Lyon Neuroscience Research Center

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


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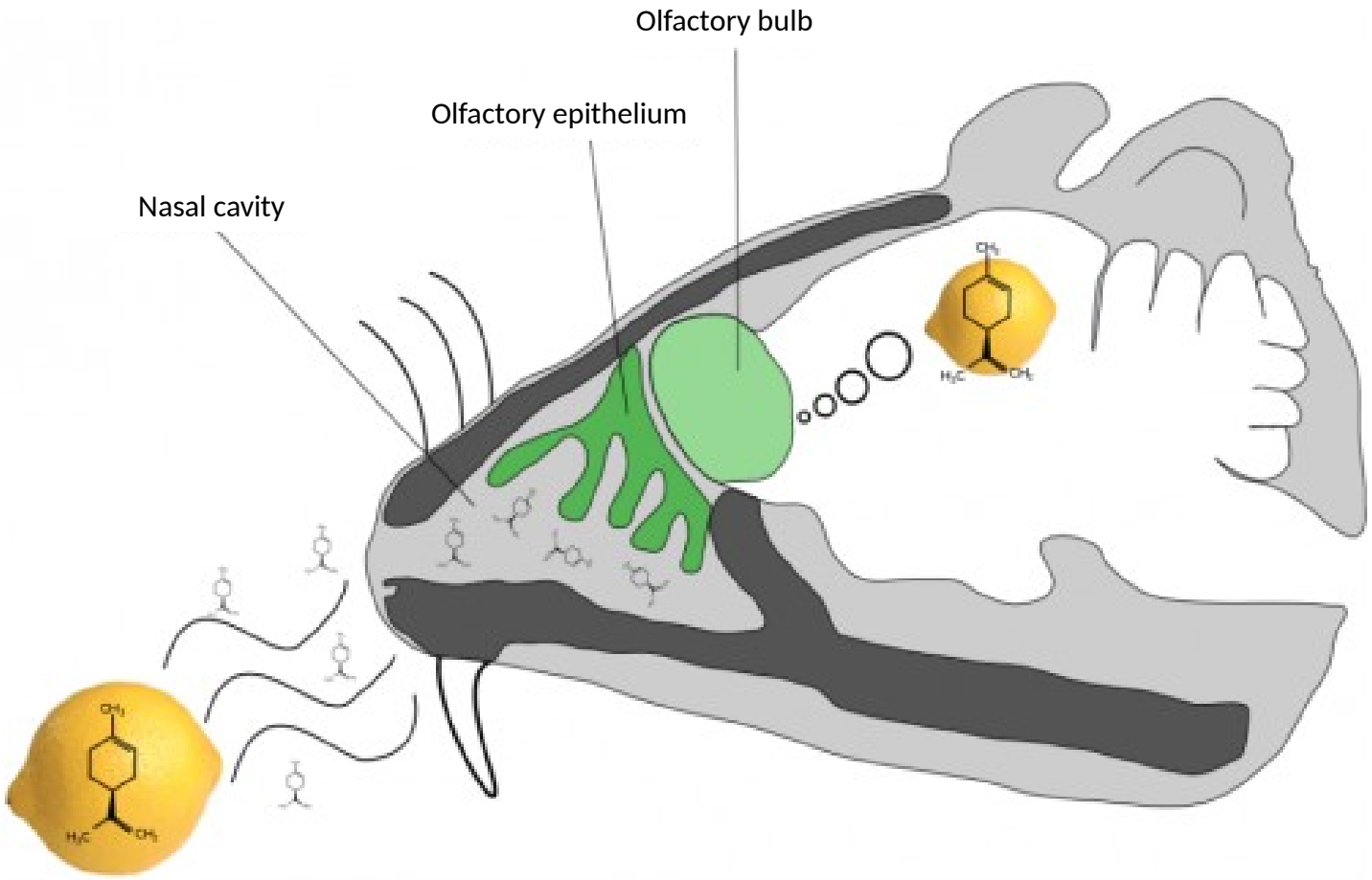
# Olfactory system

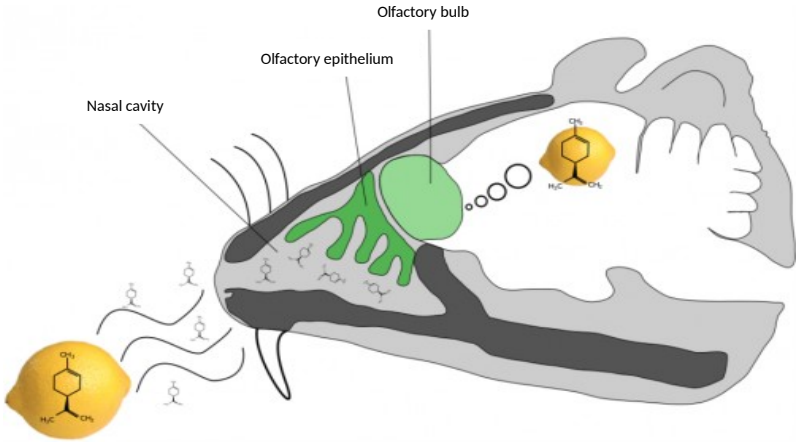
| | Food search | Danger avoidance | Social interactions |
|---|---|---|---|
| Human |  |  |  |
| Mice |  |  |  |

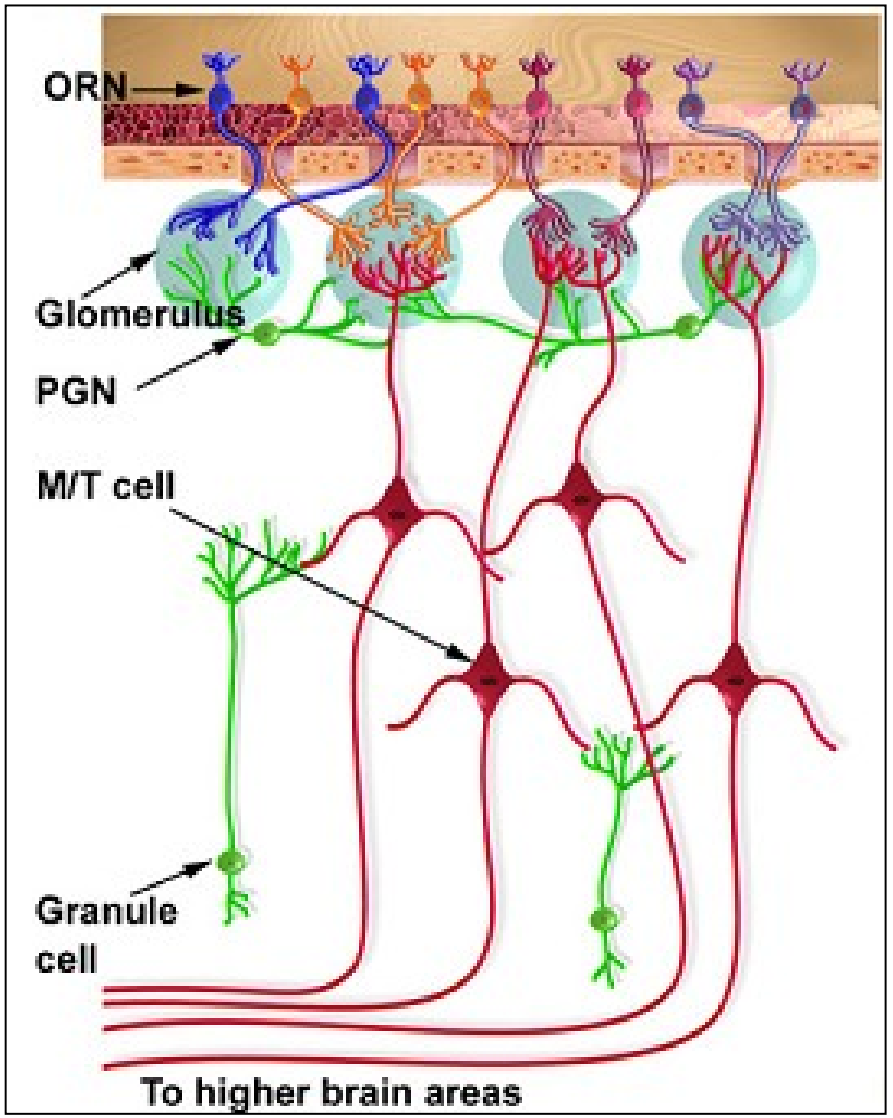
# Olfactory system




Modified from Forest, Midroit and Mandairon, 2017, Pollution atmospherique.

