

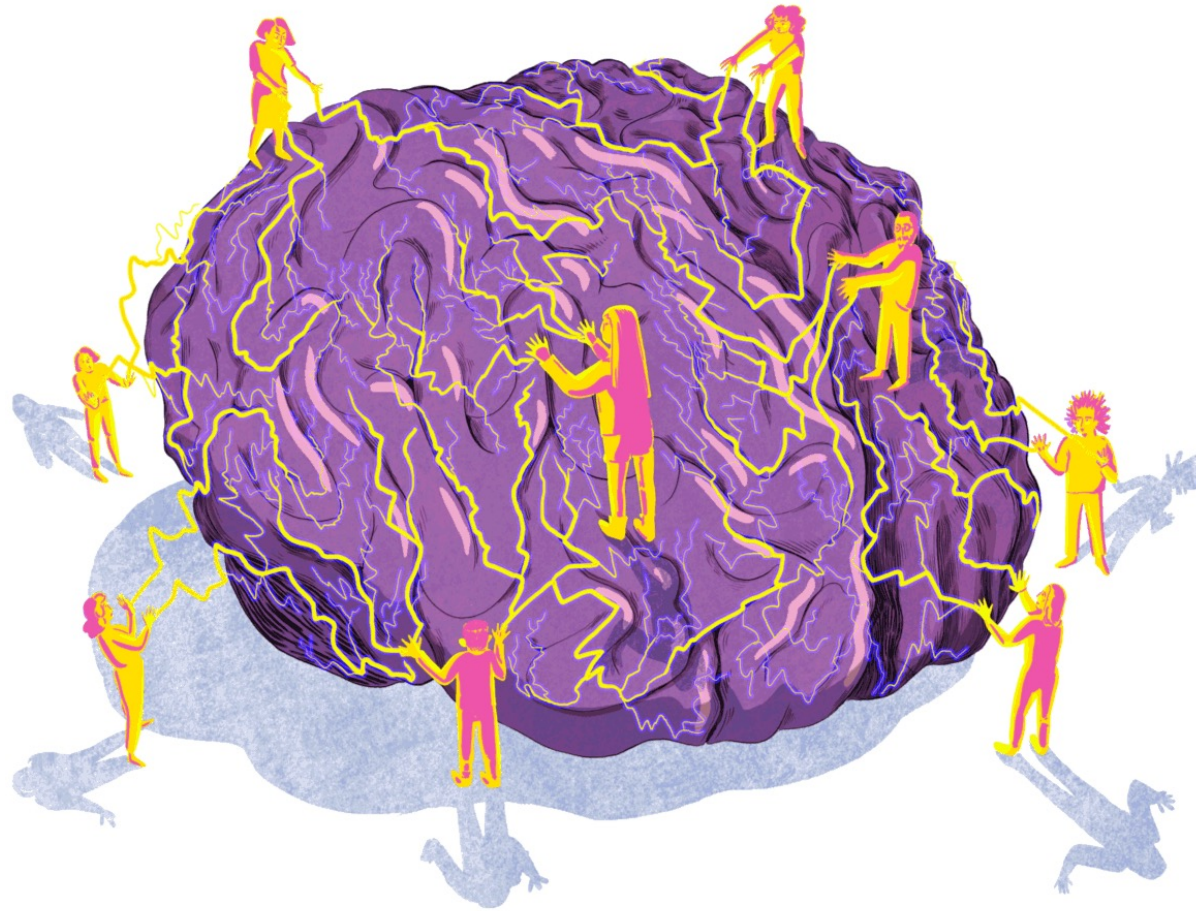
Evolving **plasticity** in brain and behaviour after targeted memory reactivation during sleep



Martyna Rakowska
[ResearchGate](#)
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Background
Aims & Hypothesis
Study Design
Results: Behavioral
Results: EEG
Results: MRI (selected)
Conclusions
Possible Mechanisms

1/3 of your life....



