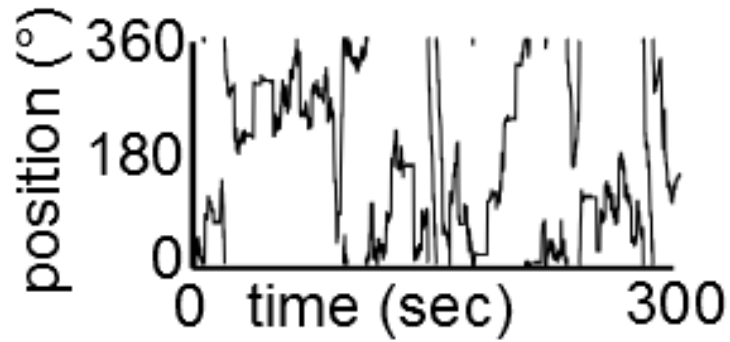
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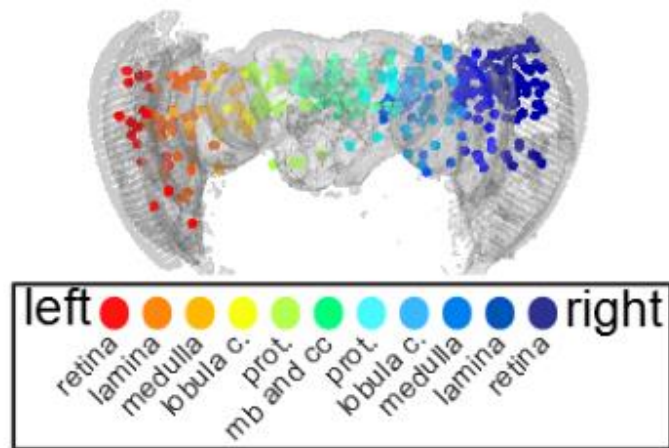


600 μ V 2 sec

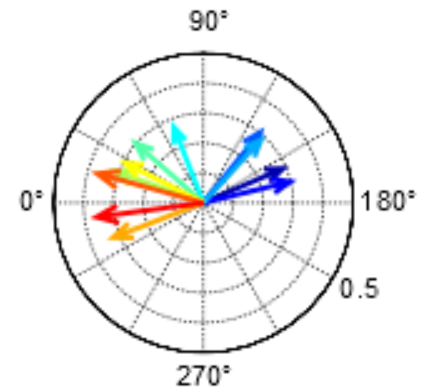
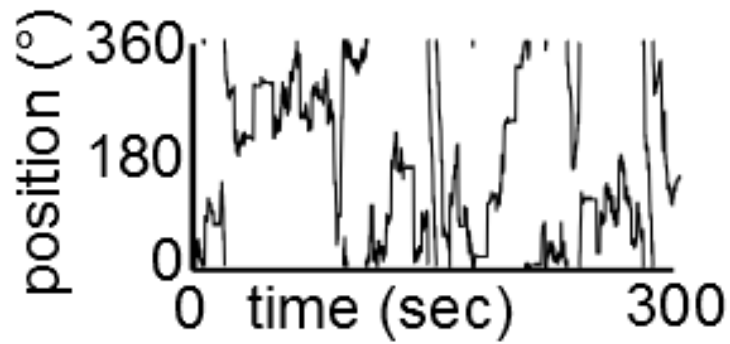


Closed-loop

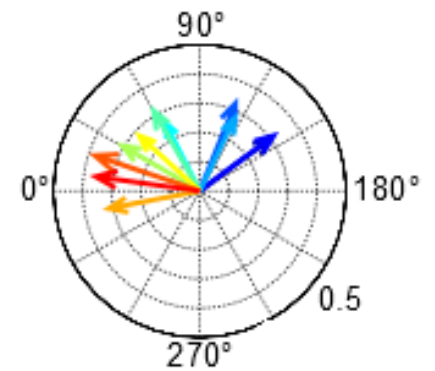
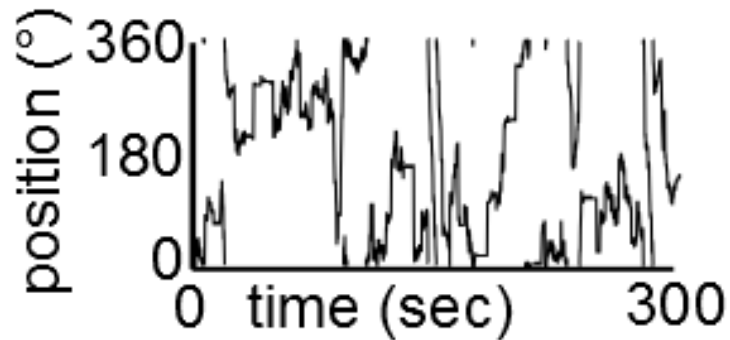


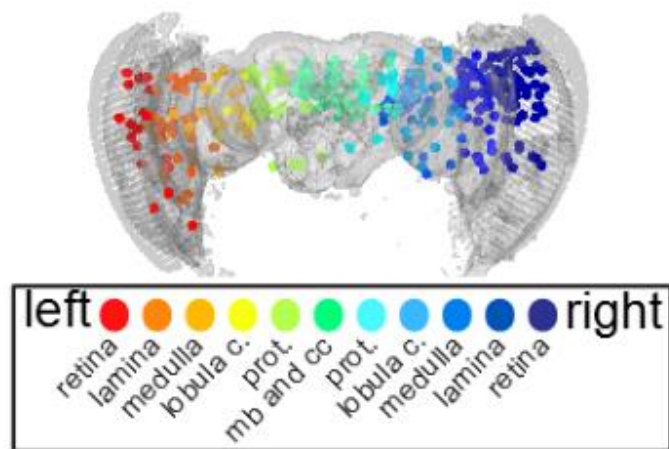


Closed-loop

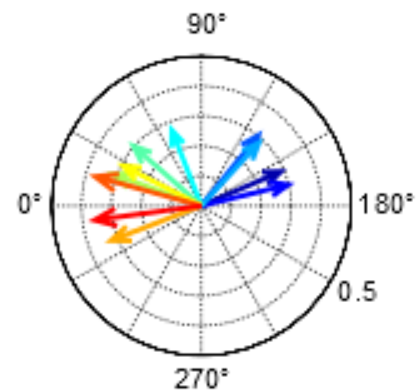
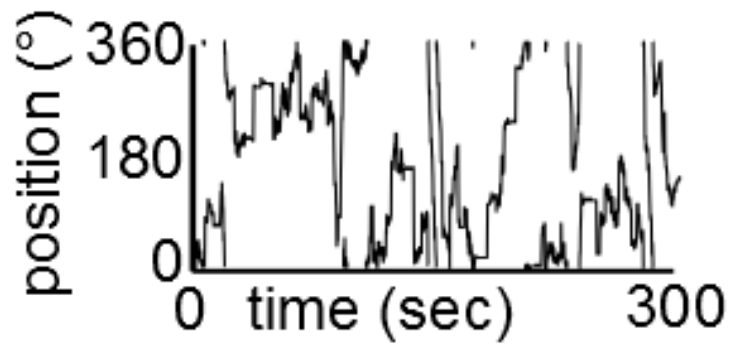


Replay?

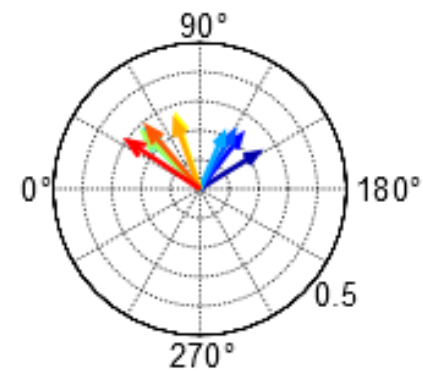
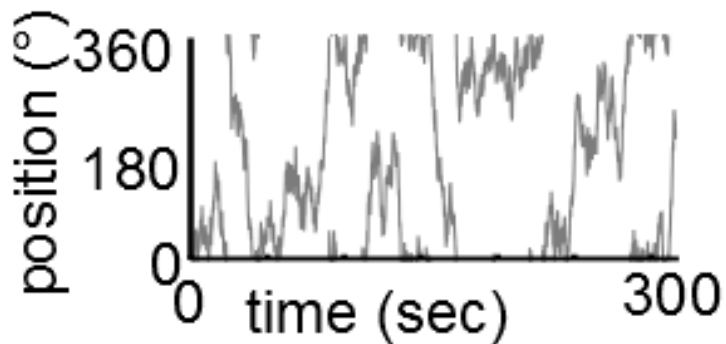


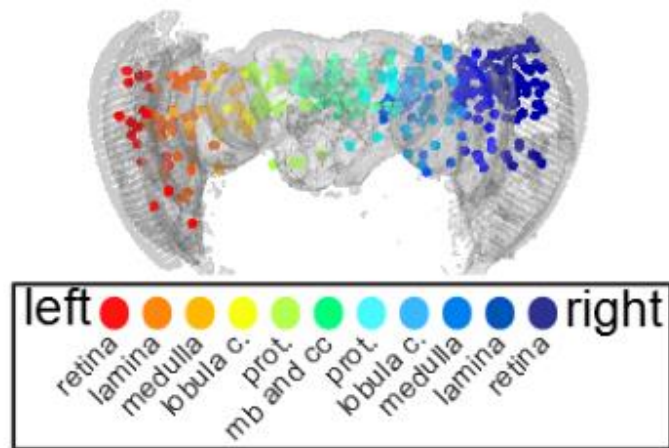


Closed-loop

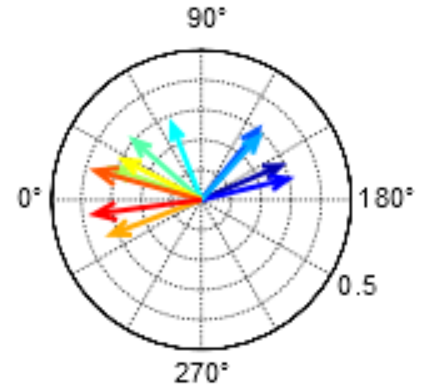
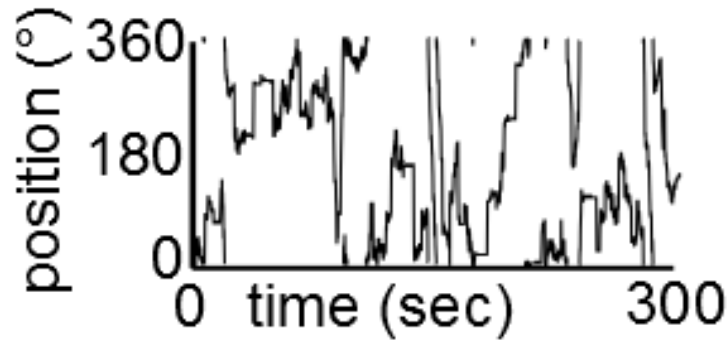


Shuffled?

