Neuronal plasticity in the olfactory bulb during simple and complex perceptual learning

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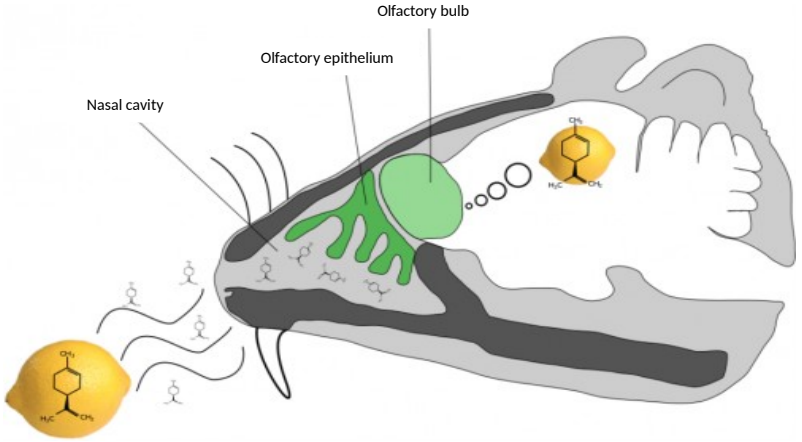
Lyon Neuroscience Research Center
Neuropop Team

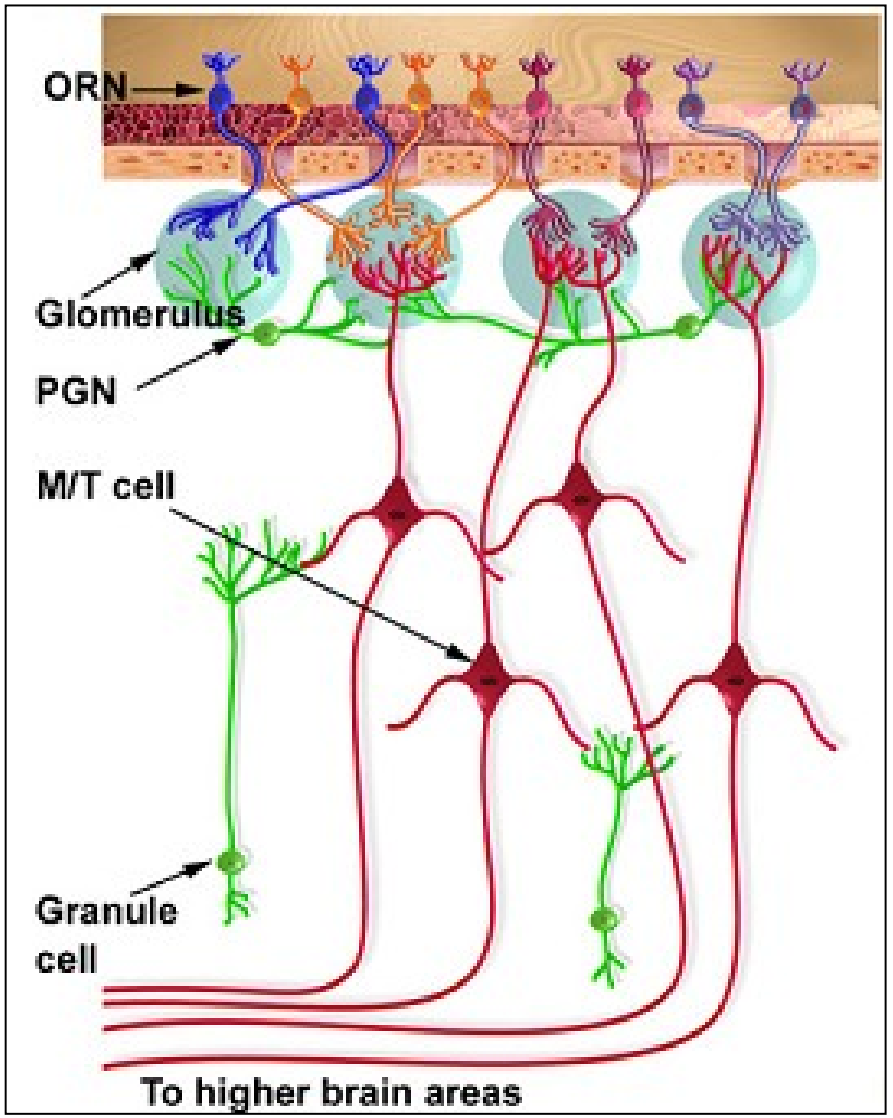
November 2017

Olfaction

	Food seeking	Danger avoidance	Social interactions
Human			
Mice			

Olfaction

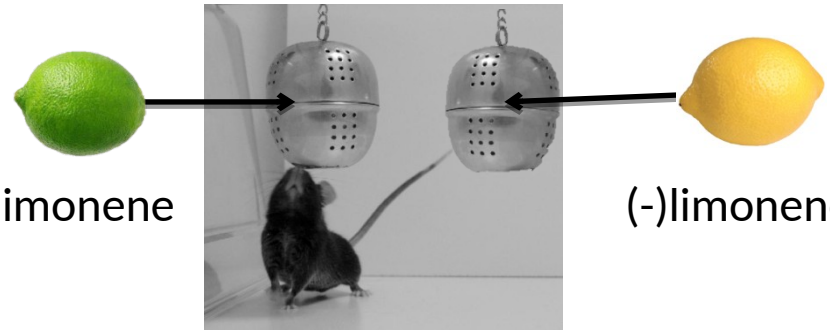




Adapted from Adam and Mizrahi 2010 Curr Opin Neurobiol

Perceptual learning

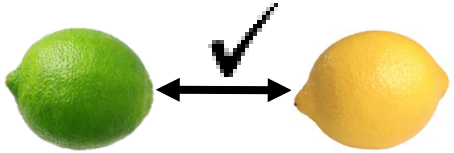
Perceptual learning is defined as an improvement of discriminating ability between two perceptually similar odorants following repeated exposures to these same odorants.

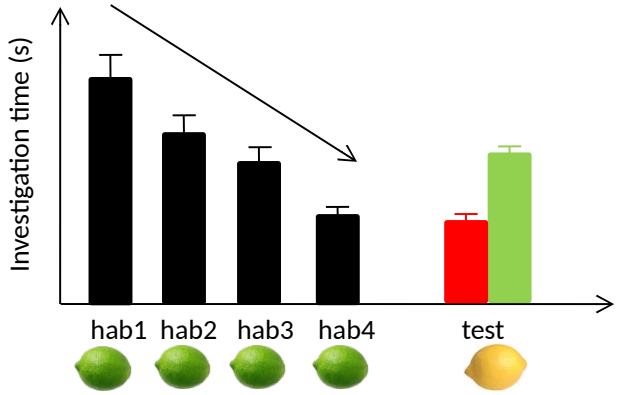


Enrichment
1h/day for 10 days

No discrimination

Discrimination





Mandairon et al., 2006, PNAS
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Moreno et al., 2012, JNeuro

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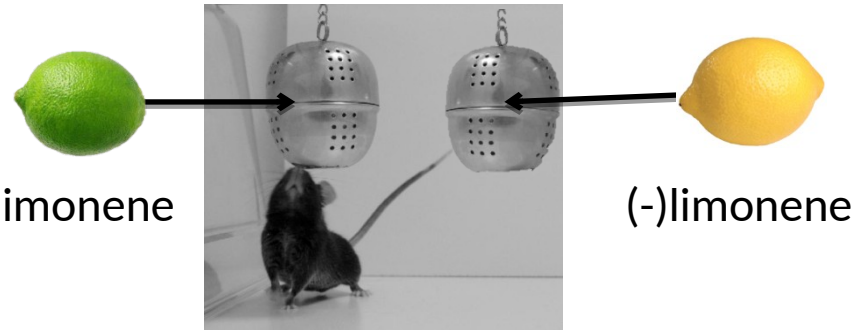

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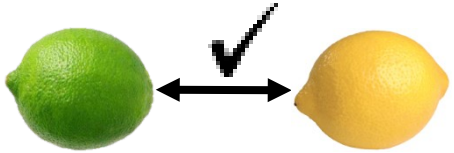

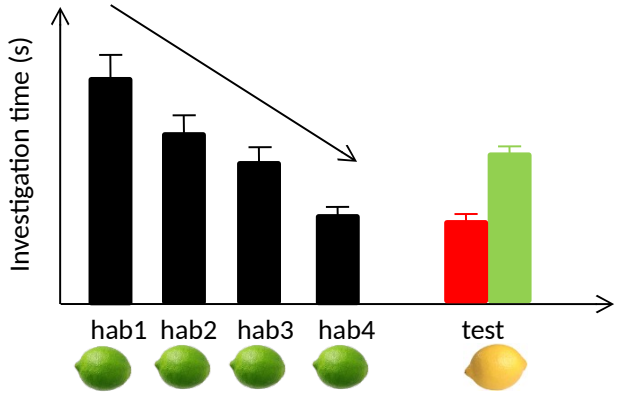

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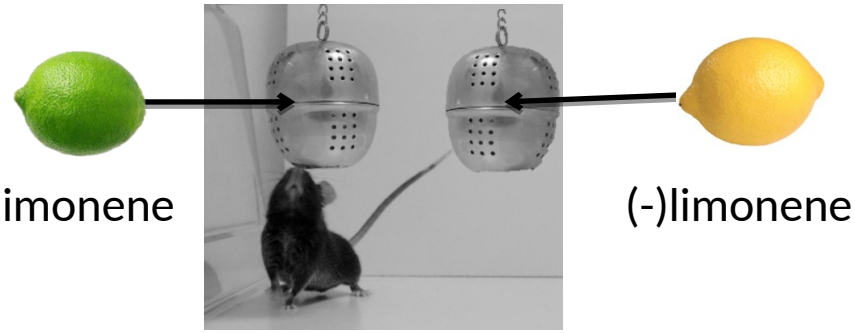

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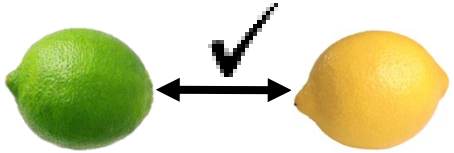
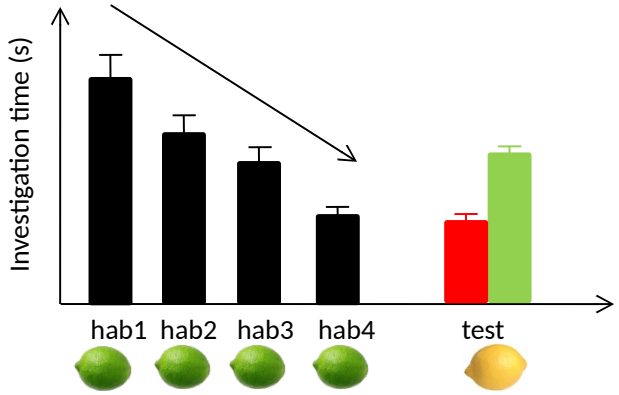
Discrimination





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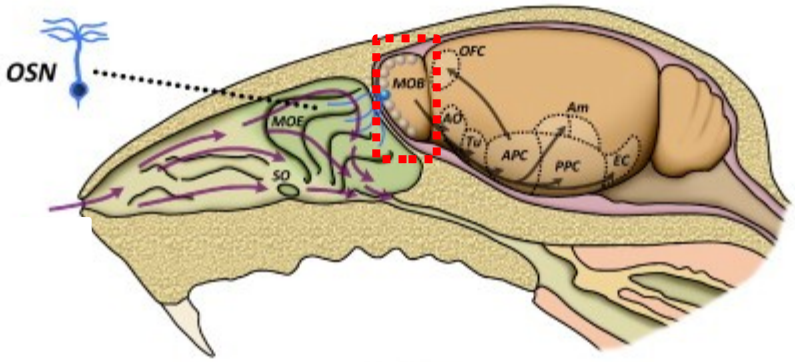
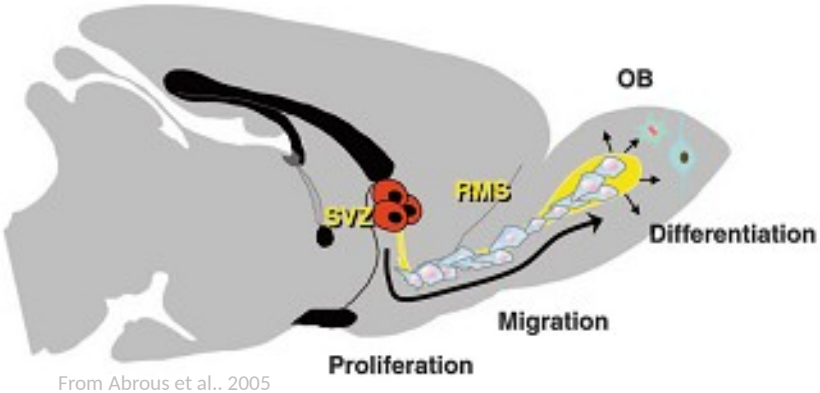


From Mainland et al. 2014

Broad activation of the olfactory bulb produces long-lasting changes in odor perception

Nathalie Mandairon[†], Conor Stack, Carly Kiselycznyk, and Christiane Linster

Department of Neurobiology and Behavior, Cornell University, Ithaca, NY 14853



From Abrous et al.. 2005

Olfactory perceptual learning requires adult neurogenesis

Mélissa M. Moreno[a], Christiane Linster[b], Olga Escanilla[b], Joëlle Sacquet[a], Anne Didier[a], and Nathalie Mandairon[a,1]

[a]Université de Lyon, Lyon 1, Centre National de la Recherche Scientifique, Unité Mixte de Recherche 5020, Neurosciences Sensorielles, Comportement, Cognition, Lyon, F-69007, France; and [b]Department of Neurobiology and Behavior, Cornell University, Ithaca, NY 14853

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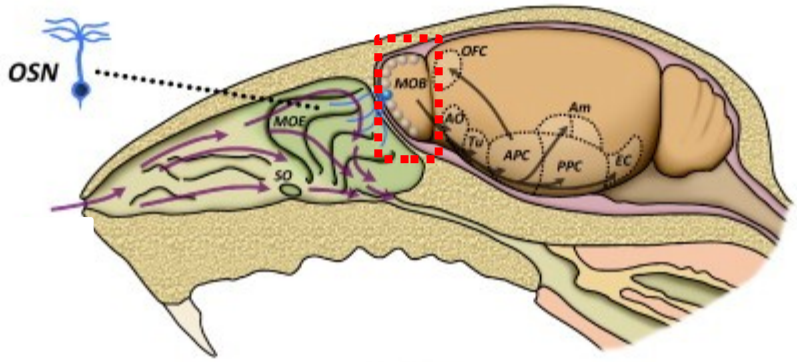
Perceptual learning



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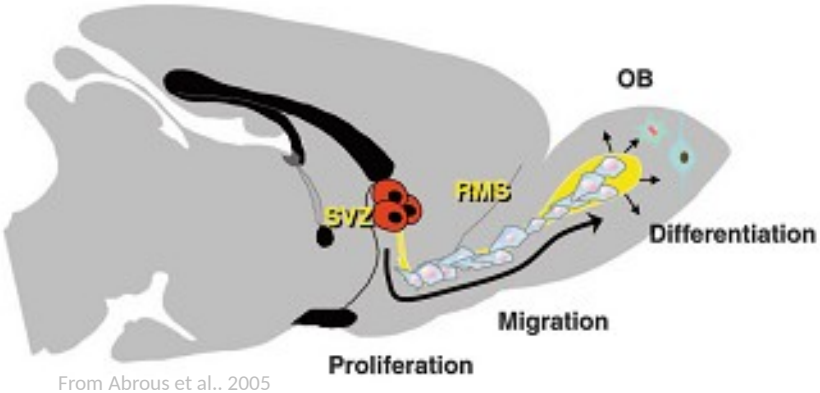

