Quantitative measurements of olfactory perceptual thresholds in *Drosophila*

Allie Hexley

8/18/16

Overview

- Motivation
- Constructing the behavior chamber
- Preliminary data
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Why quantify perceptual thresholds in Drosophila?

- We want to quantitatively determine how differences in neural activity lead to differences in perceptual discrimination
- Determine minimum concentration difference flies can detect and how that difference relates to a difference in number of neural spikes
- Produce curves for behavior vs concentration and neural activity vs concentration

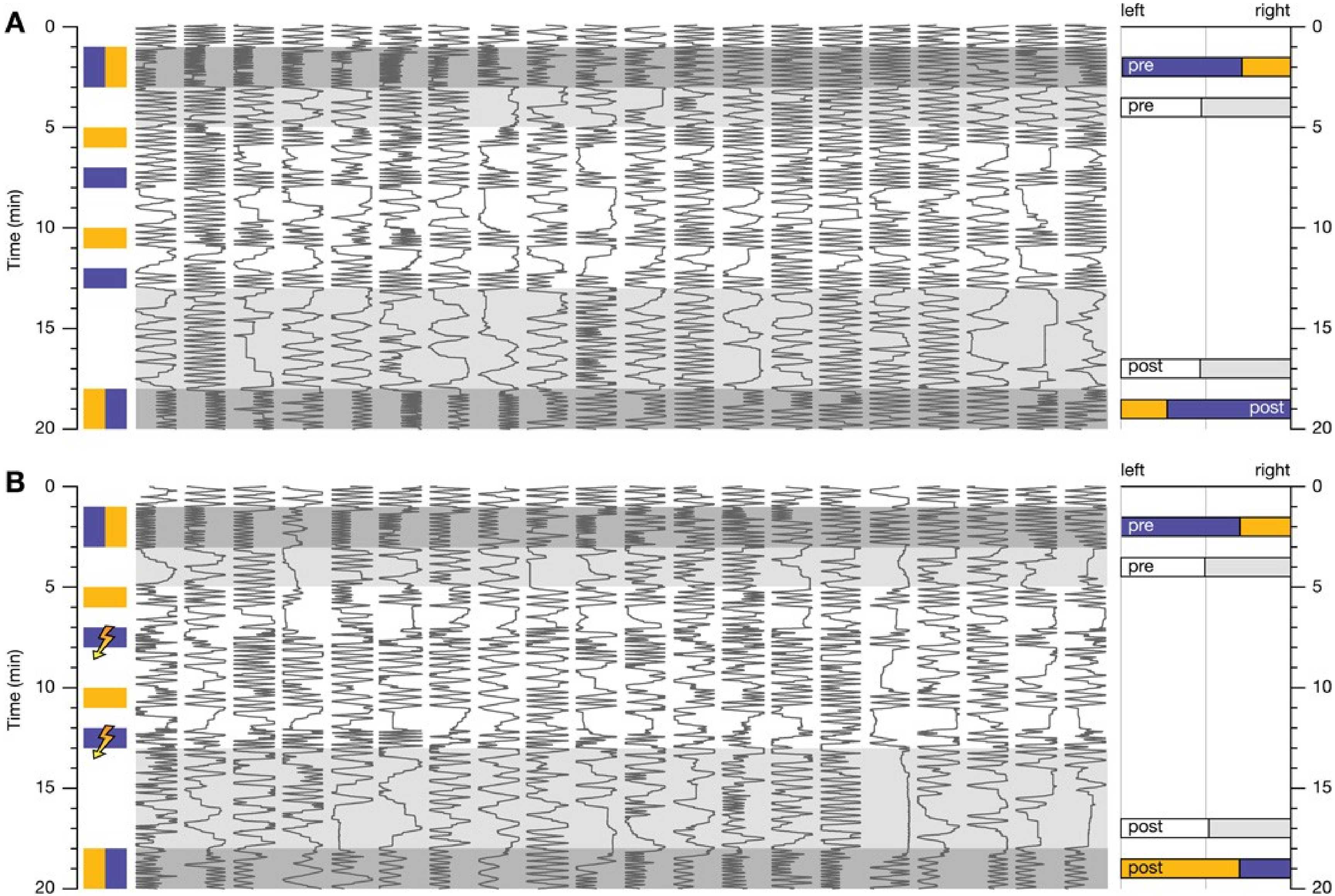
Why Drosophila?

- Numerically compact brain and a sophisticated genetic toolbox for manipulating circuit functions
- Olfactory neurons are stereotyped, so it is easy to find neurons with the same connectivity and physiology in every individual
- Genetic labels for specific neurons and these labels can be used to target specific neurons for electrophysiological measurements

Why train the flies?

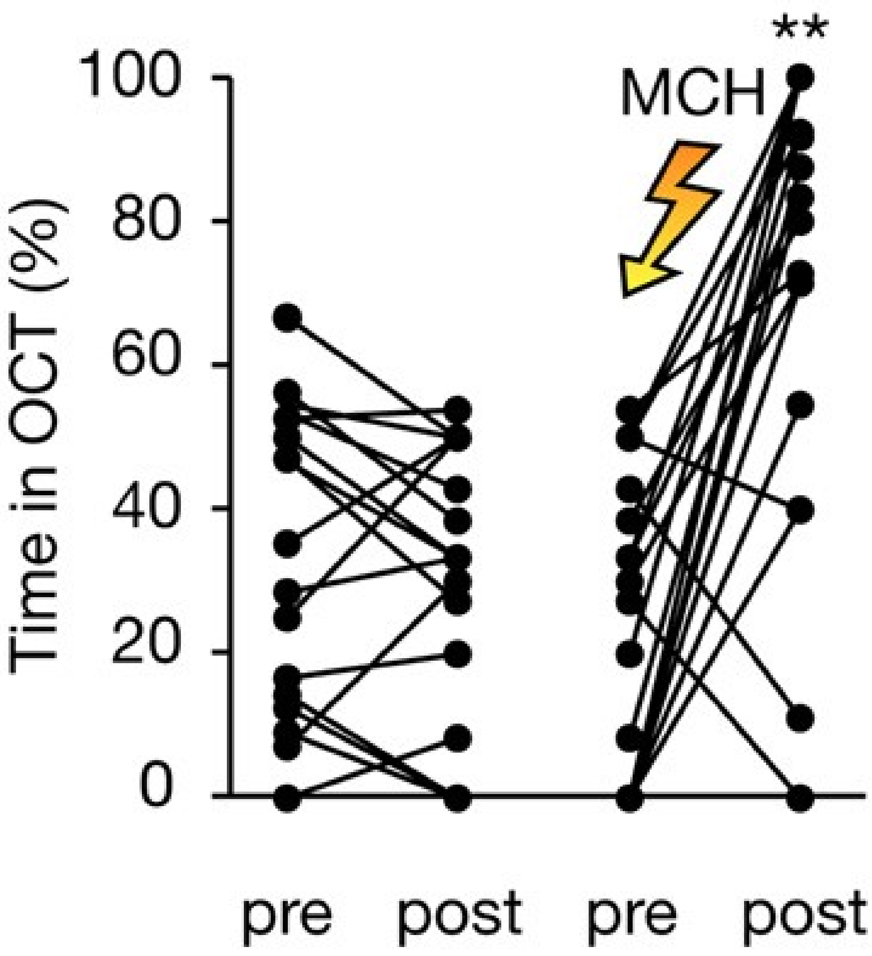
- Previous work has shown that we can train flies via Pavlovian conditioning
- Pairing an odor with electric shock causes learned aversion of that odor
- Odors used in previous work and our work: 4-methylcyclohexanol (MCH) and 3-octanol (OCT)
- We want to condition the animals so that we can push the perceptual thresholds to the limits and make sure we are calculating the minimum difference the flies can discriminate

Pavlovian olfactory conditioning causes learned aversion



Claridge-Chang *et al.*, 2009

Individual flies show learned aversion



Claridge-Chang *et al.*, 2009

Investigating behavior across concentration

- Previous work has not tested varying concentrations of odor and looked at performance limits
- What is the minimum concentration difference that the flies can distinguish?
- How does this minimum concentration difference relate to a difference in neural activity?