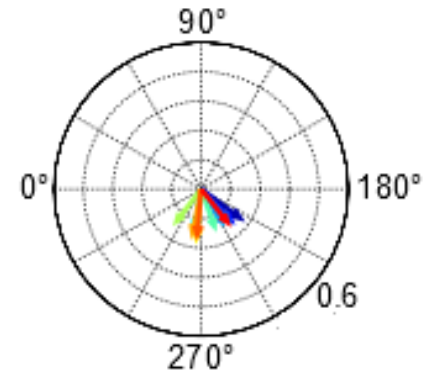
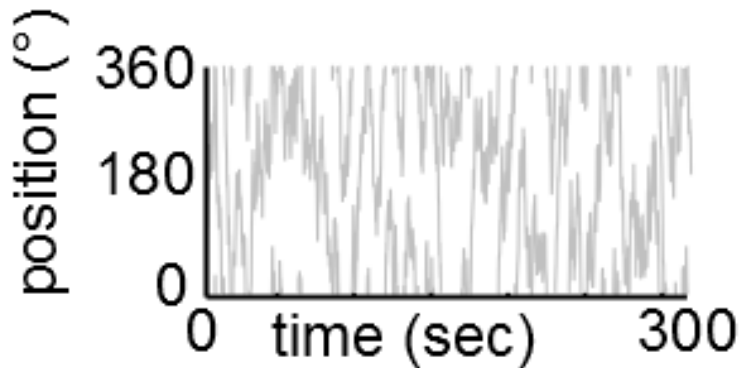


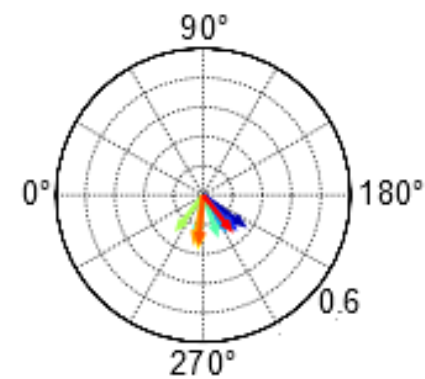
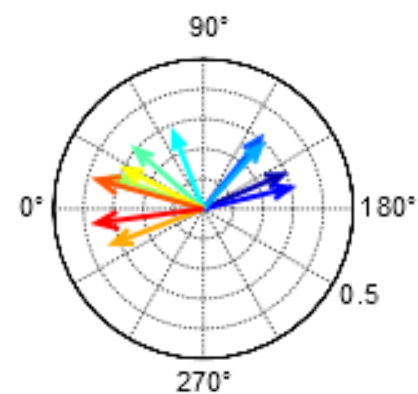
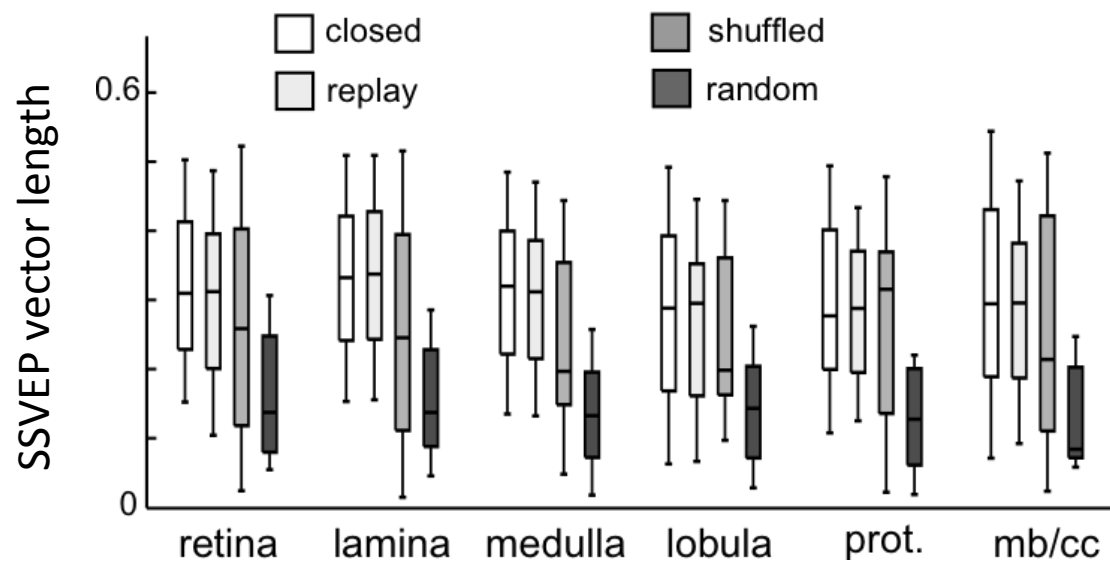
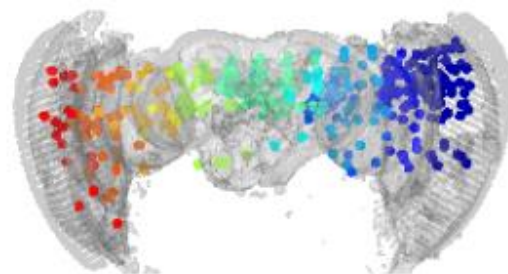


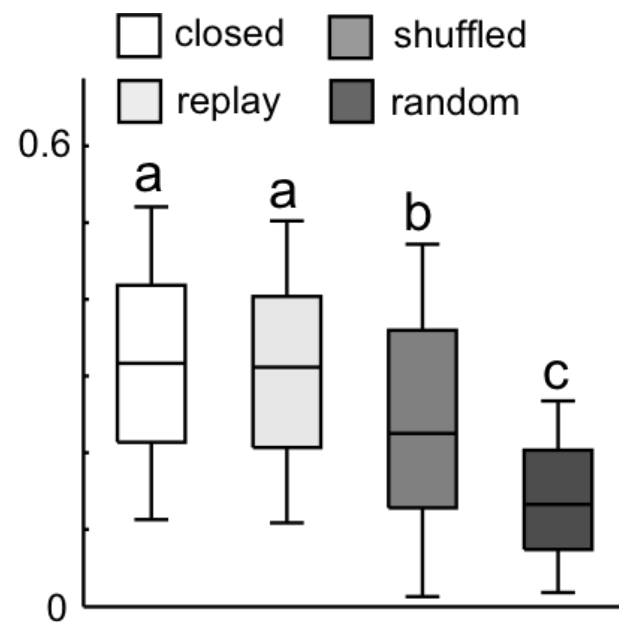
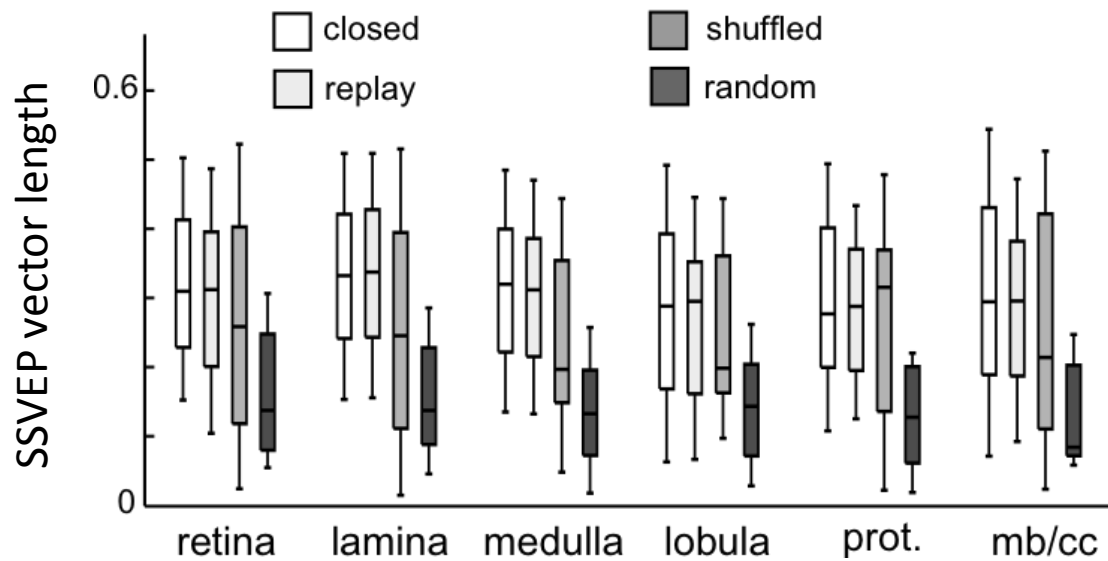
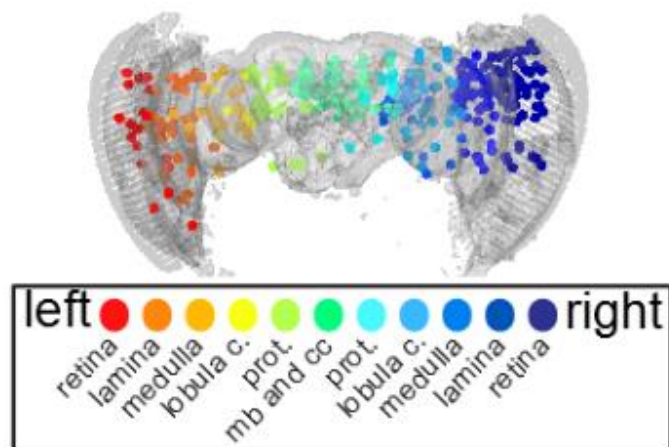
Closed-loop