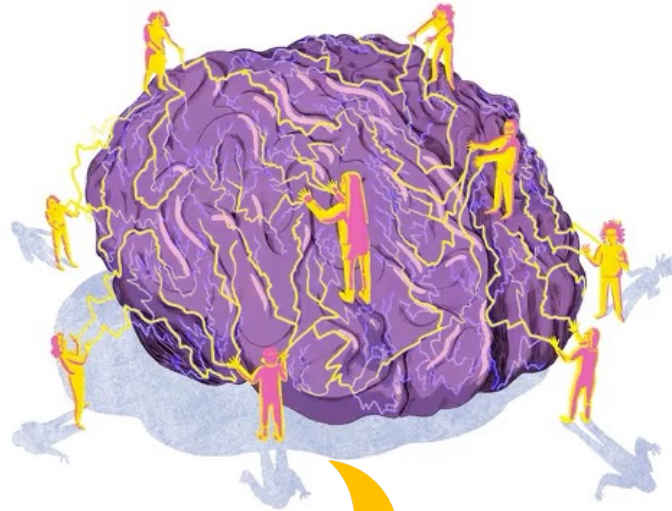
A waste of time?

Memory processes

encoding



consolidation



Memory reactivation



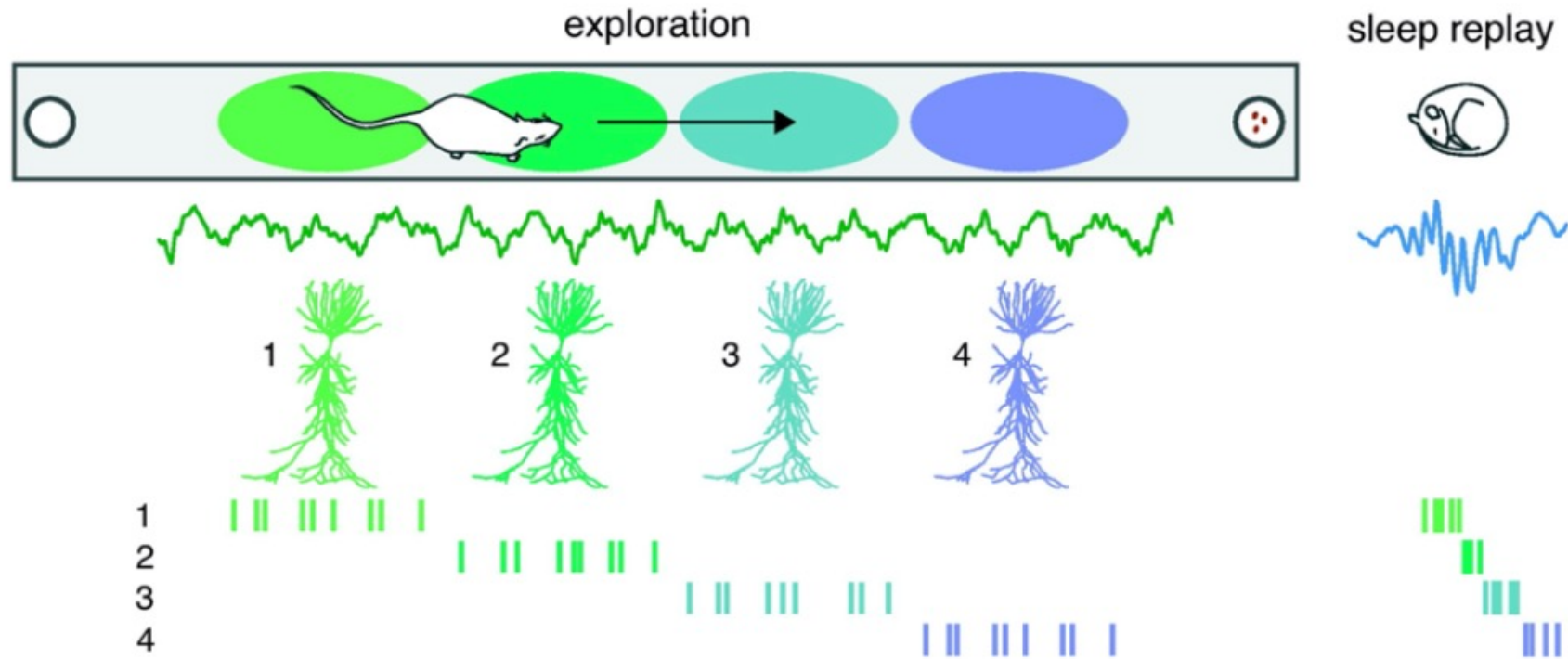
retrieval



Marie Assenat & Lily Padula

Memory reactivation during sleep

Re-emergence of brain activity pattern elicited while learning during sleep



Girardeau & Zugaro (2011)