# Olfactory system

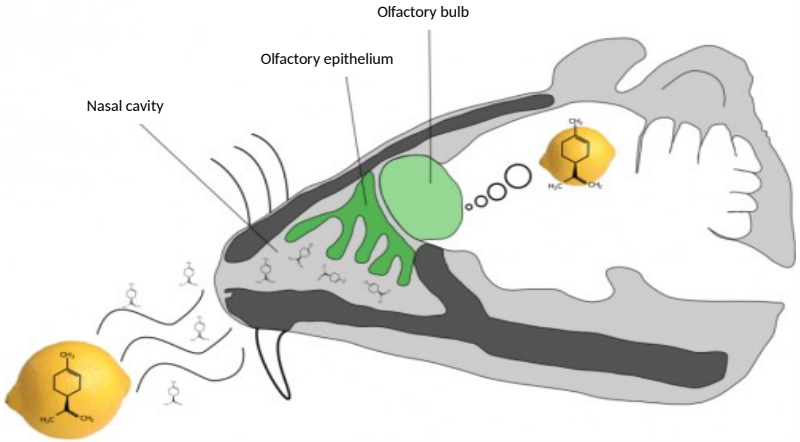


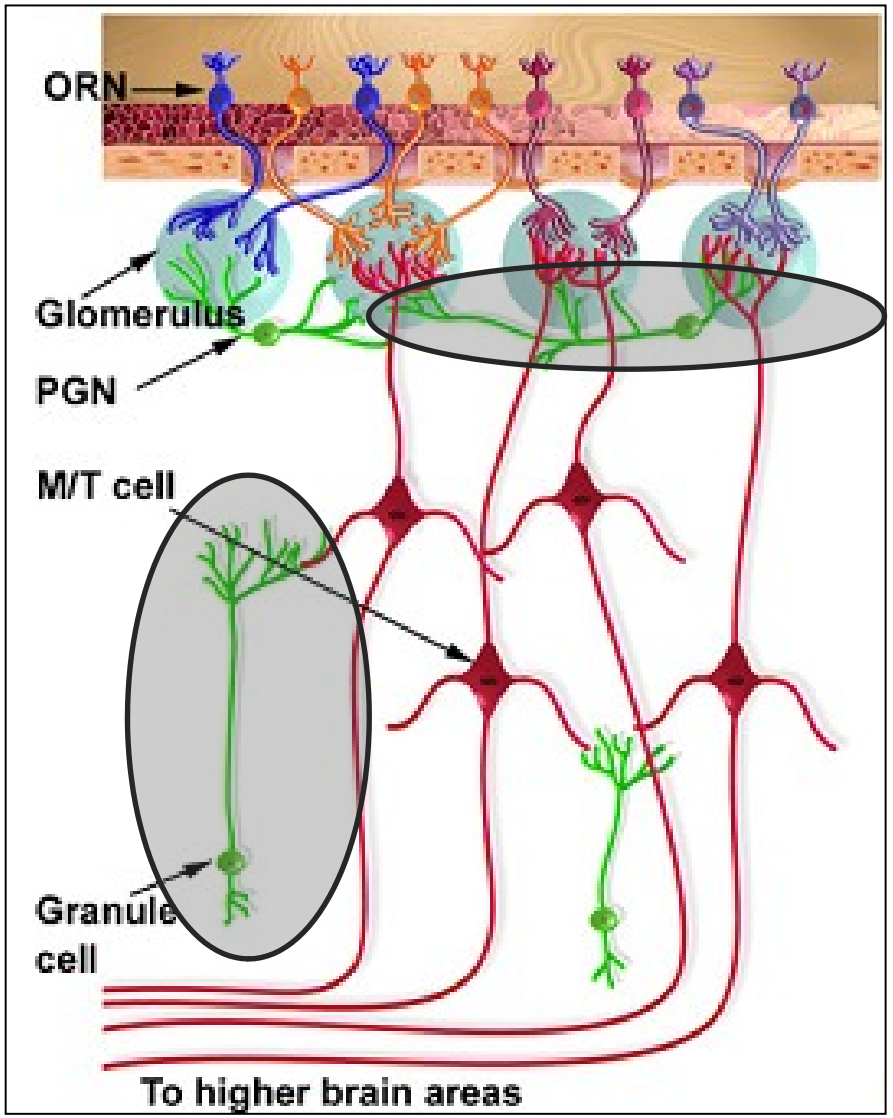




Adapted from Adam and Mizrahi 2010 Curr Opin Neurobiol

Buck and Axel, Cell, 1991; Duchamp-Viret et al., Science, 1999; Shepherd, Physiol Rev, 1972

# Olfactory system

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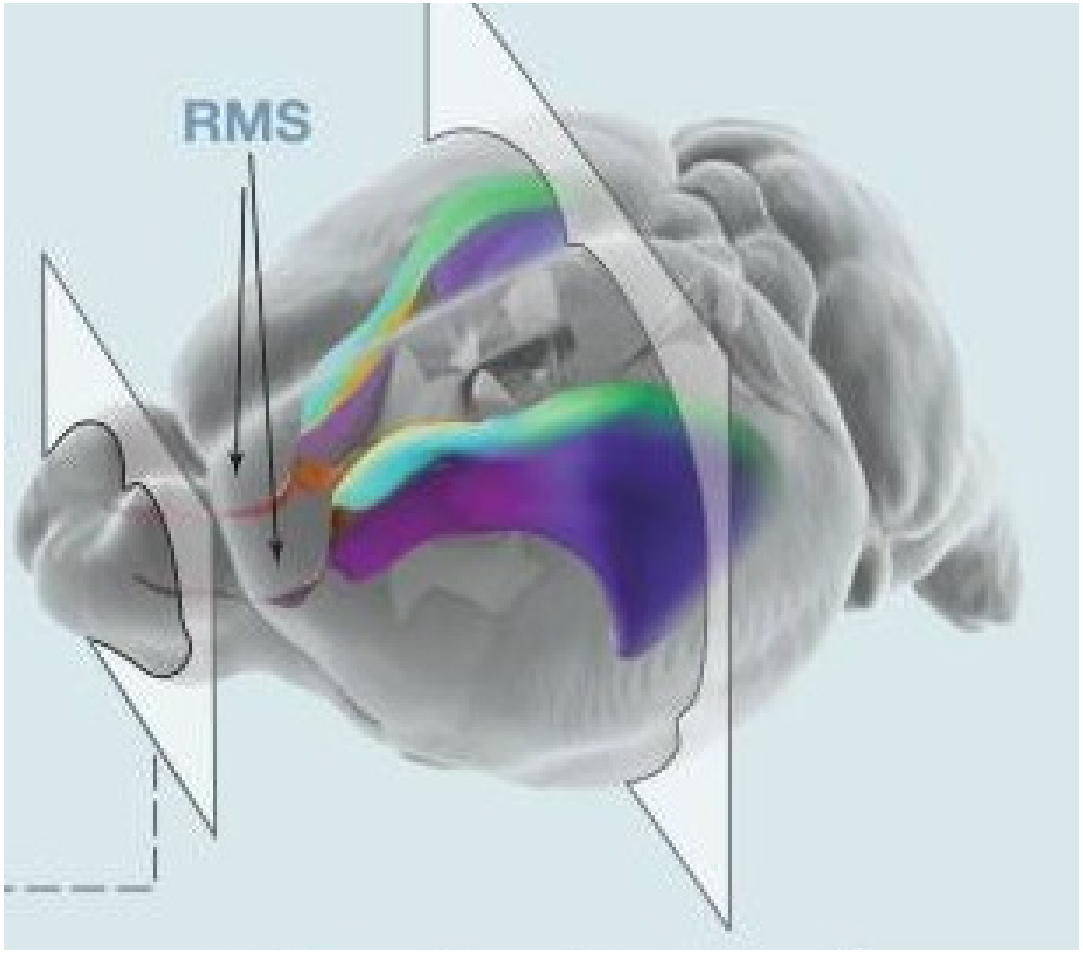
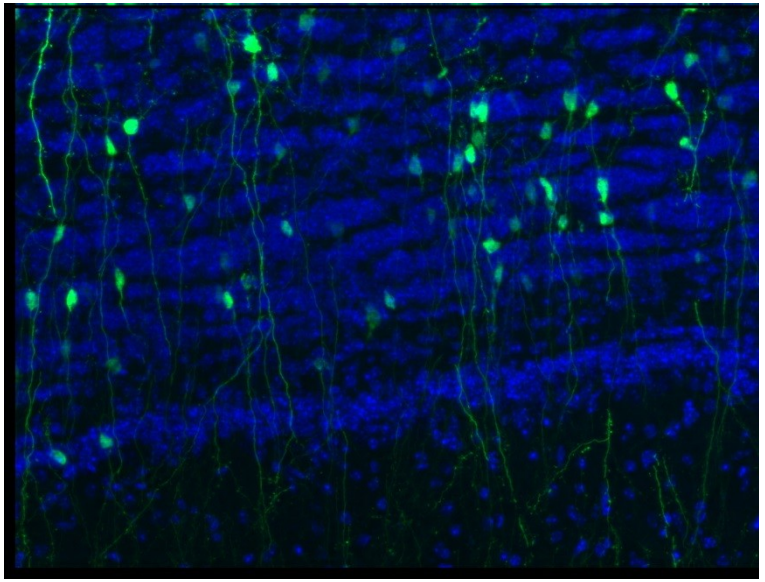
Buck and Axel, Cell, 1991; Duchamp-Viret et al., Science, 1999; Shepherd, Physiol Rev, 1972