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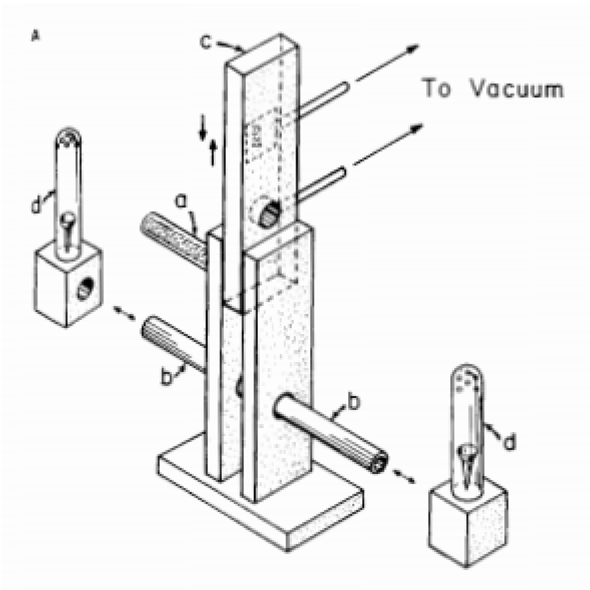
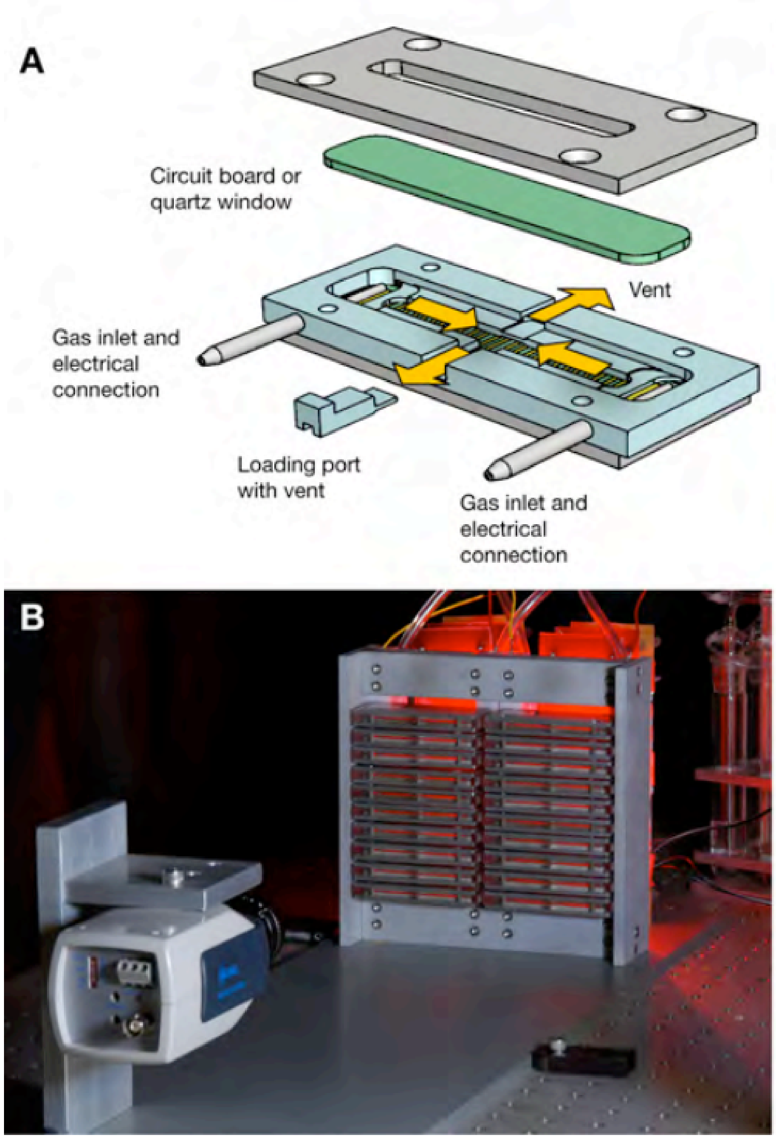
Specifications

- Allow for individual fly movements to be tracked
- Allow for Pavlovian conditioning via electric shock
- Allow two odors to be presented simultaneously on separate halves of the chamber
- Be fully-automated