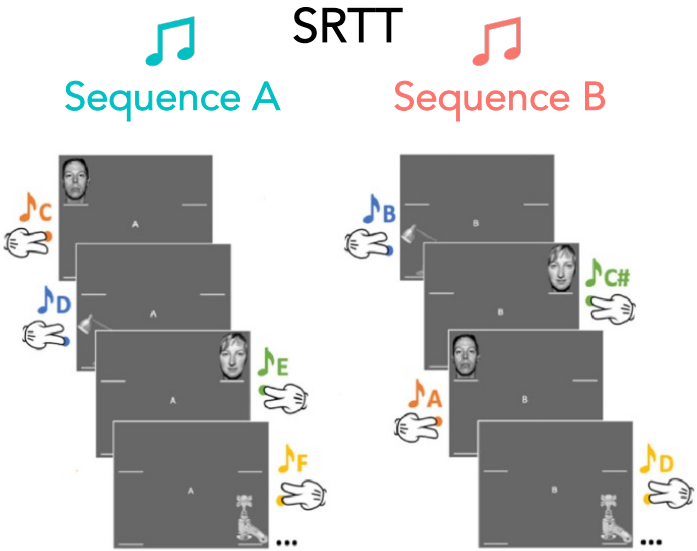
Memory reactivation is key for memory consolidation

(Diekelmann & Born, 2010; Born & Wilhelm, 2012; Deuker et al., 2013; Peigneux et al., 2004)

Targeted Memory Reactivation

TMR taps into the sleep-dependent consolidation process, thereby providing a tool to study the mechanisms of memory reactivation

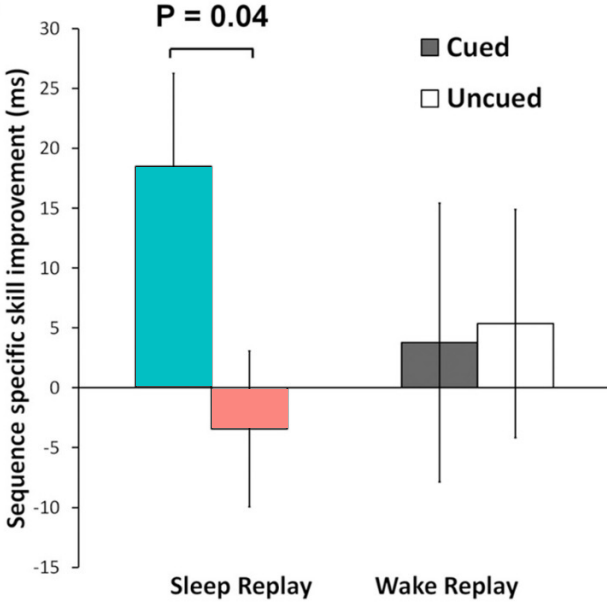
SRTT learning



sleep



testing



Cousins et al. (2014)

Aims & Hypothesis

- **Knowns:** TMR shows strong short-term behavioural effects (*e.g. Antony et al., 2012; Schönauer et al., 2014; Cousins et al., 2014, 2016; Rakowska et al., 2021*)
- **Unknown 1:** Long term effects of TMR



Unknown 1

Long-term behavioural effects of TMR

- object-location memory (*Shanahan et al., 2018*)
 - emotional memory (*Groch et al., 2017*)
 - implicit biases (*Hu et al., 2015*)
 - implicit biases replication (*Humiston & Wamsley, 2019*)
 - procedural memory
- } 1 week post-TMR