# Adult neurogenesis



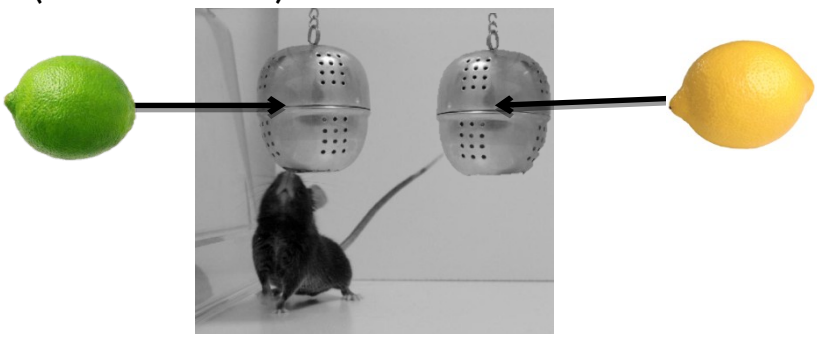

From Tong and Alvarez-Buylla, 2014, Neuron



Lledo et al. Nat Neuro 2006 ; Rocherfort et al. J Neuro 2002 ; Mandairon et al. Behav Neuro, 2006; Mandairon et al., J Neuro, 2011 ; Alonso et al., J Neuro, 2006 ; Moreno et al., PNAS, 2009

# Perceptual learning

Significant improvement of the discrimination abilities of perceptualy close odorants after repeated exposition to these same odorants(= enrichment).

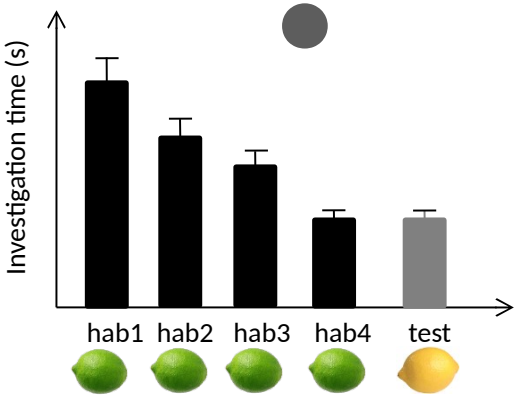


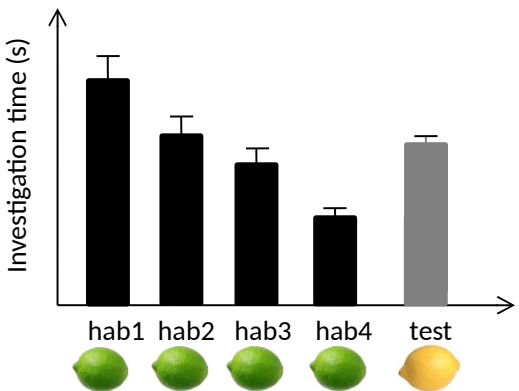
test | enrichment | test

1h/day
For 10 days

No discrimination

Discrimination

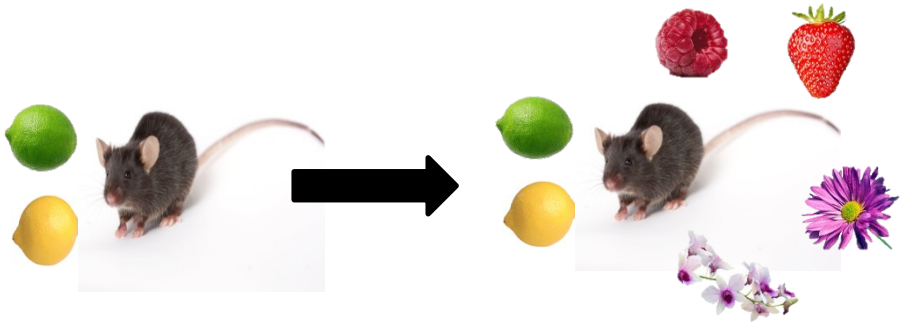


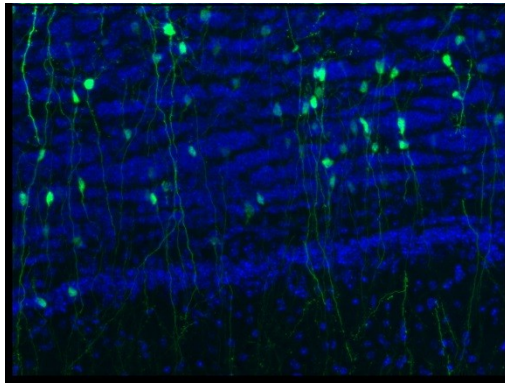

Mandairon et al., 2006
Moreno et al ., 2009, 2012

# Perceptual learning

- **Simple perceptual learning** paradigm = 1 pair of odorants.
  Real olfactory environnement is **more complexe** = several pairs of odorants



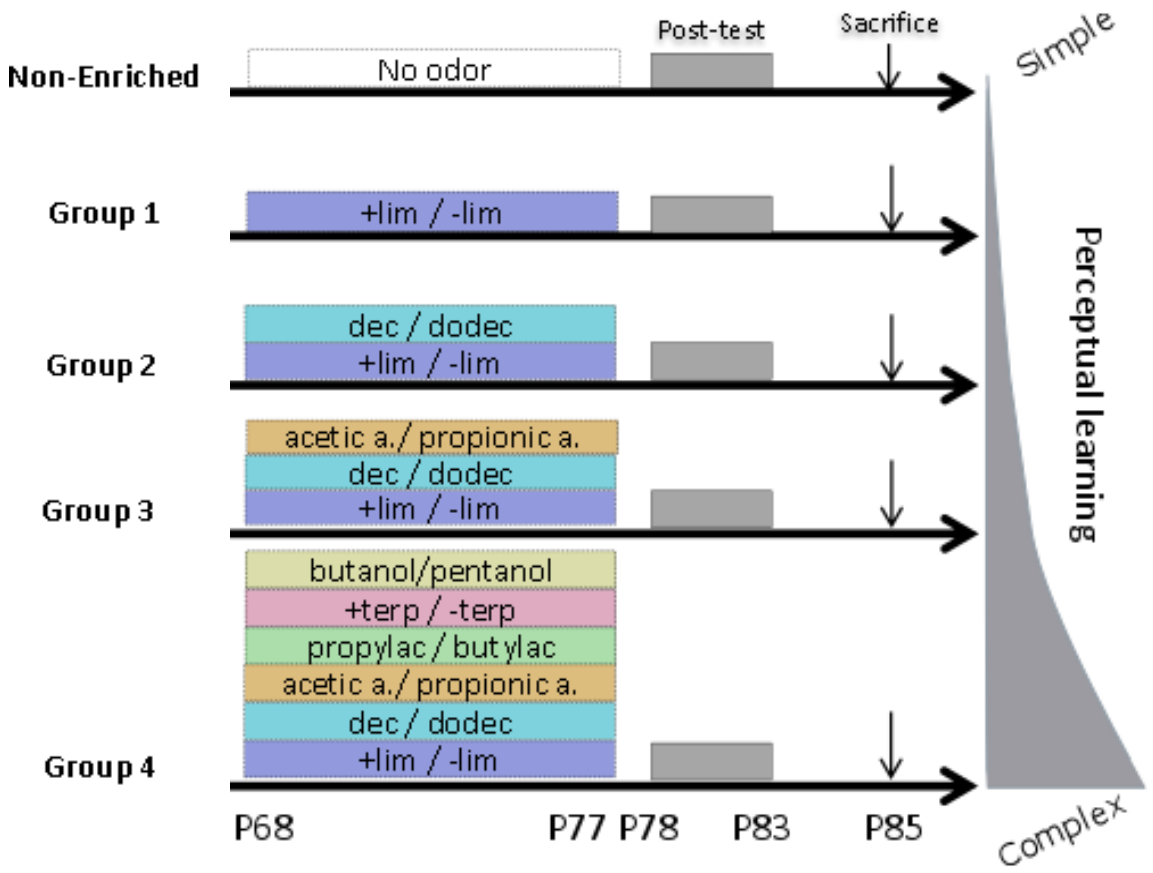
- There are **adult-born neurons** in the olfactory bulb but also **preexisting neurons**, born during ontogenesis



