Background

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

Research Question

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

Methods

m(t)

u(t)

Learning the specific reward quality

European Research Council (Advanced Investigator Commission, 2009-2013)

Modeling

MB circuit maintains the oscillator's input set-point.

MBON (attraction)

MBON (repulsion)

MBON rescue

MBON saturation

MBON (appetitive tastant)

MBON (aversive tastant)

GR

KCI

KRo

RIN

MBON

Gater

Performance Maps

Adapted from Hesseinberg et al. 2013

Caption: Learned MBON valence is driven by changes in the dynamics of the input not just its magnitude.

Caption: Memory recall & suppression via associative learning. Training achieved enhancing the feedback gain reduces chemotaxis and steering ability, while the system response becomes faster.

Caption: This system could be implemented in circuits with populations of inhibitory and excitatory neurons.

Caption: Learning the specific reward quality of taste stimuli can simply be gated by MBON output.

Caption: Learning associative demands that the change of learning depends on stimulus timing.

Caption: Learning an odour preference can be modified via associative learning. Training achieved by pairing odour with a gustatory reinforce.

Caption: The MBON is a potent modulator of MBON (repulsion) KCI and KRo.

Caption: In contrast, depressing KC-MBON synapses decreases memory suppression, thus improving chemotaxis for the encoded odor pattern.

Caption: Increasing excitability of MBON effectively increases the gain g1.

Caption: Neuronal plasticity can be seen as changing the feedback loop gains, in an odour specific manner.

Caption: MBONs valence is determined on whether it reaches the oscillator via an excitatory/inhibitory pathway.

Caption: Overall response determined by balance of excitatory vs inhibitory signal strength reaching the oscillator.

Caption: MBON rescue

Conclusions

Oscillators based chemosensory 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?