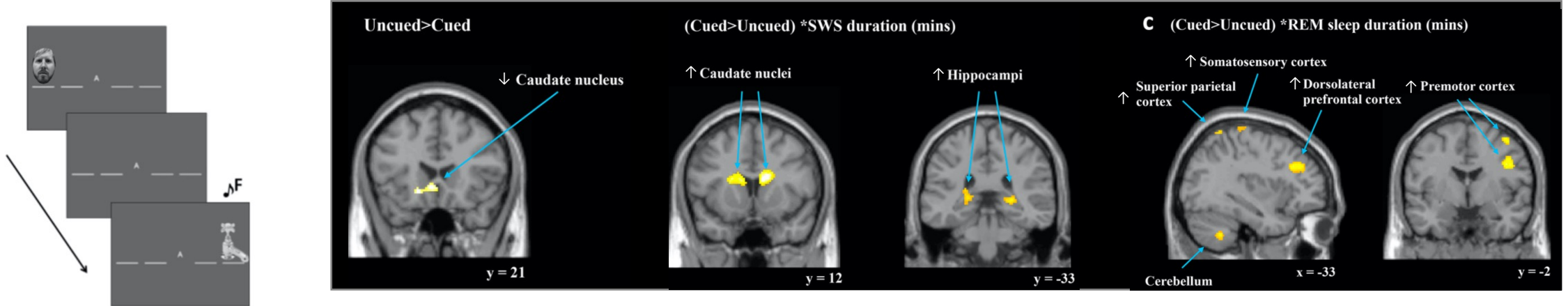
Aims & Hypothesis

- **Knowns:** TMR shows strong short-term behavioural effects (*e.g. Antony et al., 2012; Schönauer et al., 2014; Cousins et al., 2014, 2016; Rakowska et al., 2021*)
- **Unknown 1:** Long term effects of TMR
- **Unknown 2:** (Micro)structural changes and long term functional changes that contribute to sleep reactivation and underly the effects of TMR, are unknown



Unknown 2

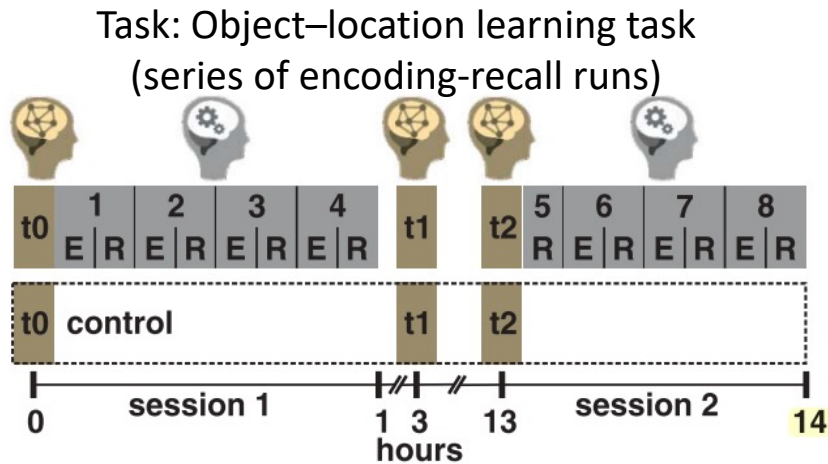
- Cousins et al. (2016), Plos Biology



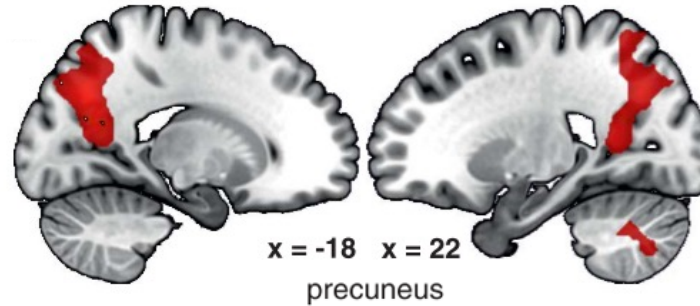
BUT: No-one looked at the **fMRI changes** underlying TMR effects in the **long-term**

