

The spatial and temporal dynamics of structural plasticity in the memory domain

Yaniv Assaf

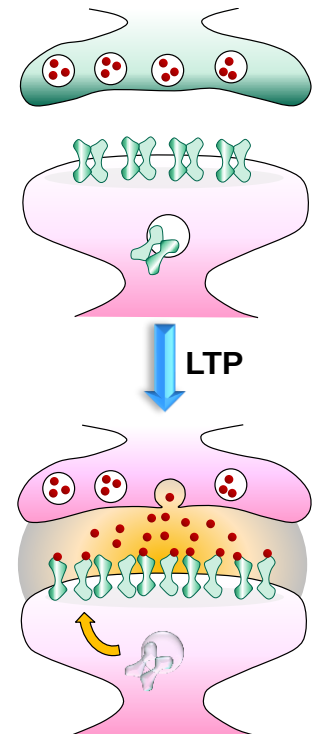
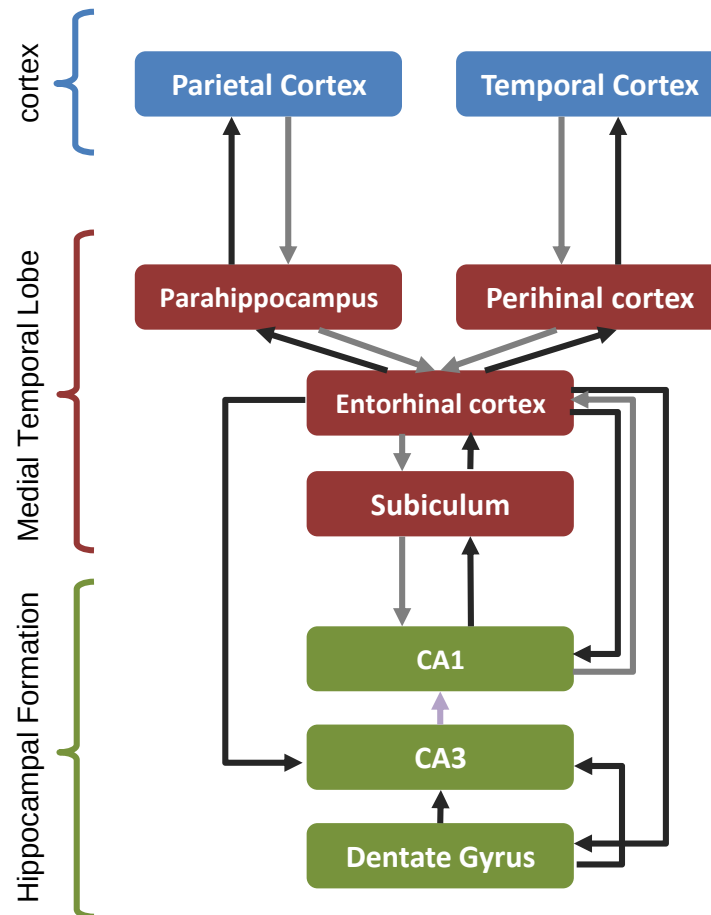


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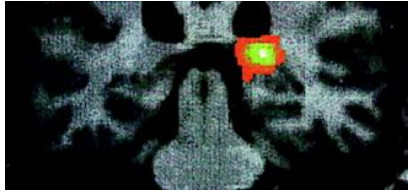
Experimental MRI Centre (EMRIC)
School of Biosciences, Cardiff University
Cardiff, The United Kingdom

The memory domain

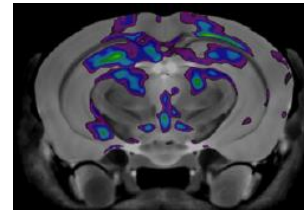


retrieval
encoding

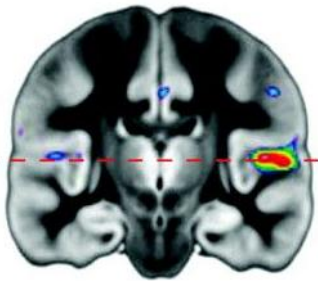
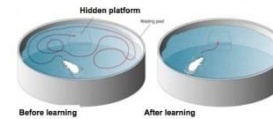
Neuro-plasticity in Adults



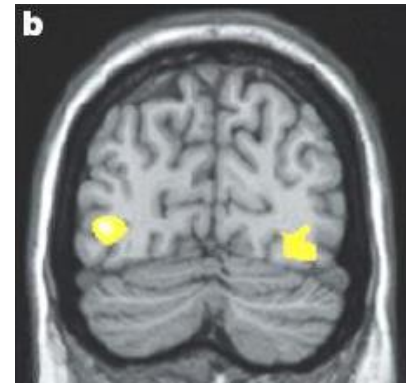
Maguire et-al, PNAS 2000



Lerch et-al,
Neuroimage,
2011



Bermudez et-al, Cereb. Cortex 2008

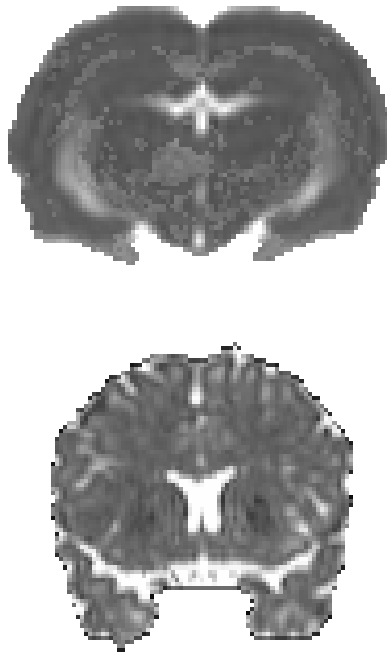


Draganski et-al, Nature 2004

What is the mechanism of the volumetric neuroplasticity related changes?

Diffusion Tensor Imaging

Mean Diffusivity (MD)

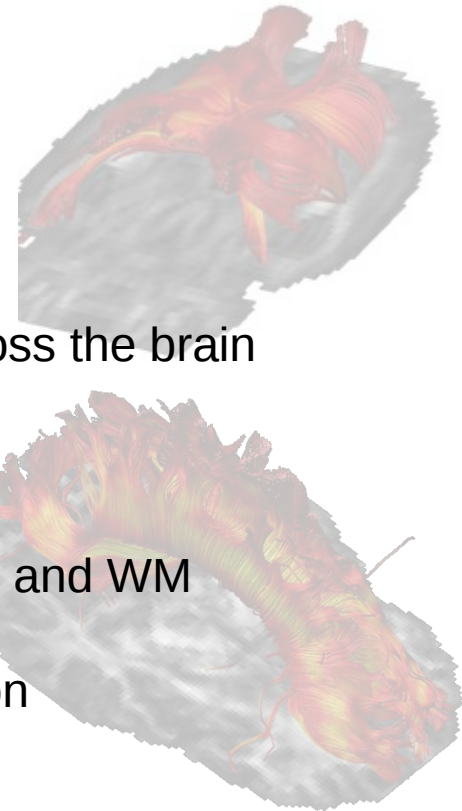


Fractional Anisotropy (FA)