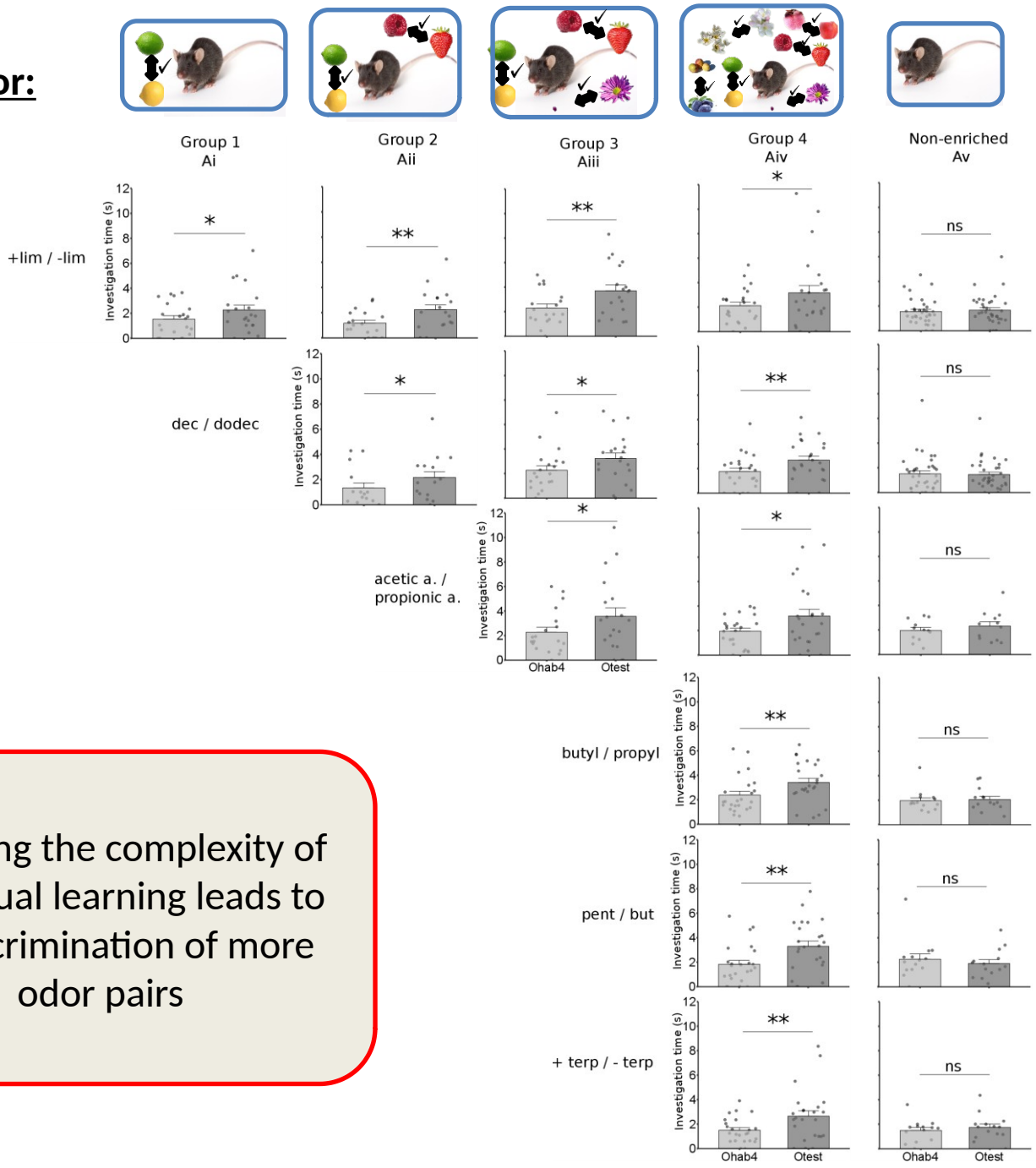
**Up to which point can we push neurogenesis?**

**Are adult-born neurons always necessary and/or sufficient?**

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

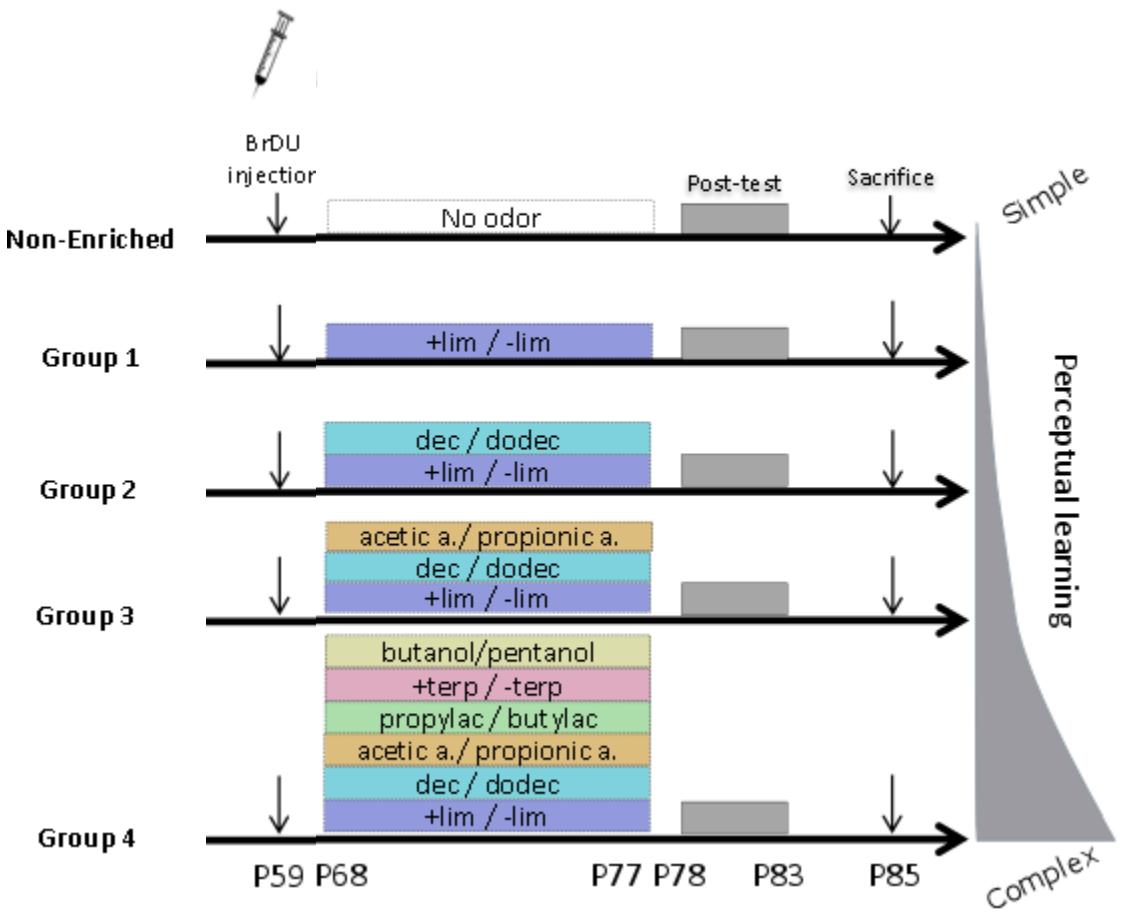


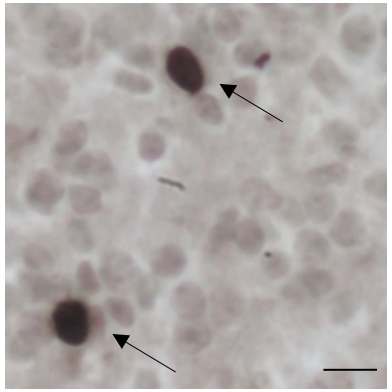
# 1 – Behavior:

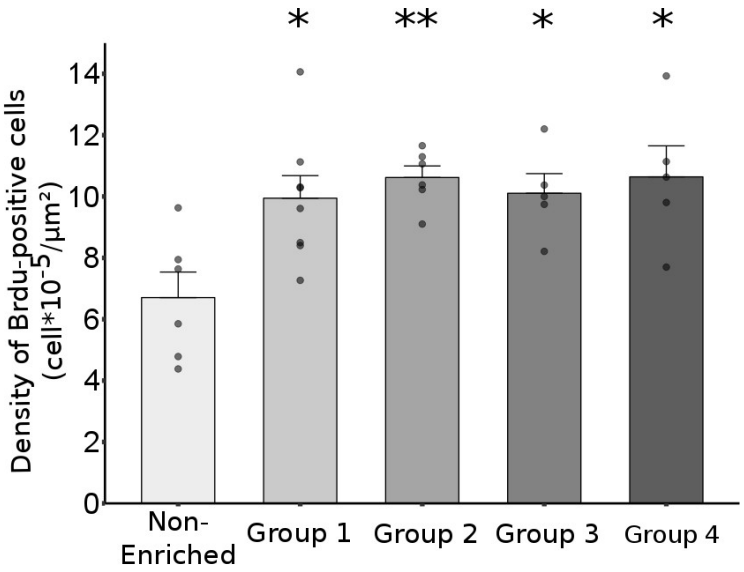



Increasing the complexity of perceptual learning leads to the discrimination of more odor pairs