Previous Designs

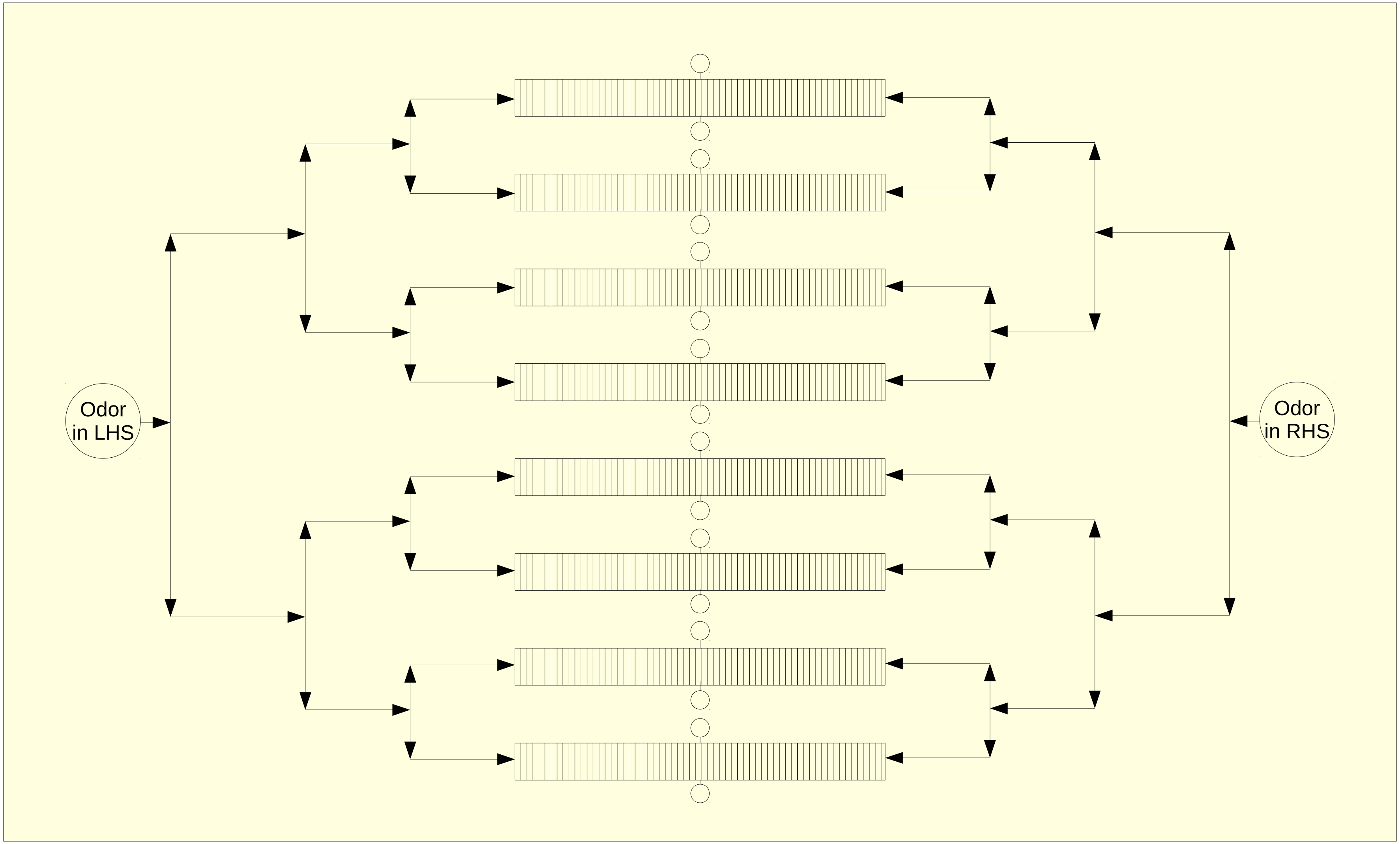


Tully and Quinn, 1985

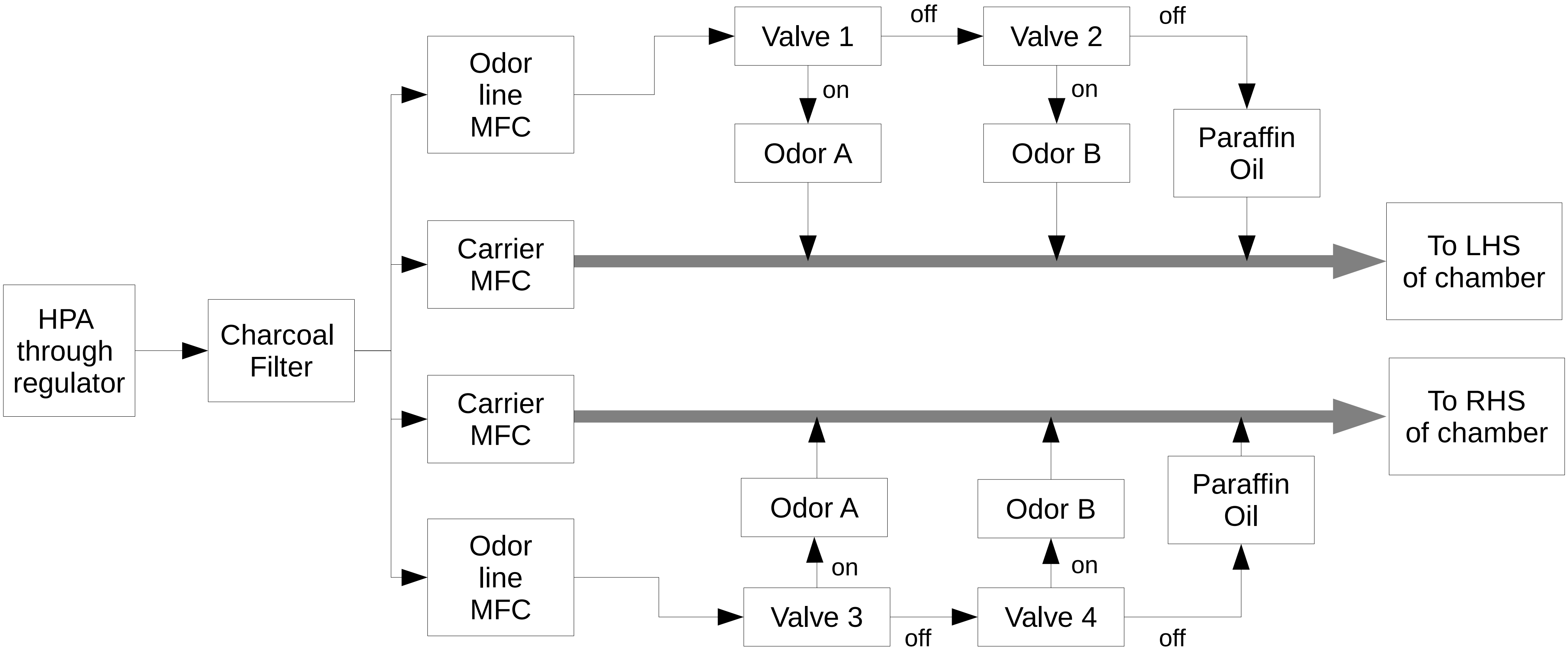


Claridge-Chang *et al.*, 2009

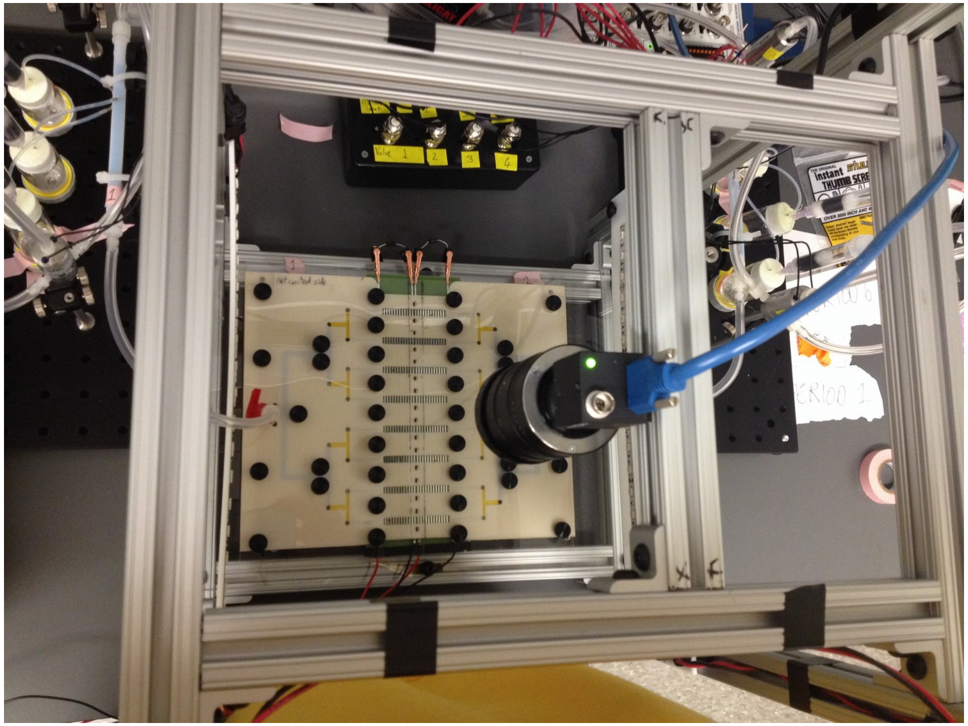
Schematic of the chamber