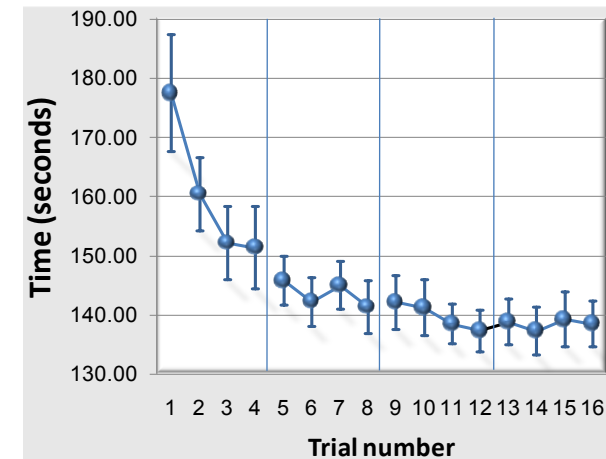
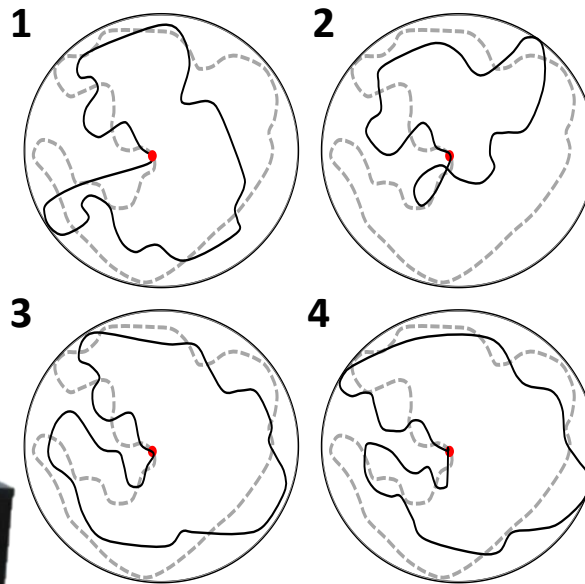
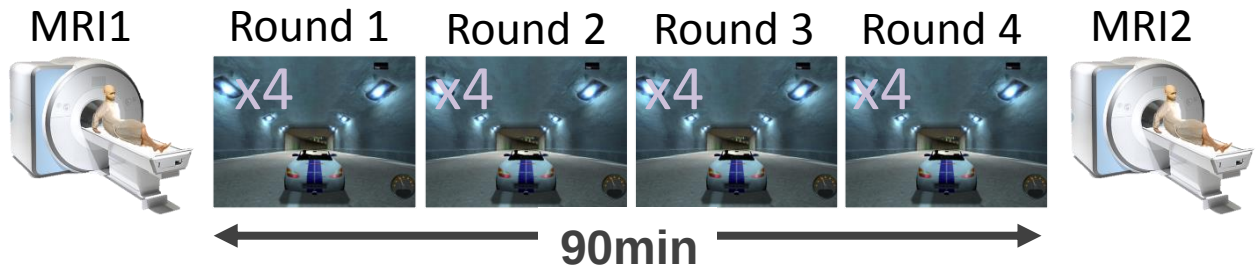
The MD:

- ✓ Robust
- ✓ Homogeneous Across the brain
- ✓ Fast Acquisition
- ✓ Well defined in GM and WM
- ✓ Simple Interpretation

Tractography

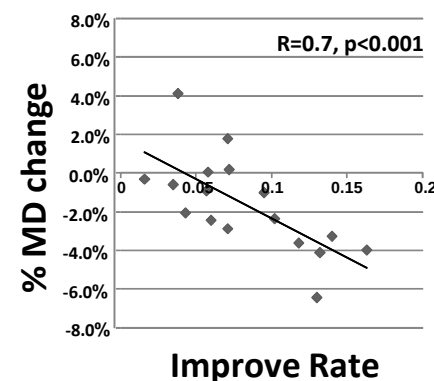
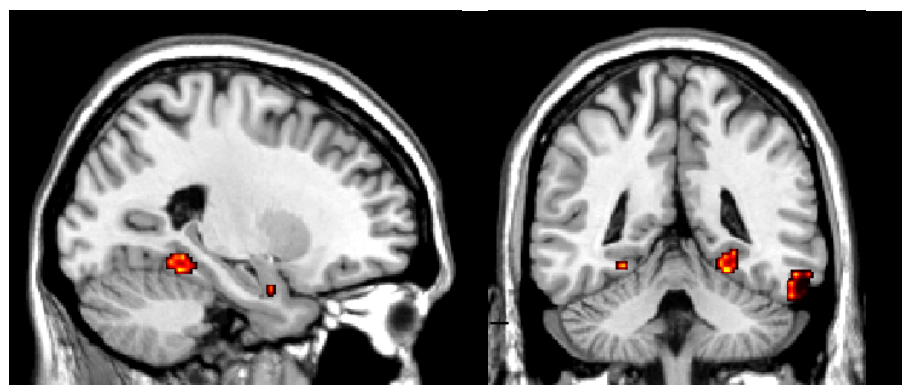
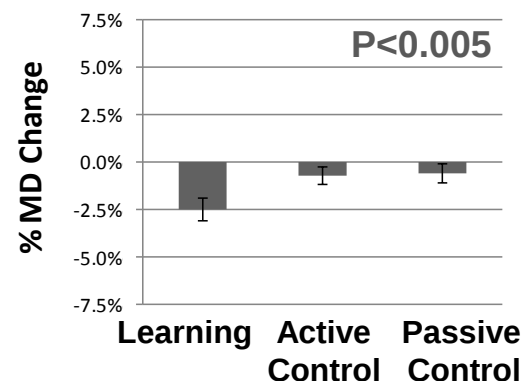
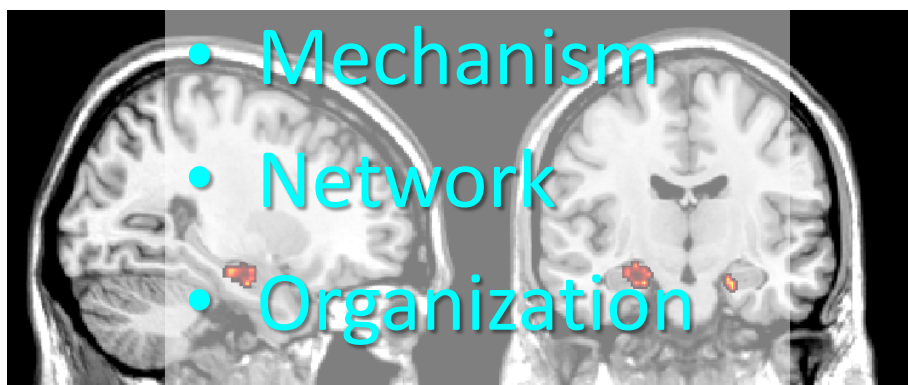
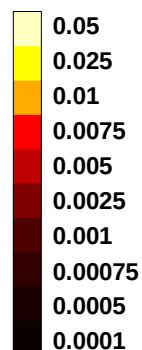