## 2 – Newborn neurons density:

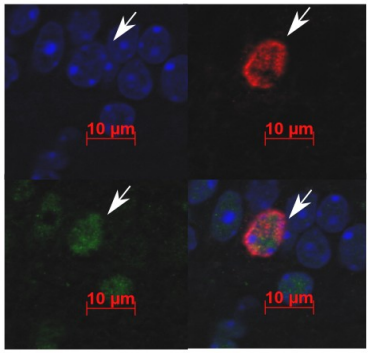


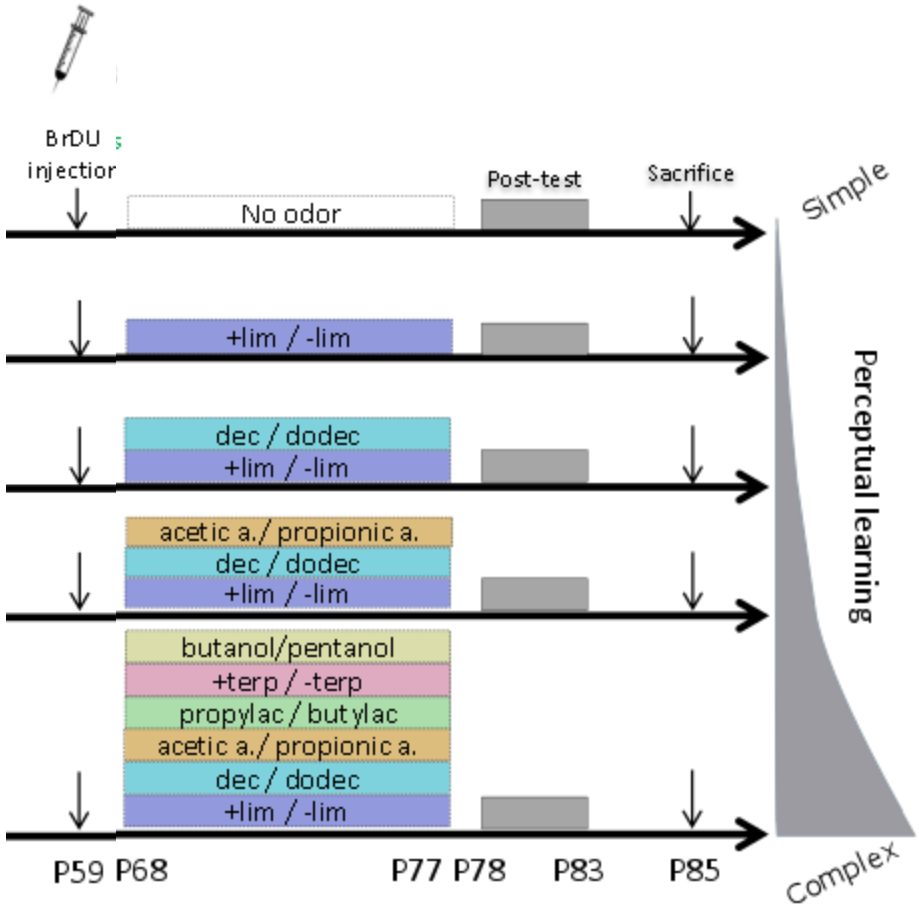



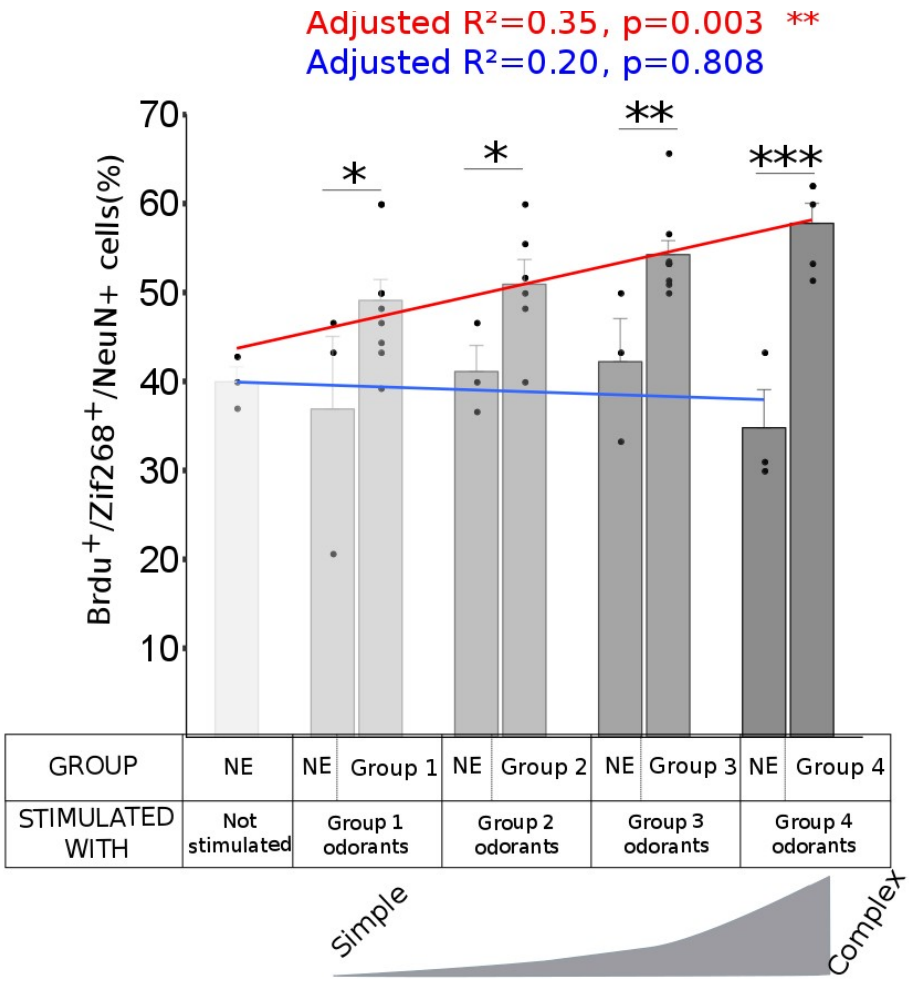



Perceptual learning increased adult-born cell density independently of the enrichment's complexity.

## 2 – Newborn neurons responsiveness:

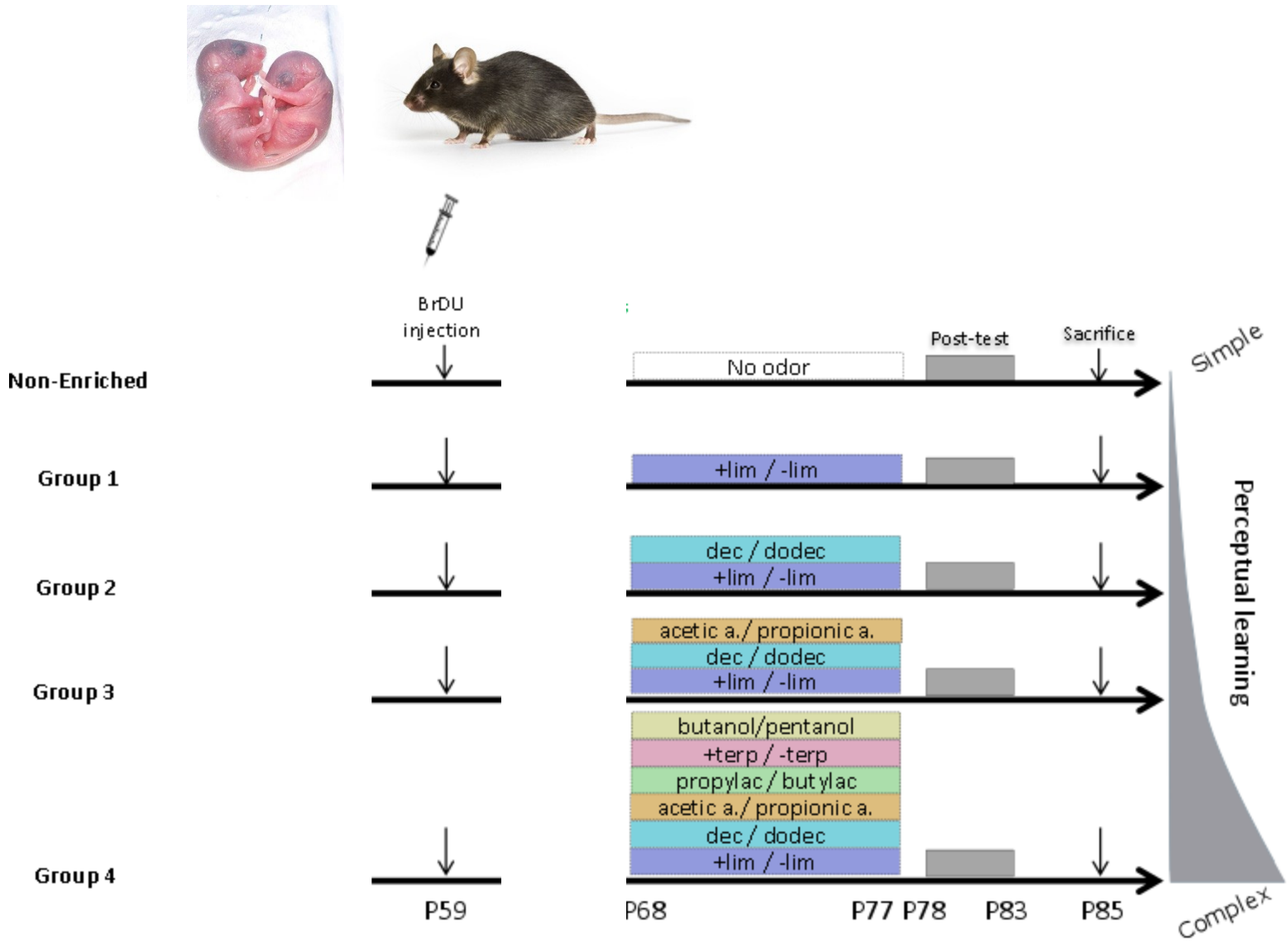



Increasing the complexity of perceptual learning enhances the recruitment of adult-born neurons in the processing of the learned odorants