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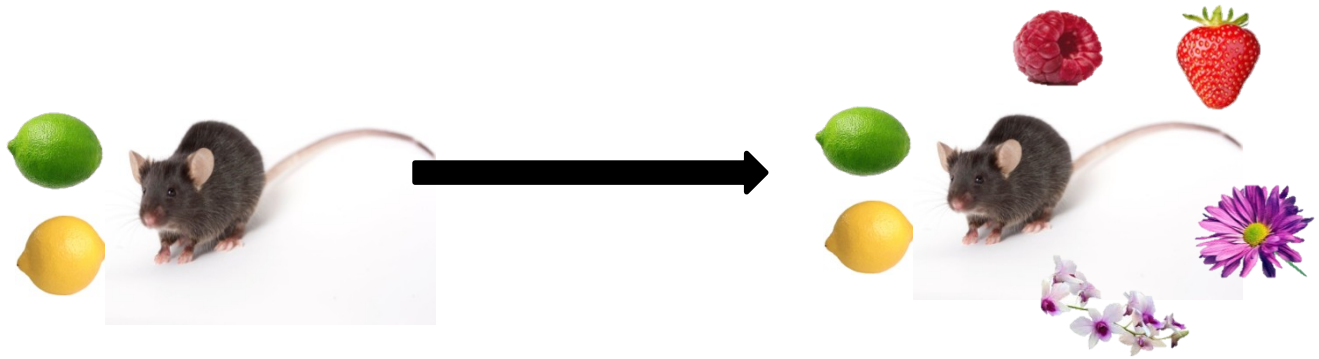

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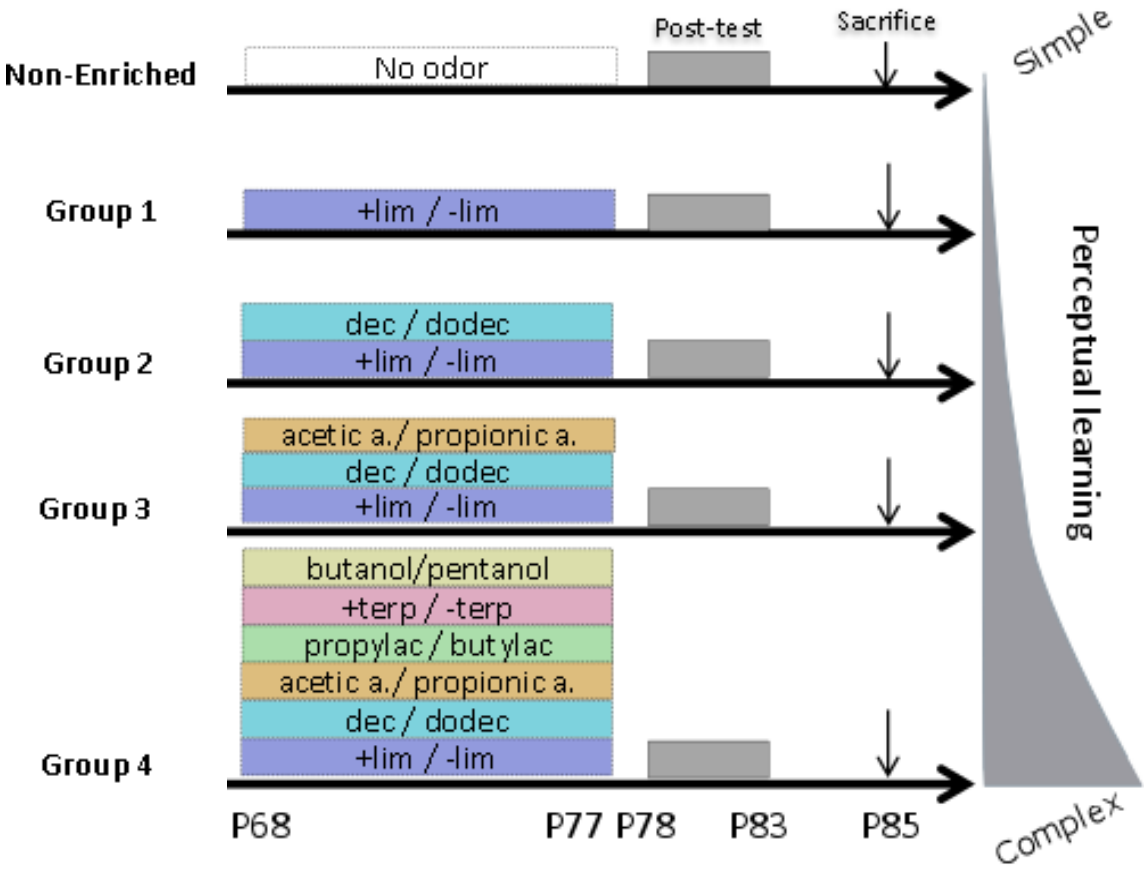
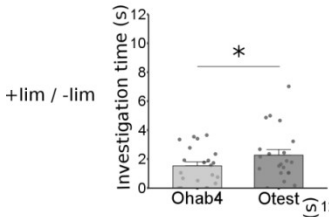
<u>Question 1</u>: Does a more complex environnement require more adult-born neurons?



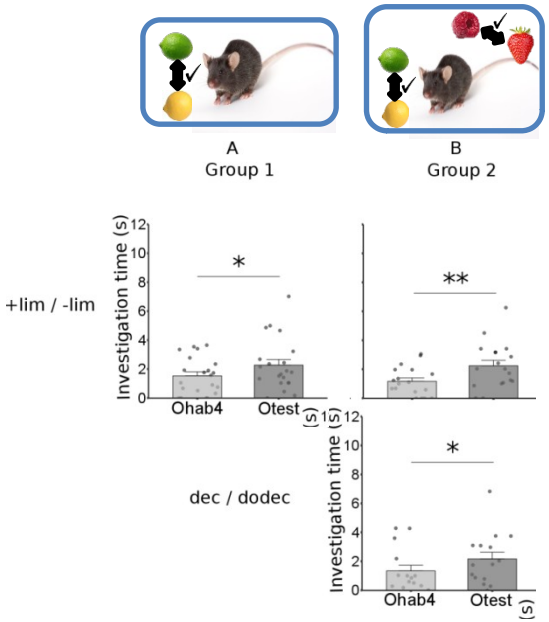
Behavior:

Behavior:

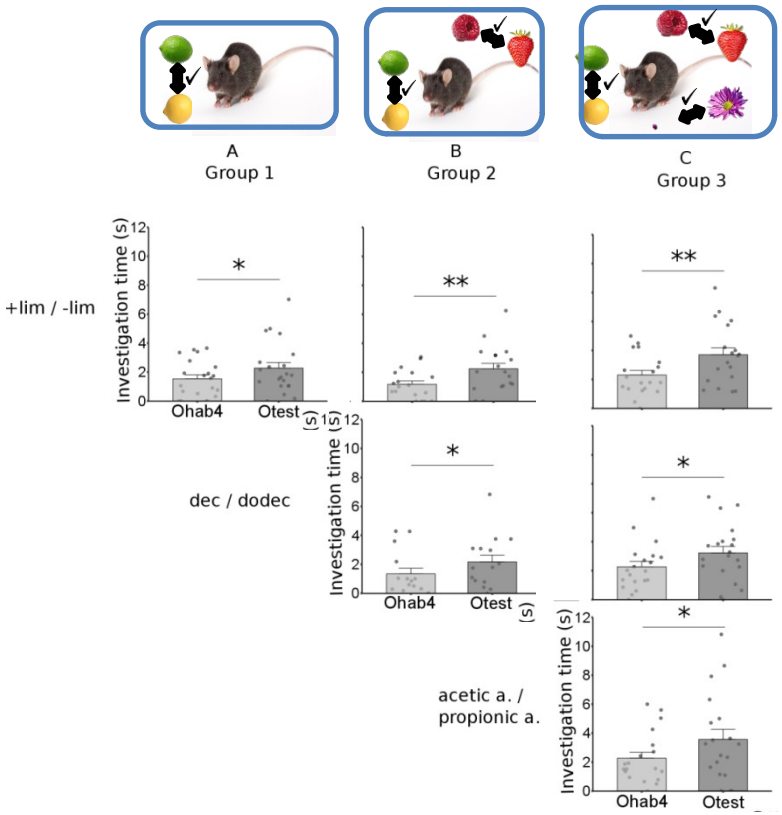
A
Group 1



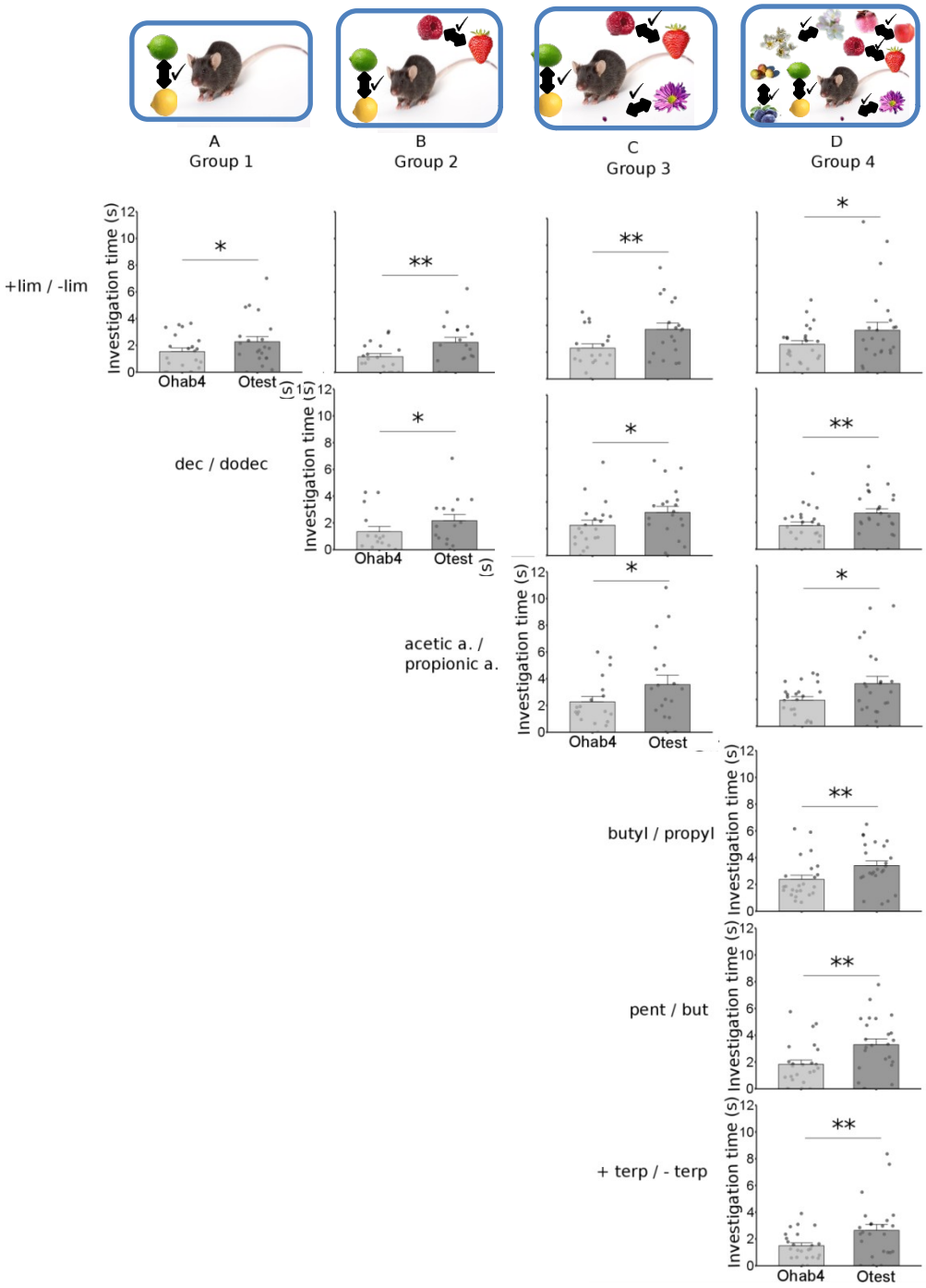
Behavior:


A
Group 1
B
Group 2
+lim / -lim
Investigation time (s)
12
10
8
6
4
2
0
*
**
Ohab4
Otest
(s)
dec / dodec
Investigation time (s)
12
10
8
6
4
2
0
*
Ohab4
Otest
(s)

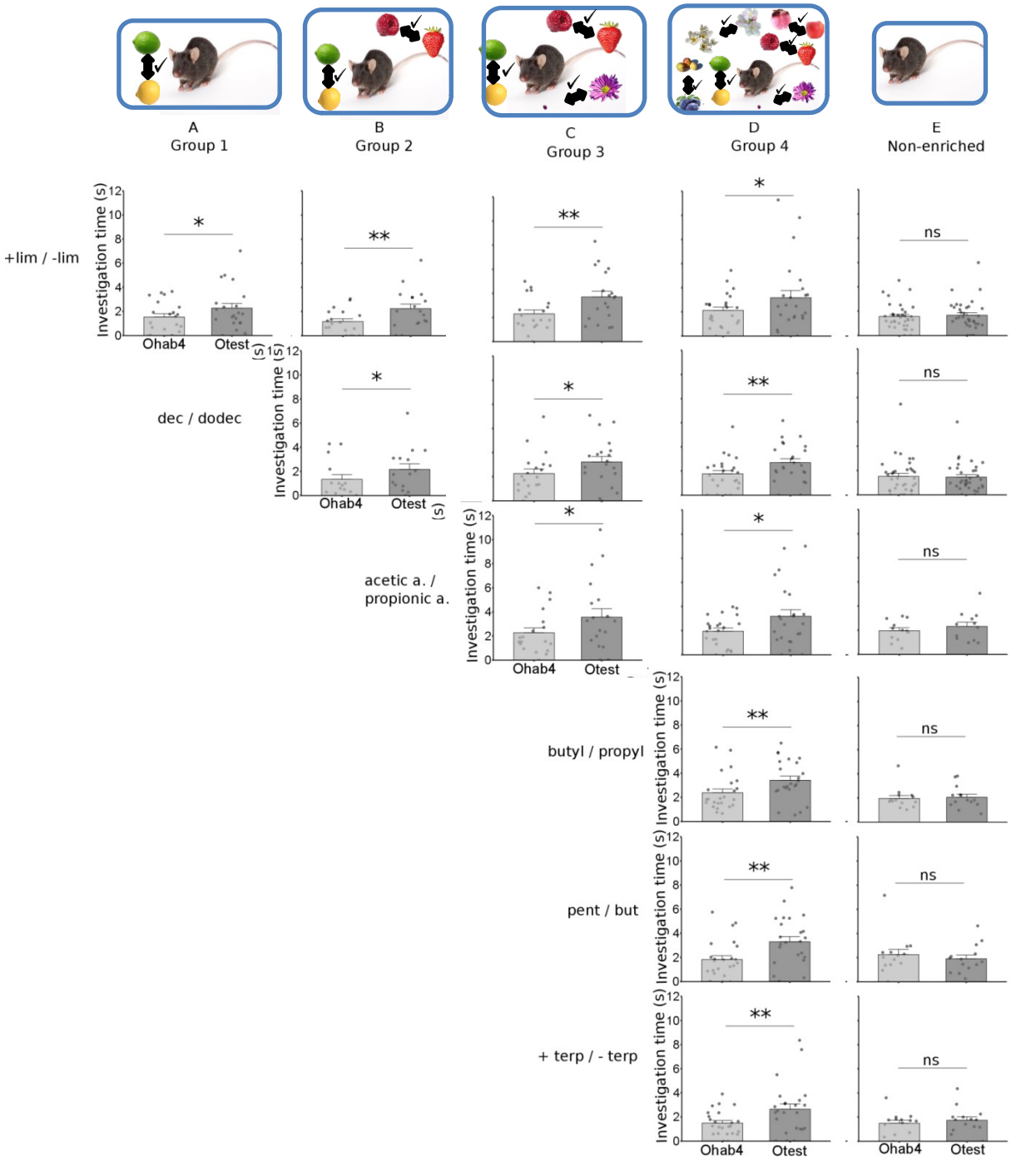
Behavior:


A
Group 1
B
Group 2
C
Group 3
+lim / -lim
dec / dodec
acetic a. /
propionic a.
Investigation time (s)
Ohab4
Otest
*
**

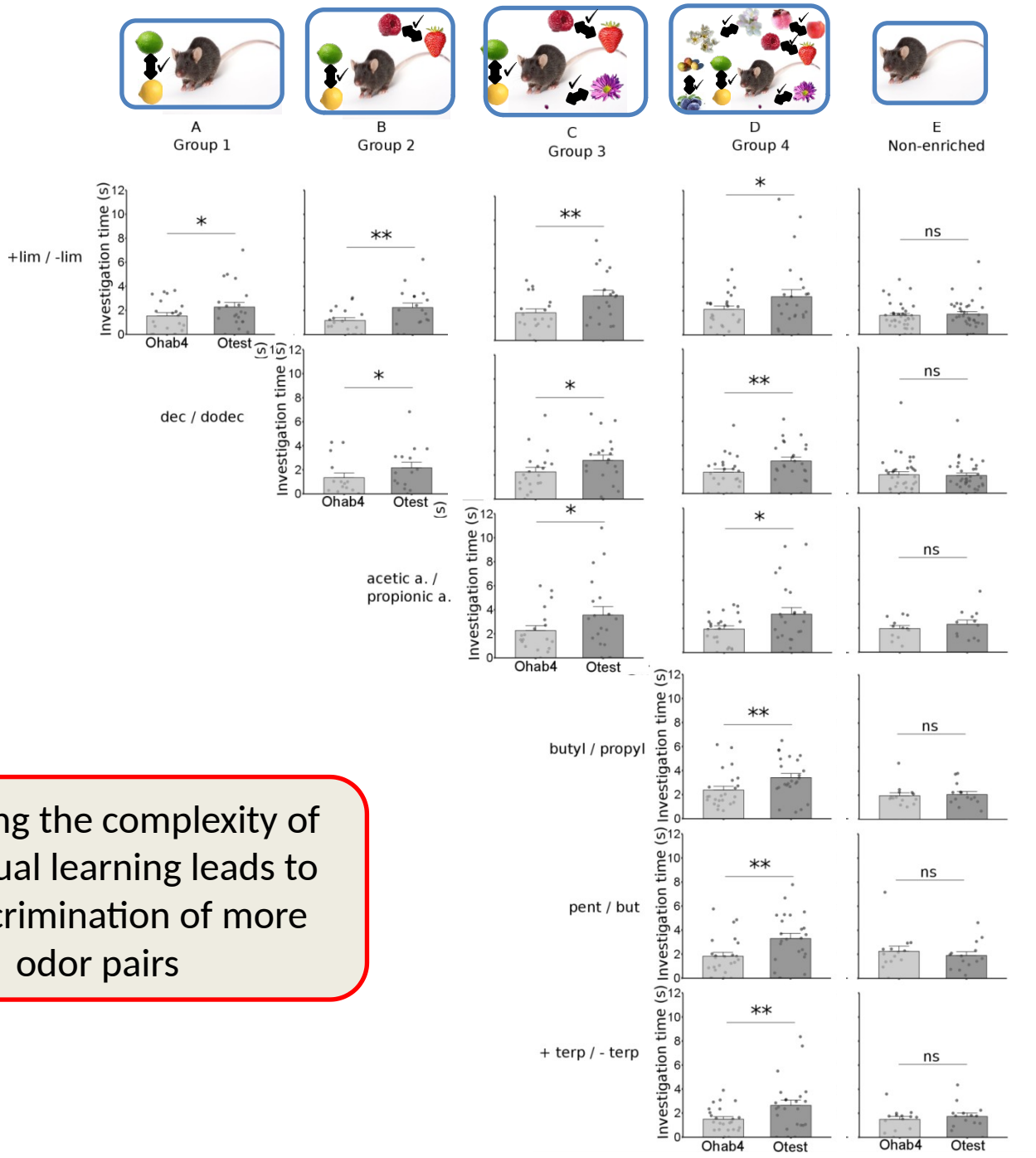
Behavior:


A
Group 1
B
Group 2
C
Group 3
D
Group 4
+lim / -lim
dec / dodec
acetic a. /
propionic a.
butyl / propyl
pent / but
+ terp / - terp
Investigation time (s)
Ohab4
Otest
*
**

Behavior:

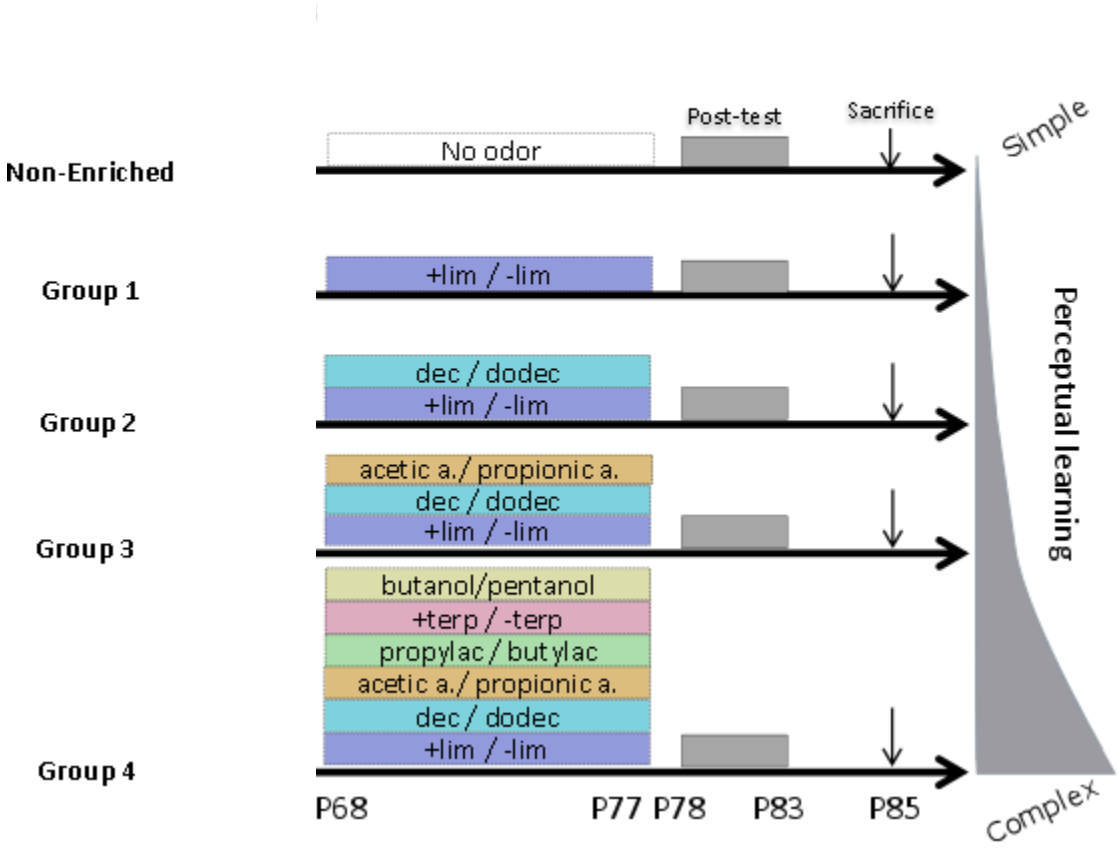

A
Group 1
B
Group 2
C
Group 3
D
Group 4
E
Non-enriched
+lim / -lim
dec / dodec
acetic a. /
propionic a.
butyl / propyl
pent / but
+ terp / - terp
Investigation time (s)
Ohab4
Otest
*
**
ns

Behavior:

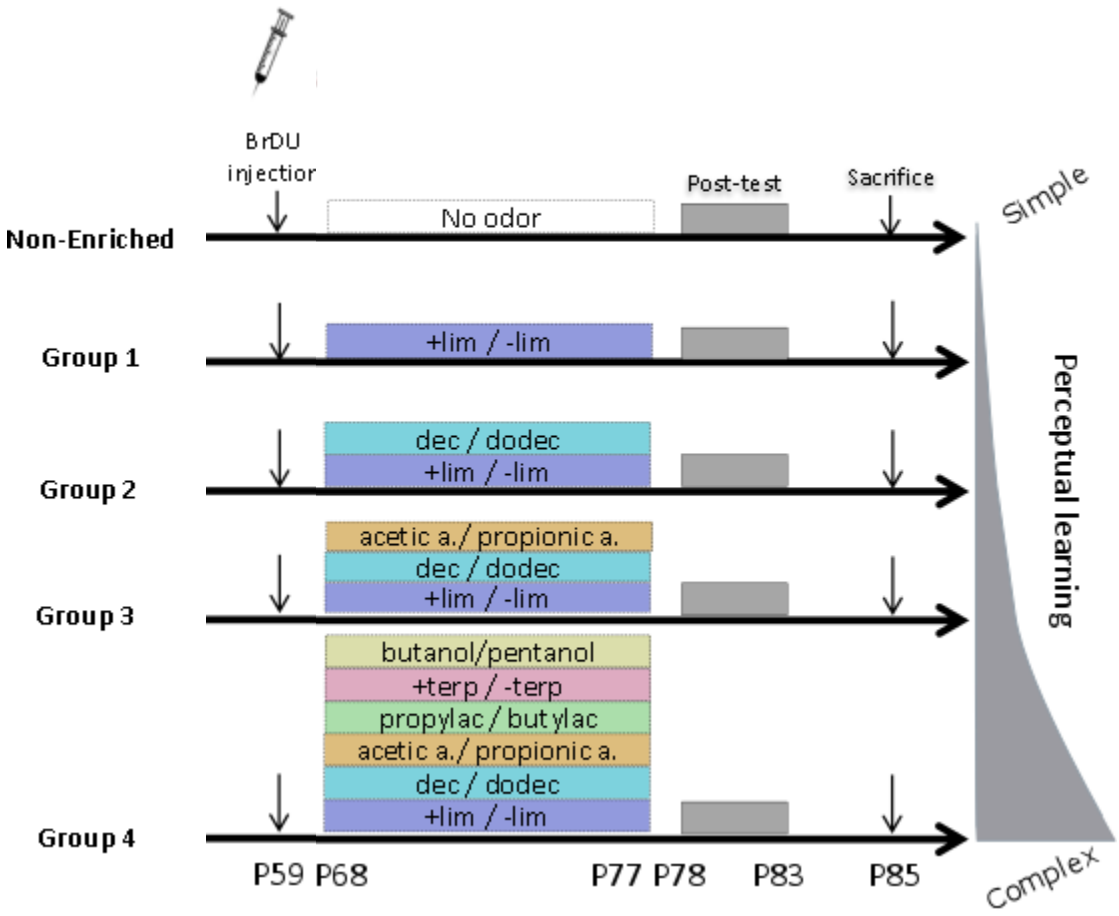


Increasing the complexity of perceptual learning leads to the discrimination of more odor pairs

Adult-born neurons density:



Adult-born neurons density:



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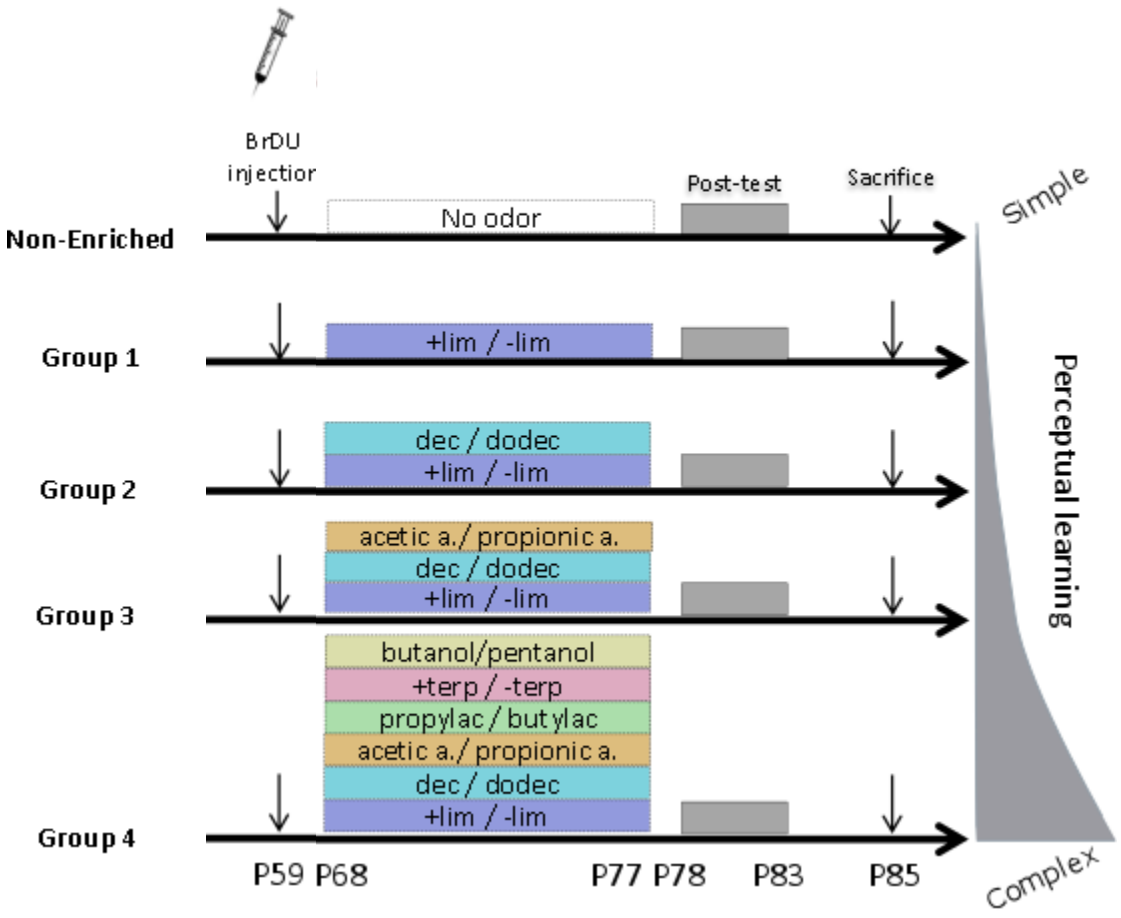
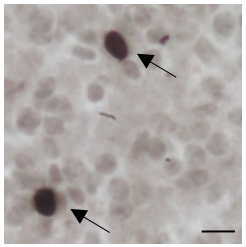
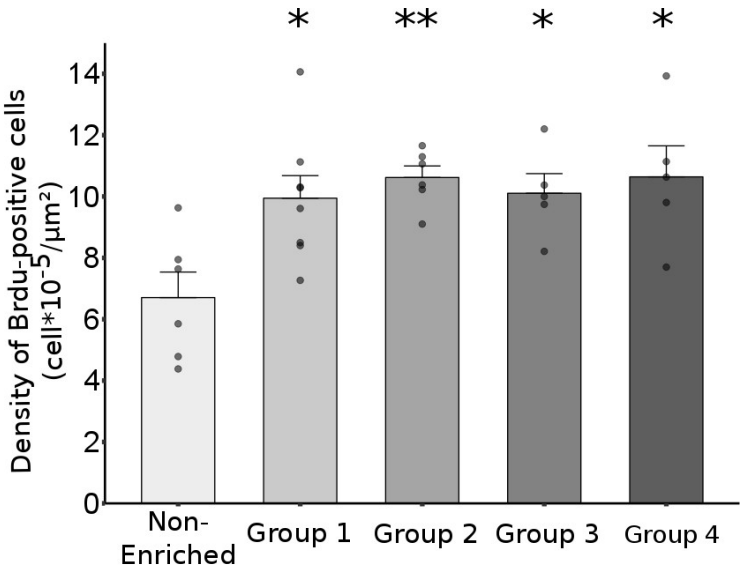
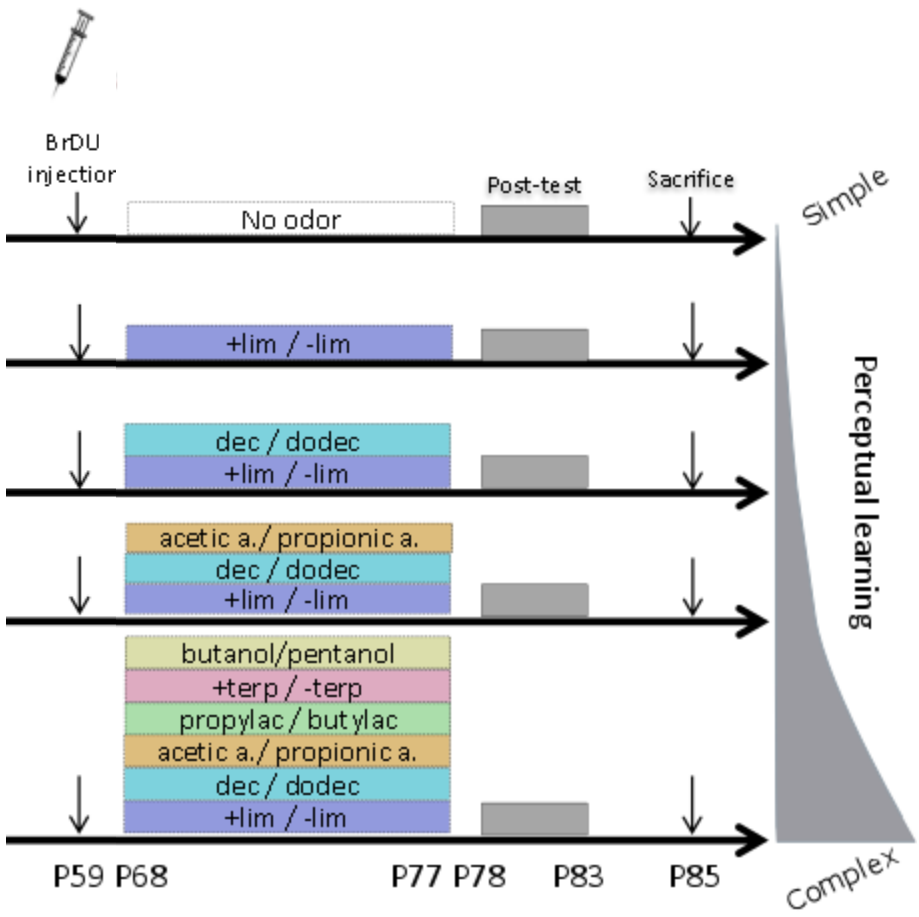






Perceptual learning increased adult-born cell density independently of the enrichment's complexity.

Adult-born neurons responsiveness:



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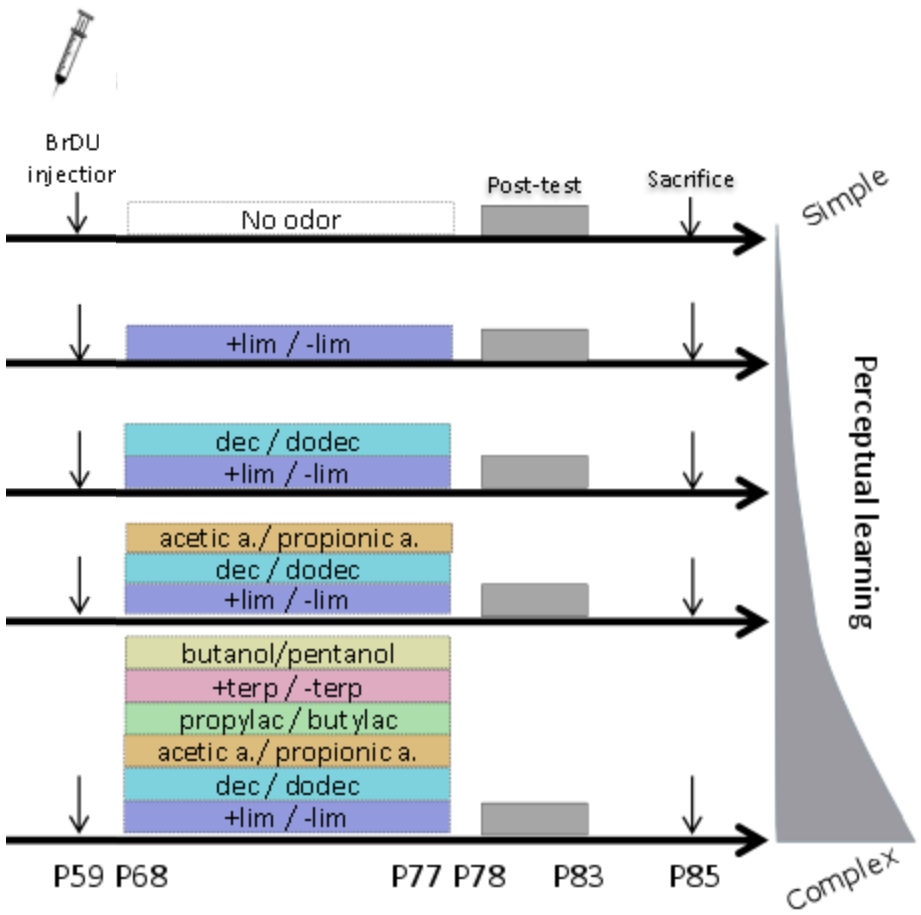

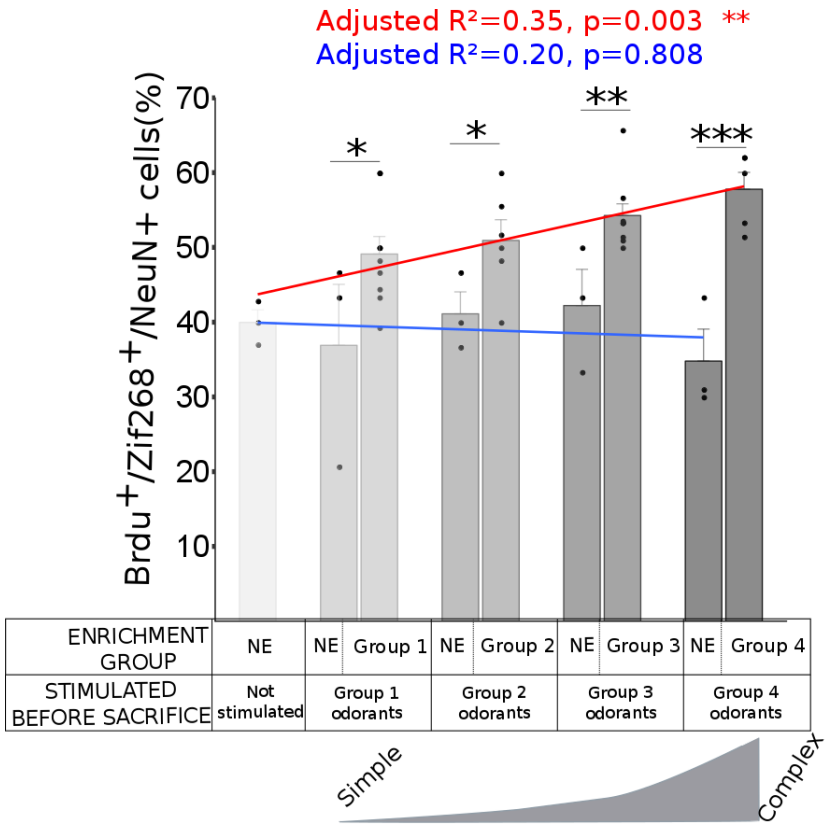

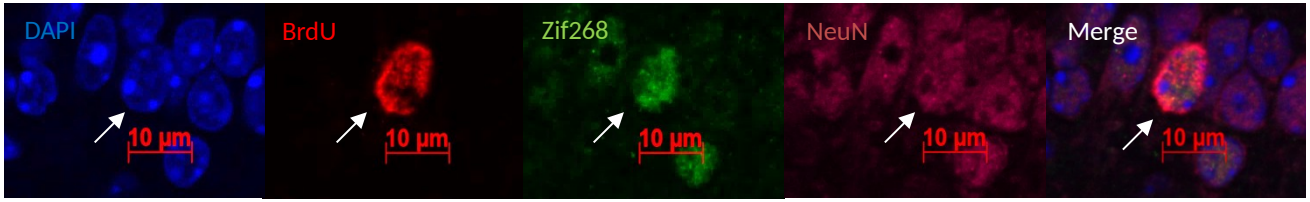

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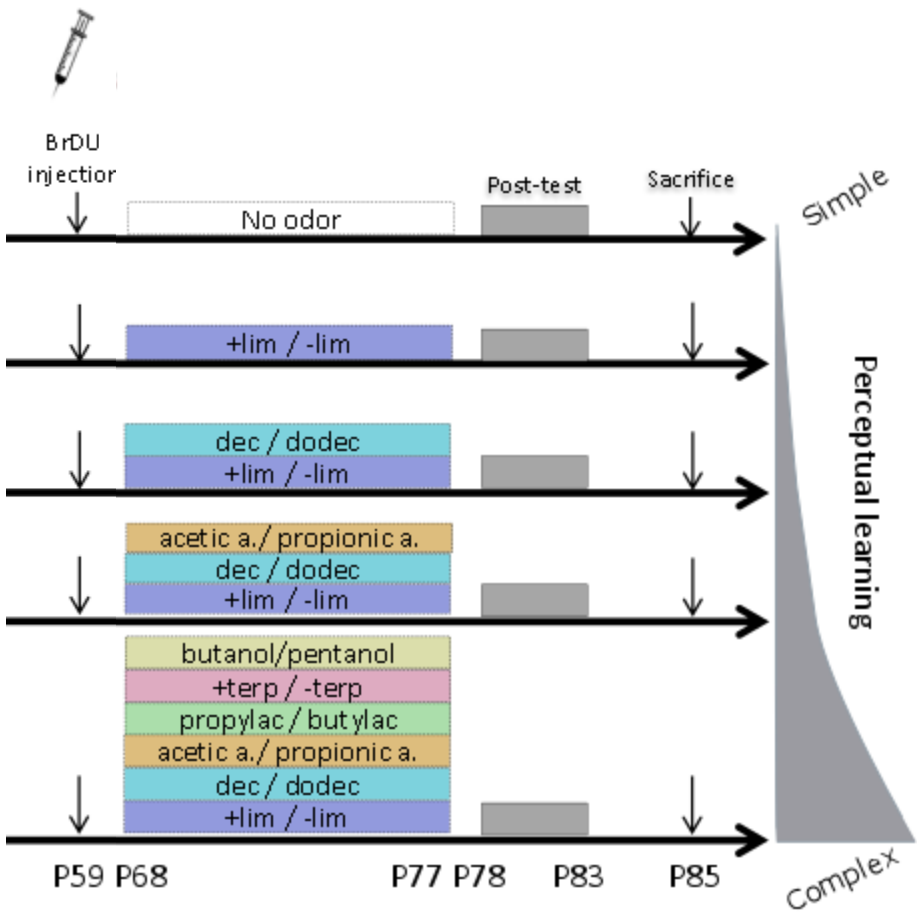
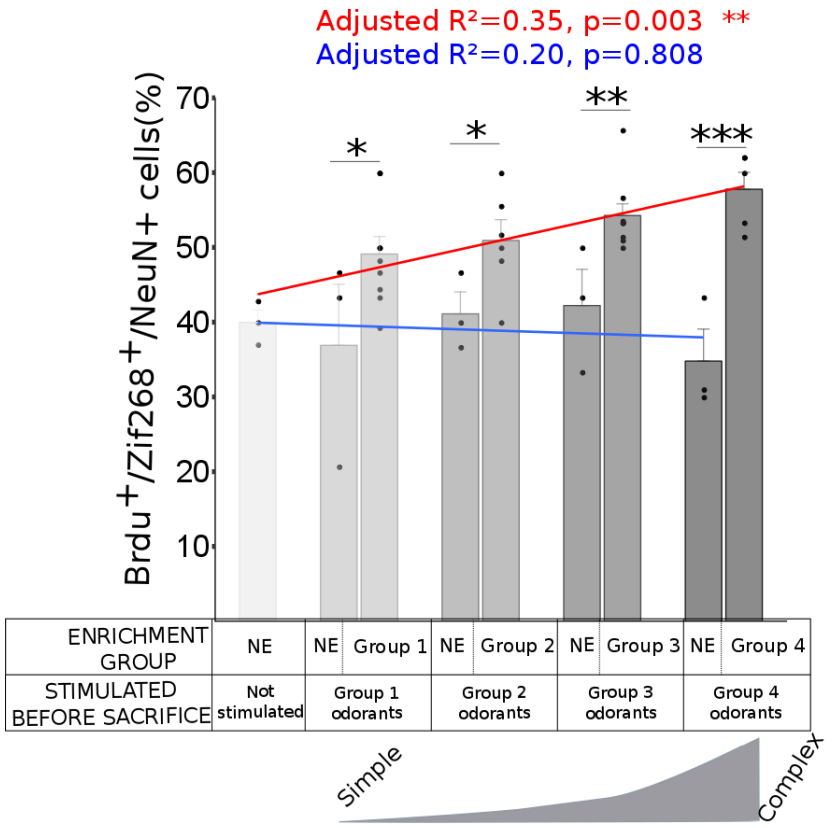
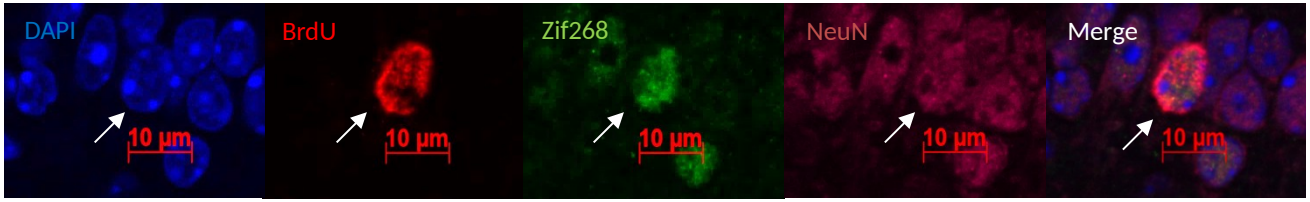
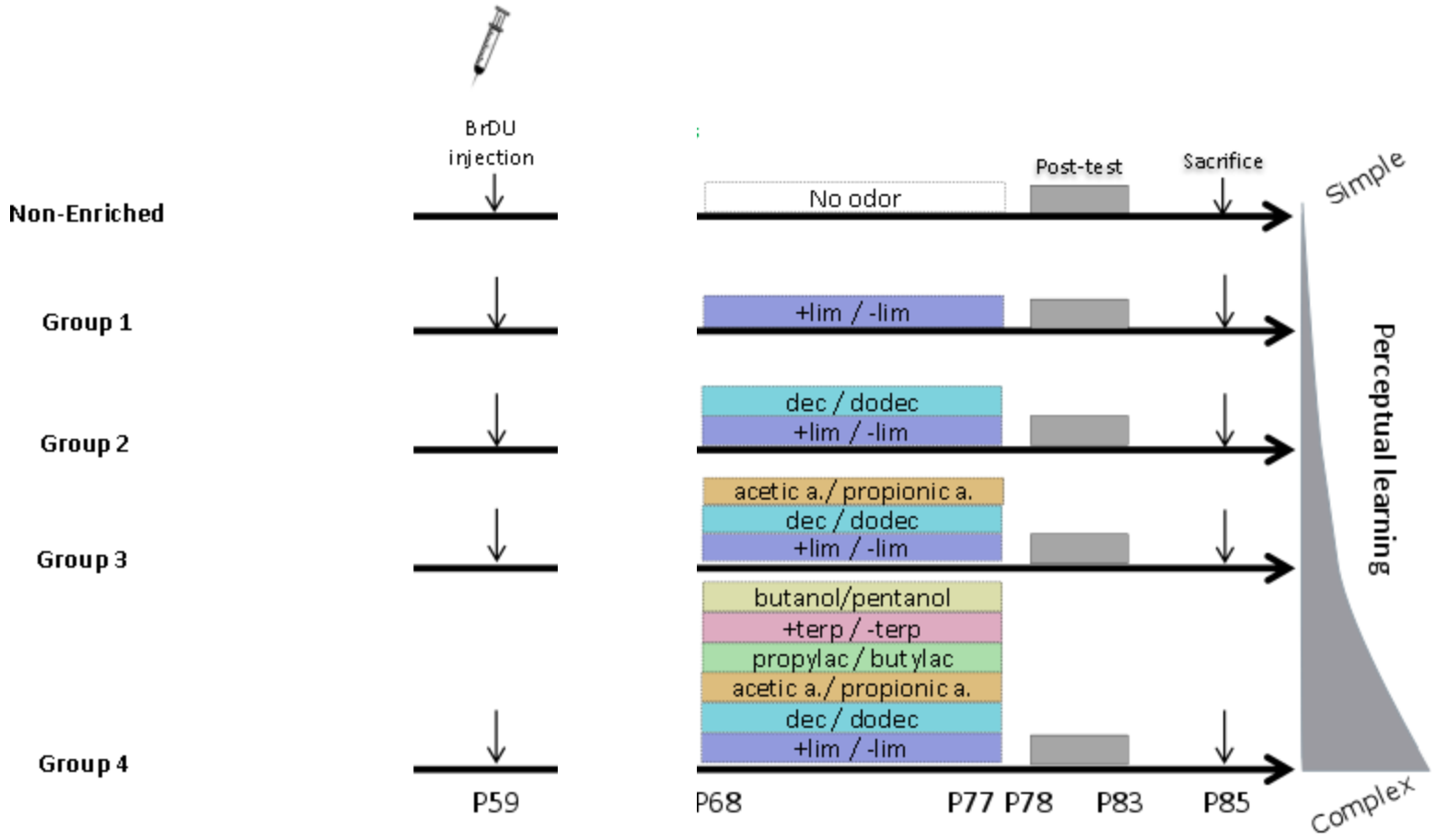