The Need for Speed

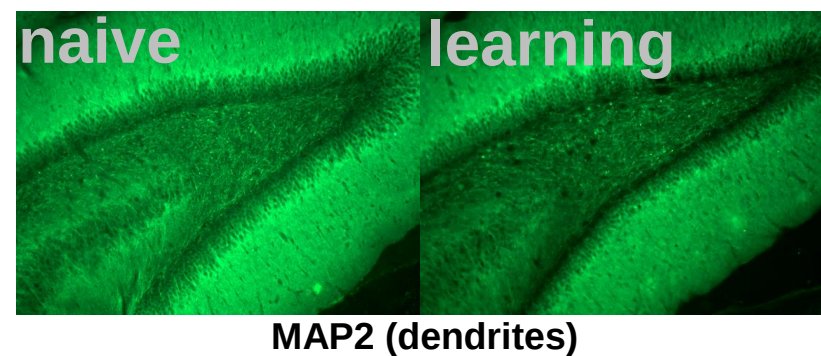
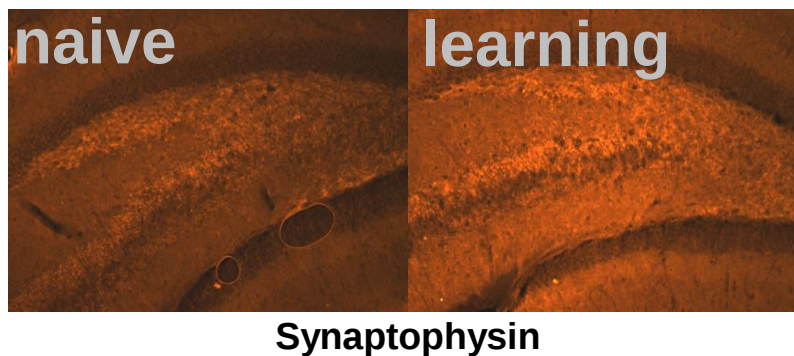
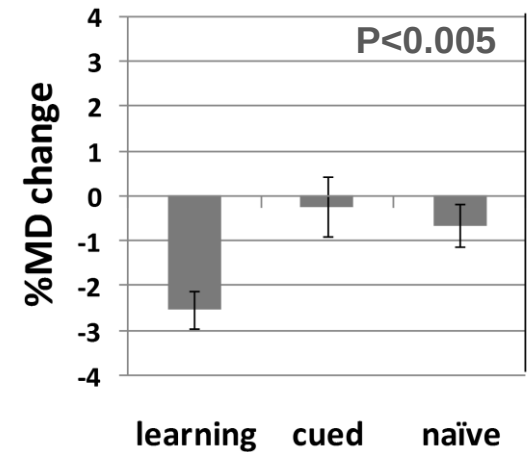
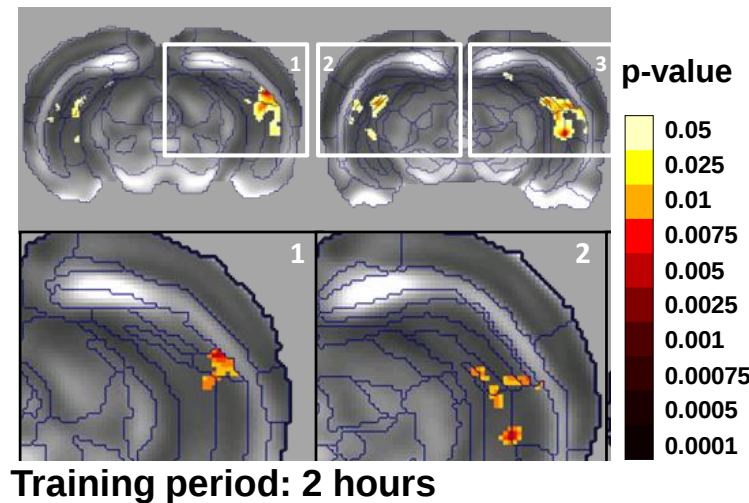
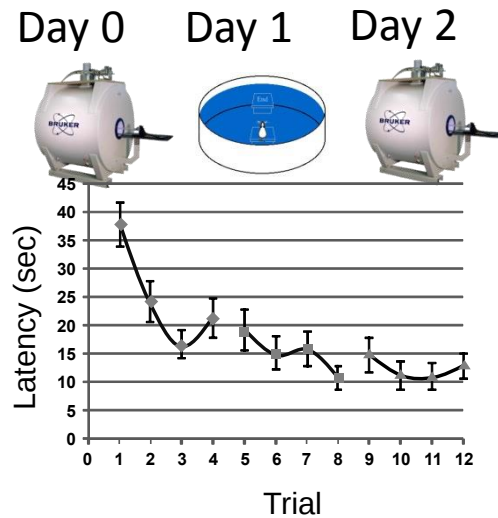