Schematic of input odor line



The behavior chamber



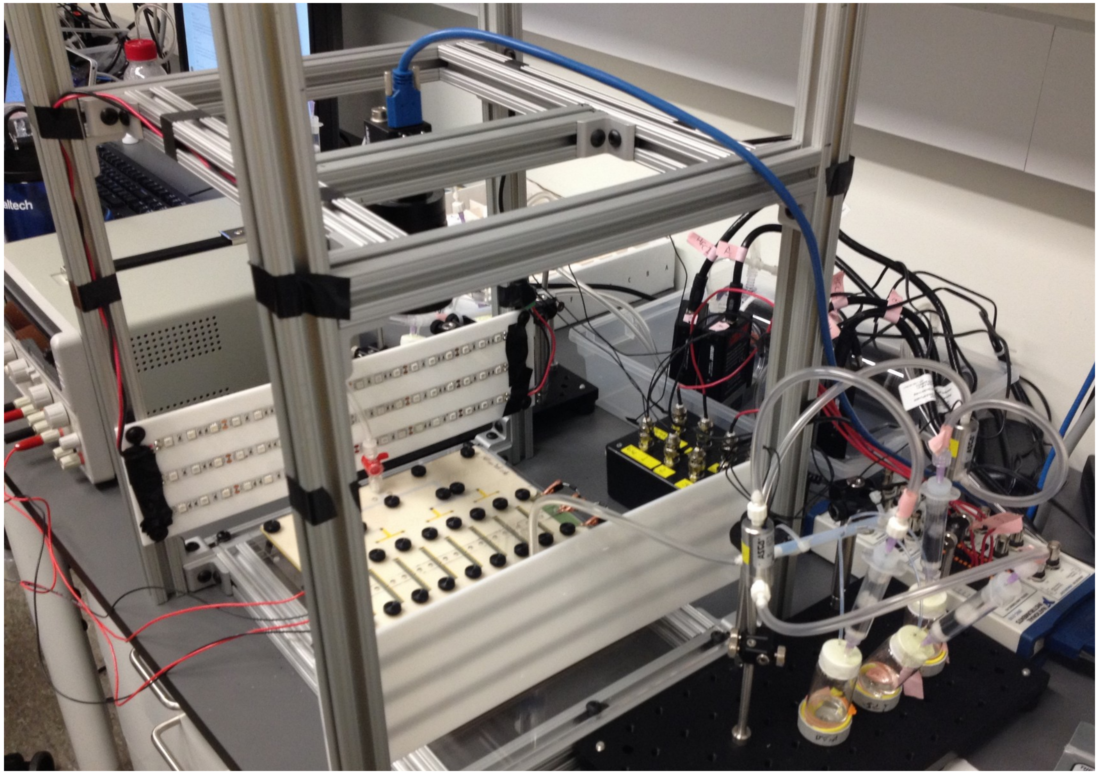


Image acquisition

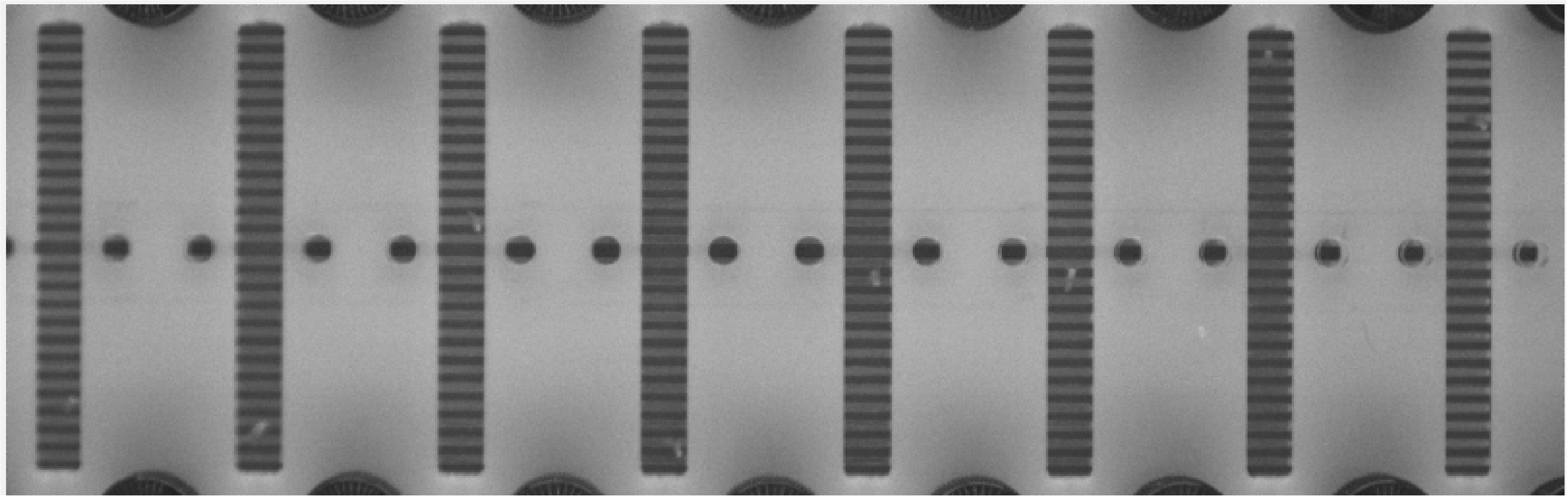
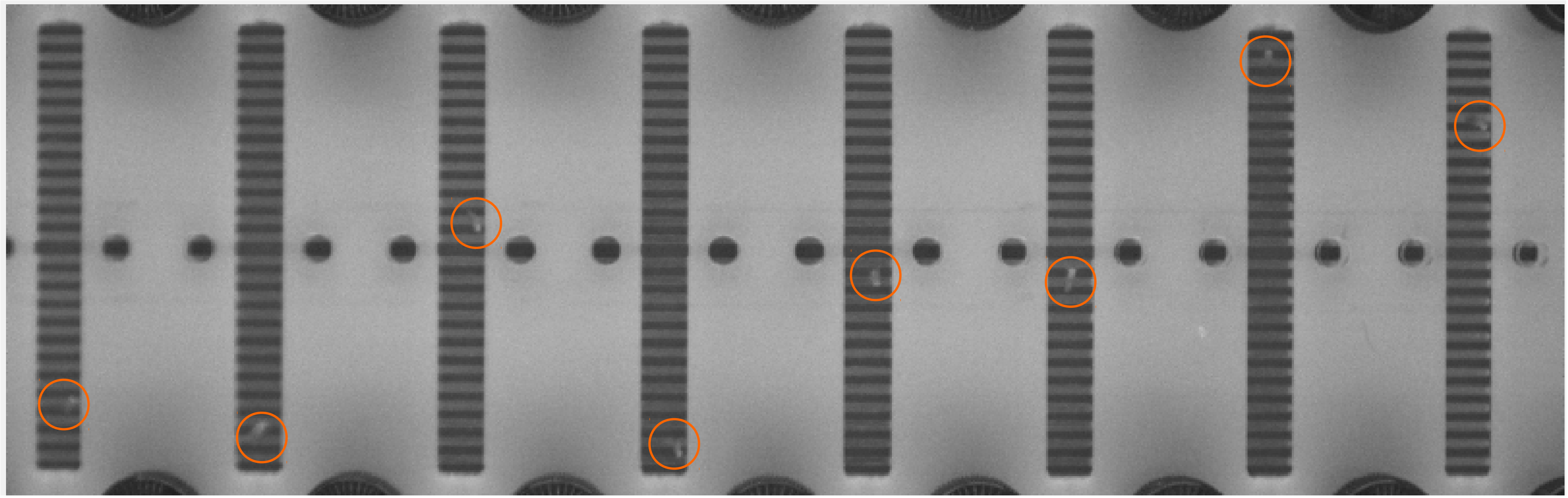