Increasing the complexity of perceptual learning enhances the recruitment of adult-born neurons in the processing of the learned odorants

Question 2: Do adult-born neurons exhibit modifications of morphology associated with learning and if so are those modifications specific to adult-born neurons ?



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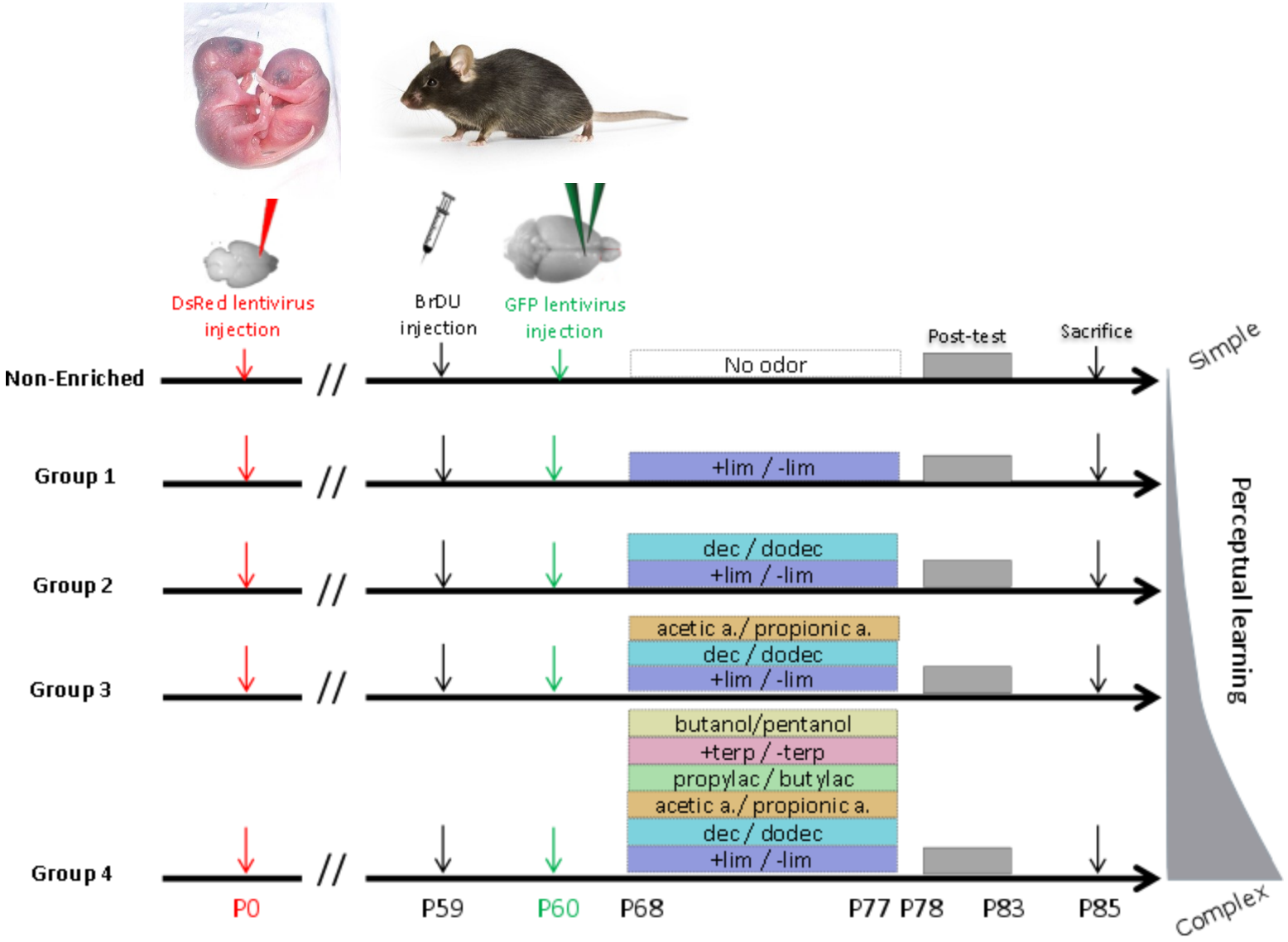
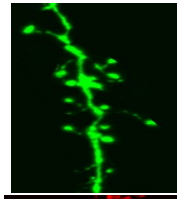
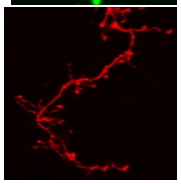
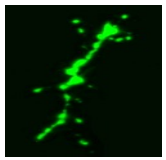
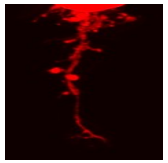


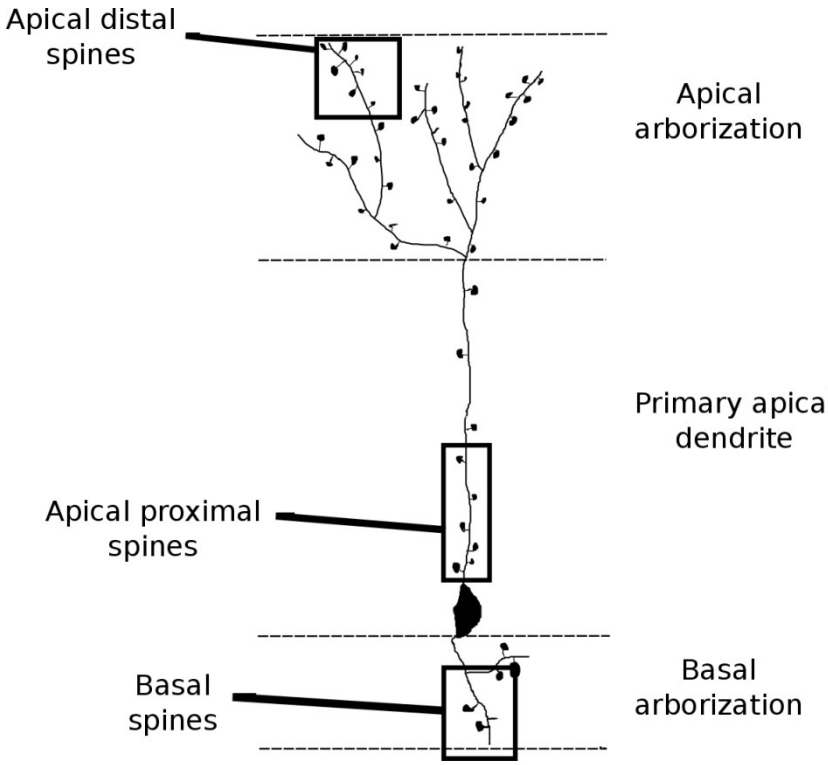
Adult-born neurons and preexisting neurons morphology:



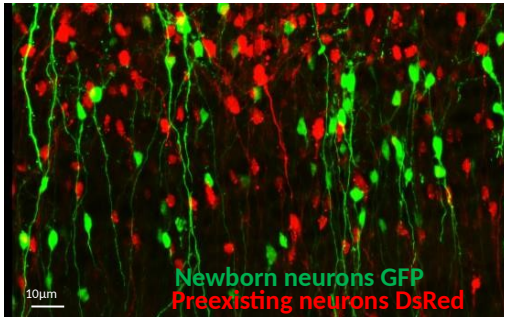


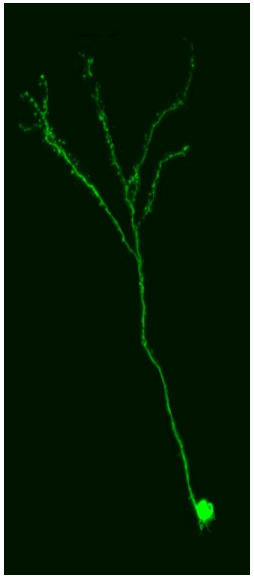


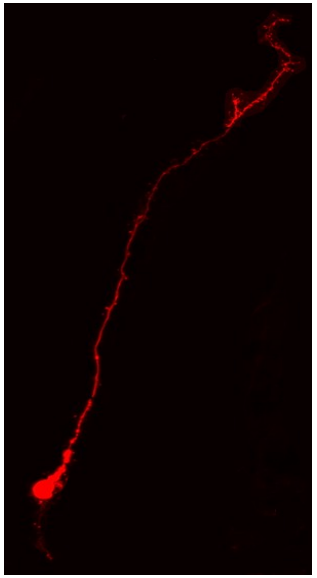




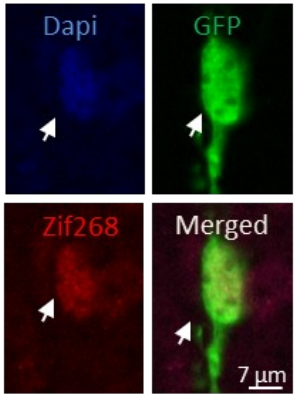
Derived from Kelsh et al. 2009



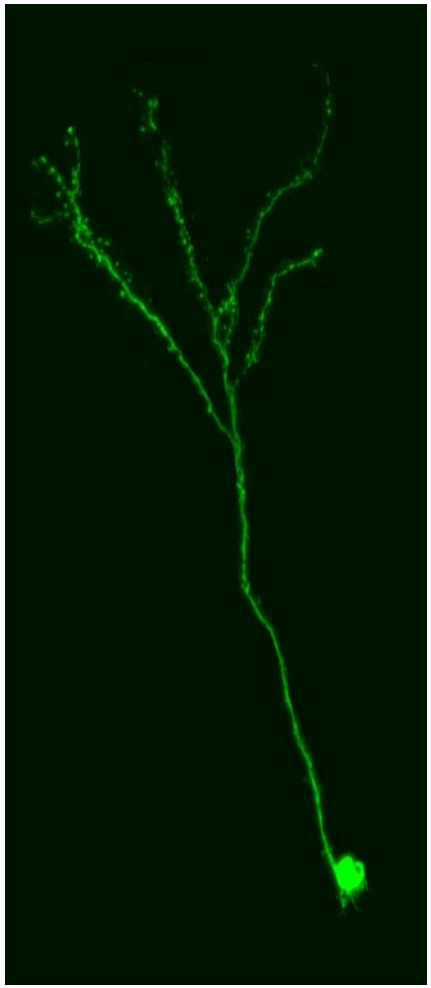




Zif+ neuron



Adult-born neurons:



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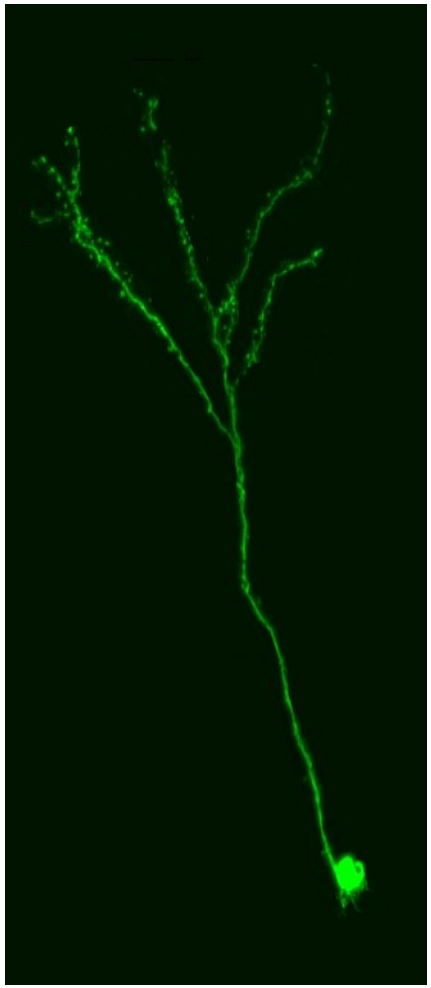

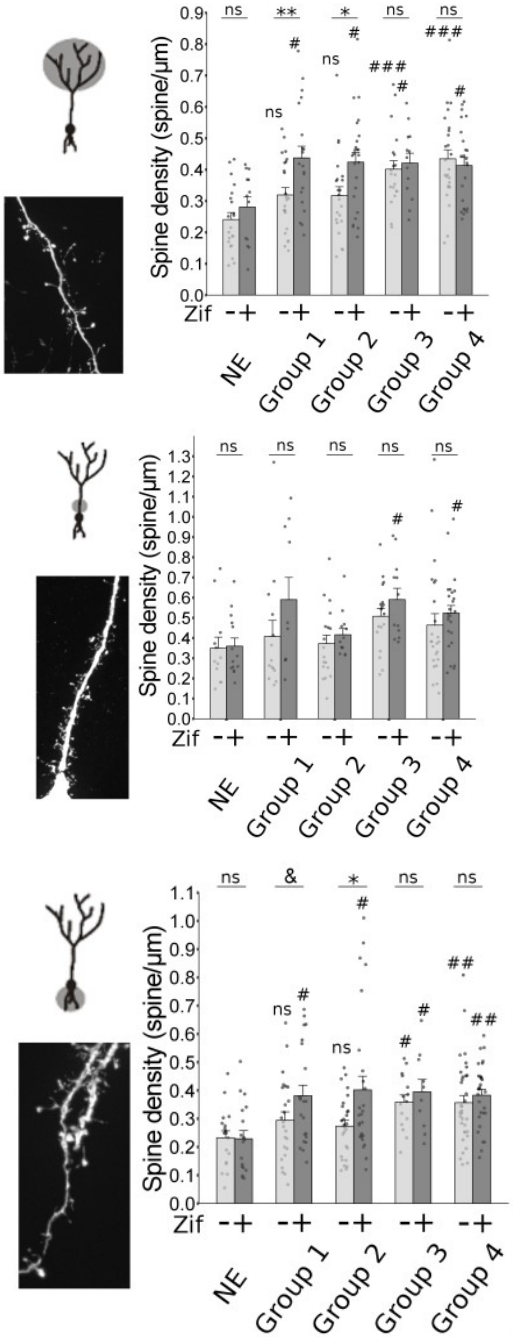

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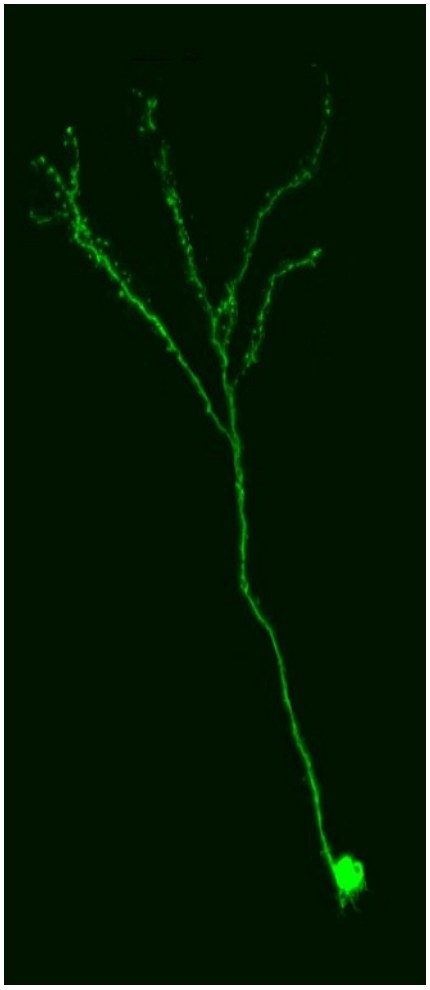
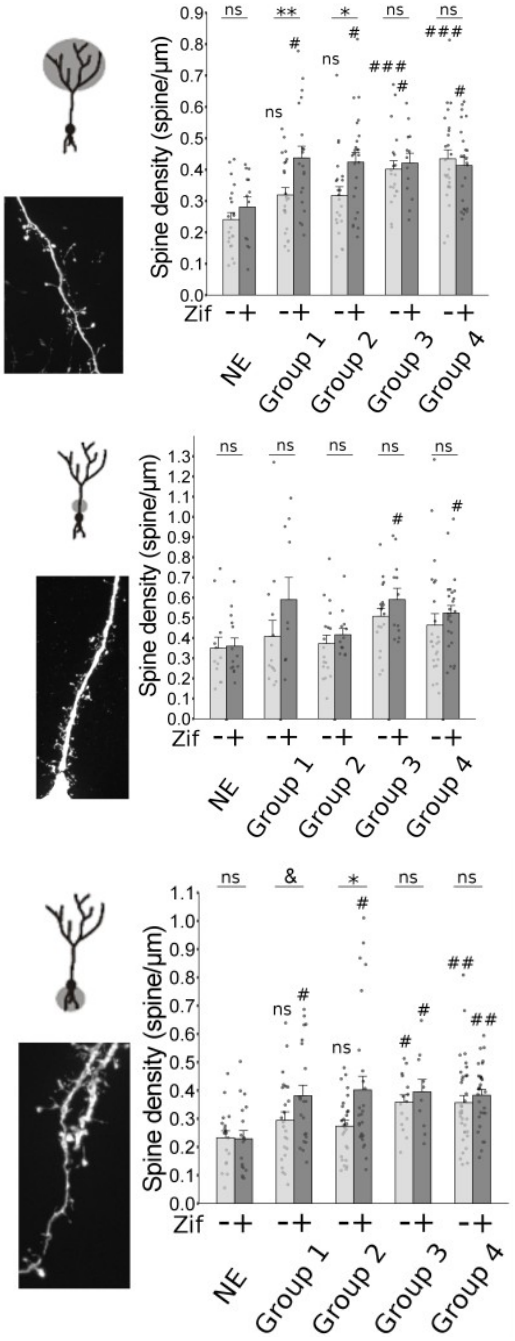
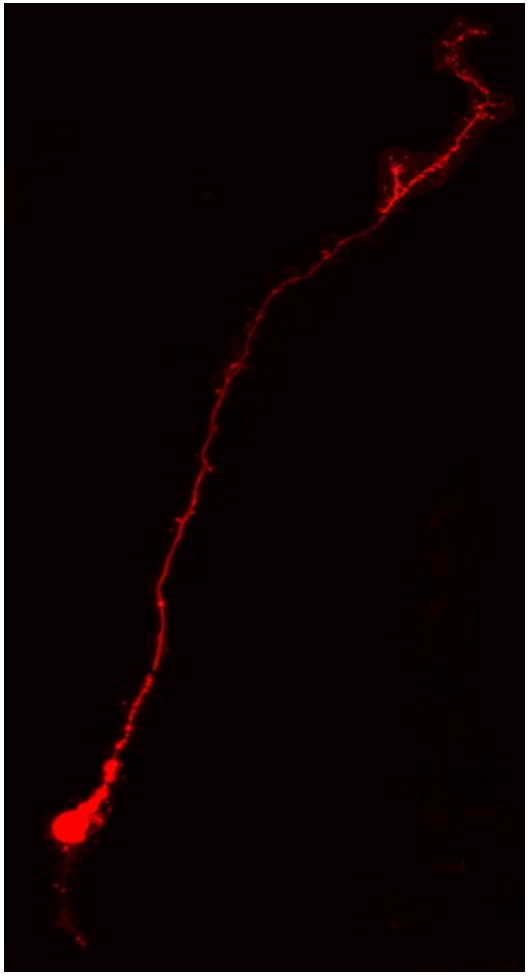
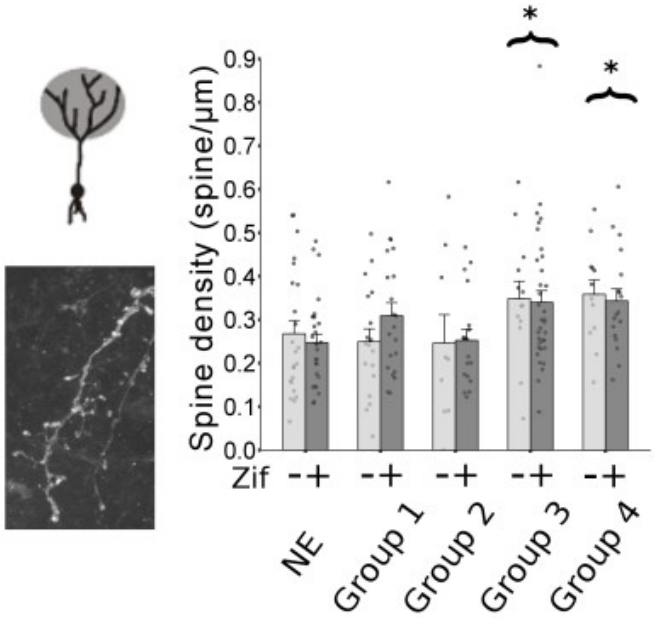




Increasing the complexity of perceptual learning increased structural plasticity of adult-born neurons

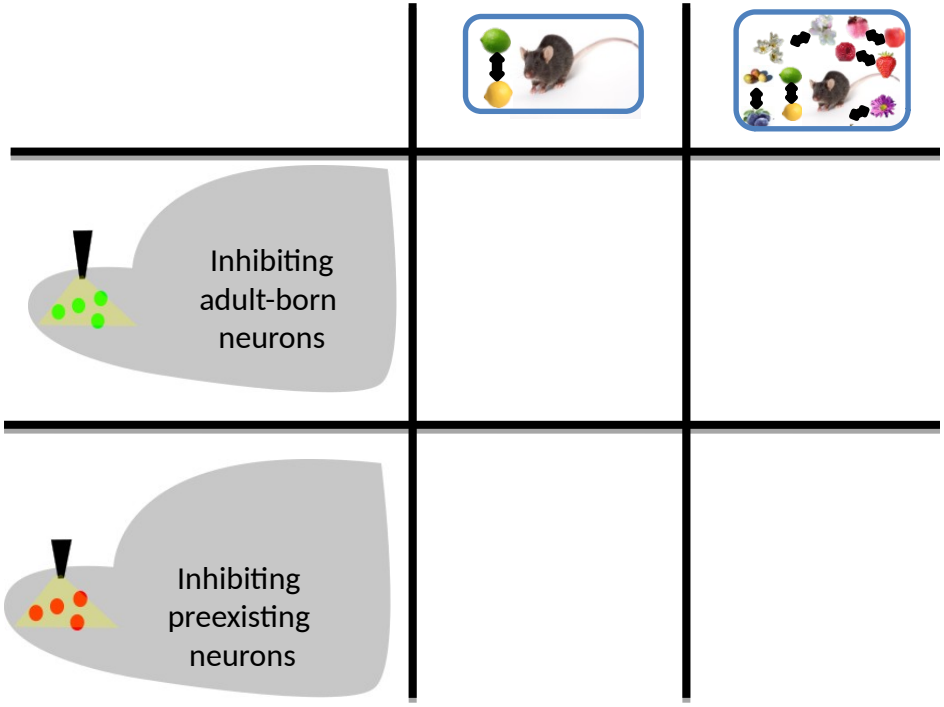
Preexisting neurons :





Perceptual learning induces limited morphological changes in preexisting neurons

Question 3: What is the relative functional contribution of each neural population to simple versus complex learning ?



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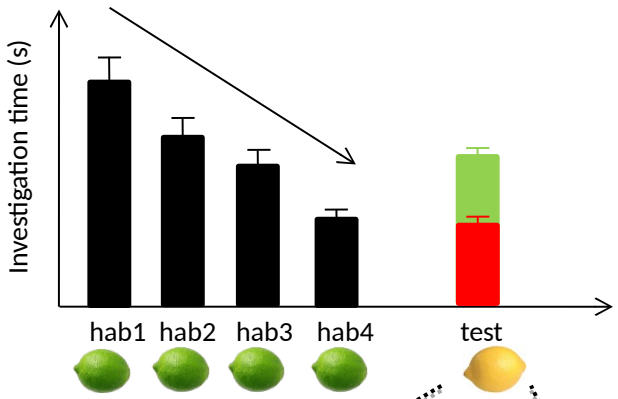

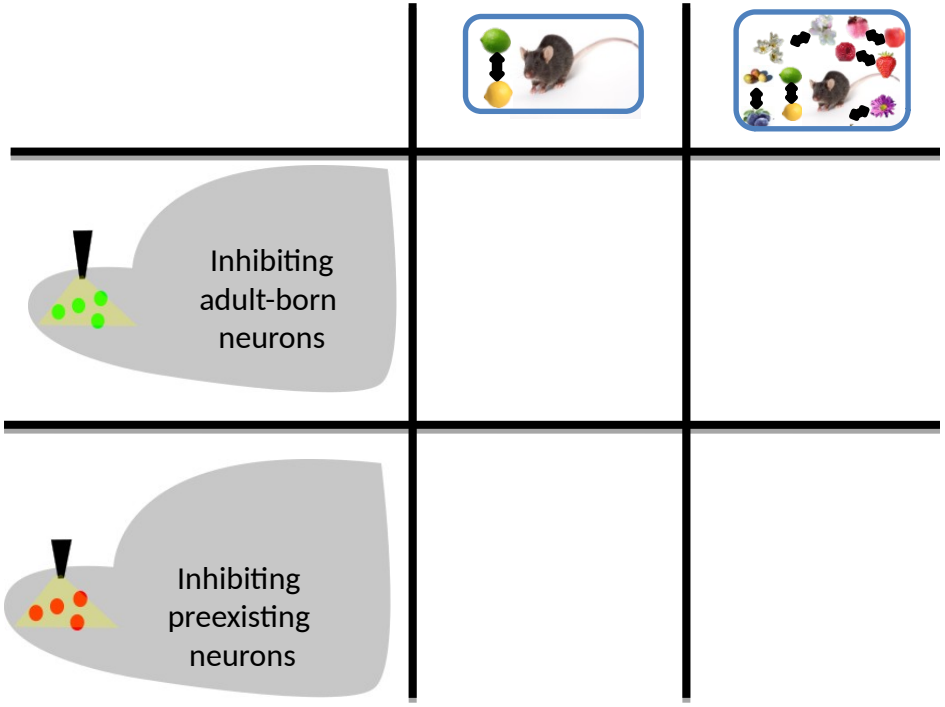

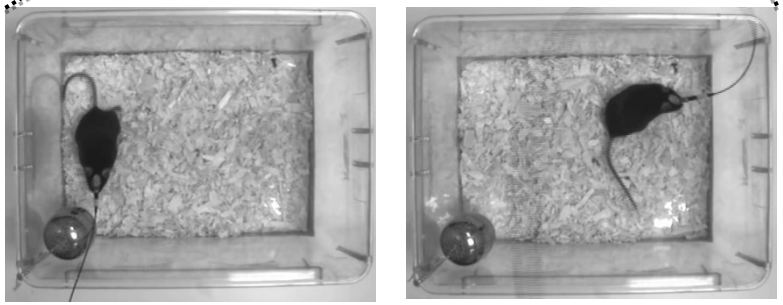

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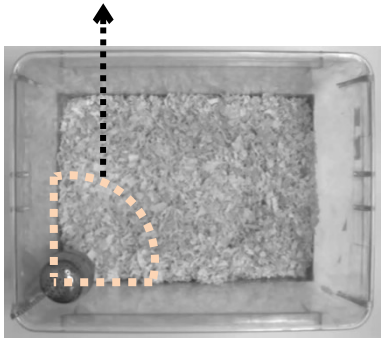
Sniffing Area