# 3 – Newborn neurons and preexisting neurons morphology:



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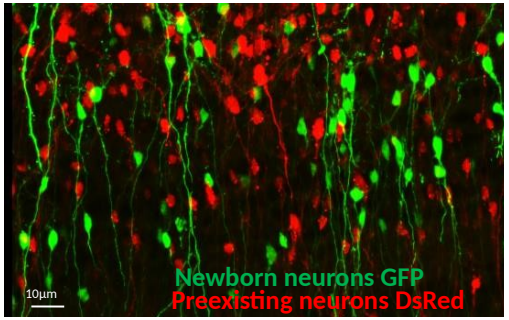
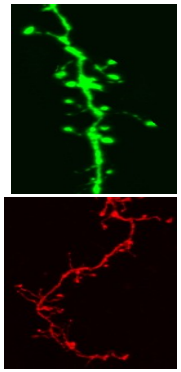
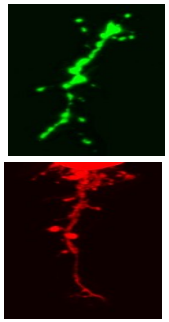
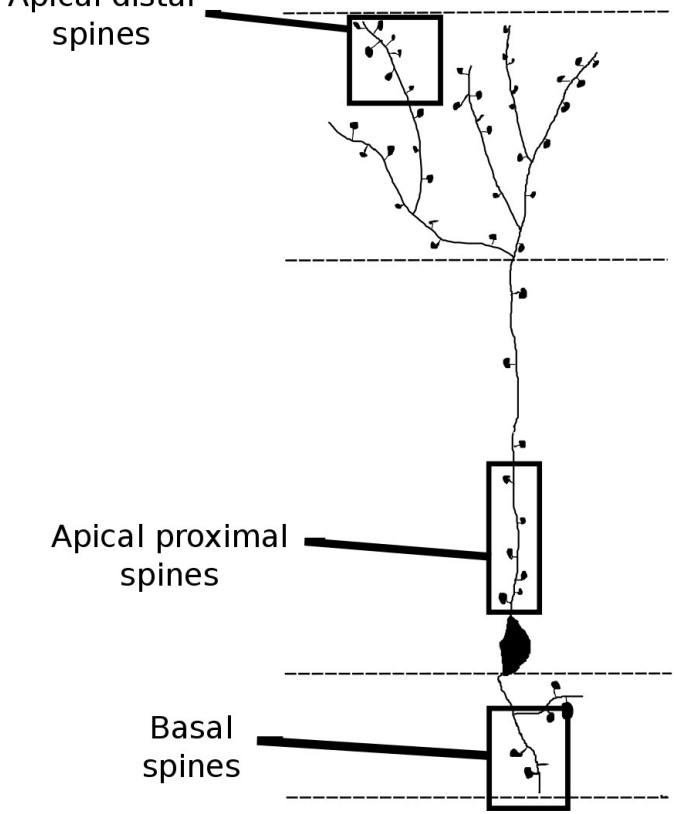
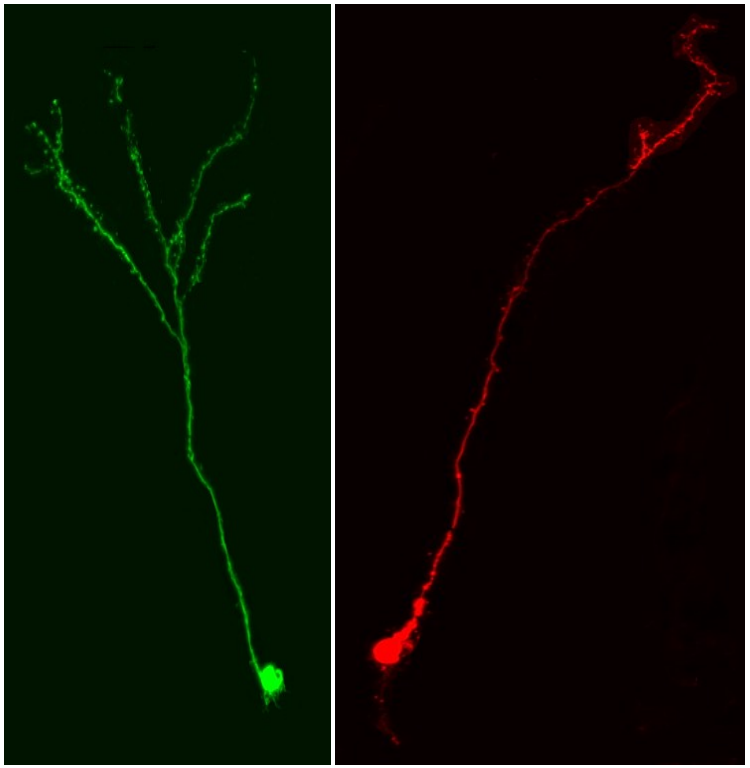