Effect of Learning and Memory

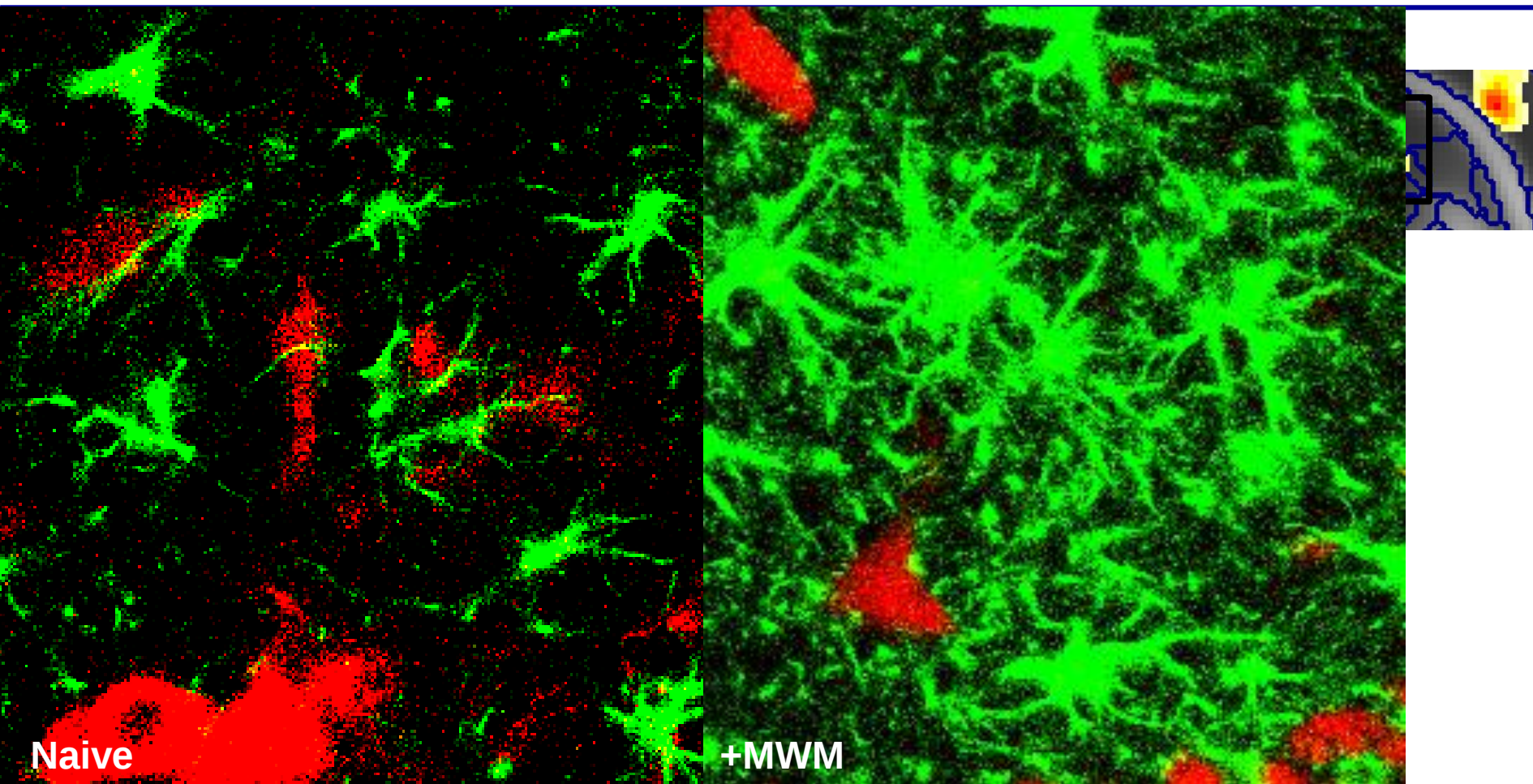
p-value



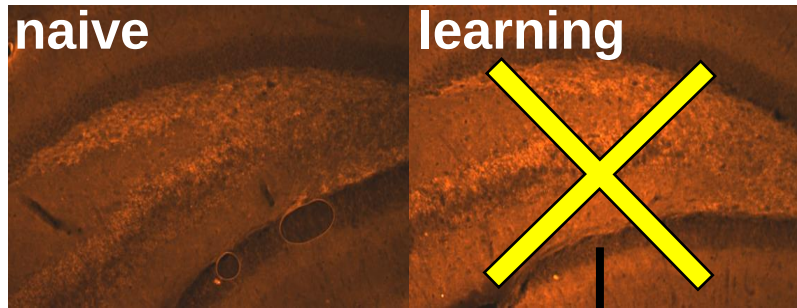
Working Memory Structural Plasticity?



Structural Remodeling

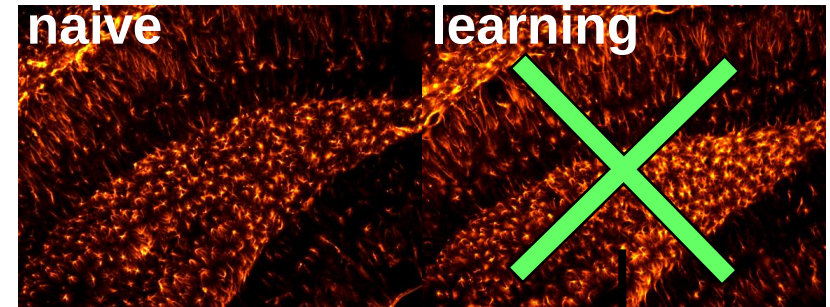
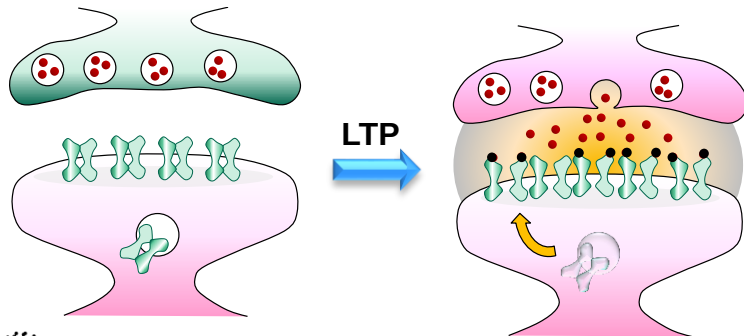