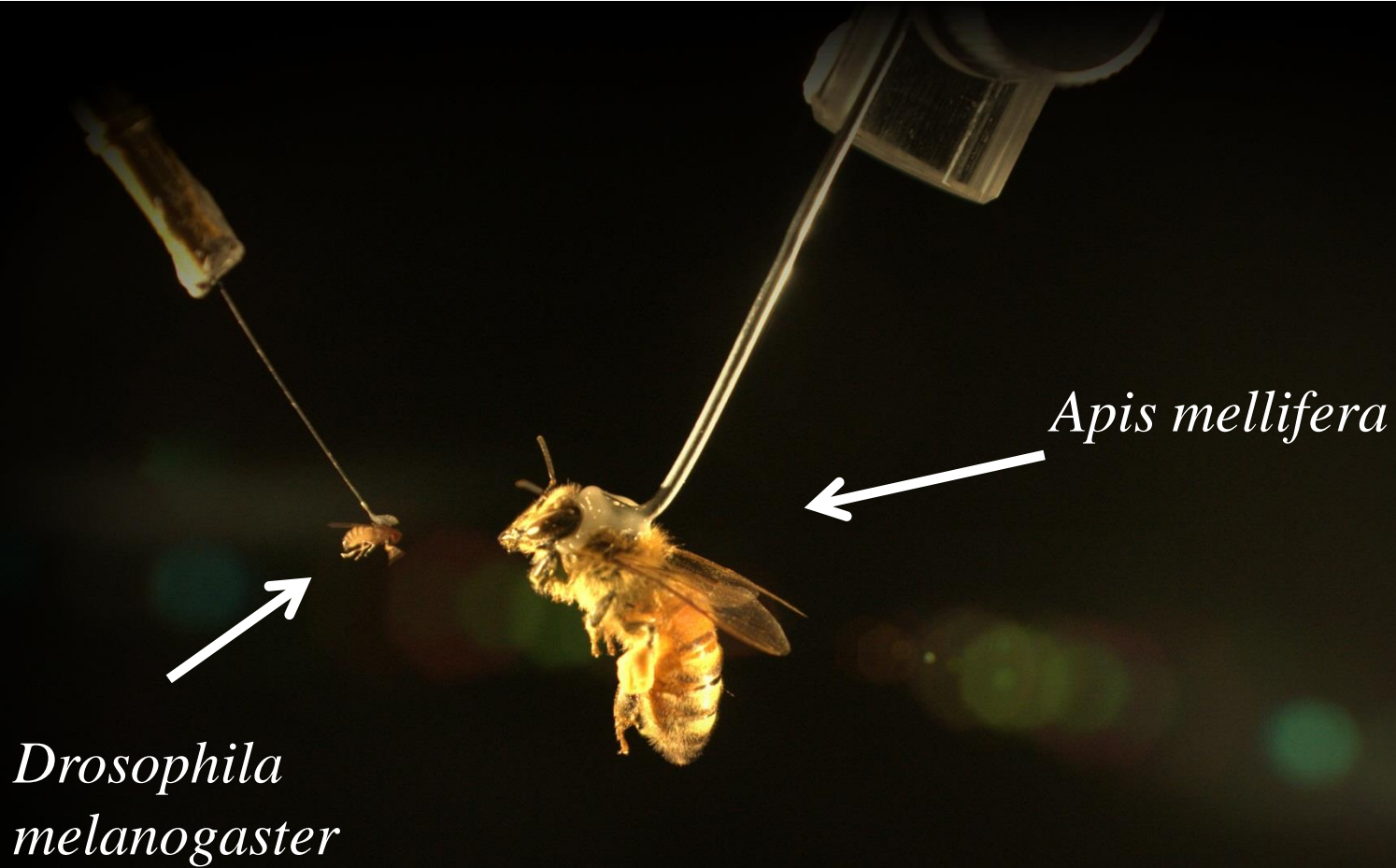
Random?



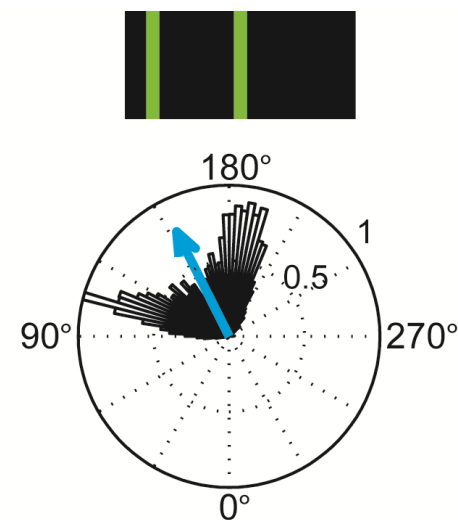
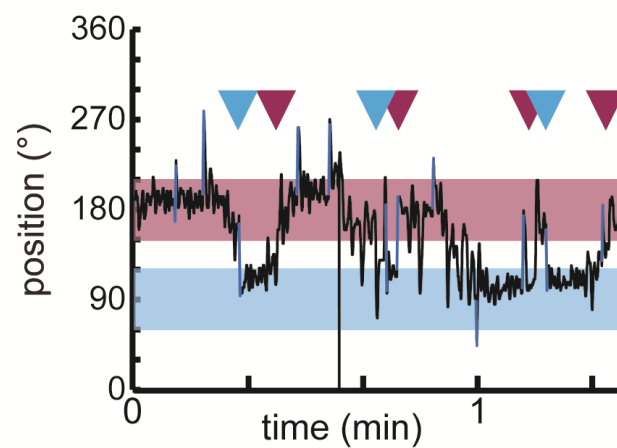
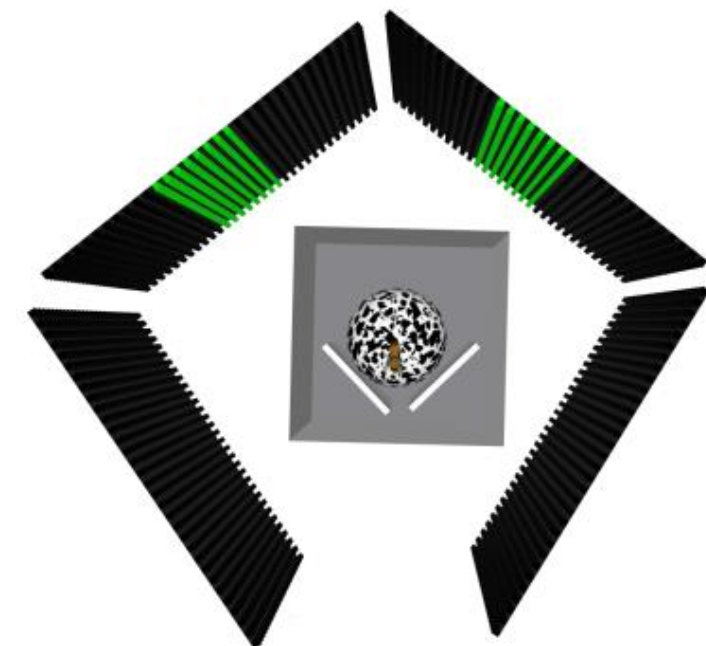
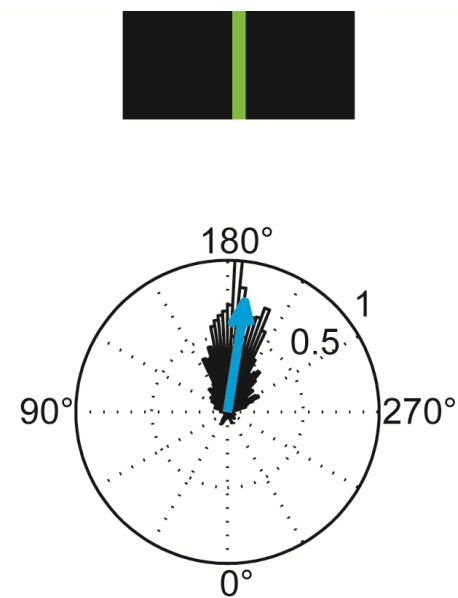
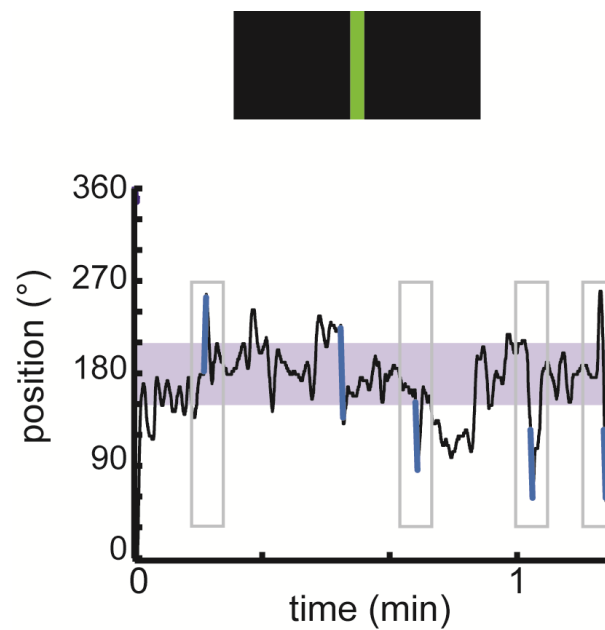




