

## Investigating activity dependent dynamics of synaptic structures using biologically plausible models of post-deafferentation network repair



University of **UH**

Engineering and Computer Science Research Conference 2019

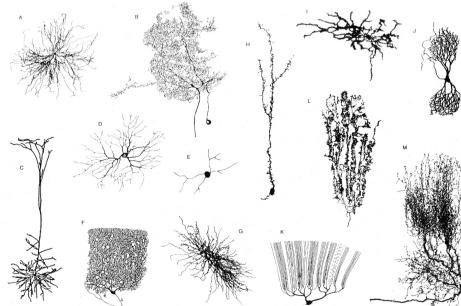
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17/04/2019

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## The brain: learning, plasticity, stability

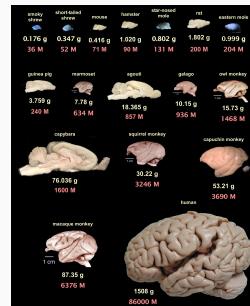
### The brain: neurons



Dendrites, Oxford University Press, 2015; Modified from Mel, B.W. Neural Computation, 1994.

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### The brain: in numbers: neurons

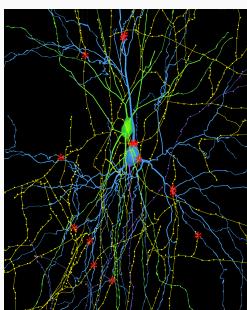


<sup>1</sup> Herculano-Houzel, S. The human brain in numbers: a linearly scaled-up primate brain. *Frontiers in human neuroscience* 3, 31 (2009)

- 86000M neurons<sup>1</sup>.

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### The brain: in numbers: synapses



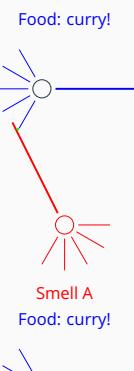
- Thousands of connections (synapses) between pairs<sup>2</sup>.
- Synapses underlie learning<sup>3</sup>.

<sup>2</sup>Image from The GAO lab

<sup>3</sup>Hebb, D. O. *The organization of behavior: A neuropsychological theory*. 1949

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### The brain: plasticity and learning



Food: curry!

Smell A

Food: curry!

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### The brain: plasticity and stability?

- Learning occurs all the time.
- In fact, whole synapses are formed and removed all the time<sup>4</sup>: structural plasticity.
- Unregulated brain activity causes disorders: epilepsy.
- So, how does the brain remain stable despite changing all the time?
- Stabilising (homeostatic) processes<sup>5</sup>?

<sup>4</sup>Holtmaat, A. J. G. D. et al. Transient and Persistent Dendritic Spines in the Neocortex In Vivo. *Neuron* 45, 279-291. ISSN: 0896-6273 (2005)

<sup>5</sup>Turrigiano, G. G. Homeostatic plasticity in neuronal networks: the more things change, the more they stay the same. *Trends in neurosciences* 22, 221-227 (1999).

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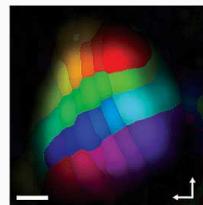
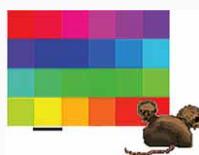
### Our research focus

- We study homeostatic structural plasticity.

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## Homeostatic structural plasticity

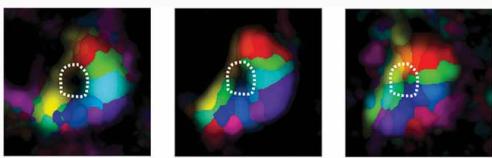
### Studying homeostatic structural plasticity: biologists



<sup>1</sup>Keck, T. et al. Massive restructuring of neuronal circuits during functional reorganization of adult visual cortex. *Nature neuroscience* 11, 1162–1167 (2008)

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after injury ...



<sup>1</sup>Keck, T. et al. Massive restructuring of neuronal circuits during functional reorganization of adult visual cortex. *Nature neuroscience* 11, 1162–1167 (2008)

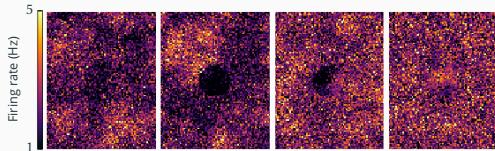
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### Our investigations: computational modelling

- We make [models of small parts of the brain](#) on computers.
- We try to [replicate](#) what biologists observe in their laboratories.
- Modelling gives us [flexibility](#):
  - we can change whatever we want, record whatever we want.
  - analyse data, test different hypotheses.
- We then [send our ideas back to biologists](#) for validation.

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Our model: replicates biological observations



**Figure 4:** Our model: 1000 neurons. Simulation duration: 7 days on the cluster with 128 CPU nodes.

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It suggests:

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