Adenylyl Cyclase and PKC Differentiate Operant and Classical Learning in *Drosophila*

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**1. Classical or Pavlovian learning**

A – Experimental design. Throughout the experiment, one yaw torque domain is coupled to one color and the other to the background coloration. The fly shows the yaw torque domain/color preference and only briefly ventures into the previously unpreferred color domain.

B – Sample data from a wildtype fly during the first test period after the final training with heat on positive (right-turning) yaw torque (red trace) and blue illumination (blue trace). The fly changes flight direction (blue trace) and hence coloration of the environment (background color of the graph). The fly shows the yaw torque domain/color preference and only briefly ventures into the previously unpreferred color domain.

C – Pooled performance indices (PI) from the first test period after training. HS het.c. – Heat shock-treated heterozygous parental controls strain; noHS het.c. – Heterozygous parental strain from the same parents. The genetic control flies (the two heterozygote strains did not differ and were used as such in all experiments). Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies. Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies. Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies. Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies.

D – The mushroom-body component mediates operant learning; the mushroom-body output is required for development of a Pavlovian response to operant stimuli.

**2. Operant or instrumental learning**

A – Experimental setup. The fly controls the angular position of a drum with four identical vertical bars in a flight simulator. The fly needs to control the angular position of the drum with four identical vertical bars in a flight simulator. Setting up one of the vertical bars in the drum triggers heat or heat shock. The fly needs to control the angular position of the drum with four identical vertical bars in a flight simulator.

**3. Learning-by-doing is most effective (in flies, too)**

A – Functional categories of discrete learning. The learning of a classical reflex is Figure 3: Comparison of classical and operant learning. Operant behavior controlling predictive stimuli facilitates learning and memory. The mushroom-body component mediates operant learning; the mushroom-body output is required for development of a Pavlovian response to operant stimuli.

**4. Purely operant learning is different**

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**5. Mushroom-bodies prevent premature habit formation**

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**6. Conclusion**

Composite learning consists of two component systems, which in turn allows for a successful mixture of both systems. Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies. Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies. Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies. Flies with blocked MB output perform worse (performance indices lower) than the genetic wildtype flies.

**Operant behavior controlling predictive stimuli facilitates learning and memory.** The mushroom-body component mediates operant learning; the mushroom-body output is required for development of a Pavlovian response to operant stimuli.

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