

POSTER PRESENTATION

Open Access

Neural representation of a spatial odor memory in the honeybee mushroom body

Martin P Nawrot^{1,2*}, Tiziano D'Albis¹, Randolph Menzel³, Martin Strube-Bloss⁴From 24th Annual Computational Neuroscience Meeting: CNS*2015
Prague, Czech Republic. 18-23 July 2015

Insects make use of lateralized olfactory information from their left and right antennae. Honeybees can learn to distinguish side-specific odor cues in classical conditioning experiments, i.e. they associate a specific stimulus combination of odor identity and spatial location (left or right) with the reward [1]. This requires inter-hemispheric transfer of lateralized information and a side-specific odor memory. Mushroom body (MB) output neurons, the so-called extrinsic neurons (ENs), make inter-hemispheric connections between the two MBs and are thus candidates for the inter-hemispheric transfer of lateralized stimulus information. We could show previously that ENs in the honeybee undergo plastic changes in classical conditioning [2].

Here, we investigate neuronal plasticity in ENs of the honeybee in a sides-specific learning paradigm. We performed multiple single-unit recordings from ENs of one MB. Prior to conditioning (PRE) each bee was repeatedly presented with two different odors on the two antennae separately. During acquisition one of these odors was repeatedly presented to the antenna contralateral to the recording side (CS+) and paired with a sugar reward, while the other odor was presented without reward (differential conditioning). Three hours after training (POST) we repeated the initial protocol presenting each of the two odors repeatedly to each of the antennae. In the behavioral test the bees distinguished the CS+ stimulus configuration of odor and side from the other three stimulus combinations.

At the neuronal level we found clear and distinct odor representations in the EN population before training (PRE) only when stimulated on the antenna *ipsilateral* to the recording side. However, no odor responses were measured in any of the ENs when stimulated at the

contralateral antenna. This picture changed drastically after training (POST). Now, the rewarded stimulus combination (CS+) resulted in a strong population response pattern. The population code for the CS+ configuration was clearly distinct from all three other stimulus configurations. Quantification of the temporal response latencies showed that the ENs encode an odor approximately within 75ms for ipsilateral stimulation. Odor representation was delayed by about 60ms for a contralateral stimulation. We discuss two alternative explanations for this temporal delay.

We hypothesized previously that ENs at the MB output encode the experience-dependent *value* of a particular stimulus [2-4]. Our results here provide additional evidence for this hypothesis. A representation of the rewarded stimulus combination (CS+) of a particular odor and its spatial location (left or right) develops only due to reward conditioning. Before learning, only ipsilateral odor information was represented.

Acknowledgements

Funding was received from the Federal Ministry of Education and Research (BMBF) within the *Bernstein Focus Neuronal Basis of Learning* (BFNL) through grant 01GQ0941 to M.N. and R.M.

Authors' details

¹Bernstein Center for Computational Neuroscience Berlin, Berlin, Germany. ²Computational Systems Neuroscience, Department of Biology, University of Cologne, Cologne, Germany. ³Institute of Biology - Neurobiology, Freie Universität Berlin, Berlin, Germany. ⁴Department of Behavioral Physiology & Sociobiology, Biocenter, University of Würzburg, Würzburg, Germany.

Published: 18 December 2015

References

1. Sandoz JC, Menzel R: Side-Specificity of Olfactory Learning in the Honeybee: Generalization between Odors and Sides. *Learning & Memory* 2001, **8**:286-294.
2. Strube-Bloss MF, Nawrot MP, Menzel R: Mushroom body output neurons encode odor-reward associations. *J Neurosci* 2011, **31**:3129-3140.
3. Menzel R: The insect mushroom body, an experience-dependent recoding device. *J Physiol Paris* 2014, **108**:84-95.

* Correspondence: martin.nawrot@fu-berlin.de¹Bernstein Center for Computational Neuroscience Berlin, Berlin, Germany
Full list of author information is available at the end of the article

4. Kloppenburg P, Nawrot MP: **Neural Coding: Sparse but On Time.** *Current Biology* 2014, **24**:R957-R959.

doi:10.1186/1471-2202-16-S1-P240

Cite this article as: Nawrot *et al.*: Neural representation of a spatial odor memory in the honeybee mushroom body. *BMC Neuroscience* 2015 **16**(Suppl 1):P240.

**Submit your next manuscript to BioMed Central
and take full advantage of:**

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

