



Max-Planck-Institut
für biologische Kybernetik

Microstructural Changes Over Time Following Learning of Object-Location Association Task



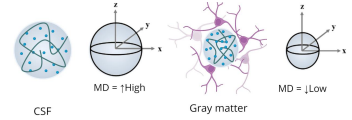
Thananya Charoenpattarawut¹, Svenja Klinkowski^{1,2}, and Svenja Brodt^{1,2}

¹Max Planck Institute for Biological Cybernetics, ²Institute for Medical Psychology, University of Tübingen

Background

- Neocortical memory traces had been found to emerge already 3 h after encoding session of object-location association task¹.
- Here, microstructure remodeling related to memory formation across 24 hours since the encoding started was investigated with diffusion-weighted (dwMRI), and quantitative MRI (qMRI).

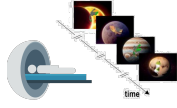
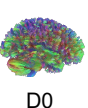
- Memory-related plasticity in gray-matter is associated with decrease in averaged, non-directional water molecule movement (mean diffusivity, MD)^{1,2,3,4}



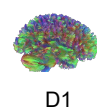
What microstructural changes precede the 24-hour MD decreases observed after learning?

Methods

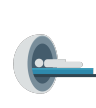
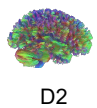
multi-shell dwMRI (b = 1000, 2500 s/mm²)
qMRI (bSSFP)



multi-shell dwMRI
qMRI



multi-shell dwMRI
qMRI



Encoding
r0 r1 r2 r3 r4 r5 r6 r7 r8
fMRI
single-shell dwMRI (b = 1000 s/mm²)

Analysis

- Whole-brain analysis** on 6 mm smoothed MNI space data of DKI; comparing baseline to 24 h delay to identify ROIs with learning-induced MD decrease.
- Based on identified ROIs, we analyzed dwMRI- and qMRI-derived indices reflecting microstructural changes over time during encoding and at D2, D1, and during encoding session.

- Participants:** n = 120; learn n = 80, control n = 40
- 3 sessions of simultaneous **multi-shell dwMRI** and **qMRI**
- Encoding: simultaneous **fMRI** and **single-shell dwMRI**
- Task:** "Alien" (abstract visual stimuli) and planet background association⁵