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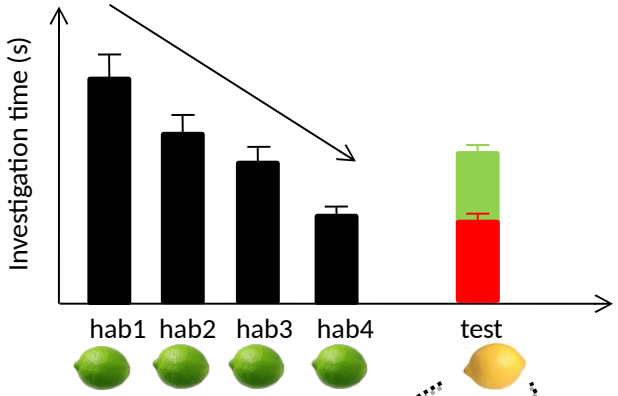
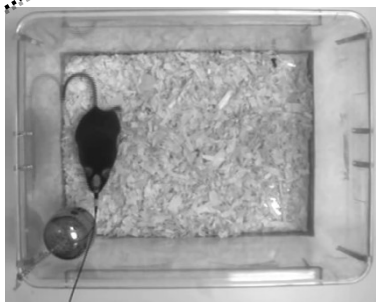


Inhibiting adult-born neurons	Discrimination Impaired ?	Discrimination Impaired ?
Inhibiting preexisting neurons	Discrimination OK ?	Discrimination Impaired ?



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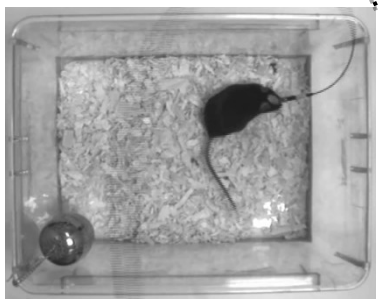

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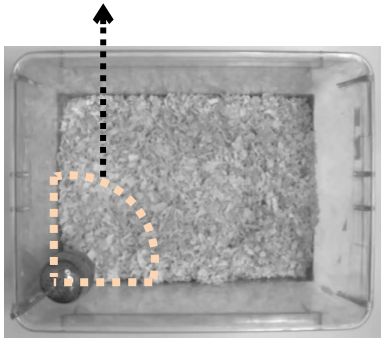
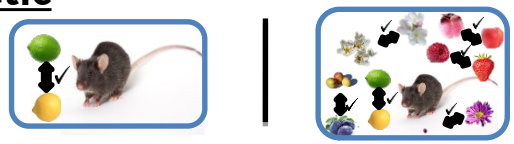
Sniffing Area



Optogenetic

Optogenetic



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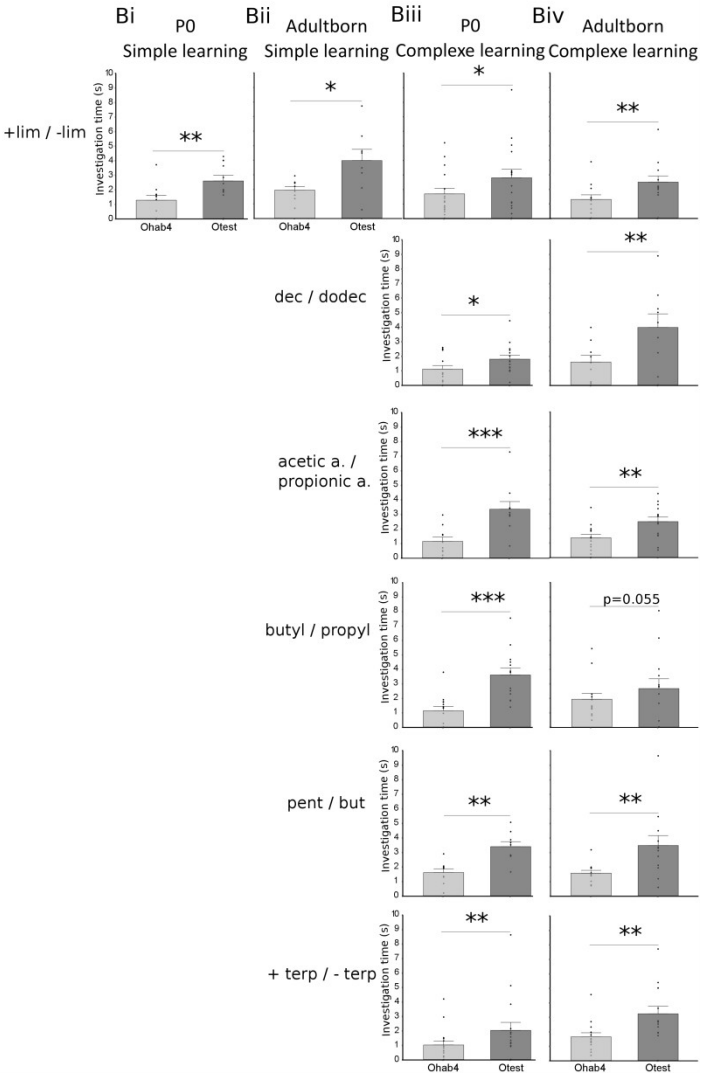
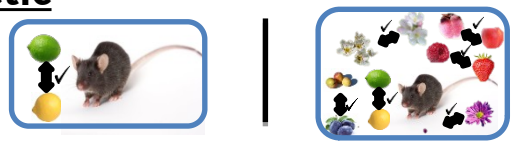


Optogenetic



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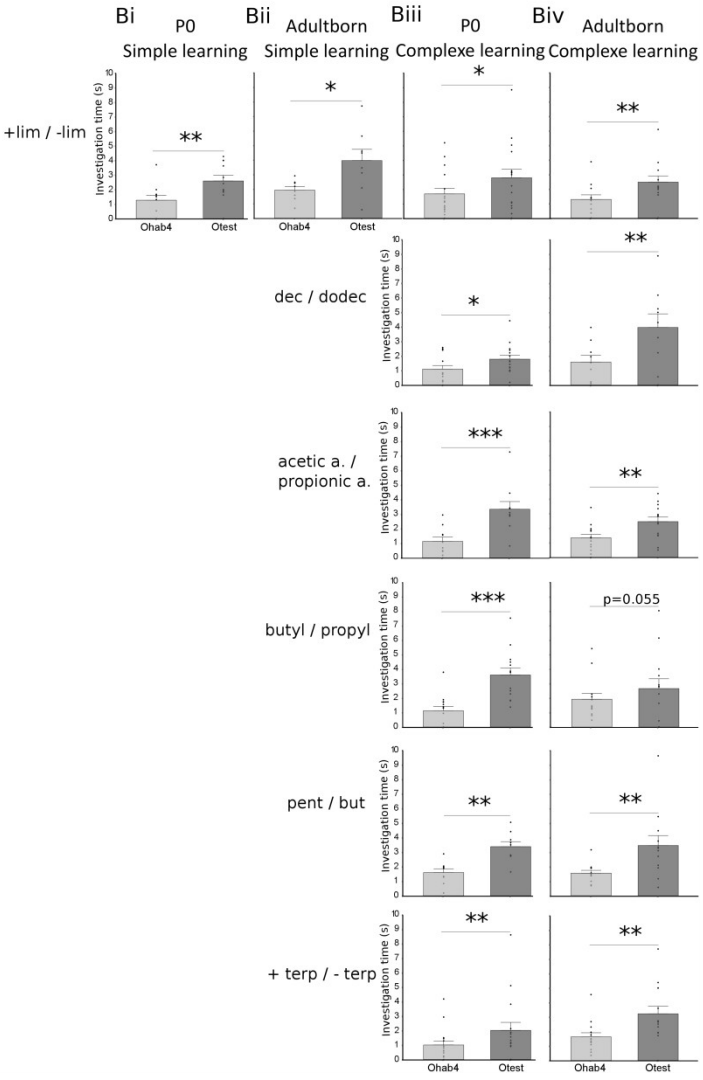

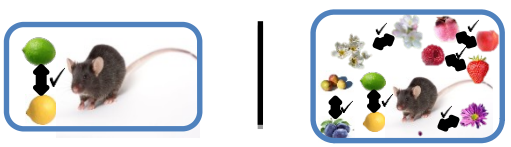

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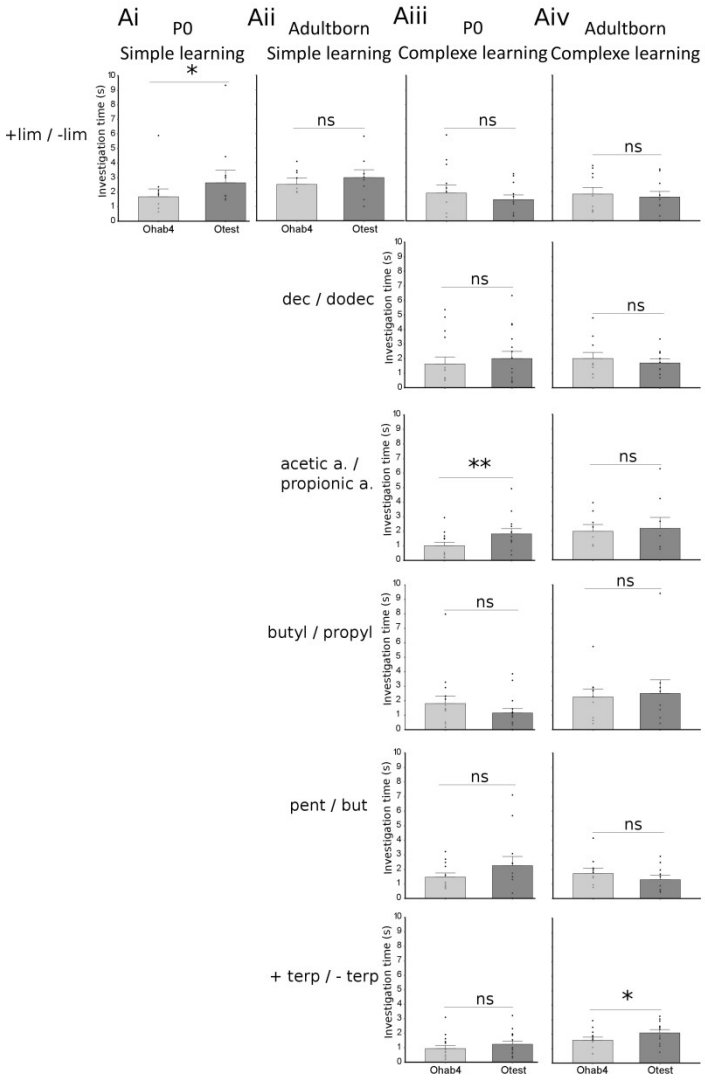

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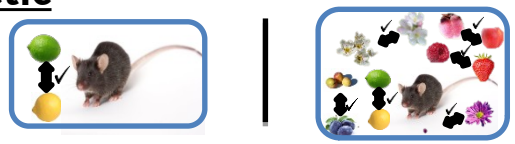

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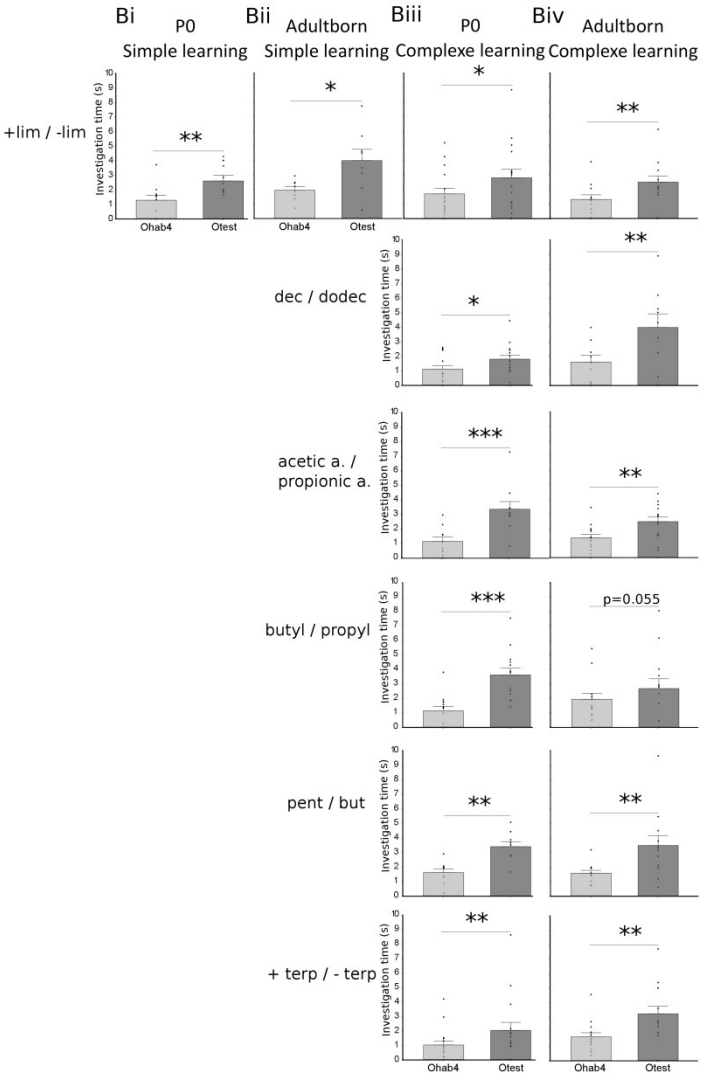