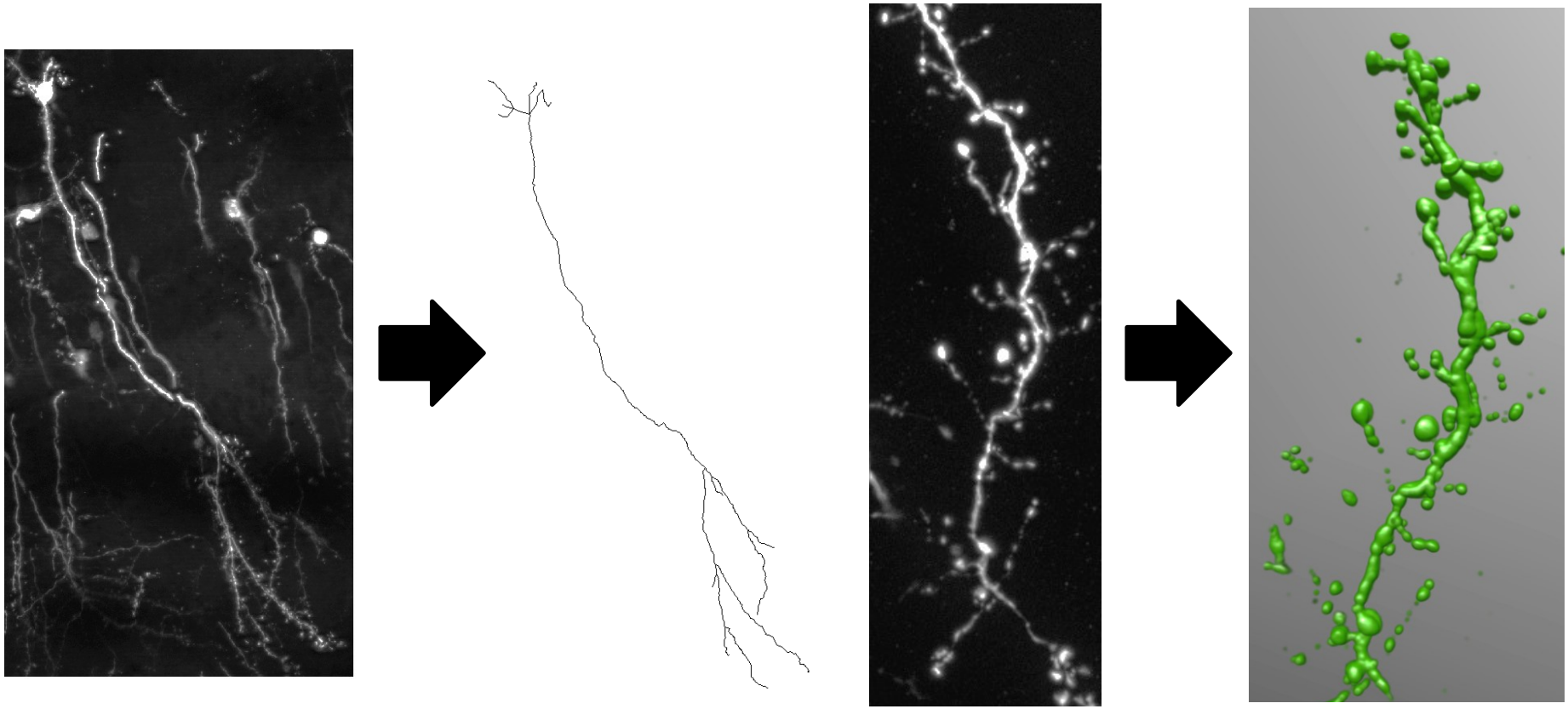


Derived from Kelsh et al. 2009

## 3 – Newborn neurons and preexisting neurons morphology:

NeuronStudio



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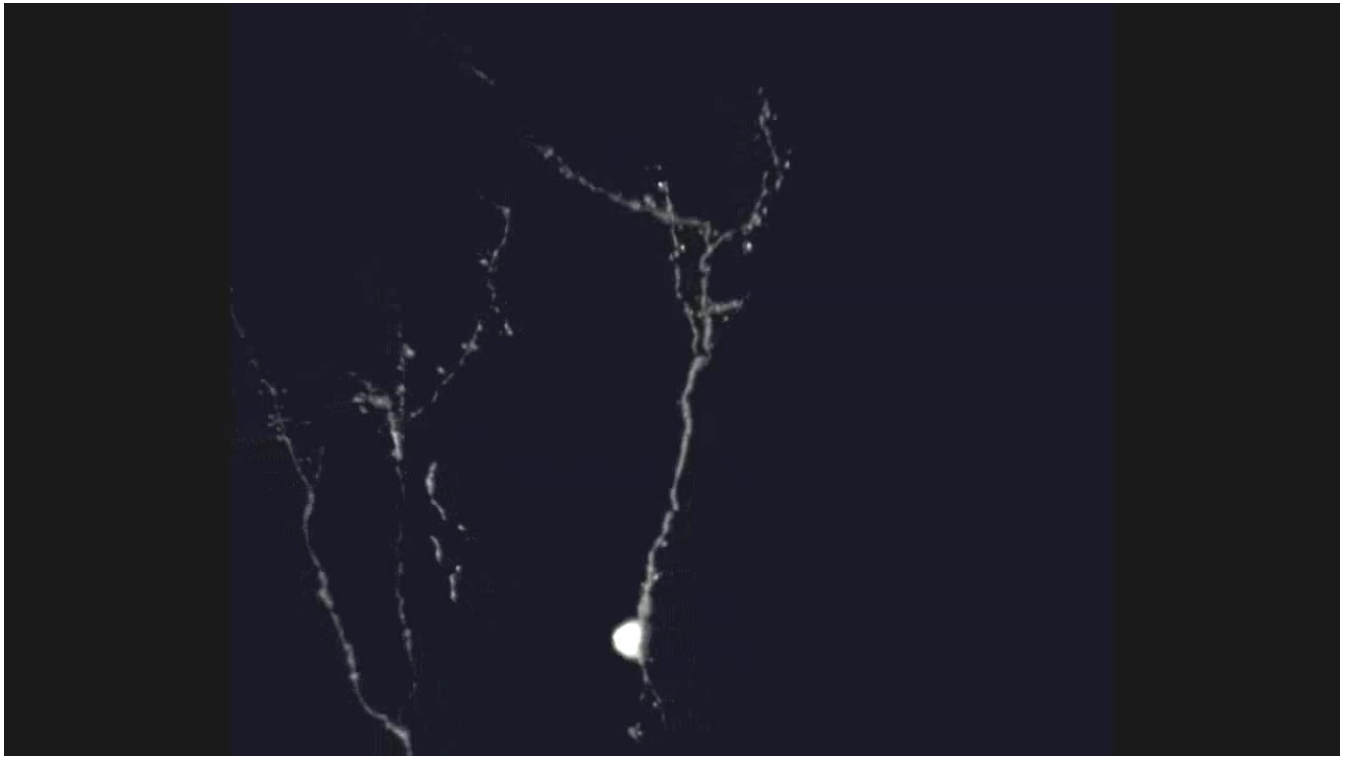
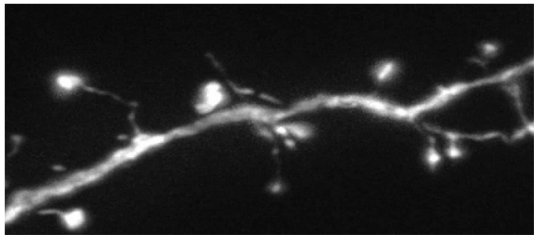
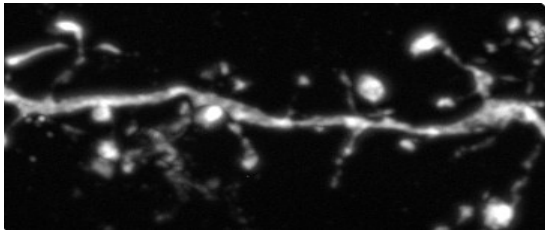
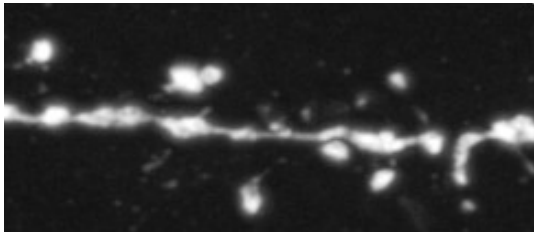
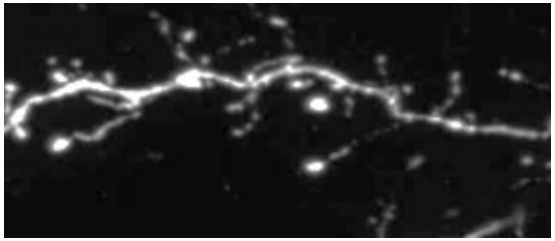


