Neurogenetic dissection of learning-by-doing in Drosophila

Björn Brems
FU Berlin, Institut für Biologie - Neurobiologie, Mangini-Luise-Strasse 28/30, 14195 Berlin, Germany
bjorn@brems.net, http://brems.net

1. Introduction

Learning-by-doing is a learning paradigm, which is well-established in species as diverse as monkeys, cats or fruit flies. Despite the impact learning-by-doing has on society and economy, there is still a lack of knowledge of the neurobiological bases of this phenomenon. To study its neurobiological basis, we hypothesized that the generation effect may be brought about by a mechanism of habituation, and that the component of skill-learning is necessary for the generalization of fact-learning.

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

Fig. 1: Comparison of active and passive learning in flies. Active learning ('by doing', left) results in a higher learning score than passive learning ('by receiving', right). N=30.

3. Composite Conditioning in Drosophila

Fig. 2: Composite Conditioning in Drosophila. The fly's behavior can be made contigous with an arbitrary number of different stimuli, enabling the experimenter exquisite control over the fly's behavior. The same sequence of sensory inputs induces a large learning score only if it is perceived actively (left), if it is perceived passively (right).

4. Fact- and skill-learning interact hierarchically

Fig. 3: Fact- and skill-learning interact hierarchically. The learning-by-doing effect is blocked when the skill-learning component is suppressed, while the fact-learning component remains intact. This interaction suggests a hierarchical relationship between the two processes.

5. Suppression of skill-learning allows generalization

Fig. 4: Suppression of skill-learning allows generalization. The generalization effect is abolished when the skill-learning component is blocked, while the fact-learning component remains intact. This suggests that the skill-learning component is necessary for the generalization of fact-learning.

6. Blocking mushroom bodies

Fig. 5: Blocking mushroom bodies. The mushroom bodies (MB) are a pair of brain structures that are thought to be involved in the consolidation of habits. Blocking the MBs prevents habit-formation, suggesting a gate-keeping role for the MBs.

7. Mushroom-bodies prevent premature habit formation

Fig. 6: Mushroom-bodies prevent premature habit formation. Blocking the MBs significantly reduces the rate of habit-formation, suggesting a role for the MBs in the consolidation of habits.

8. Conclusion

In conclusion, we have shown that the learning-by-doing effect is brought about by a mechanism of habituation, and that the component of skill-learning is necessary for the generalization of fact-learning. This interaction reveals the gate-keeping role of the MBs, and prevents premature habit-formation.