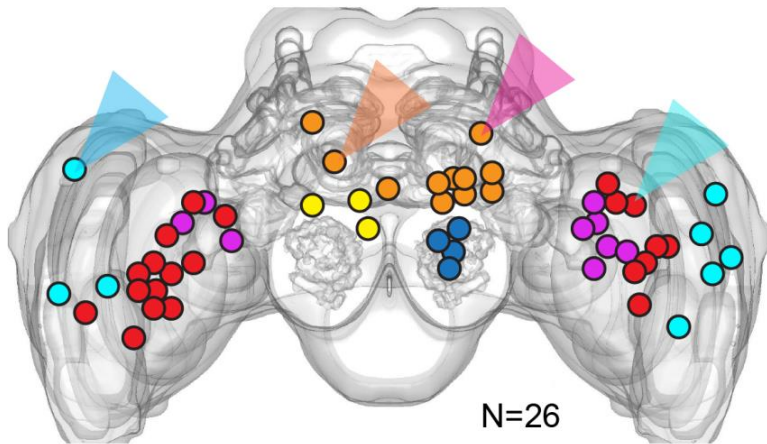
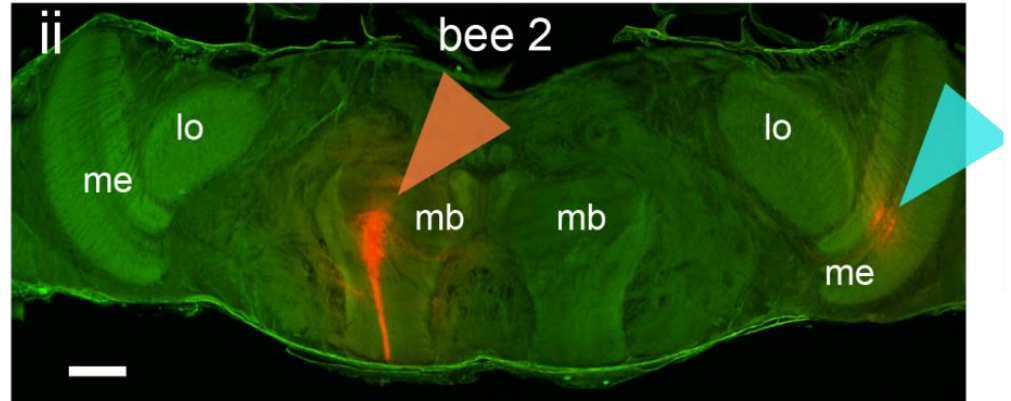
What about bees?



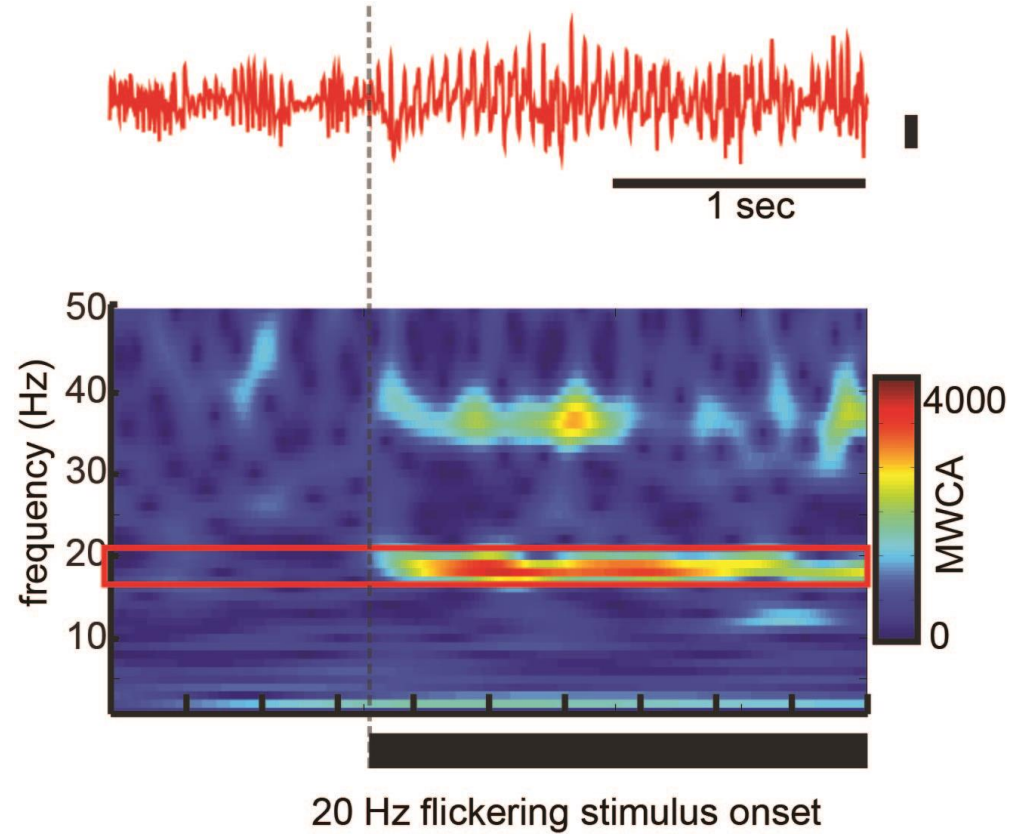
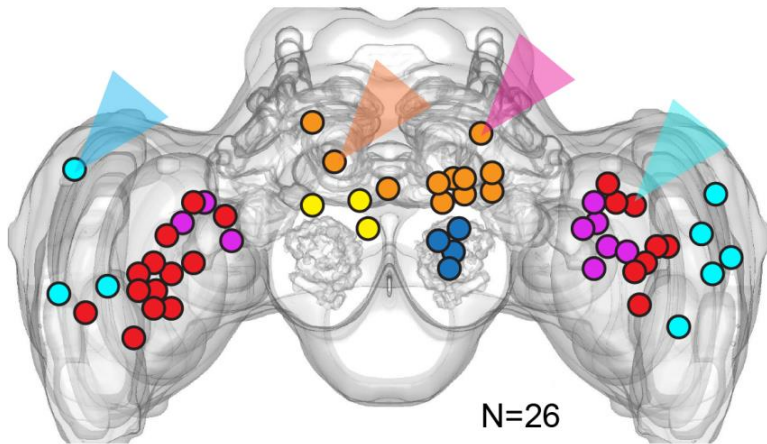


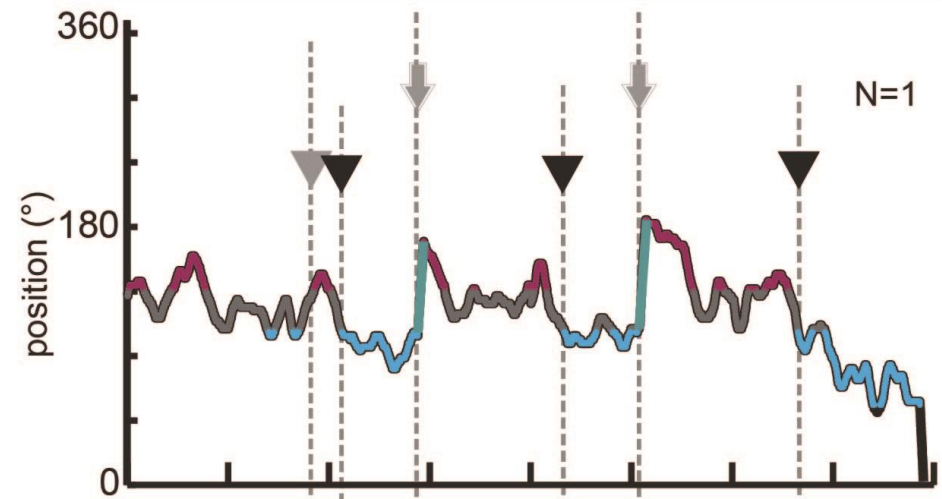
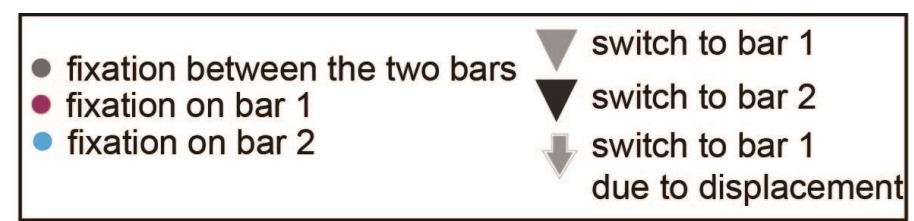
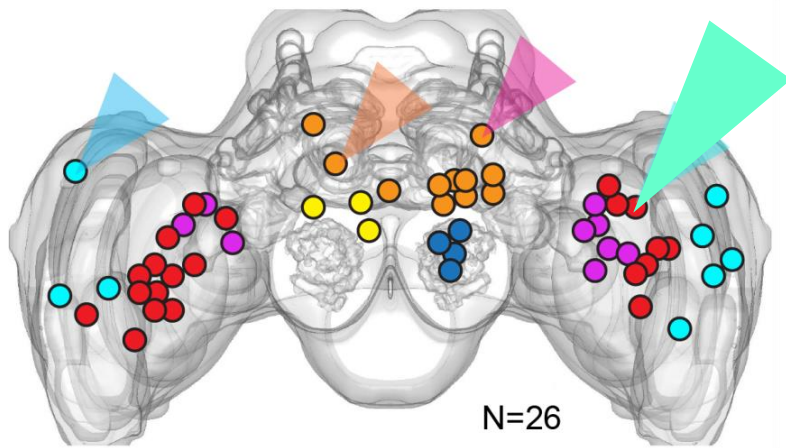
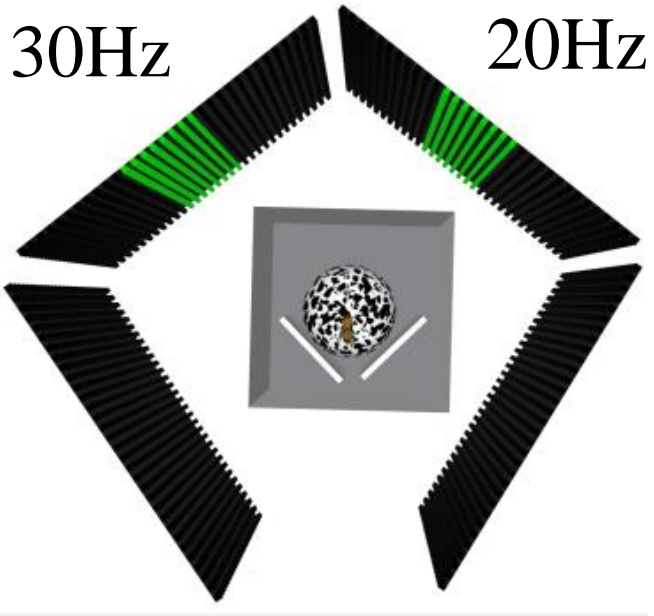