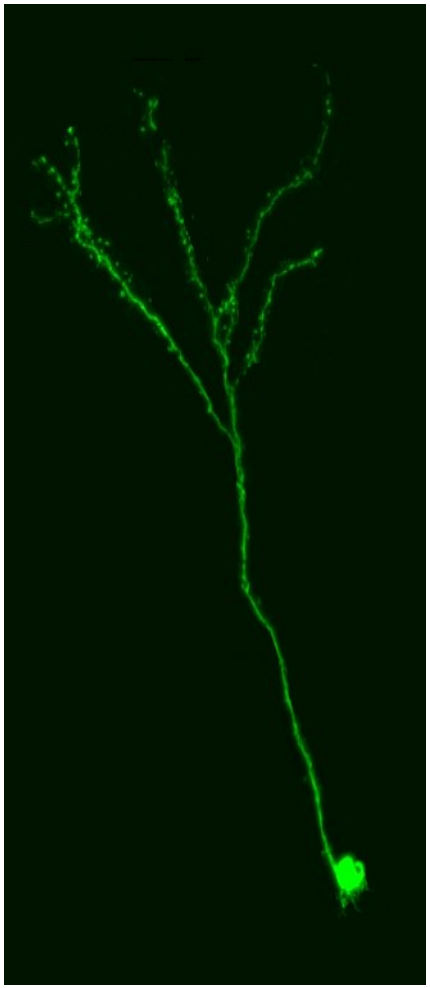


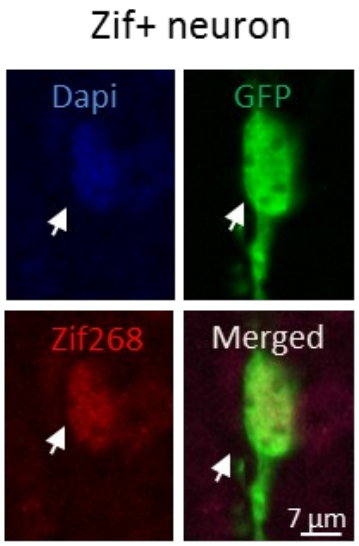


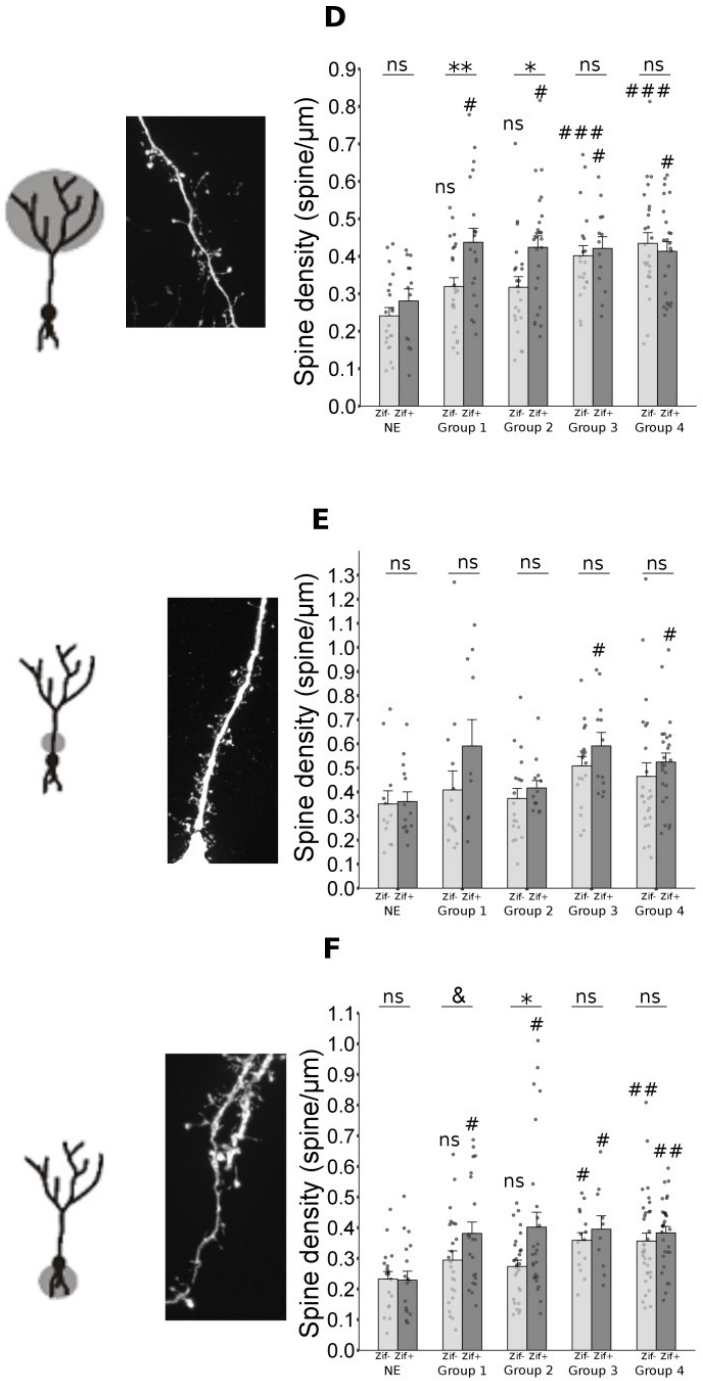




# 3a – Adult-born neurons

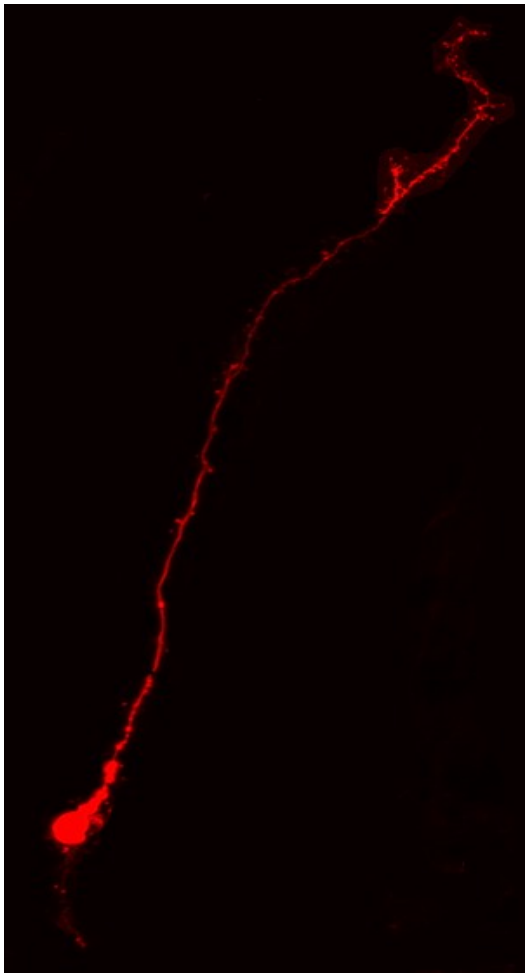


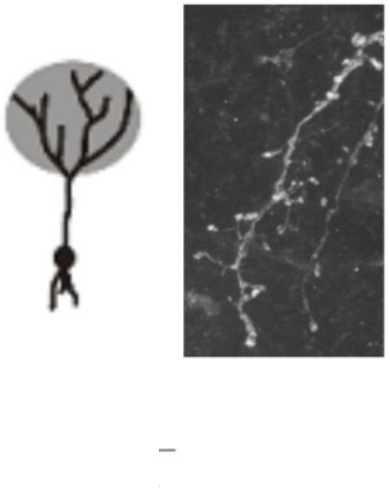


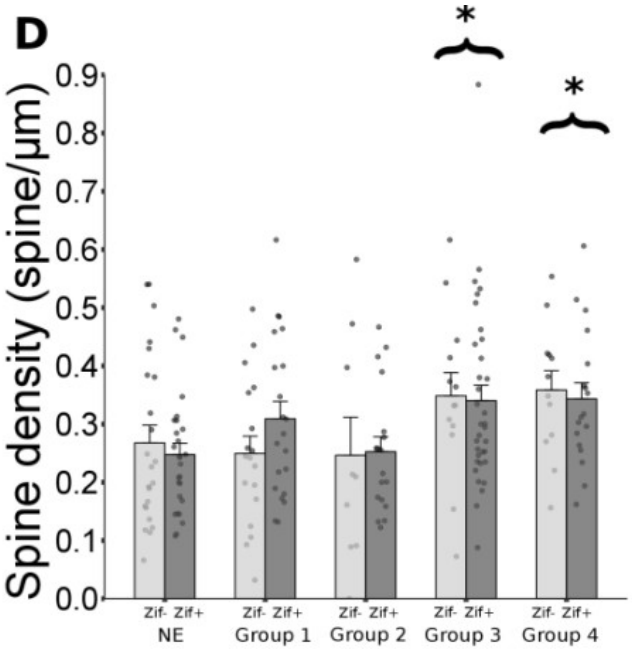




Increasing the complexity of perceptual learning induces a higher structural plasticity of adult-born neurons

# 3b – Preexisting neurons

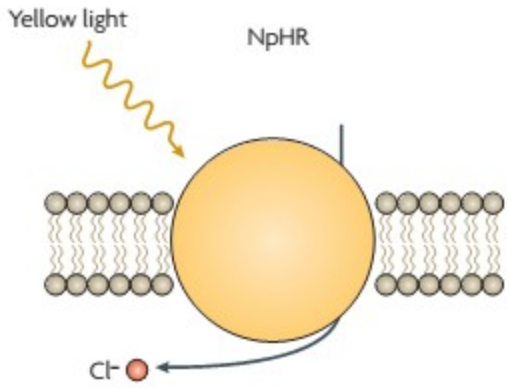


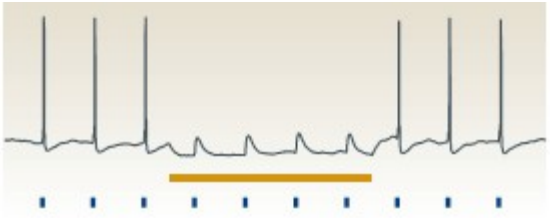




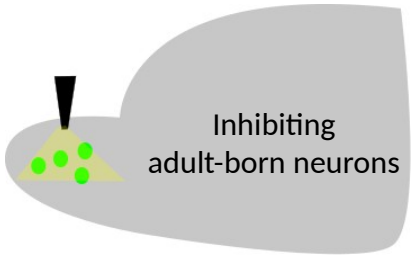
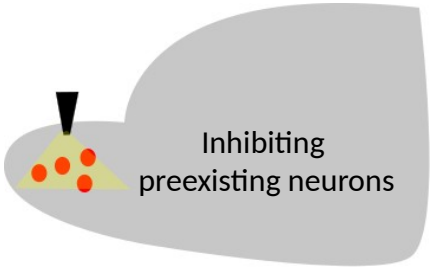

Perceptual learning induces more limited morphological changes in preexisting neurons

# 4 – Optogenetic



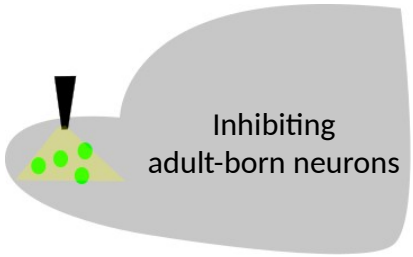
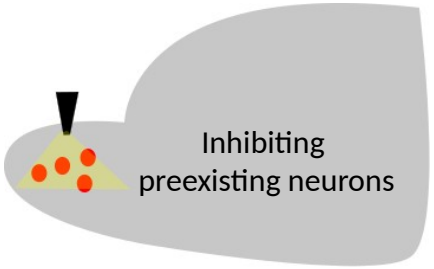



Adapted from Zhang et al. 2007, Nat Reviews Neuroscience

| |  |  |
|---|---|---|
|  Inhibiting adult-born neurons | NO discrimination ? | NO discrimination ? |
|  Inhibiting preexisting neurons | Discrimination OK ? | NO discrimination ? |

# 4 – Optogenetic

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

| |  |  |
|---|---|---|
|  Inhibiting adult-born neurons | Discrimination  | Discrimination  |
|  Inhibiting preexisting neurons | Discrimination  | Discrimination  |

# Conclusion

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**Perceptual learning** is associated with:

- 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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**Perceptual learning** is associated with:

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- Increase spines density at the apical domain of preexisting neurons in complex learning paradigm

And:

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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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And:

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

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- Increase spines density at the apical domain of preexisting neurons in complex learning paradigm

And:

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

## Take home message:

**Adult neurogenesis** exhibits **limits in its adaptive abilities to answer complex behavioral demands** but at the same time can be both **necessary and sufficient for simple learnings.**

# AKNOWLEDGEMENTS
# Neuropop Team