Source of MD reduction



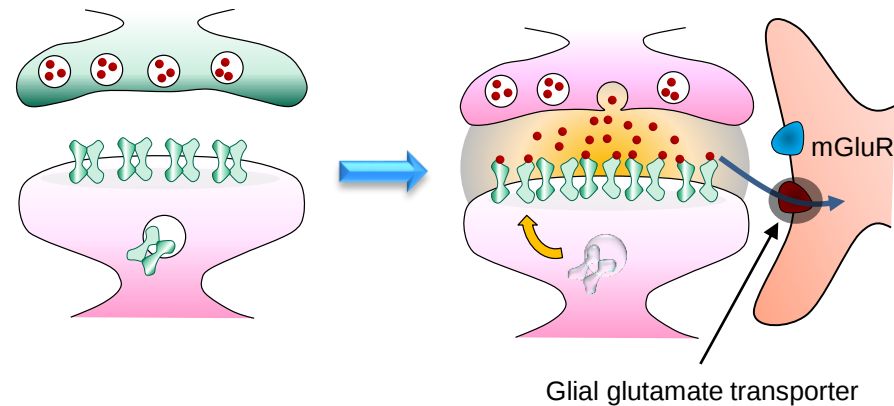
Synaptophysin

NMDA antagonist

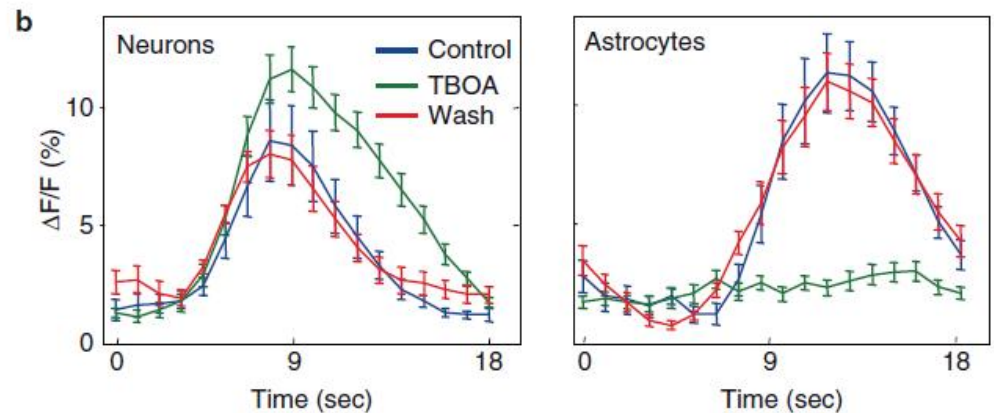
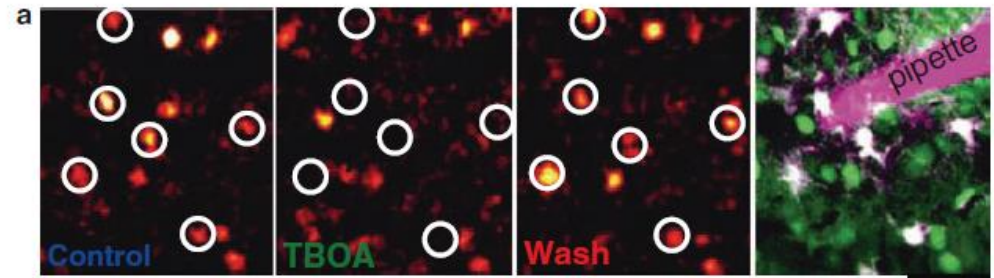
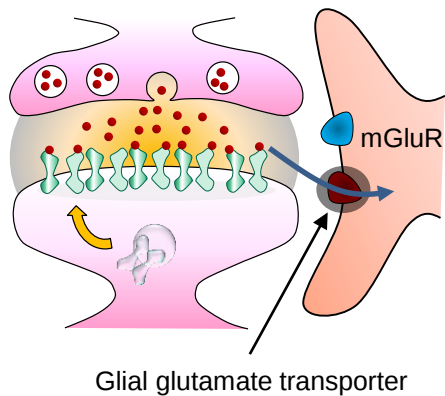


GFAP (astrocytes)

Glutamate transporter antagonist

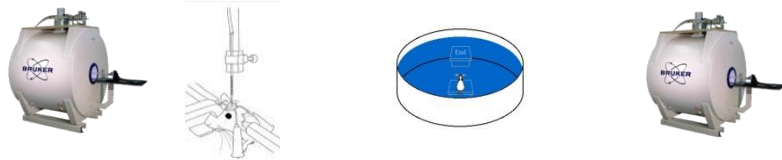


Blocking astrocyte activation

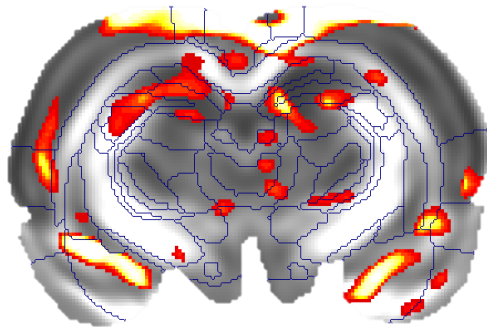
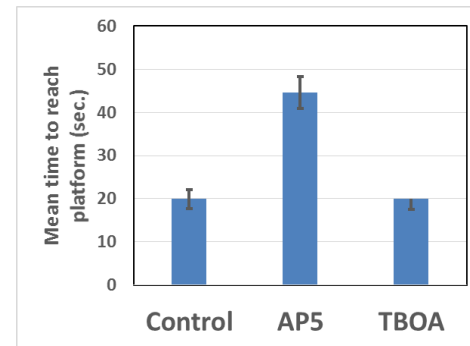


Yu, Schummers, Sur,
in: "Imaging the brain with optical methods, pp 45-65, 2010

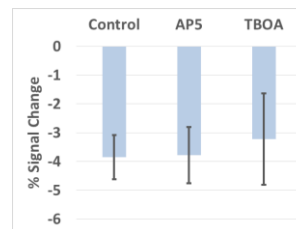
Pharmacological Interference to learning



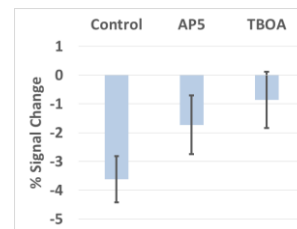
Group1 – aCSF
Group2 – AP5
Group3 - TBOA



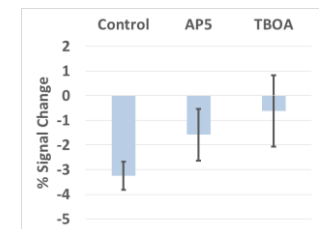
Dentate Gyrus



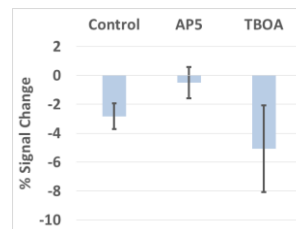
CA1



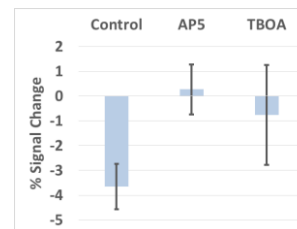
Entorhinal



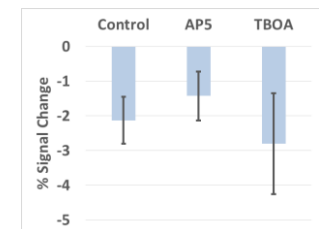
Cingulate Cortex



S1



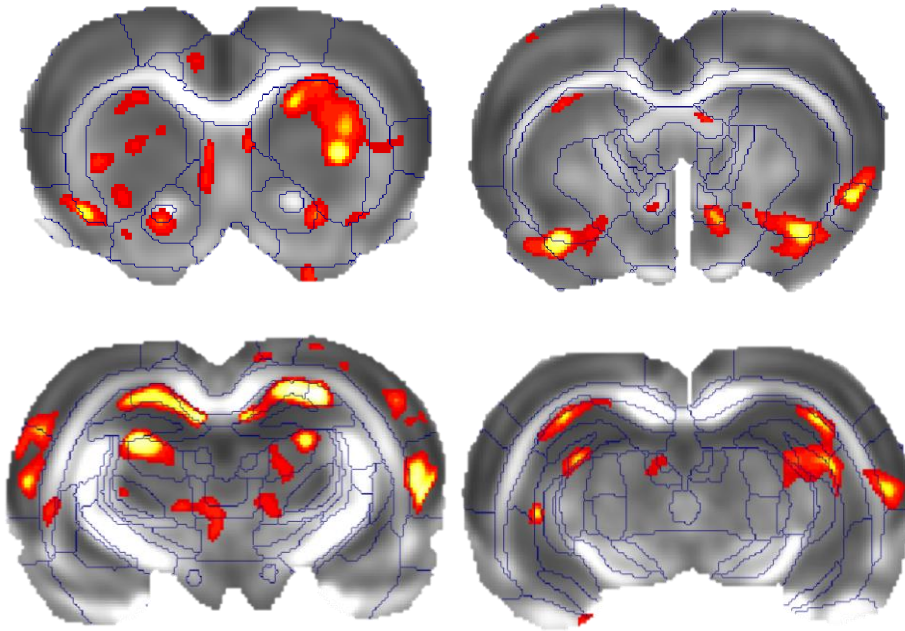
Amygdala



The temporal dynamics of brain plasticity

Exp. 3	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	<u>Consolidation</u> 5 session 4 trials in each session Overnight
Exp. 2	Day 0	session1	Session 2	Session 3	Day 1			<u>Long Term Memory</u> 3 session 4 trials in each session Overnight
Exp. 1	Day 0	session1	Session 2	Session 3	Day 0			<u>Short Term Memory</u> 3 session 4 trials in each session Short term memory