Image acquisition



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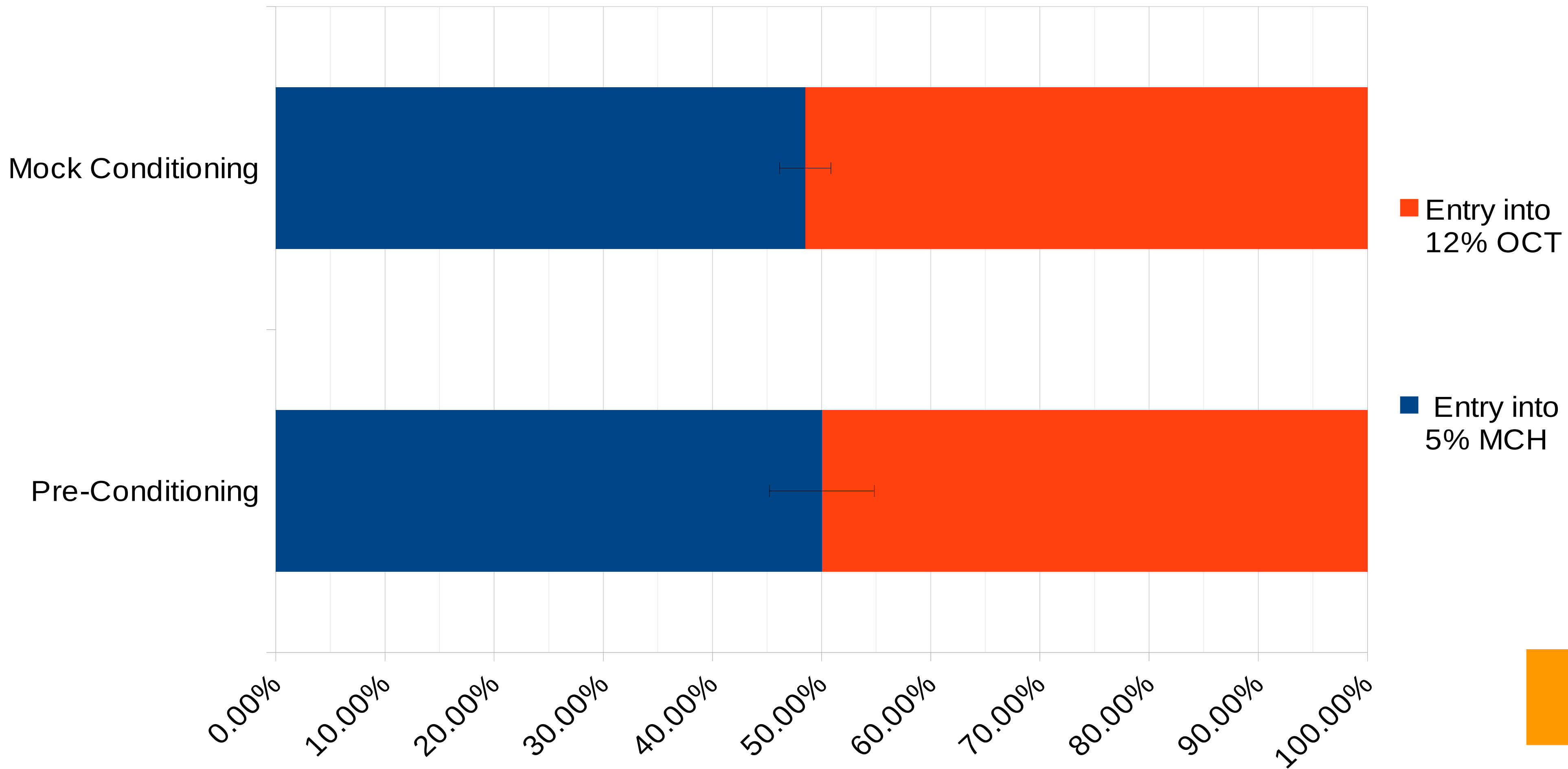
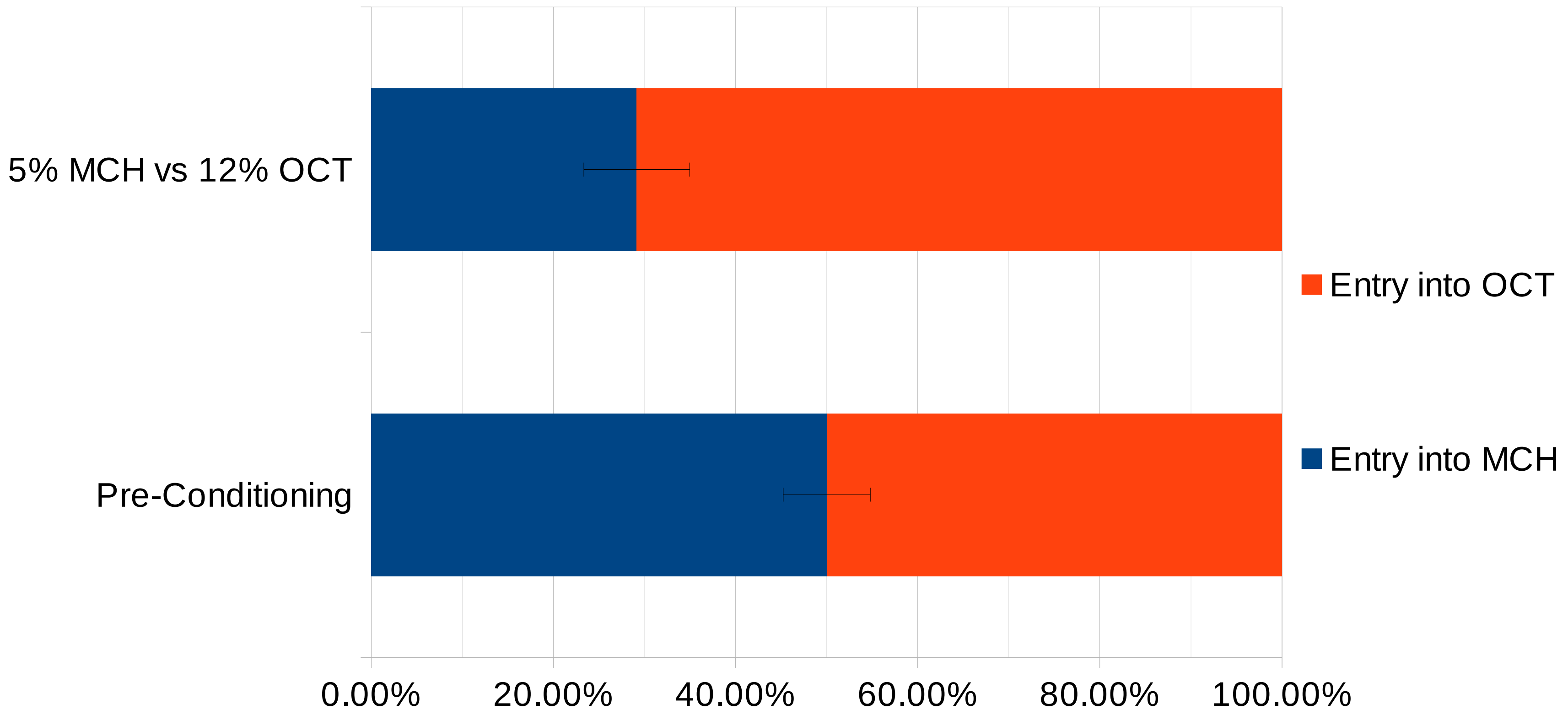
Mock conditioning

- Innate preference is maintained after mock conditioning.

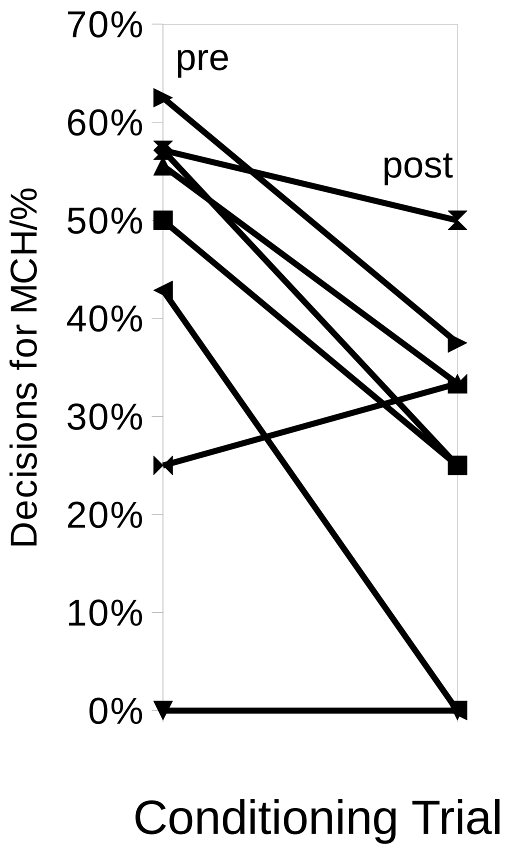


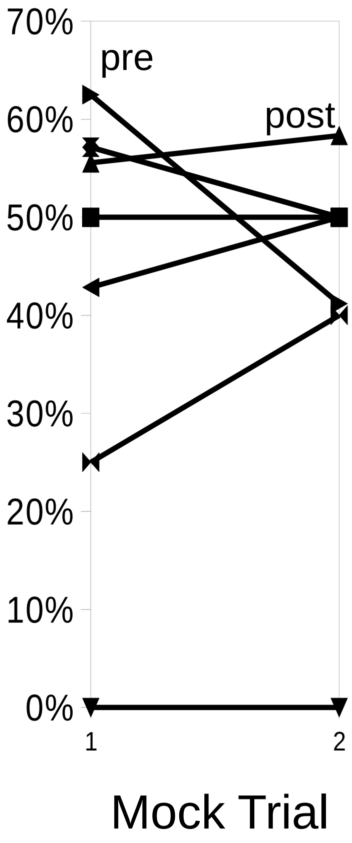
Flies learn aversion to MCH

- When presentation of MCH is paired with electric shocks, flies learn aversion to MCH.