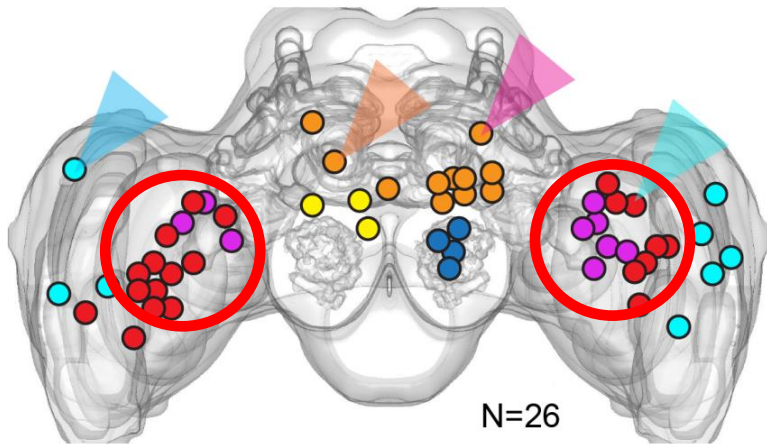
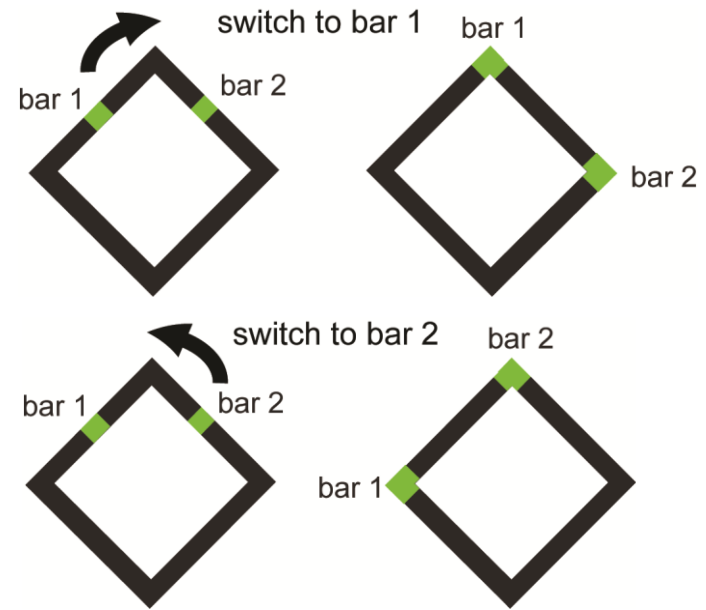
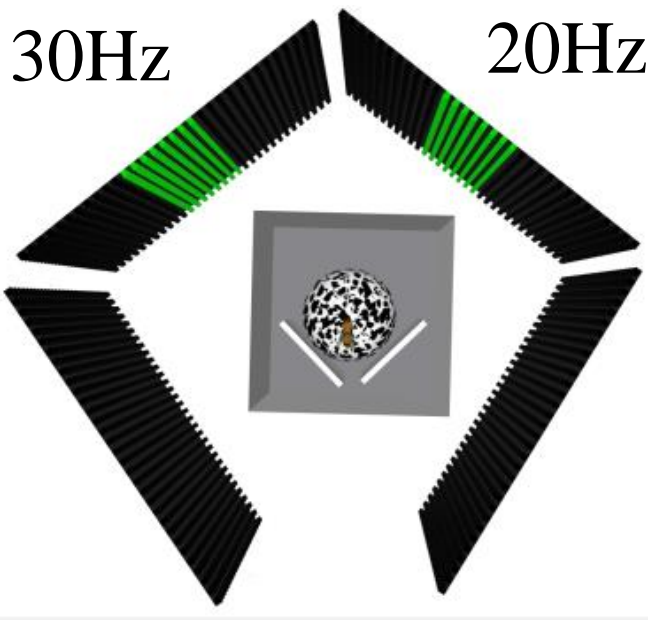
Brain recordings



SSVEPs again

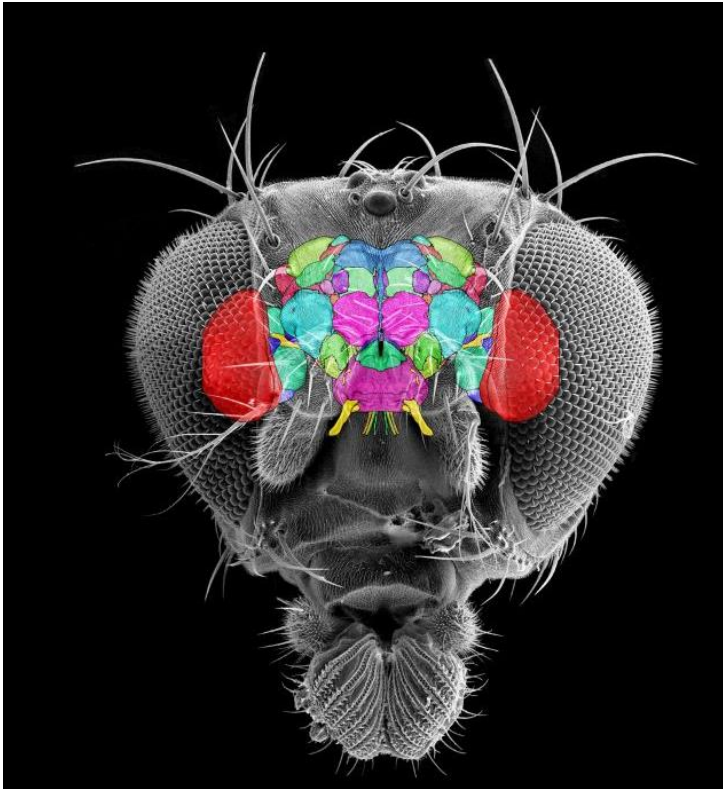






A switch to the front can be intentional or due to a random displacement

Summary and questions



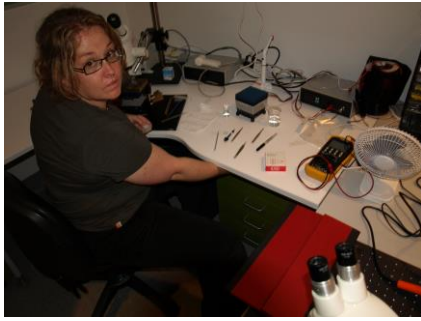
SSVEPs are modulated by attention-like behaviour in insects

Selective attention is already evident in the insect optic lobes

Evidence of top-down process?