Short Term Memory



Dorsal Hippocampus (CA1)
Thalamus (LP)
Ventral Pallidum
Dorsal striatum (CPu)
Entorhinal Cortex
Auditory Cortex
Dentate gyrus

Exp. 1

Day 0



session1



Session 2



Session 3

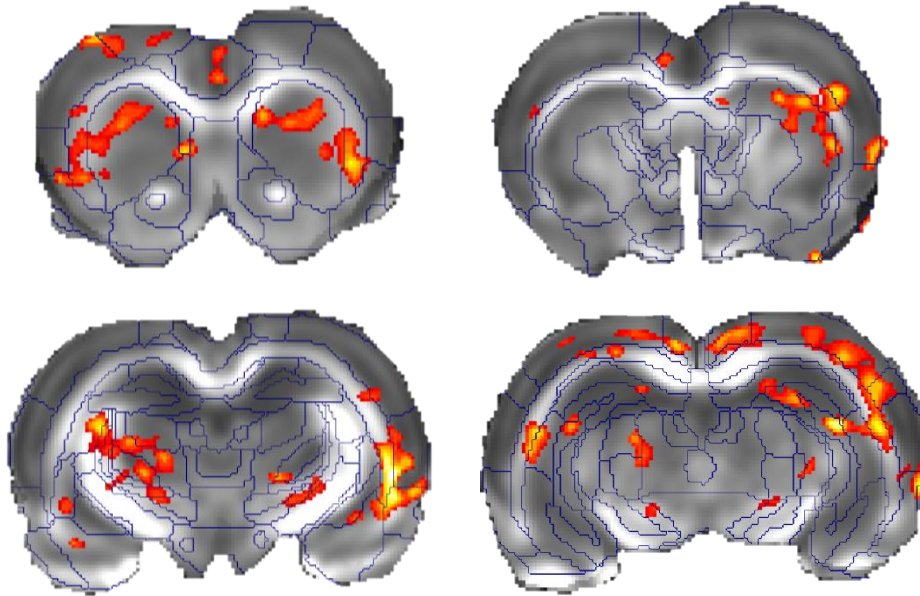


Day 0



3 session
4 trials in each session
Short term memory

Long Term Memory



Sensory Cortex (S1/S2)
Cingulate Cortex
Entorhinal Cortex
Dentate Gyrus
Dorsal Striatum
Thalamus (ventral nuc.)

Exp. 2

Day 0



session1



Session 2



Session 3



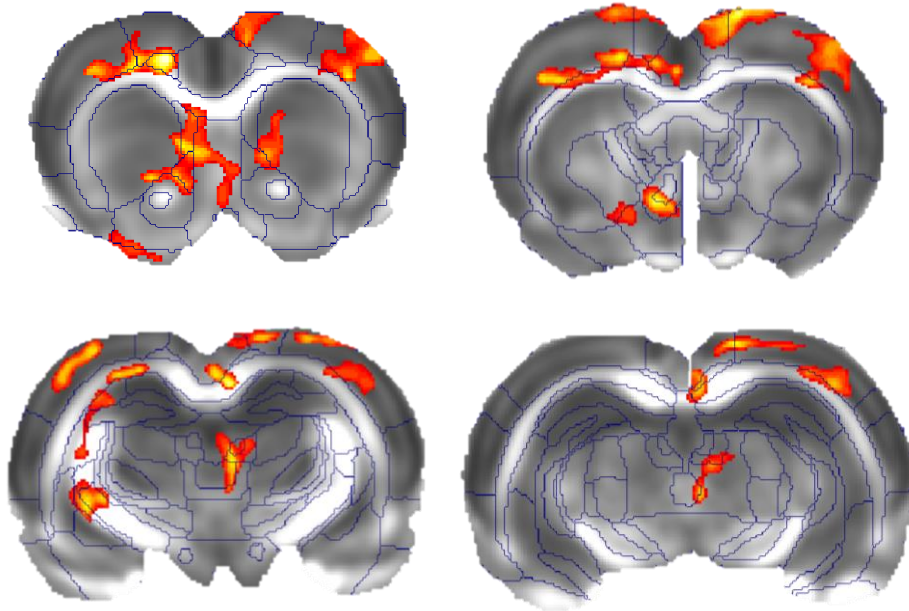
Day 1



3 session
4 trials in each session
Overnight



Retrieval



Motor Cortex (M1/M2)
Sensory Cortex (S1/S2)
Cingulate Cortex
Septal Nuc.
Visual Cortex
Dentate gyrus