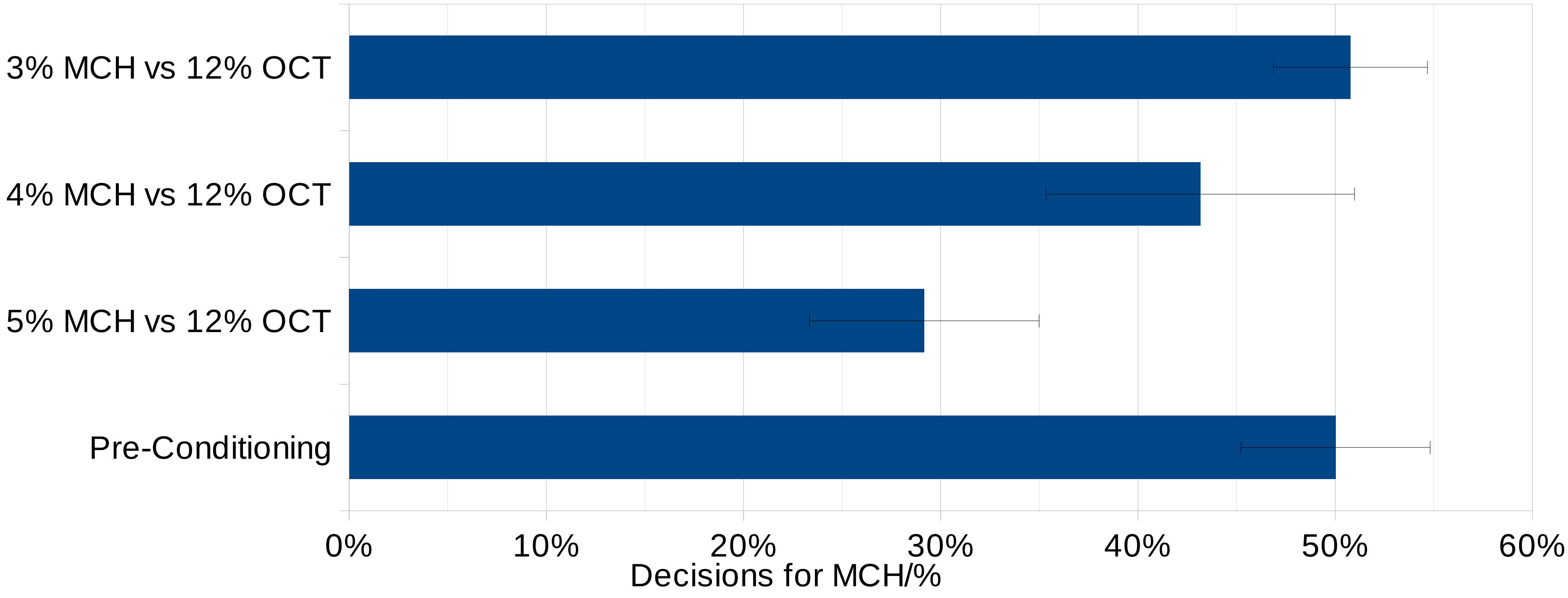
Flies learn aversion to MCH





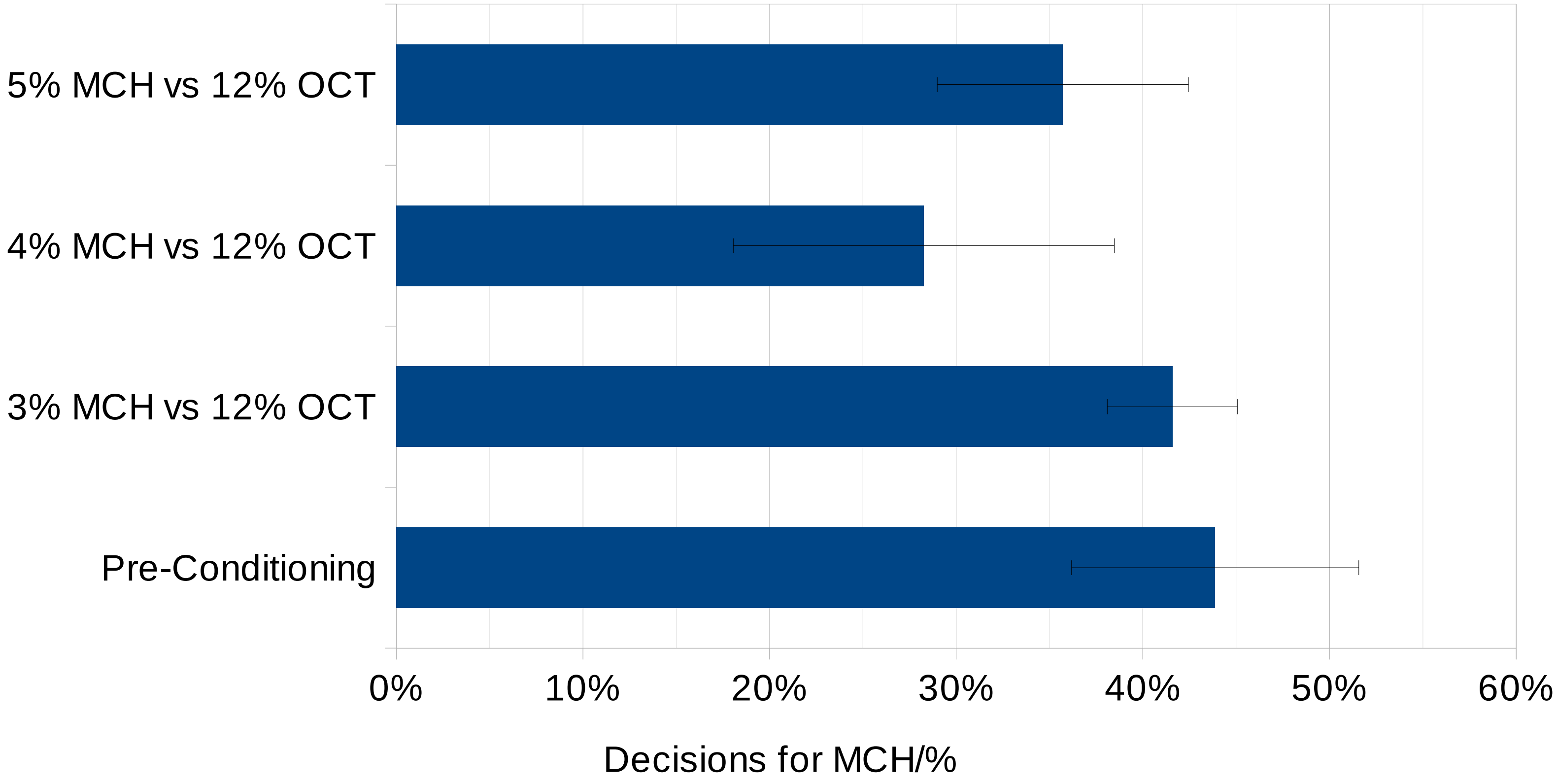
Maintaining learned aversion along concentration curve

- Training Against 5% MCH
- Learned aversion to 5% MCH, but learned aversion not maintained when tested at 3% MCH



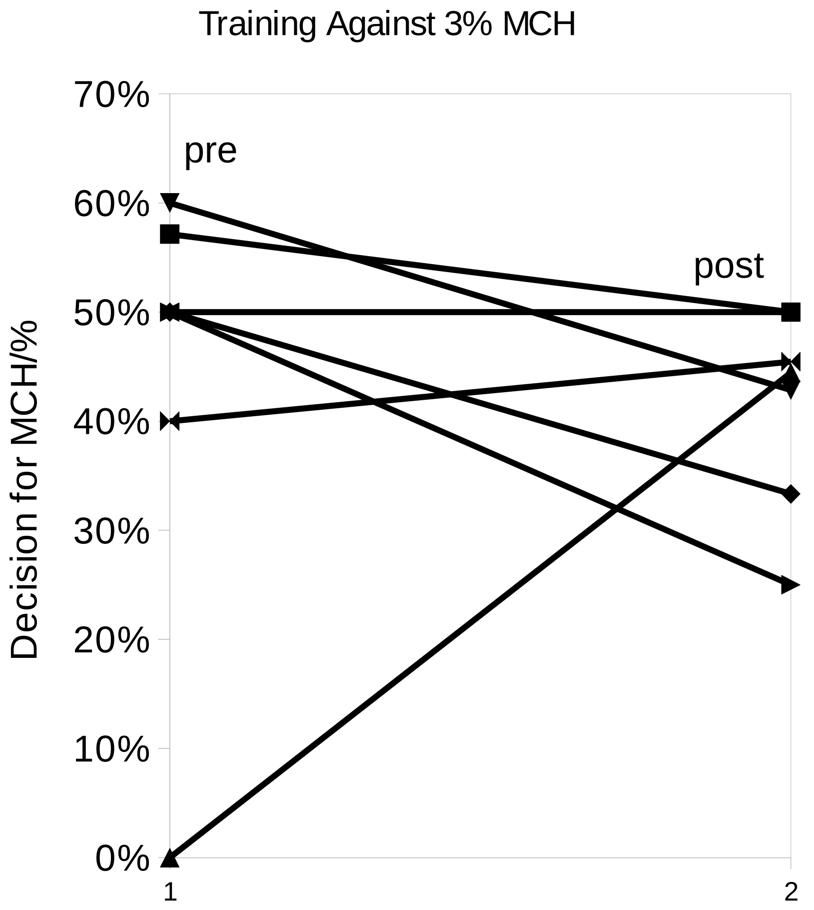
Maintaining learned aversion along concentration curve