dwMRI and qMRI Preprocessing

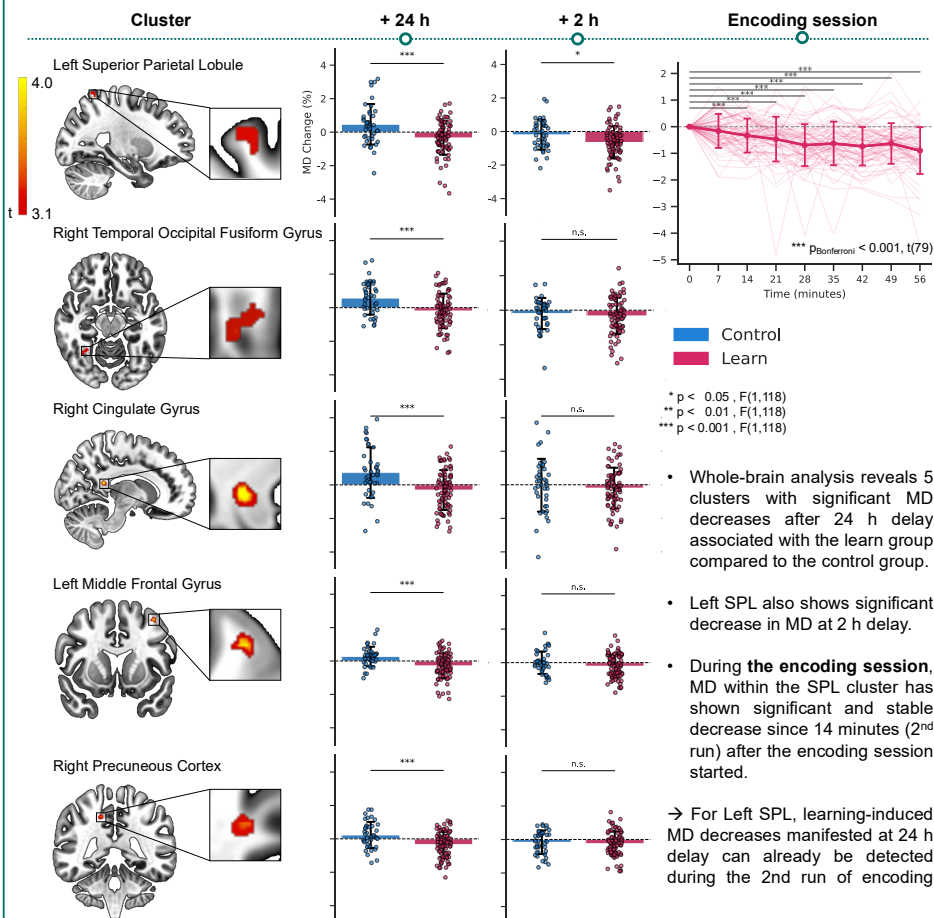
- dwMRI:**



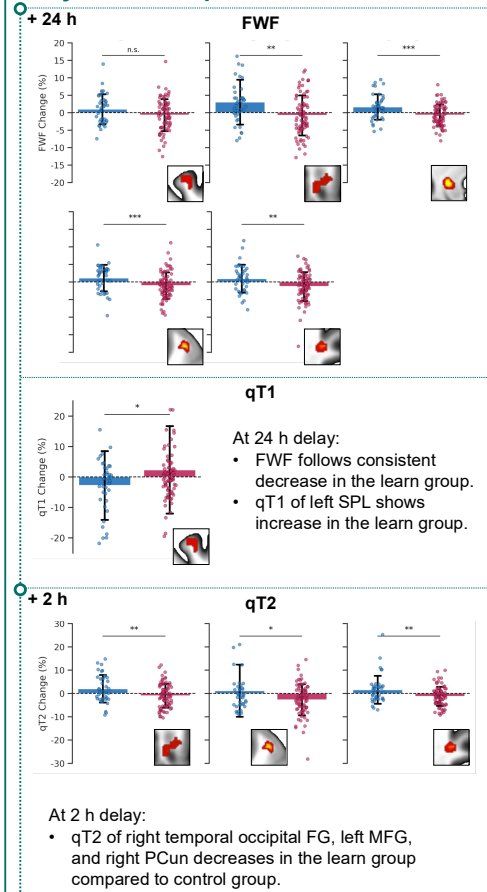
- qMRI:** customized whole-brain 3D sagittal pc-bSSFP acquisitions for joint R1 and R2 relaxometry quantitative maps of T1 (qT1) and T2 (qT2) were calculated by MIRACLE algorithm^{6,7}.

[†] eddy correction with --estimate_move_by_susceptibility

Characterization of Learning-Induced Mean Diffusivity (MD) Changes



Microstructural Changes Reflected by FWF and qMRI-derived indices



Conclusion

- Whole-brain analysis reveals 5 clusters with significant MD decreases after 24 h delay associated with the learn group compared to the control group.
- In the left SPL cluster, the MD decrease occurs as earliest as 14 minutes after encoding session and endure until 24 h later.
- Learning-induced MD decrease observed 24 h after learning could result in different temporal dynamic of microstructure remodeling
- Incorporating several MRI-derived biomarkers has the potential to characterize the dynamic of structural plasticity during memory formation

Reference

- 1 Brodt et al., 2018, Science
- 2 Sagi et al., 2012, Neuron
- 3 Stee et al., 2023, iScience
- 4 Tavor et al., 2020, Hum Brain Map
- 5 Klinkowski et al., 2025, bioRxiv
- 6 Birk et al., 2025, Sci Rep
- 7 Birk et al., 2026, Magn Reson Med

Thananya Charoenpattarawut (Office 4.A.10)
thananya.charoenpattarawut@tuebingen.mpg.de