Corpus Callosum
Fornix

Exp. 3

Day 0



Day 1



Day 2



Day 3



Day 4



Day 5

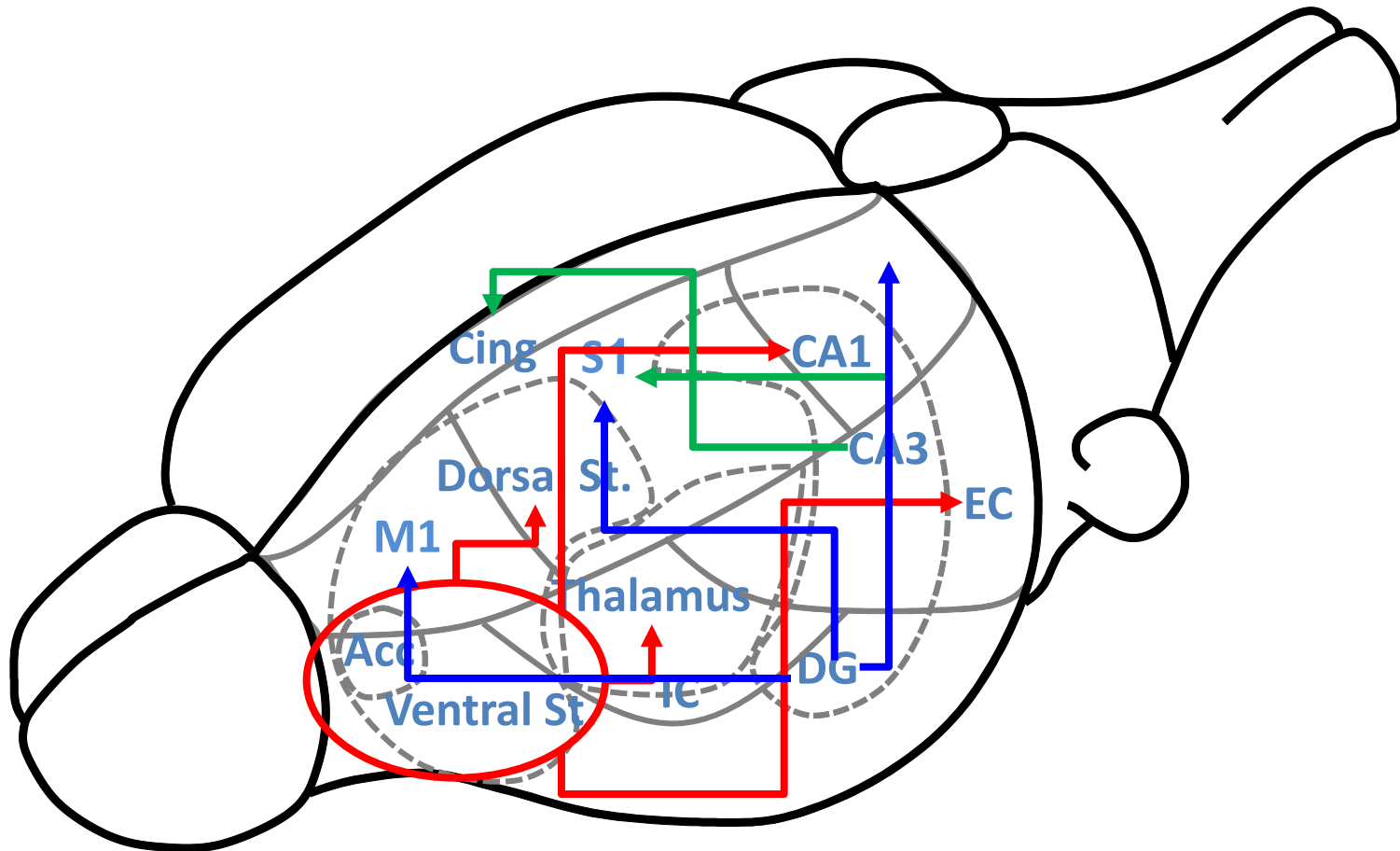


Day 6

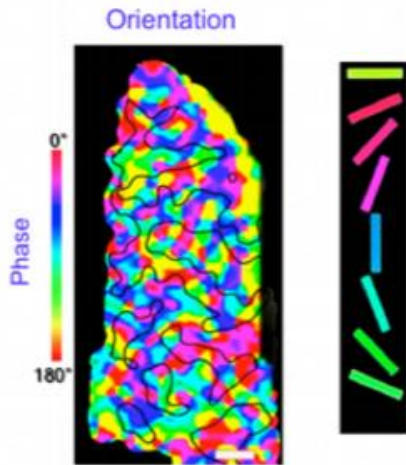


5 session
4 trials in each session
Overnight

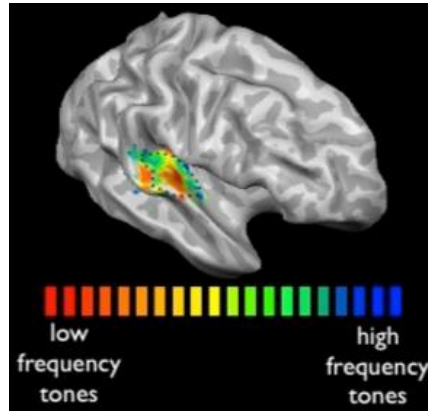
Dynamics of Plasticity



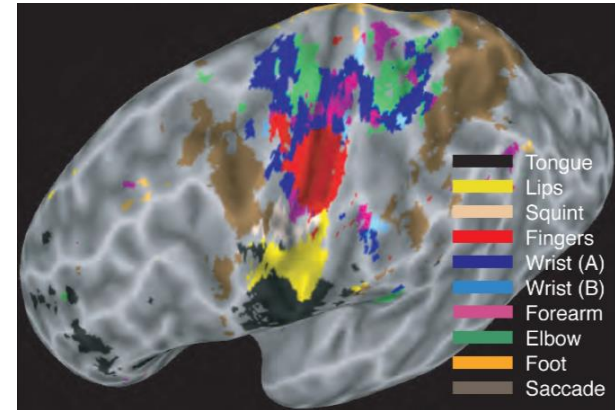
Spatial Organization?



Yacoub et al.
PNAS 105, 10607, 2008

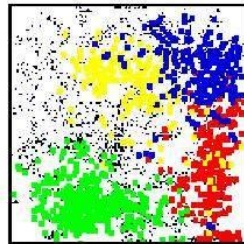
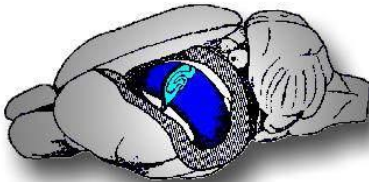


De Costa et al.
Journal of Neuroscience 31, 14067, 2011



© Michael Graziano

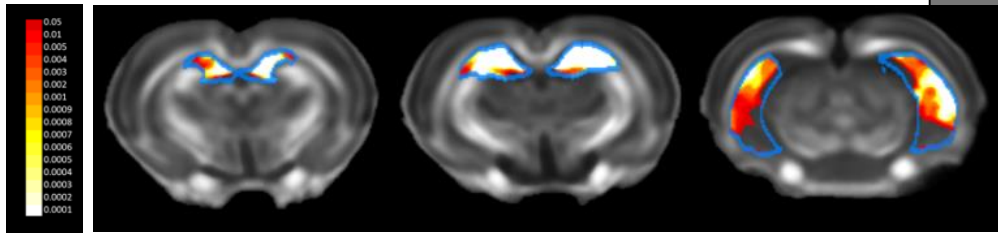
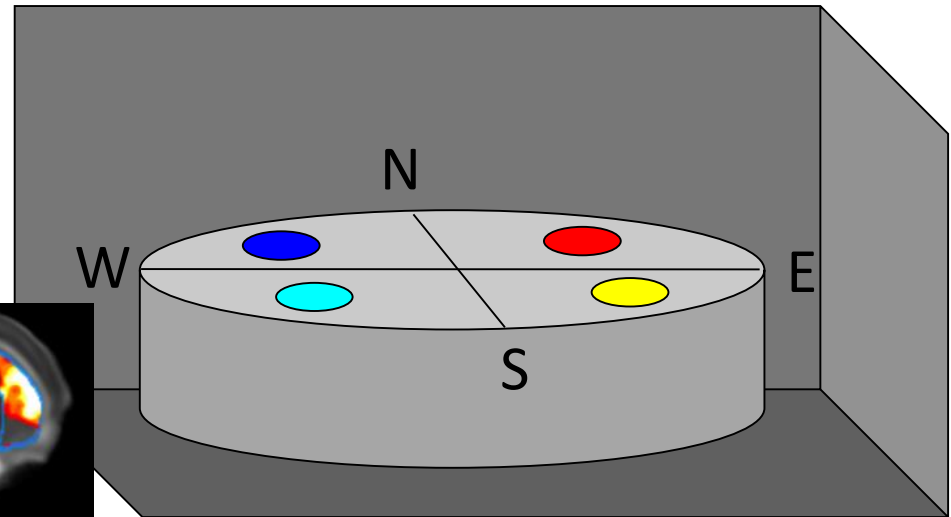
Is there a system level organization within the hippocampus?