- Training against 3% MCH



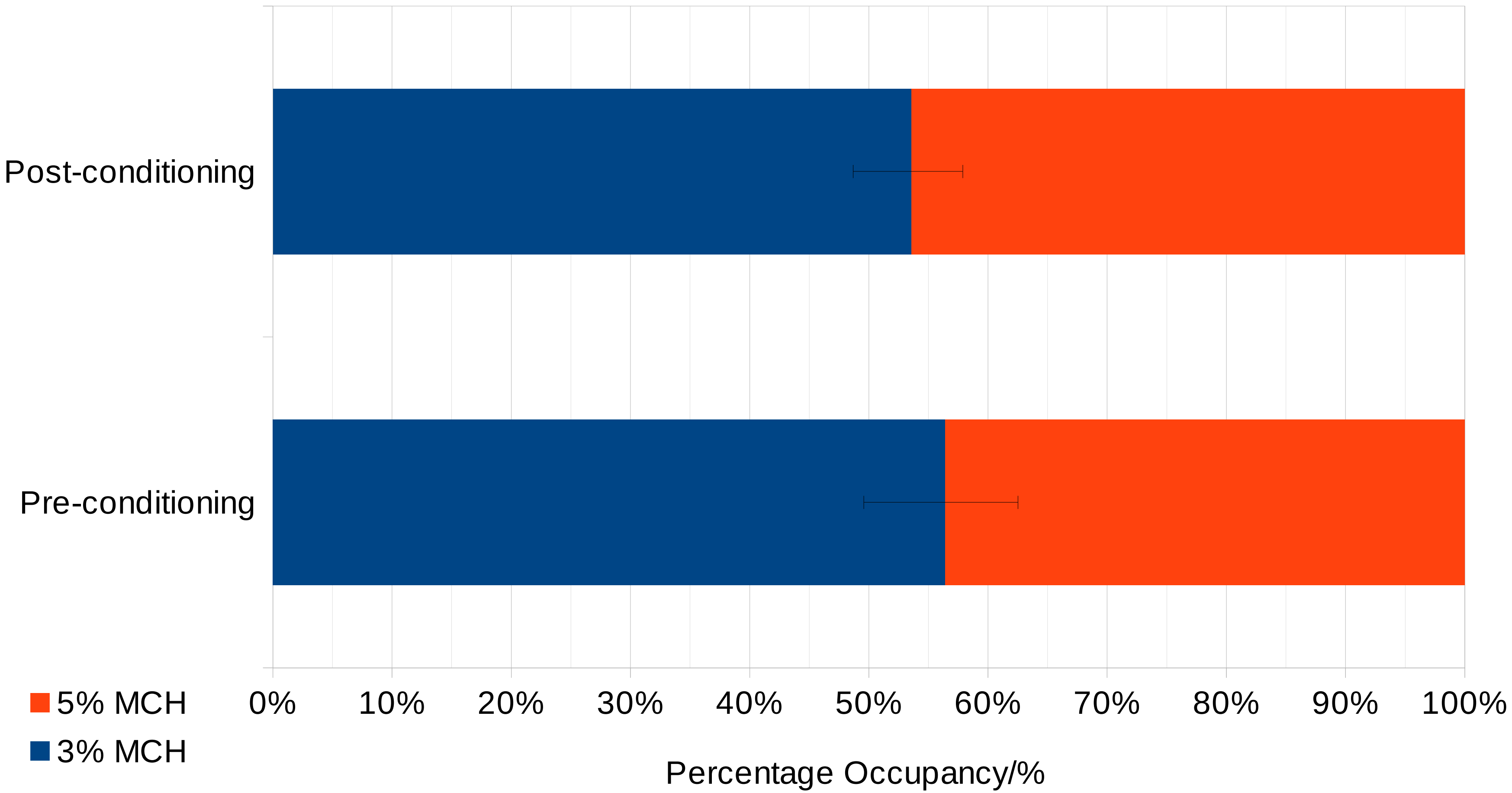
Maintaining learned aversion along concentration curve

- Training against 3% MCH



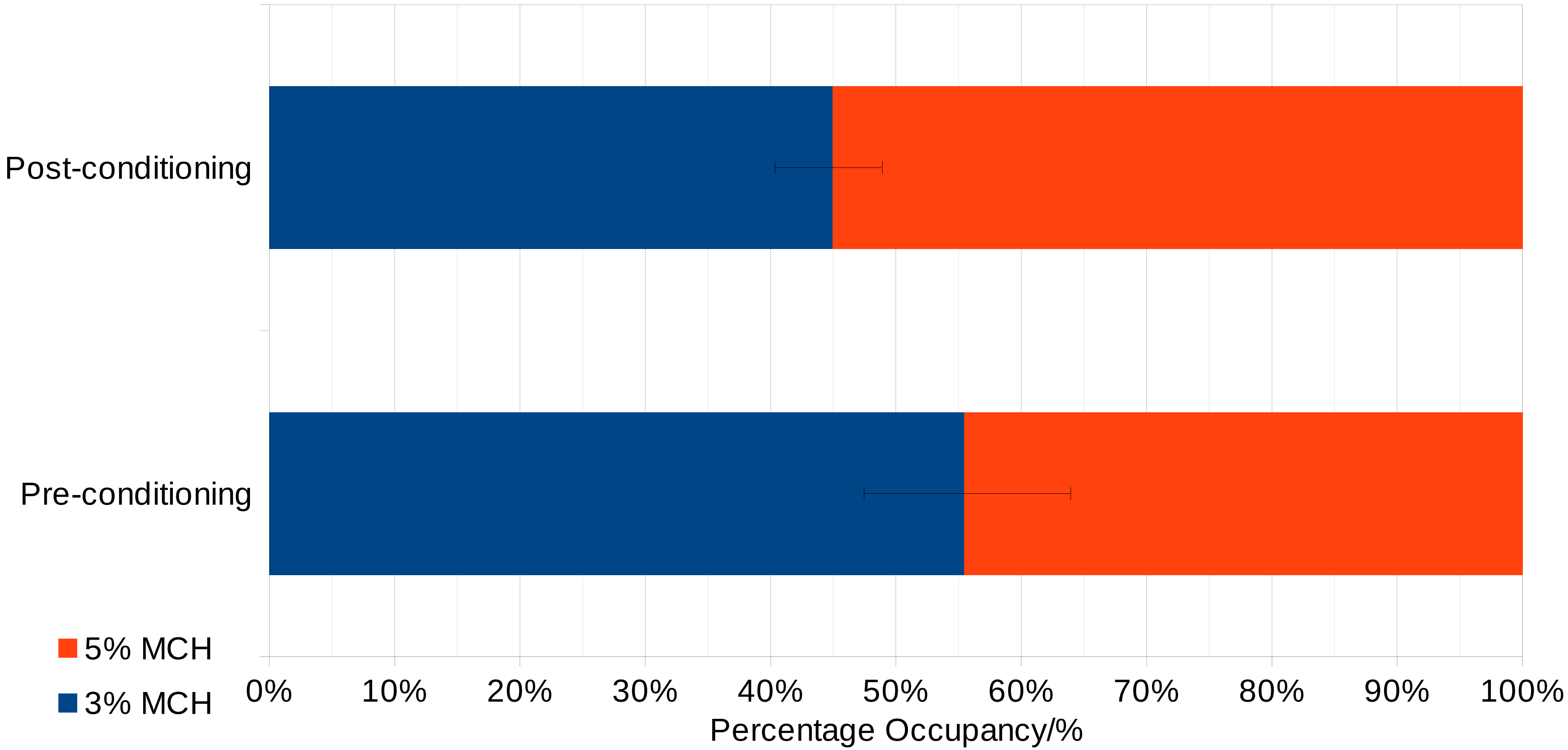
Can *Drosophila* distinguish 5% MCH from 3% MCH?

- Training against 5% MCH, no obvious aversion learned to 5% MCH



Can *Drosophila* distinguish 5% MCH from 3% MCH?

- Training against 3% MCH, no obvious aversion learned to 3% MCH



Conclusions

- None of these results are statistically significant because the sample size is too small
- However the results are suggestive that the flies cannot learn aversion to 5% MCH vs 3% MCH
- Possible hypotheses:
  - Flies cannot disciminate between 5% and 3% MCH (concentrations are near saturation point for discrimination)
  - Flies are generalizing learned aversion to all concentrations of MCH, so perceiving 5% and 3% to be equally aversive regardless of the concentration trained against

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Next steps

- Repeat experiments with a much larger population of flies (n=50)
- Repeat experiments with a much larger range/number of concentrations (n=6)
- This will allow us to see if this data is statistically significant
- Produce behavior vs concentration curve to see how behavior varies across concentration

Looking ahead

- Record neuron spiking in flies showing behavior change after conditioning and produce spike rate vs concentration curve to see how neural activity depends on odor concentration
- Test with a variety of odors and see if generalization along concentration is the same for all odors or if it differs depending on the odor used

Thank you!

