Mushroom body output neuron 02 regulates the transition from goal-directed actions to habits in *Drosophila*

T25-2A

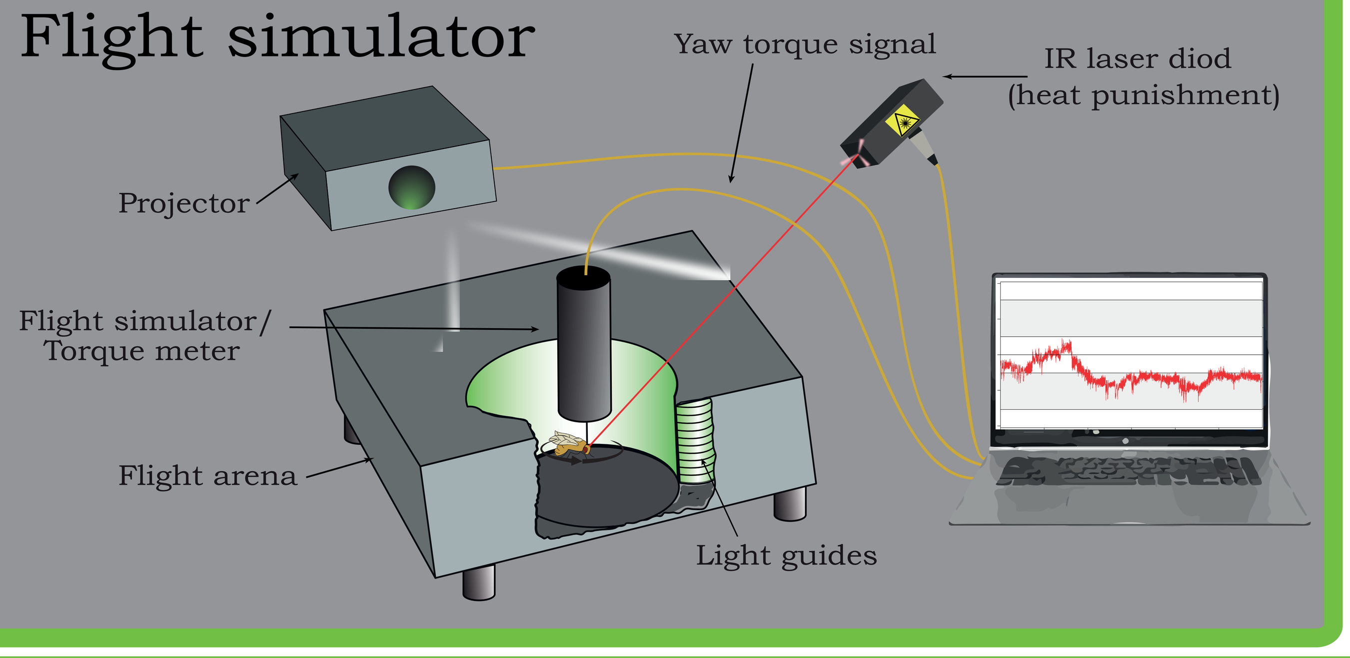
Radostina Lyutova, Silvia Marcato, Björn Brembs