Shuffled visual stimuli evoke weaker SSVEPs than replay

SSVEPs predict which object insects will fixate



Angelique Paulk



Jacqui Stacey



Yanqiong Zhou



Thomas Pearson



Leonie Kirszenblat



Mandyam Srinivasan



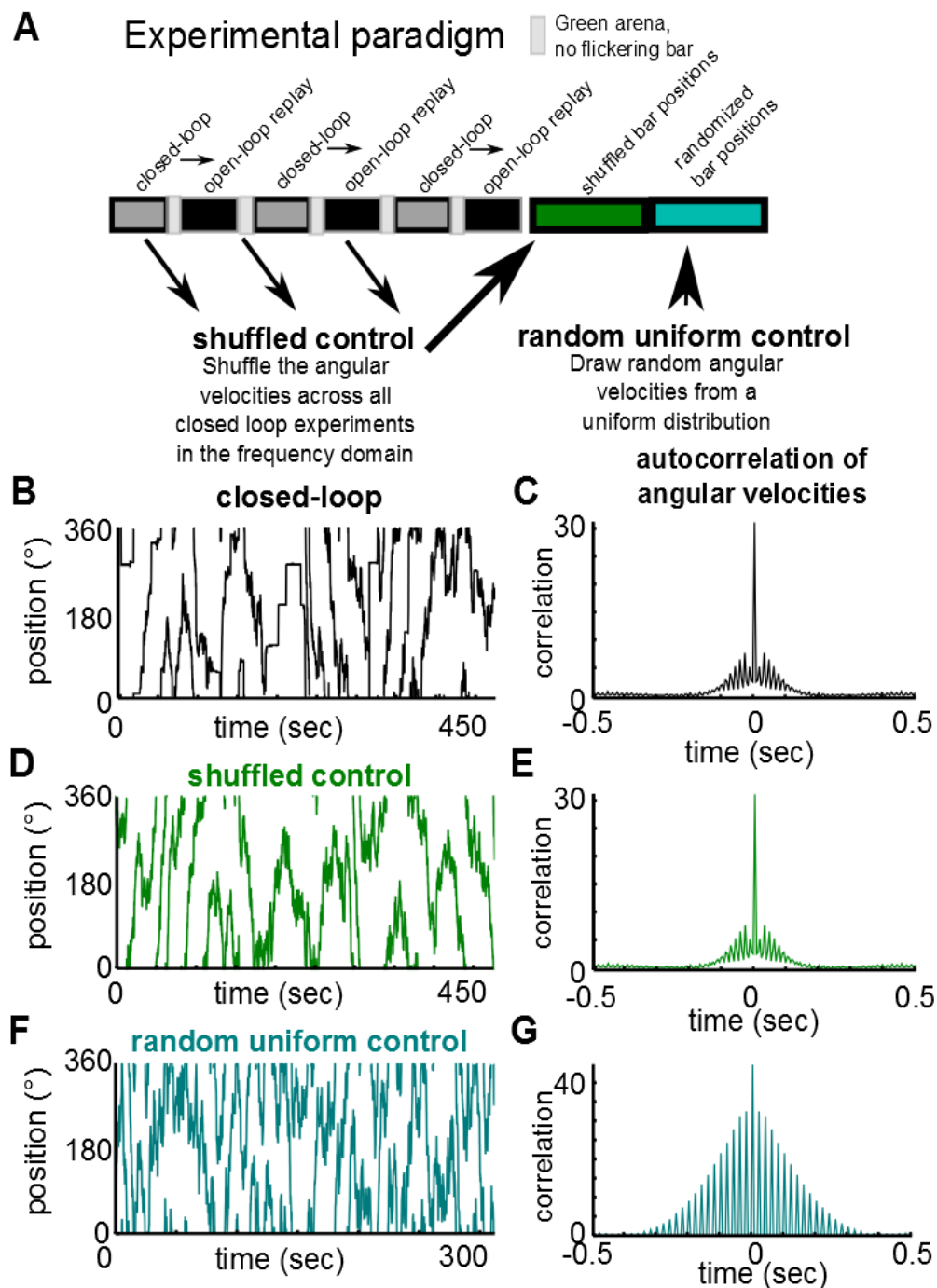
Richard Moore

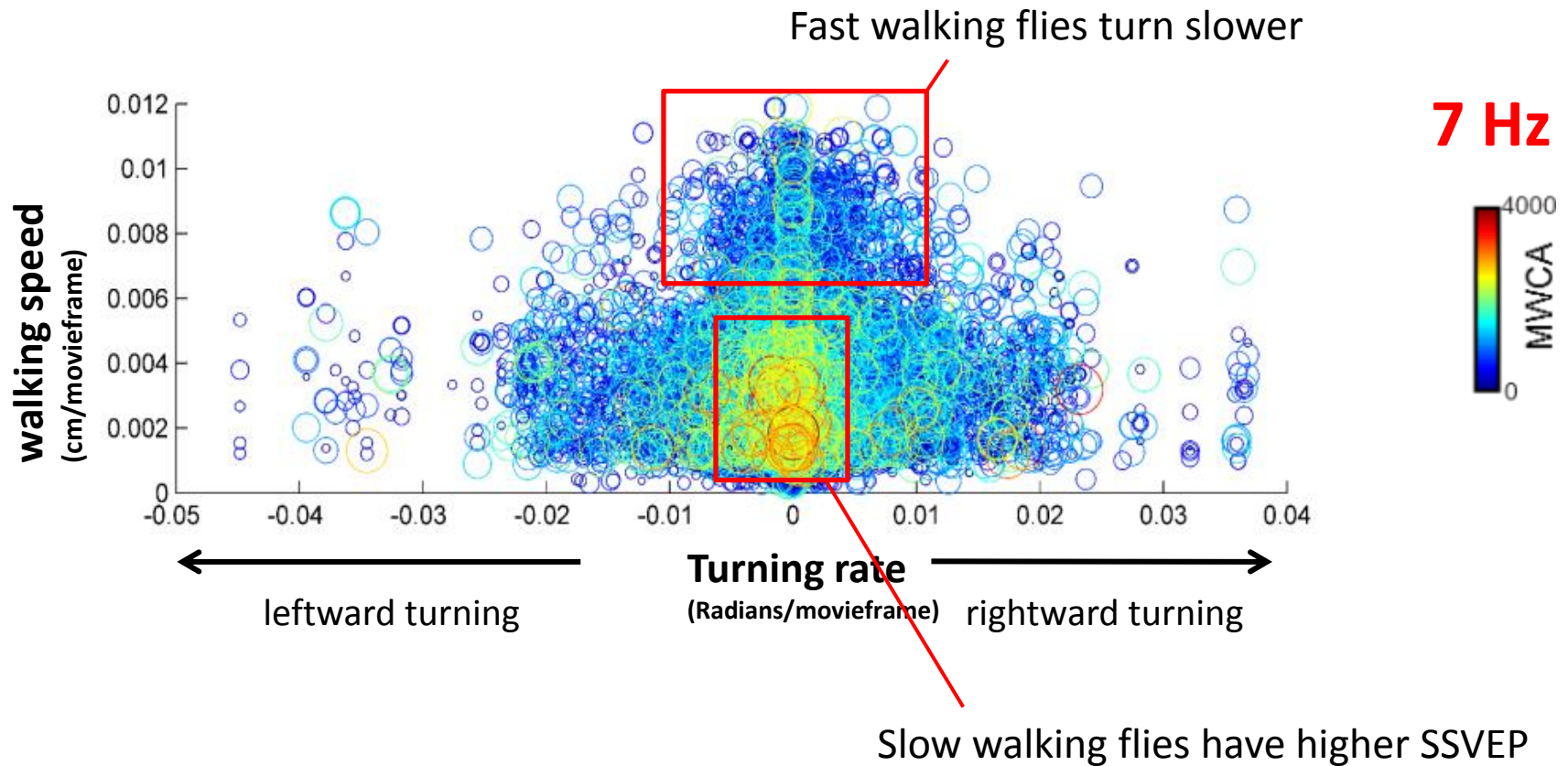
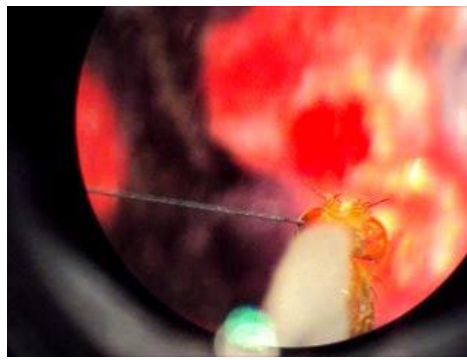


Gavin Taylor

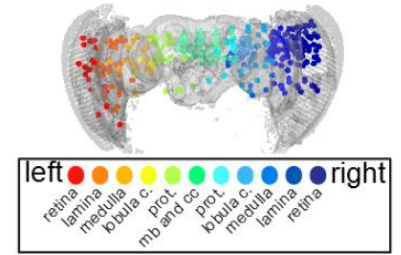
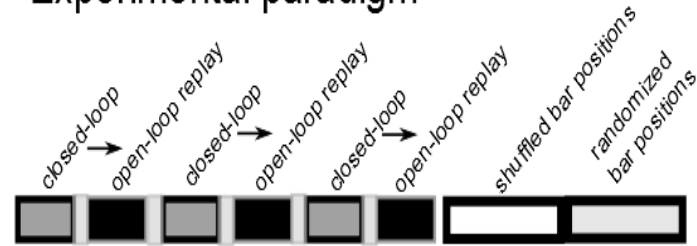


Australian Government
Australian Research Council

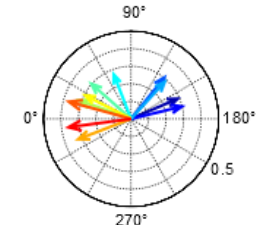
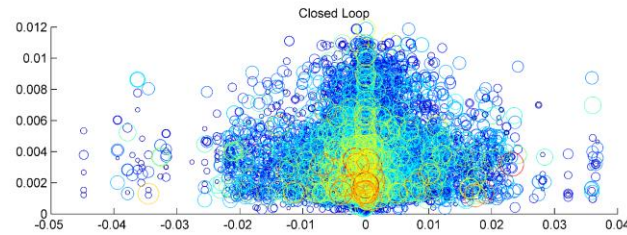




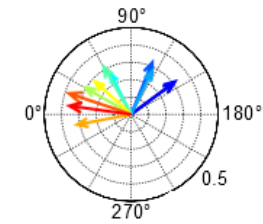
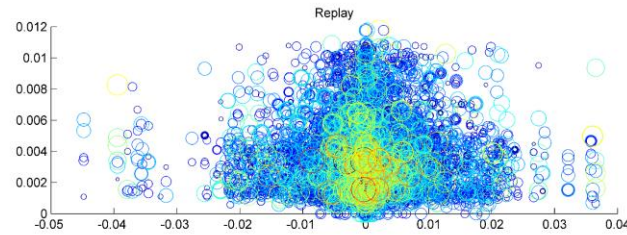
Experimental paradigm



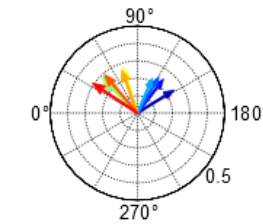
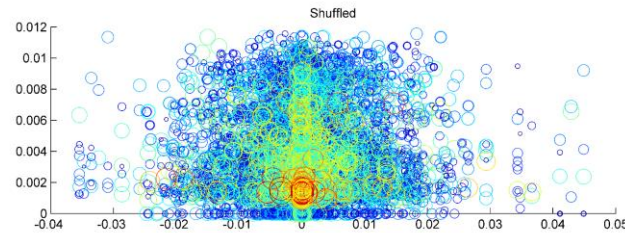
Closed-loop