Acknowledgements

Elizabeth Hong

The Hong Lab

SURF & NSF

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Questions?

Allie Hexley | ahexley@mit.edu

Back-up Slides

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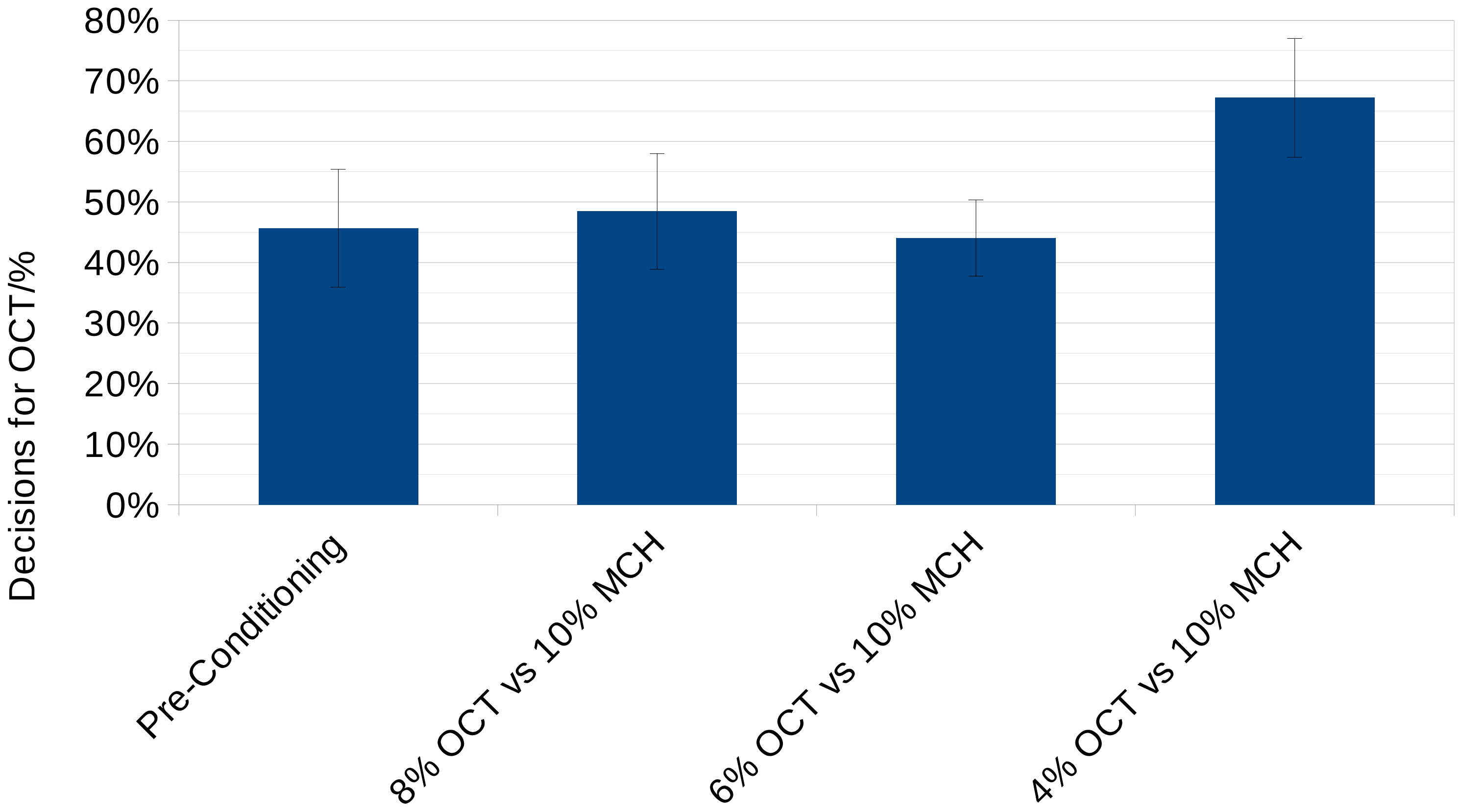
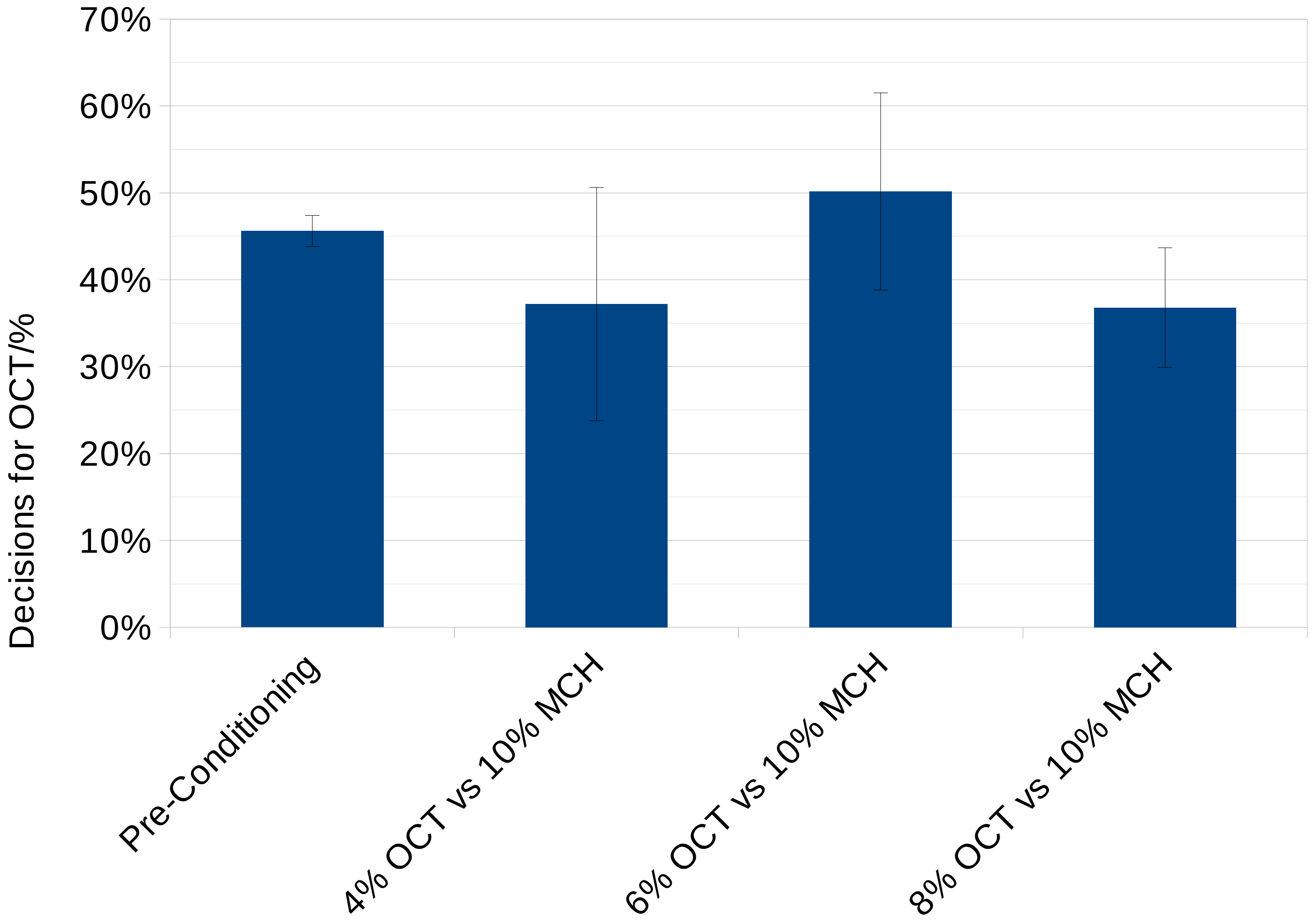
Maintaining learned aversion along concentration curve

- Training against 8% OCT



Maintaining learned aversion along concentration curve

- Training against 4% OCT



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- T. Tully and W.G. Quinn. Classical Conditioning and retention in normal and mutant Drosophila melanogaster. *J Comp Physiol.* 1985.