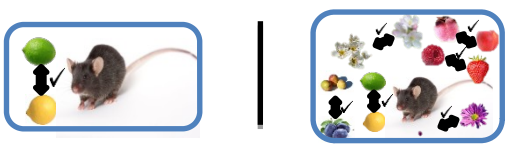

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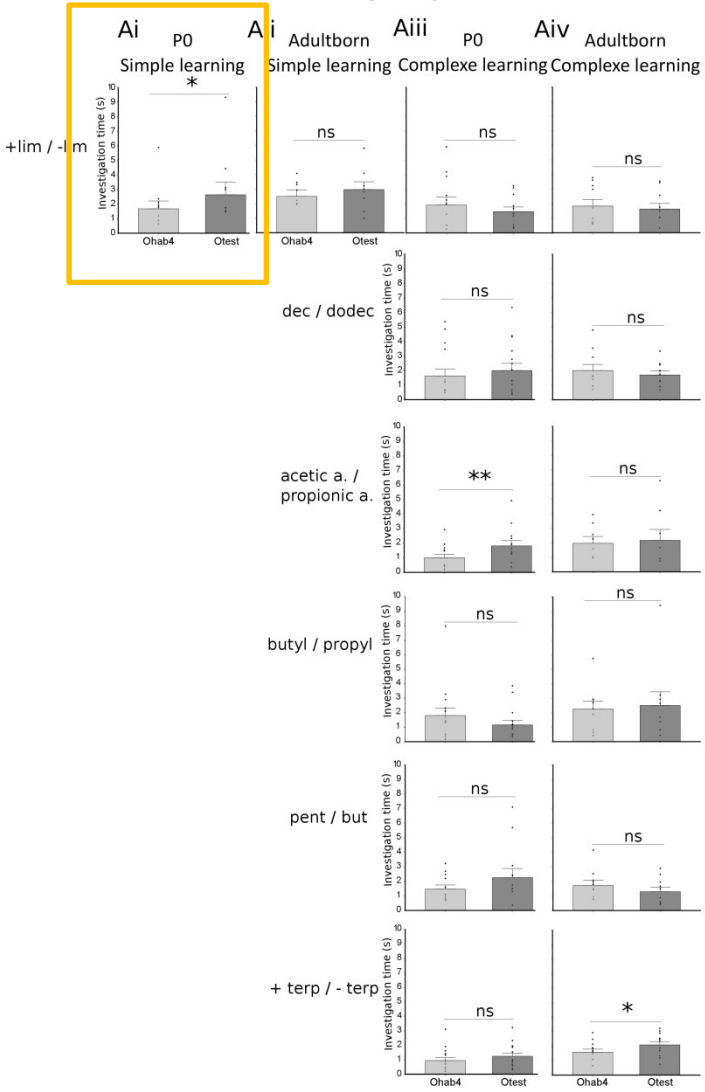

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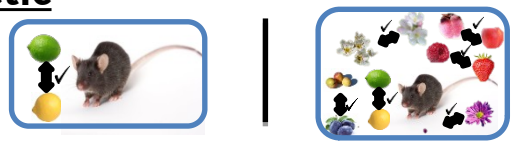
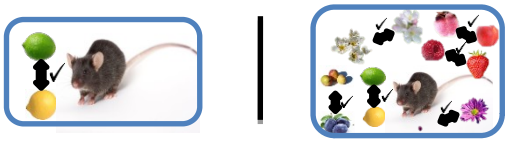
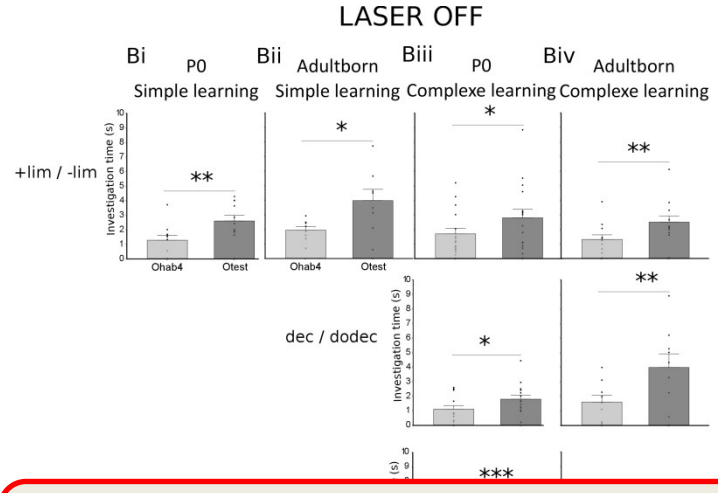
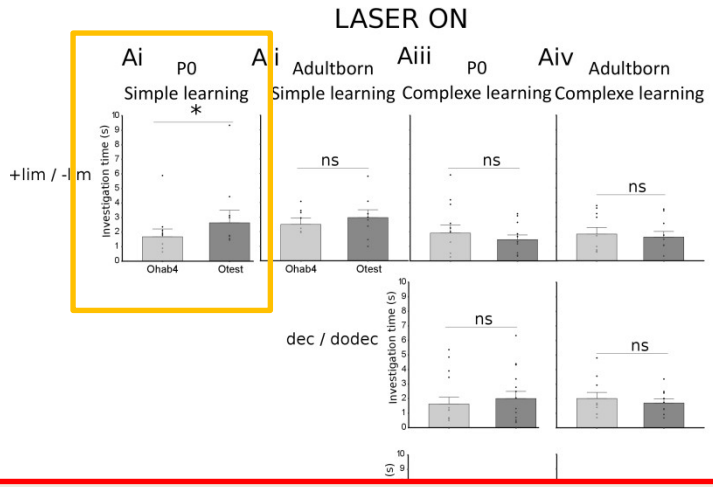
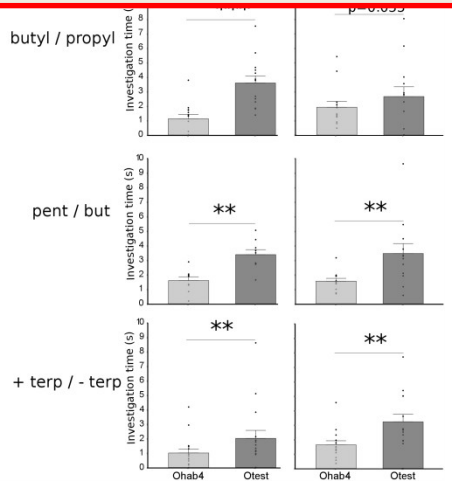


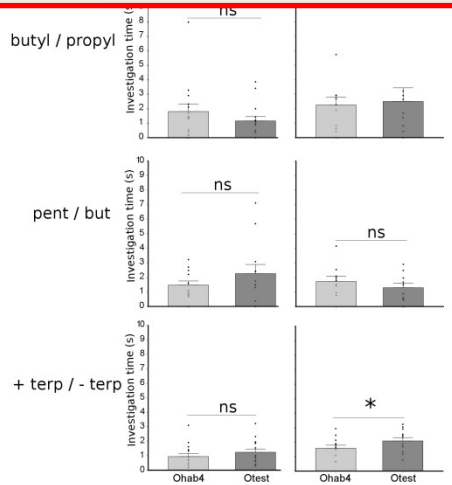




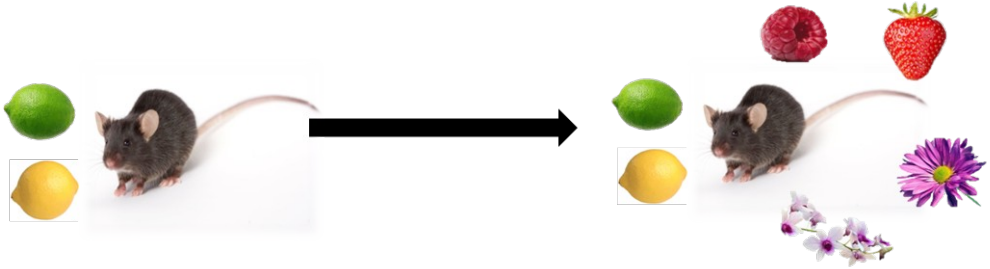


Optogenetically inhibiting either preexisting or adult-born neurons reveals their functionally distinct involvement in simple and complex perceptual learning.

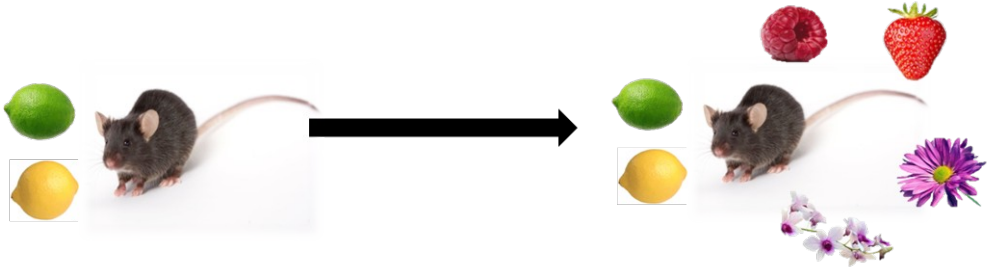




Conclusion

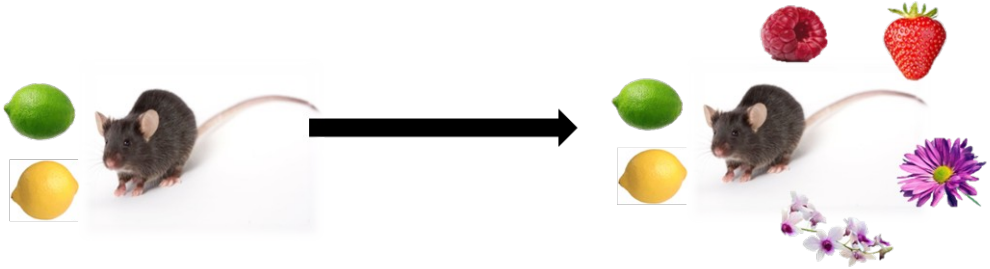


Conclusion



Perceptual learning is associated with:

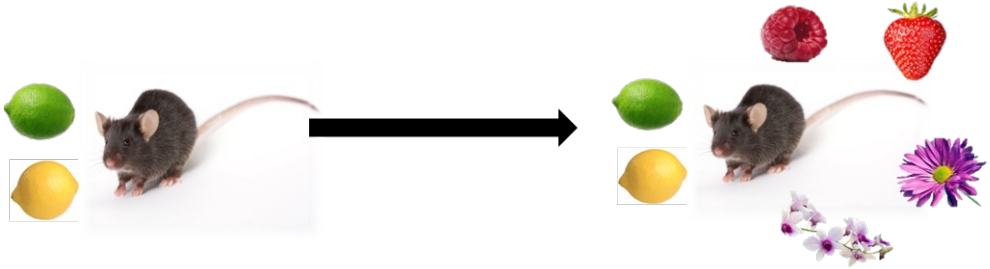
Conclusion



Perceptual learning is associated with:

- Increased survival of adult-born neurons independently of learning complexity

Conclusion



Perceptual learning is associated with:

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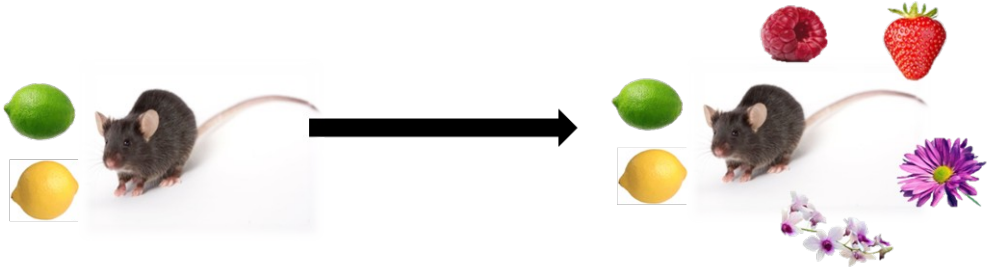
Conclusion



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- Increased survival of adult-born neurons independently of learning complexity
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- Increased spines density at the apical distal, apical proximal and basal domains of adult-born neurons both in simple and complex learning paradigms

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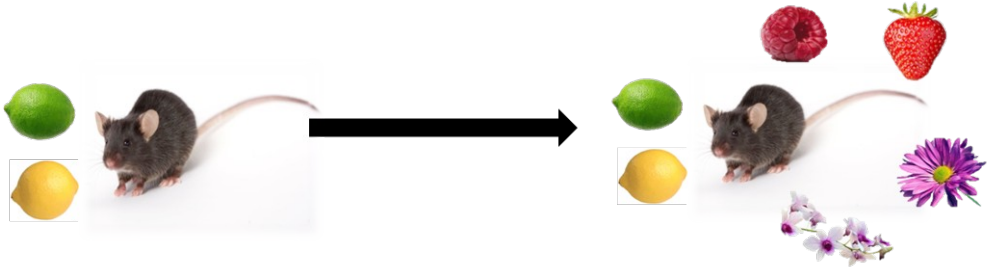

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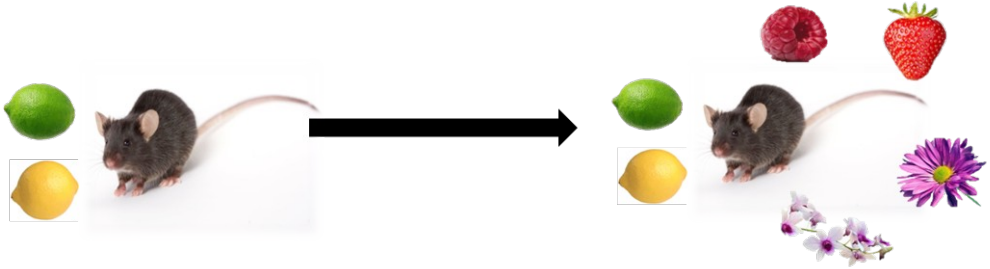
And:

Conclusion



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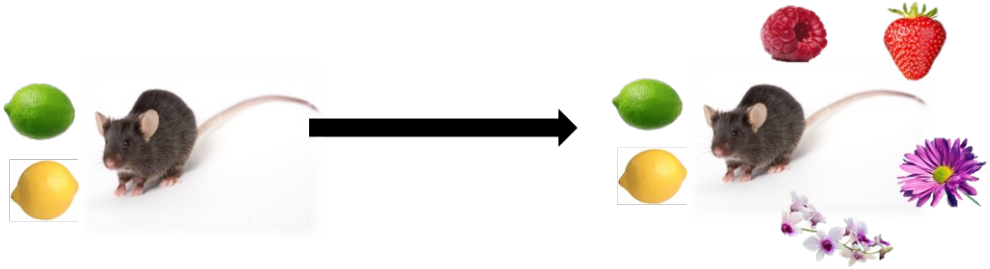

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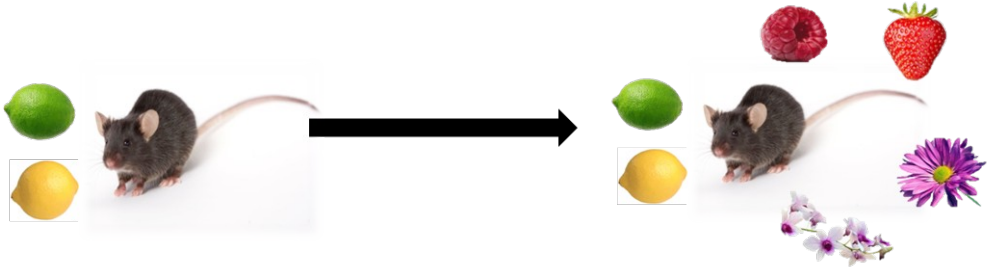
And:

- Adult-born neurons are necessary to underlie simple and complex perceptual learning
- Preexisting neurons are necessary for complex but not for simple perceptual learning

Conclusion



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Take home message:

Adult neurogenesis exhibits **limits in its adaptive abilities to answer complex behavioral demands** but at the same time **is necessary for simple and complex olfactory learning**.

Aknowledgements

¨Lyon

Nathalie Mandairon
Anne Didier
Marion Richard
Jeremy Forest
Maellie Midroit
Claire Terrier
Joëlle Sacquet
Marine Breton

Laura Chalençon
Marc Thevenet

¨Paris
Isabelle Caillé