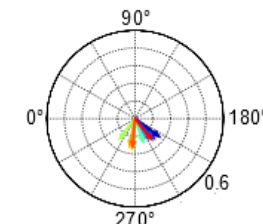
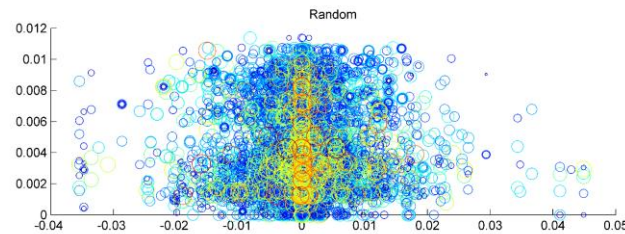
Replay



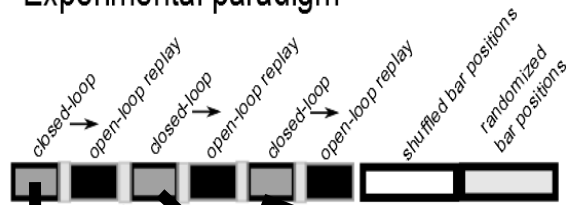
Shuffled



Random



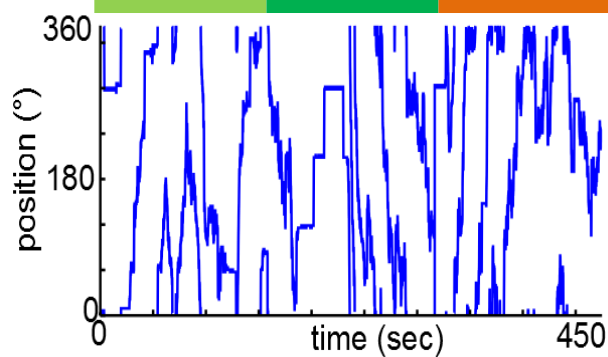
Experimental paradigm



Exp. 1

Exp. 2

Exp. 3



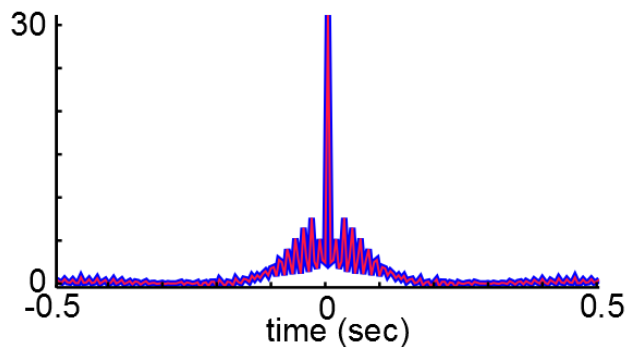
Unwrap and
differentiate

Angular velocities

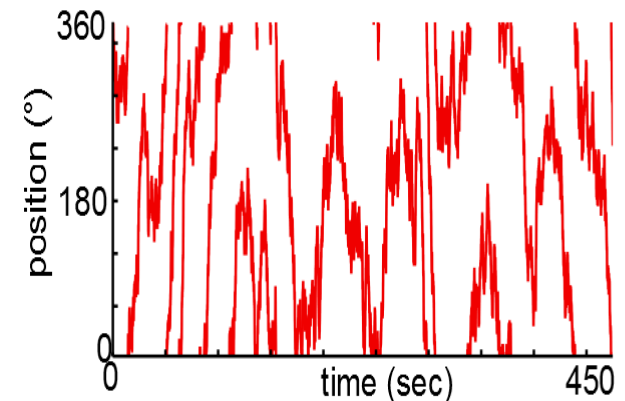
Fourier transform

1. Separate the amplitude and phase components
2. Randomize the order of the phase components
3. Combine the amplitude and phase components and perform an inverse Fourier transform to get a sequence of angular velocities

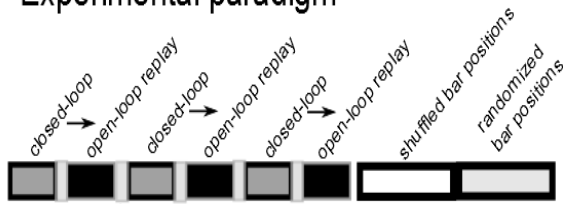
Autocorrelation of the angular velocities



Assemble the
shuffled data
sequentially from
the scrambled
angular velocities



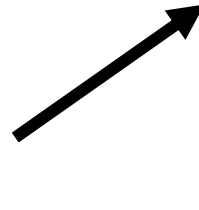
Experimental paradigm



Uniform distribution of angular changes from -180° to 180°



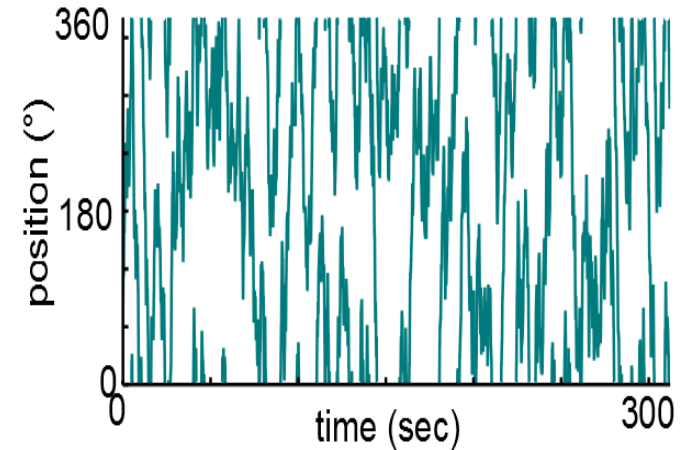
Shuffle the order at random



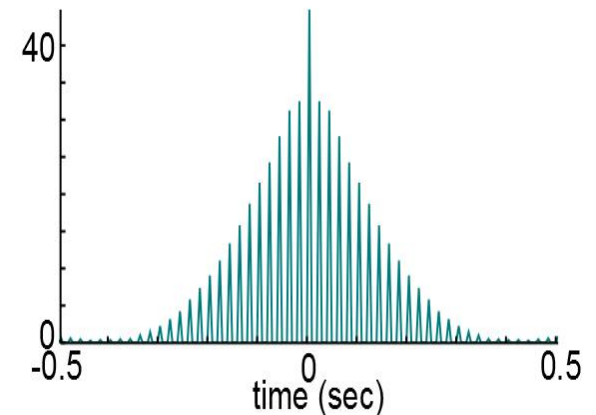
Reconstruct the shuffled angular velocities into bar positions