No place maps (based on electrophysiology)

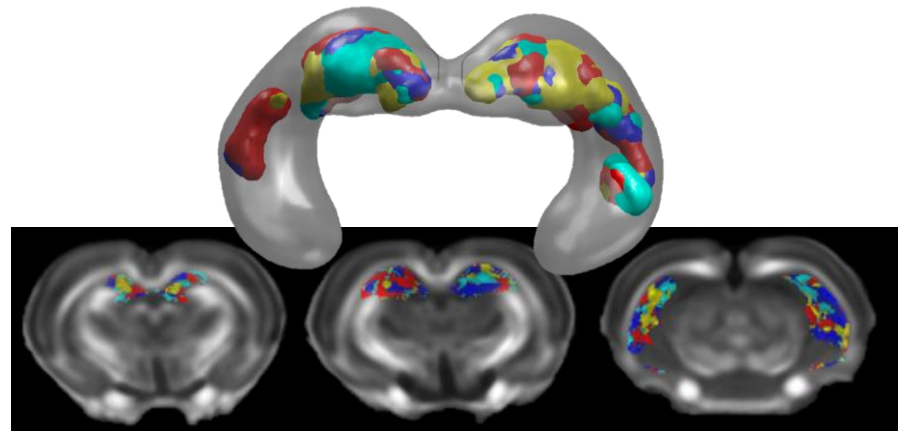
Spatial Organization in the hippocampus?

4 groups: for each the platform is located at a different quadrant (n=52).

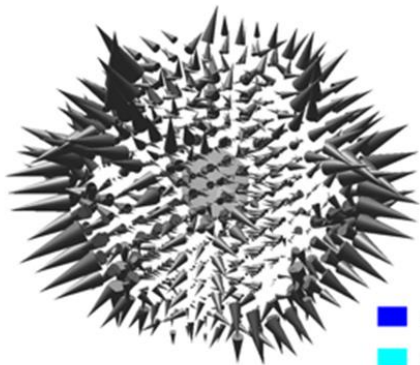
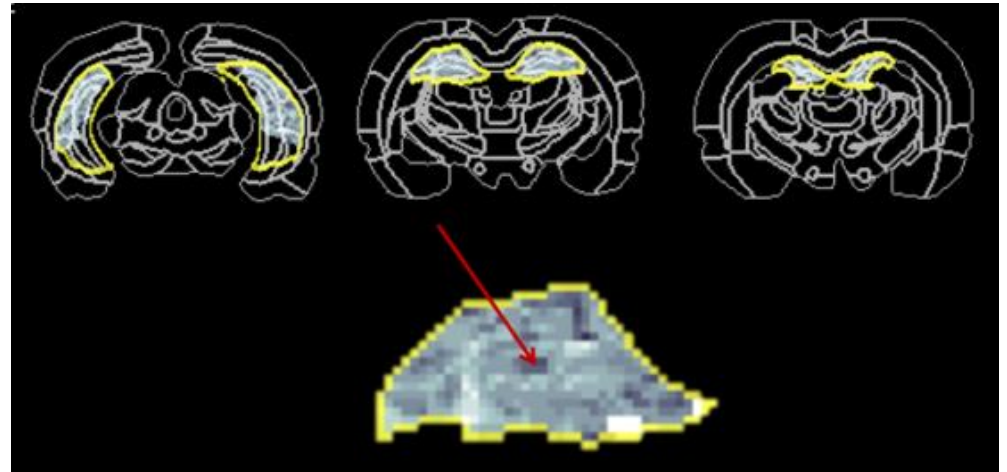
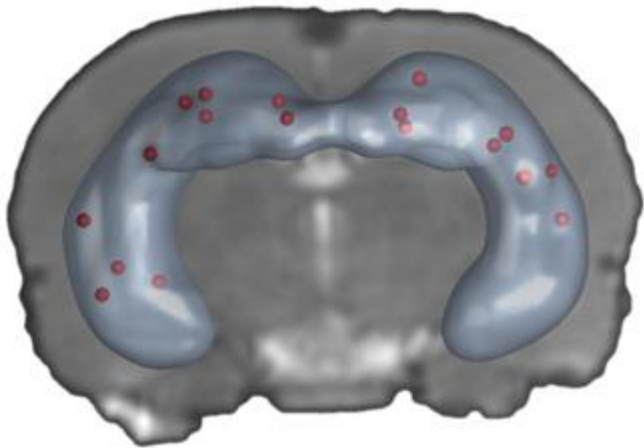


Is there a preference for location?

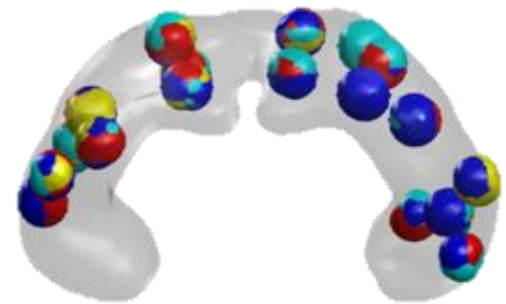
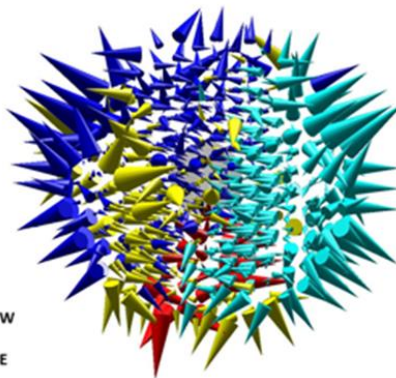
(i.e. voxels where MD reduction was larger for specific platform location)



Preference for Index

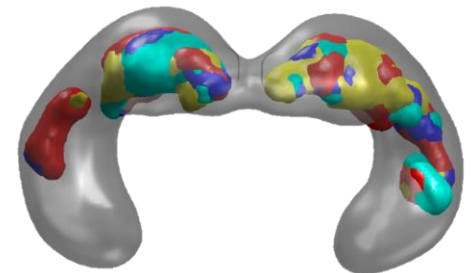


■ SW ■ NW
■ SE ■ NE



Summary

- Diffusion MRI based characterization of neuroplasticity opens new opportunities to explore the memory domain
- The mechanism of diffusion MRI changes seems to be strongly related to astrocyte activity
- Structural neuroplasticity is a dynamic process that progress in space and time within the brain
- Diffusion MRI enables measurement of neuroplasticity on the system level for the whole brain providing a more holistic and comprehensive characterization of this process



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Mr. Nadav Mark

Strauss Center for Computational
Neuroimaging



Omri



Shir



Ido



Assi



Shani



Maya



Hadas



Rotem



Eyal



Omri



Ittai



Dana



Thank You