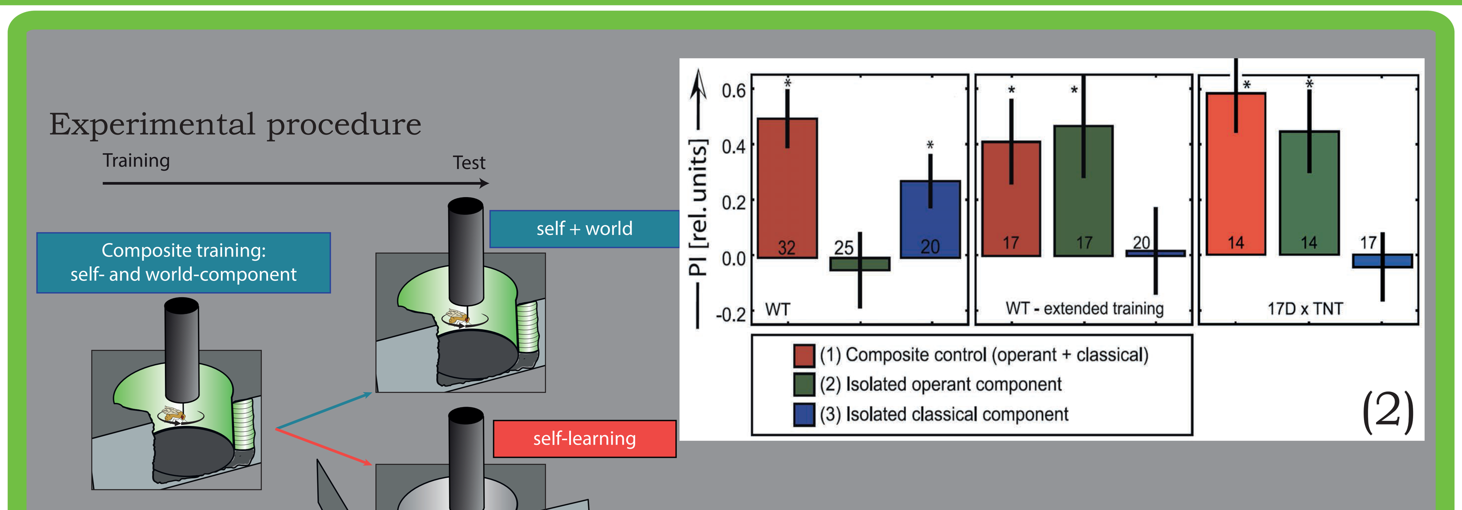
Institute of Zoology - Neurogenetics, University of Regensburg, Regensburg, Germany

Background

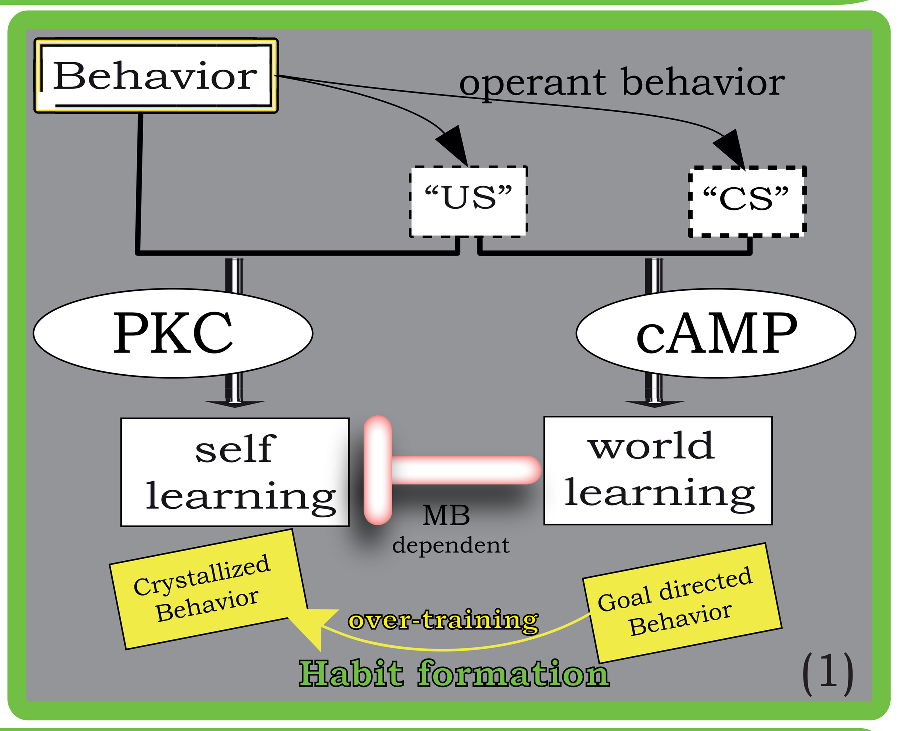
Goal-directed exploration of the environment allows an animal to learn about the relationships between stimuli and how the environment responds to its actions. In this goal-directed phase, animals can flexibly apply learned relationships to other contexts. However, flexibility usually implies a cost in time, together with higher cognitive and energetic costs. In contrast, the formation of habits ensures fast and efficient behaviors. The learning mechanisms that lead to flexible and efficient behaviors, respectively, interact with each other. During the early, goal-directed phase of such composite operant learning situations, the process that mediates learning about relations in the environment (world-learning) is known to inhibit the process that renders behaviors stereotypic and efficient (self-learning), presumably in order to prevent premature habit formation. In humans, imbalance between flexible actions and habitual responses can be linked to neuropsychiatric disorders such as obsessive-compulsive disorder or addiction. We use the fruit fly *Drosophila* to sudy the interactions between world- and self-learning which mediate the transition mechanism from goal-directed actions to habitual responses. In *Drosophila* goal-directed behavior inhibits habit formation at the level of the mushroom bodies (MBs), such that inhibition of the MBs results in premature habit formation. We identified a single MB output neuron (MBON-β2β'2a) controlling the transition from goal-directed actions to habits. Together with the behavioral results, the anatomy of this neuron indicates that non-olfactory MB Kenyon cells of the β2- and β'2-lobes are involved in this transition. These neurons receive input via their dendrites in the little-studied lateral and dorsal accessory calyx regions of the MBs.