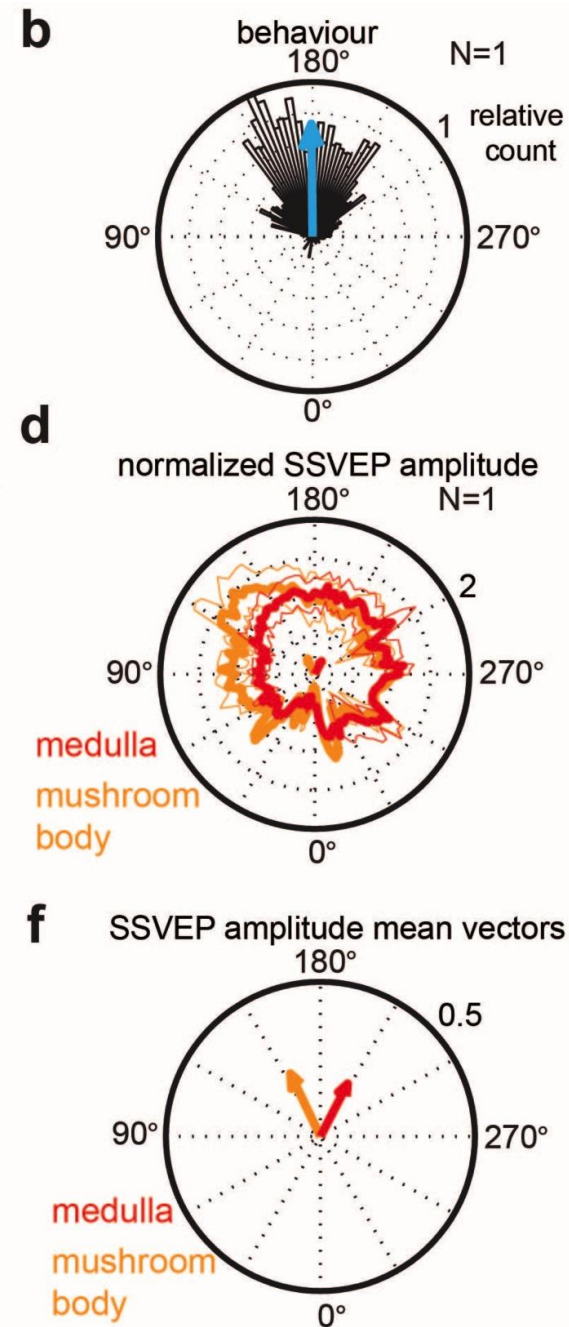
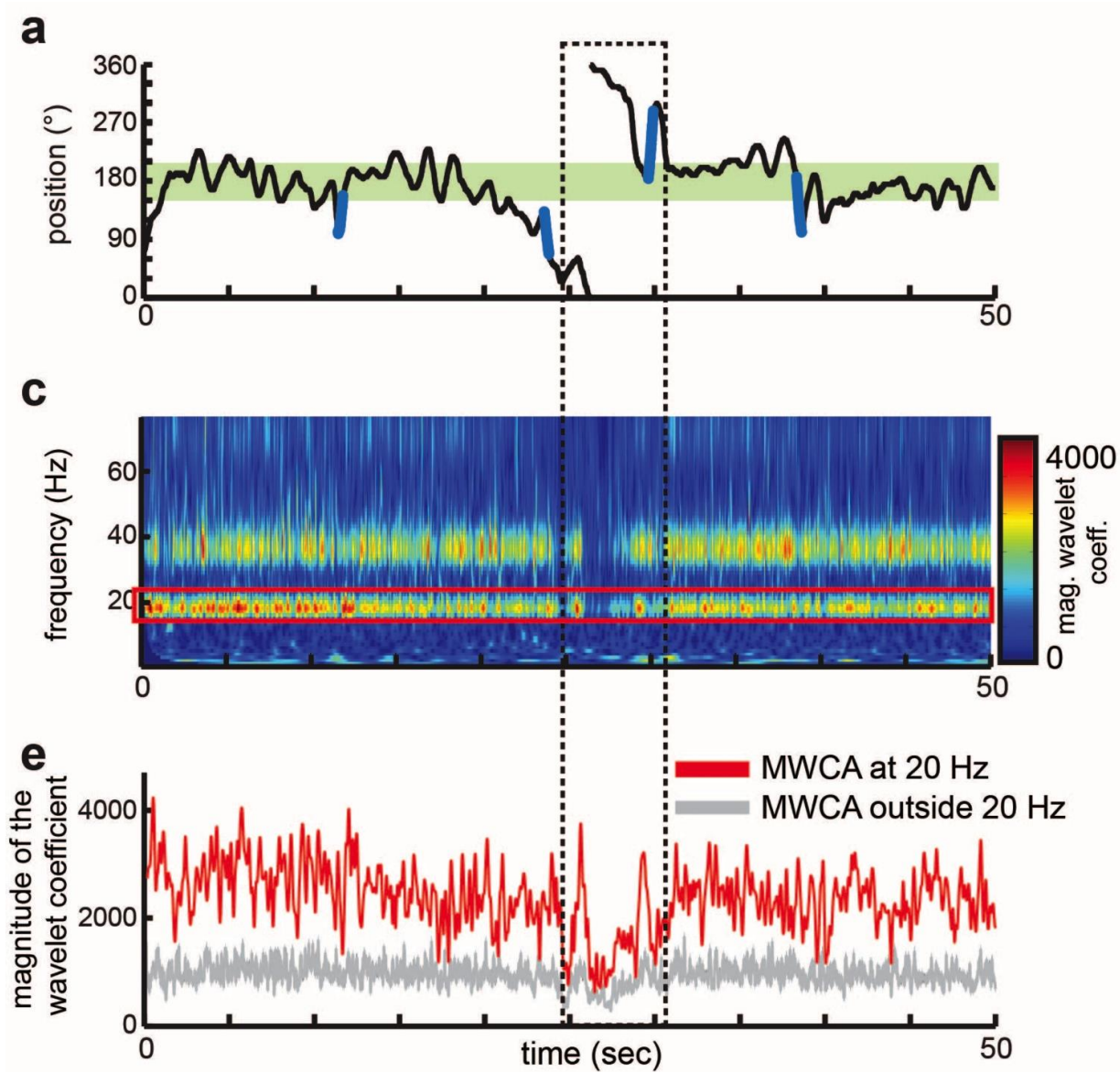
Adjusted to resemble the autocorrelation function of the angular velocities in behavioral data:

Random uniform control

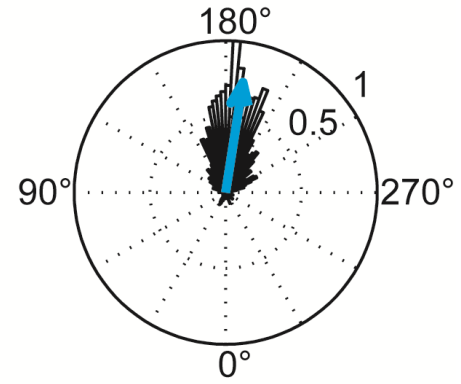
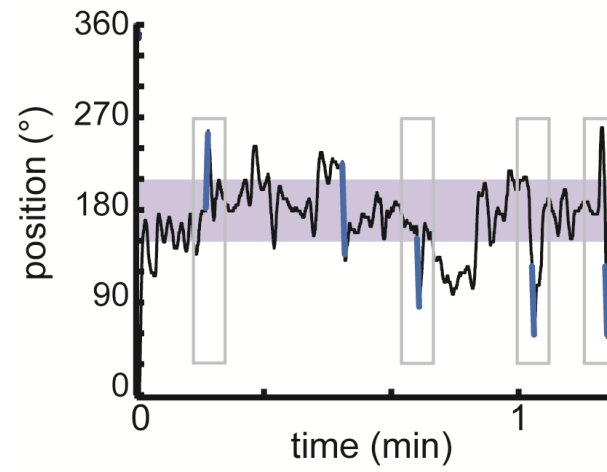


Autocorrelation of the angular velocities



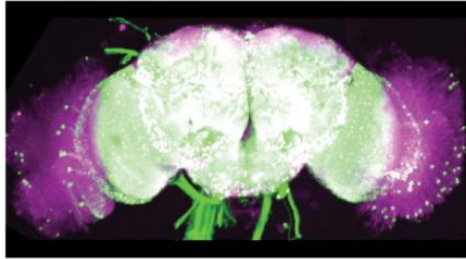


20Hz

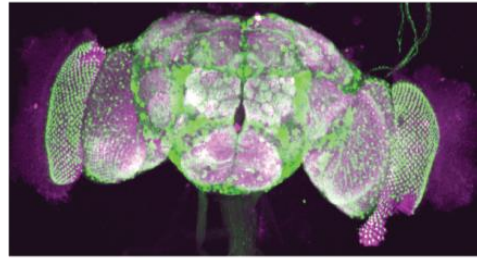


Why study *Drosophila*?

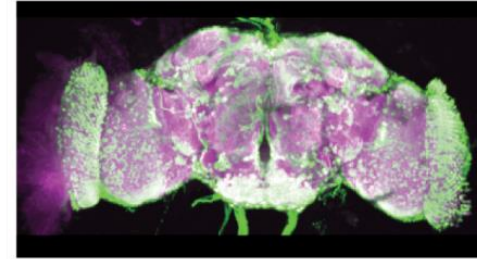
acetylcholine
(Cha-GAL4/UAS-GFP)



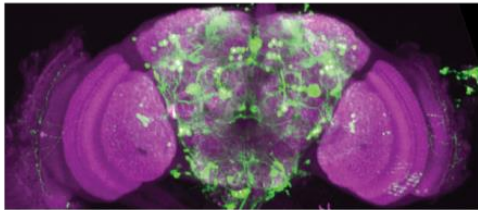
GABA
(GAD1-GAL4/UAS-GFP)



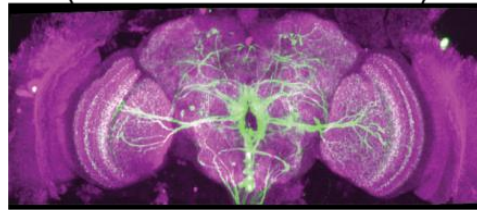
glutamate
(vGlut-GAL4/UAS-GFP)



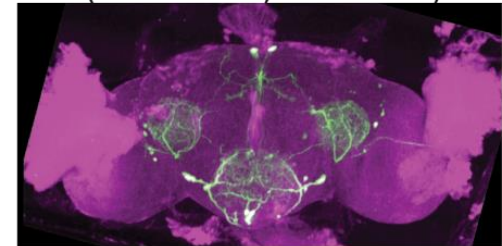
dopamine
(TH-GAL4/UAS-GFP)



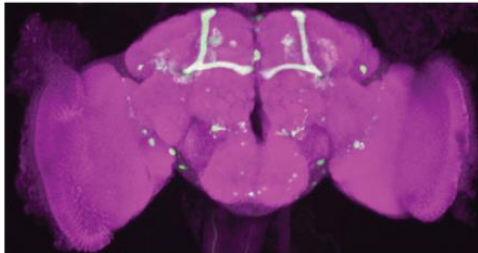
octopamine
(TDC2-GAL4/UAS-GFP)



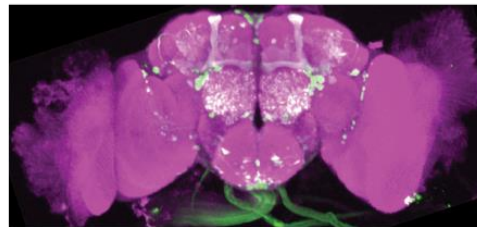
serotonin
(TRH-GAL4/UAS-GFP)



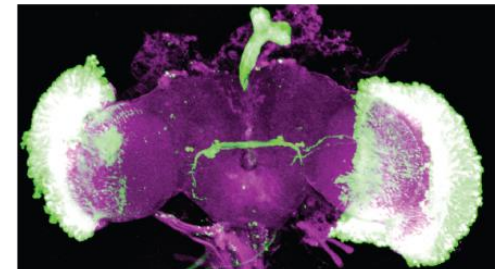
mushroom bodies
(c309-GAL4/UAS-GFP)



antennal lobes
(7B-GAL4/UAS-GFP)



optic lobes
(GMR-GAL4/UAS-GFP)



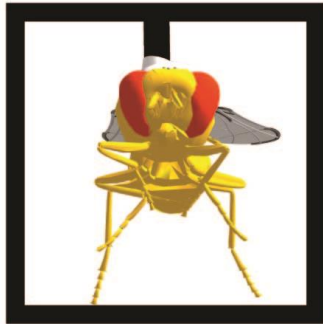
nc82
GFP

100 μ m

Behavioural context: it matters



fly on ball



suspended fly