Unknown 2

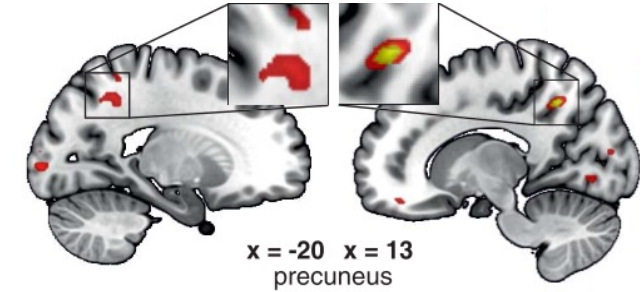
● Brodt et al. (2018), Science



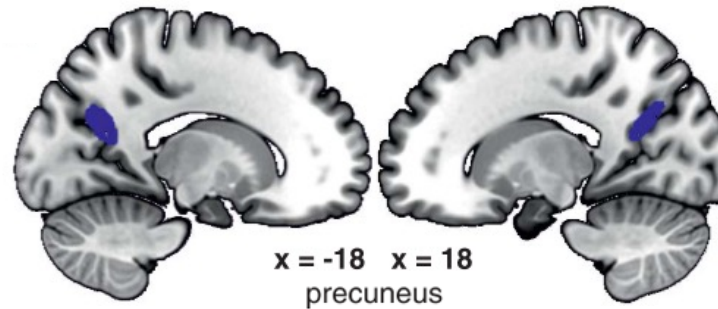
fMRI: ↑ 1.5h after training



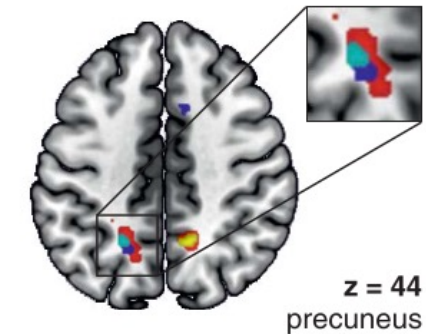
DTI: ↓MD 1.5h after training



fMRI: ↑ 12h after training



DTI: ↓MD 12h after training



BUT: No-one looked at the **microstructural changes** underlying **TMR** (short- or long- term)

Aims & Hypothesis

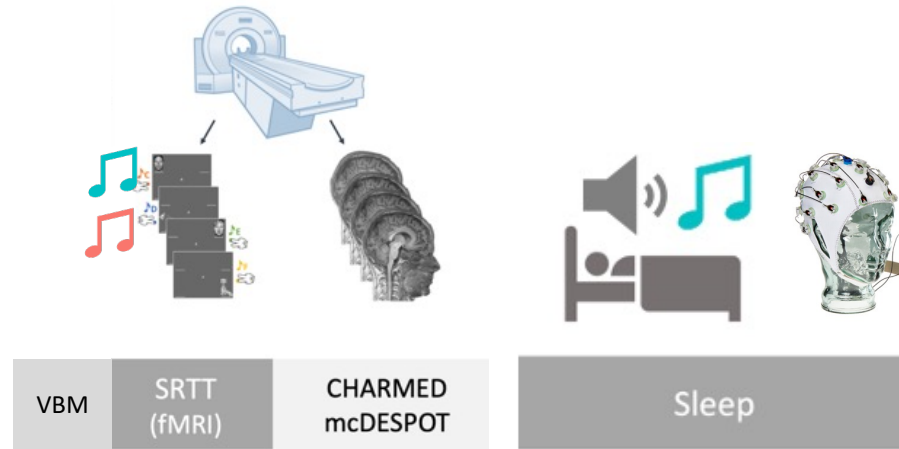
- **Knowns:** TMR shows strong short-term behavioural effects (*e.g. Antony et al., 2012; Schönauer et al., 2014; Cousins et al., 2014, 2016; Rakowska et al., 2021*)
- **Unknown 1:** Long term effects of TMR
- **Unknown 2:** (Micro)structural changes and long term functional changes that contribute to sleep reactivation and underly the effects of TMR, are unknown
- **Aim:** To investigate the effect of TMR during sleep on long term behaviour and brain plasticity



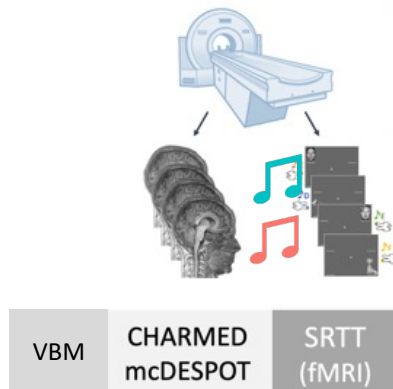
- **Q:** How do memories evolve as they consolidate, and what physical changes in the brain underpin this evolution?