Flight simulator

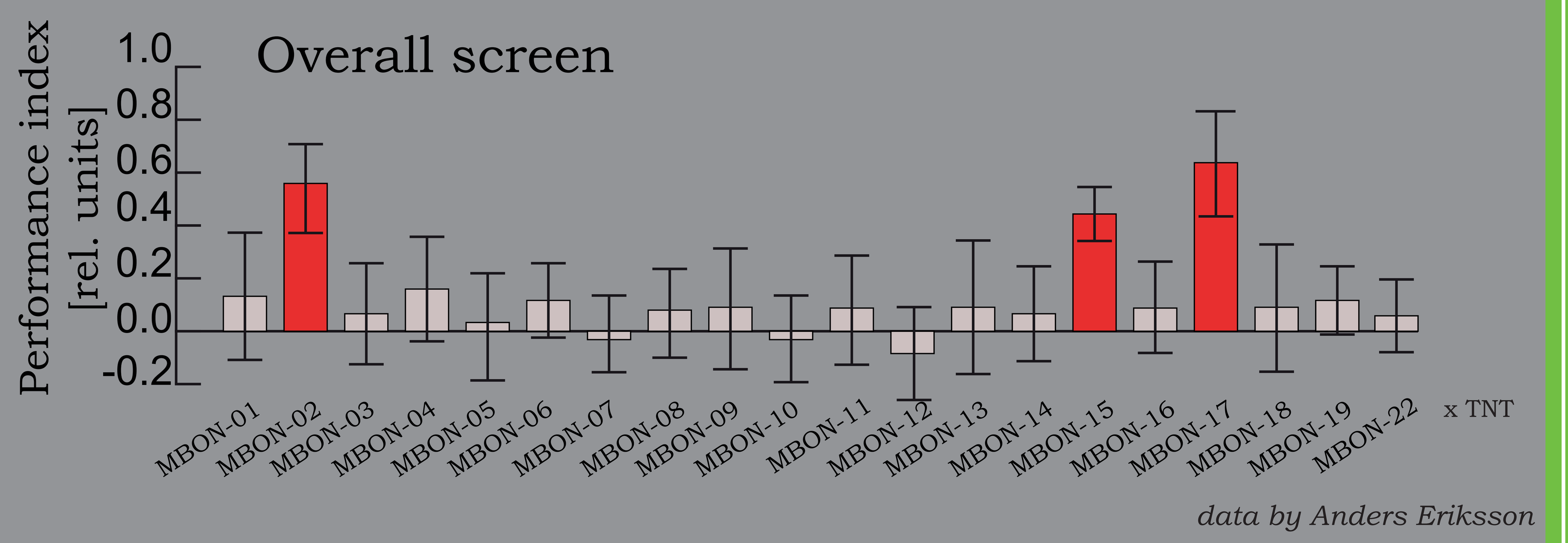




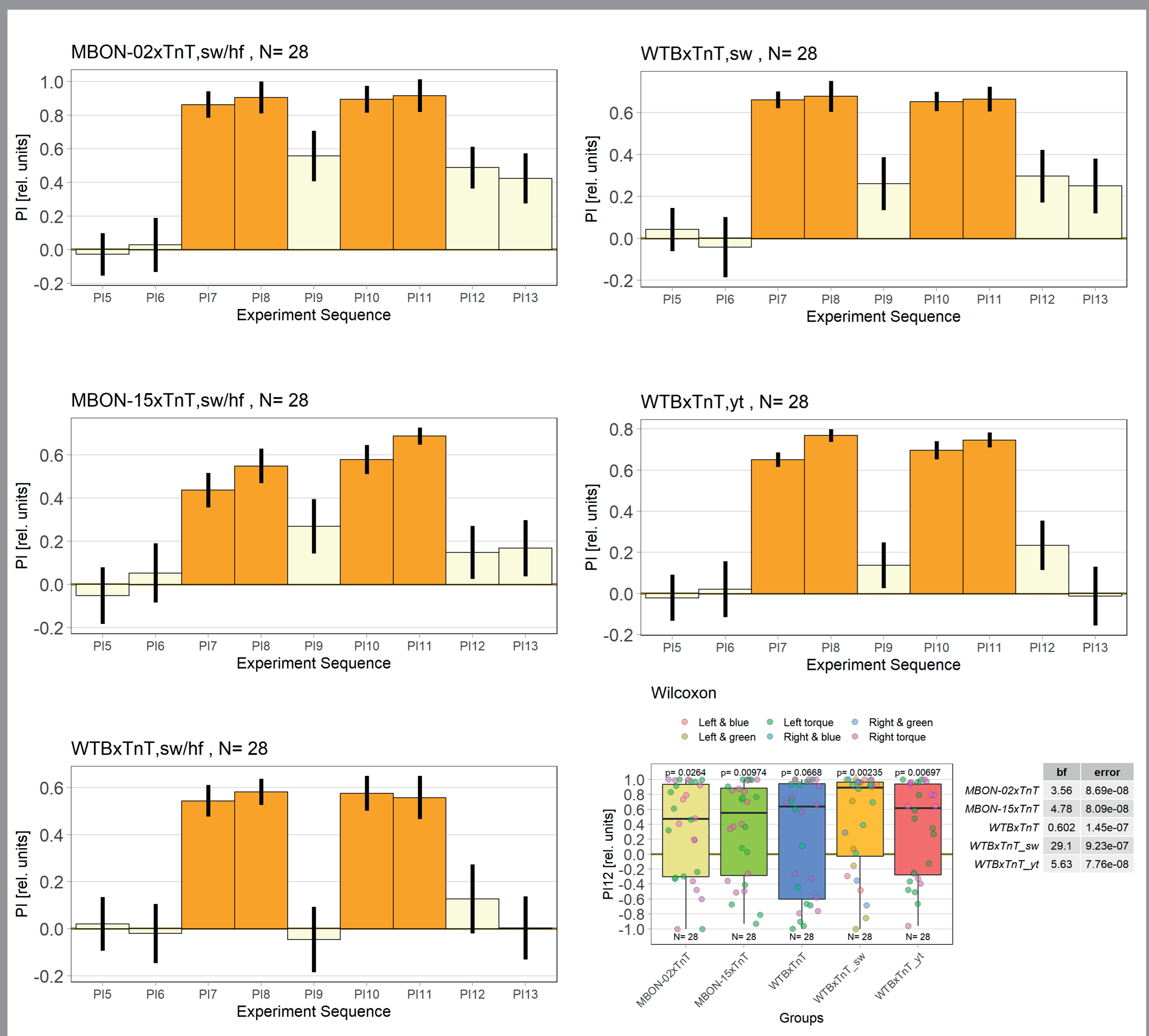
Silencing of MB α/β lobes results in premature habit formation.



