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The Mushroom Body Pathway within a Chemotaxis Sensory-motor Loop

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Background

Would these compromise the ability of the oscillator to steer when driven by neural circuits?

Circuit has only been tested by directly coupling to the input stimulus.

How does the memory engram modify the sensori-motor loop to change odour preferences?

Research Question

Memory is encoded via efficacy changes in KC-MBON synapses:

Learning associations induce either synaptic potentiation (P) or depression (D).

How can memory suppression bypass P or D to temporarily revert to innate preferences?

Memory Suppression

If learning via potentiation of KC-MBON synapses then re-inhibitory gates set point.

MBON (attraction) within the feedback circuit, this pattern can be resolved by reading to neuromodulatory effects on excitability.

Increasing excitability of MBONs effectively increases the gain g₁. This impairs chemotaxis, destabilizing any learned response.

In contrast, depressing KC-MBON synapses decreases g₁, thus improving chemotaxis for the encoded odour pattern.

MB Hypothesis

Oscillator based chemotaxis requires input to operate around a set-point.

An integral feedback circuit can be used to maintain the set-point and transform input stimuli as perturbations around it.

The MB output can be coupled to the Oscillator to produce approach or avoidance behaviour, in an odour specific manner, via coupling MBONs to excitatory/inhibitory pathways converging to the Oscillator.

The feedback loop hypothesis predicts that gain reduction increases chemotaxis performance; thus synaptic depression at KC-MBON connections could mediate this.

Learning via synaptic depression poses a conundrum for memory suppression:

how does the gating circuit recover the initial (non-zero) synaptic levels within the feedback circuit, a neuromodulatory effect on MBONs could provide a mechanism to temporarily revert to naive state.

Methods

Conclusions

We introduce feedback dynamics to re-scale the artificial direct input feed to the oscillator. These act to adapt output to operate around a set-point, while the stimulus-timing is compromised, and if chemotaxis works.

Using a fully adaptive integral feedback to maintain the input signal. Changes in stimulus can be detected as the agent moves in the gradient.

Perturbing input around a set point is mainly what the oscillator requires, and thus such feedback could be employed to maintain the set-point.

We found this to be sufficient for chemotaxis, set it apart performance driven on the dynamics of the input not just its magnitude.

Increasing the feedback gain g₂ or g₁ makes learning to be detected as the agent moves in the gradient.

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