Results

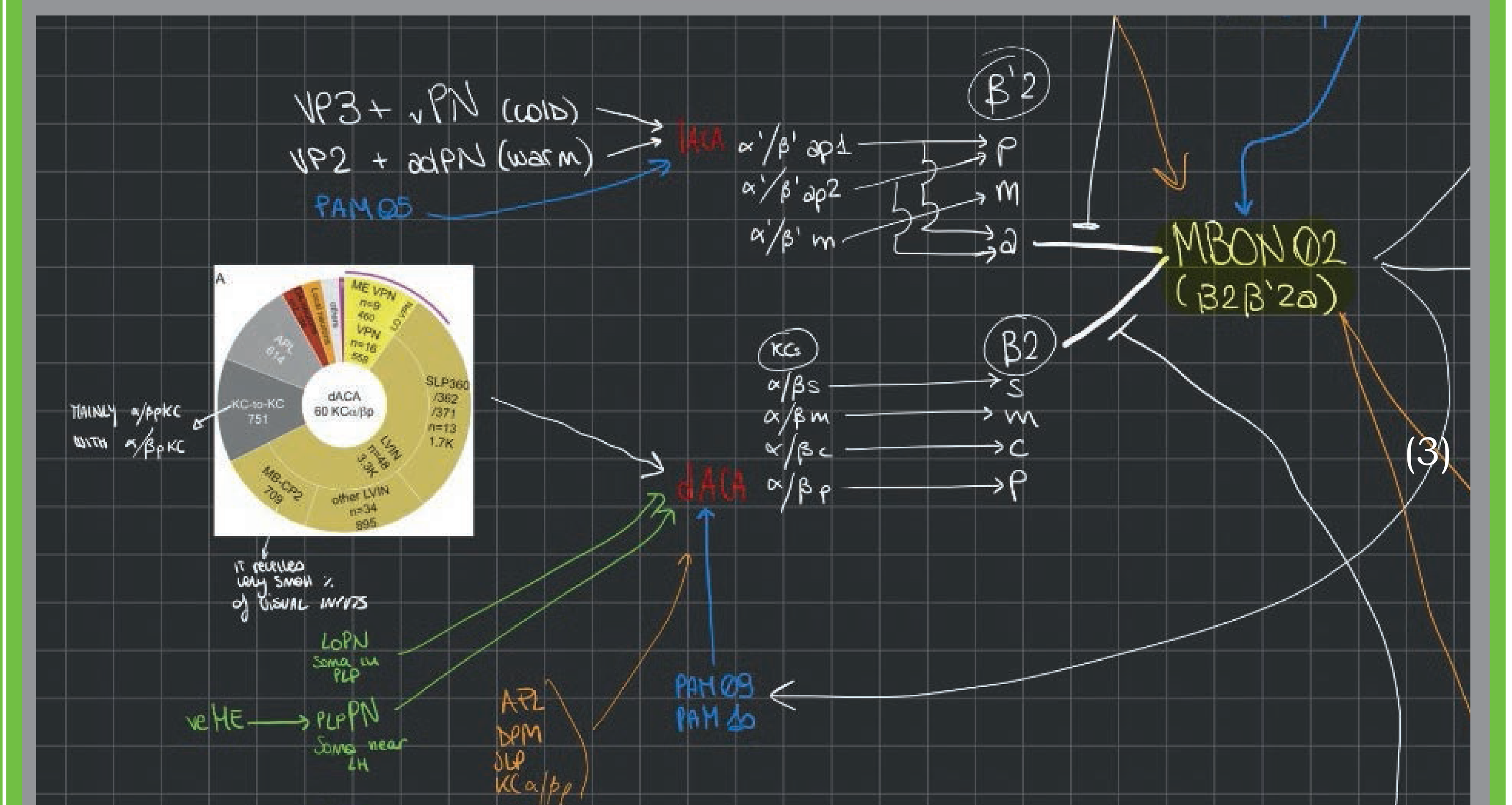


Silencing of three different MBONs results in premature habit formation.



Retest of candidate MBONs verifies MBON02 as potential site of memory interaction.

Outlook



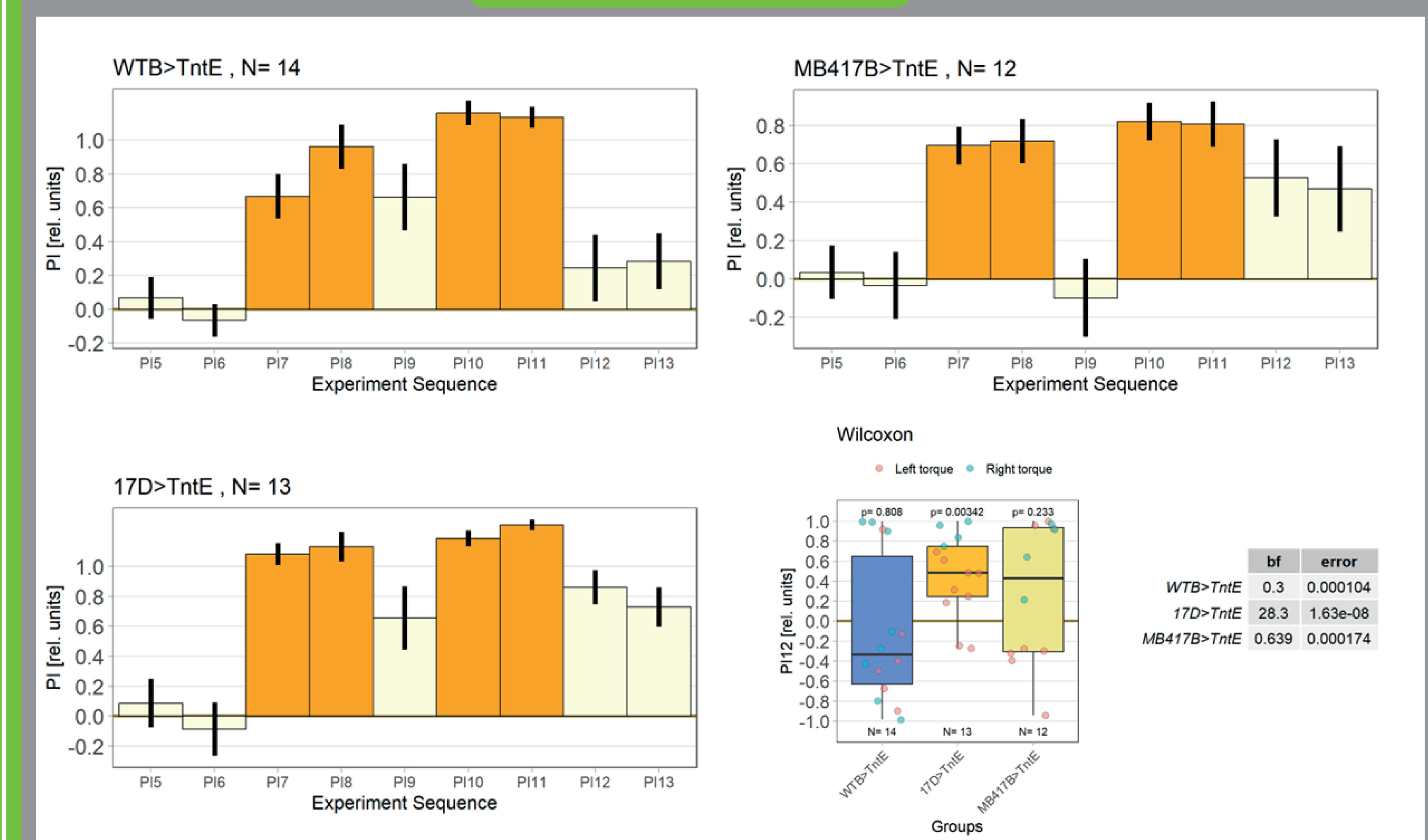
Does MBON02 act as a coincidence detector?

Are both, β (visual) and β´ (thermosensory) input necessary and/or sufficient for inhibiting premature habit formation?

Does dopaminergic signaling modulate the transition from goal-directed actions to habits?

Are dopaminergic neurons a site of interaction between memory types?

preliminary



Silencing of α'/β'ap,α'/β'm,α/βs,α/βp KCs results in premature habit formation.

References

(1) Colomb J, Brembs B. The biology of psychology: "Simple" conditioning? Communicative & integrative biology. 2010;3(2):142-5

(2) Brembs. Mushroom Bodies Regulate Habit Formation in *Drosophila*. Current biology. 2009. 1351–1355. DOI: 10.1016/j.cub.2009.06.014

(3) Li et al. The connectome of the adult *Drosophila* mushroom body provides insights into function. 2020. eLife 9:e62576. DOI: 10.7554/eLife.62576

Contact

radostina.lyutova@ur.de
+49-941-943-3084
University of Regensburg, Institute of Zoology - Neurogenetics
Universitätsstr. 31, 93053 Regensburg, Germany

NWG 2023, March 22-24, Göttingen