Study design

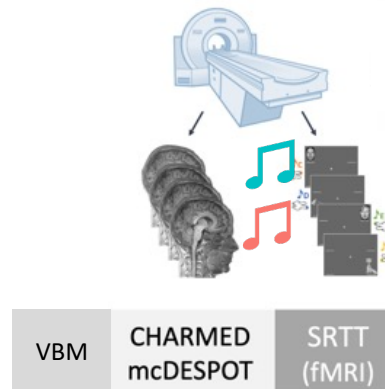
SESSION 1 (8 PM)



SESSION 2 (24 H AFTER S1, 8 PM)



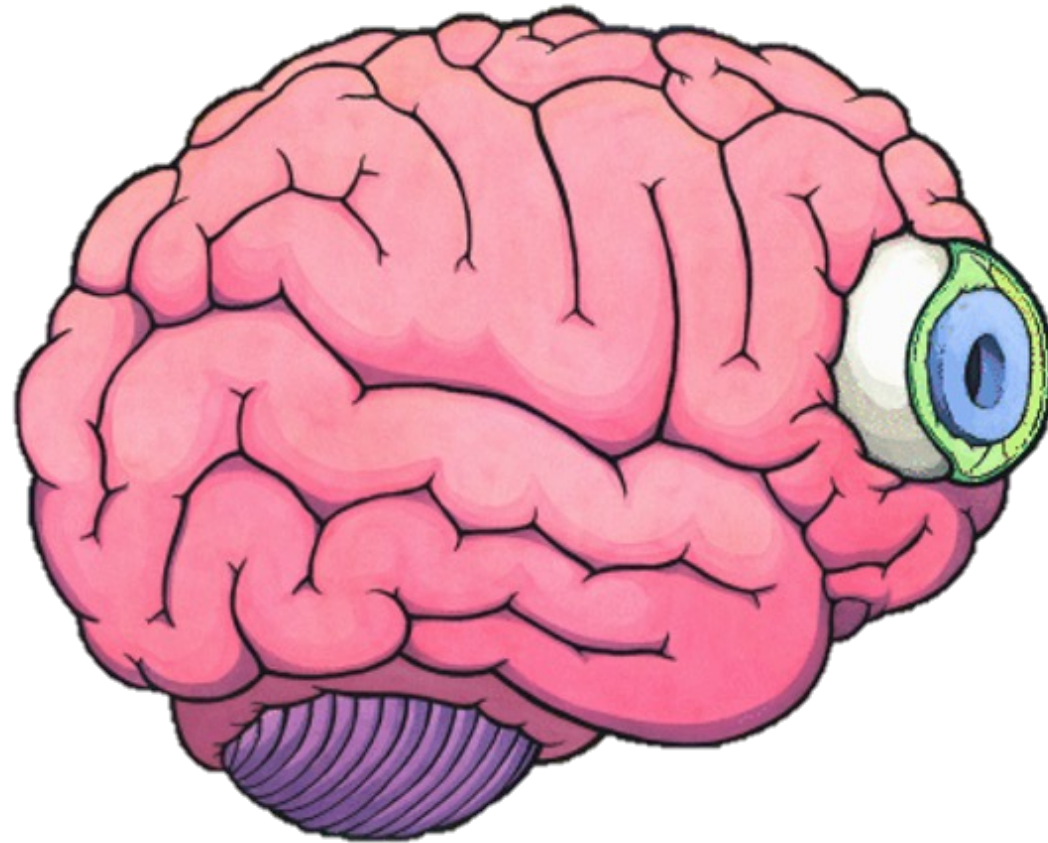
SESSION 3 (10 DAYS AFTER S1, 8 PM)



SESSION 4 (20 days after S1, 8 PM)

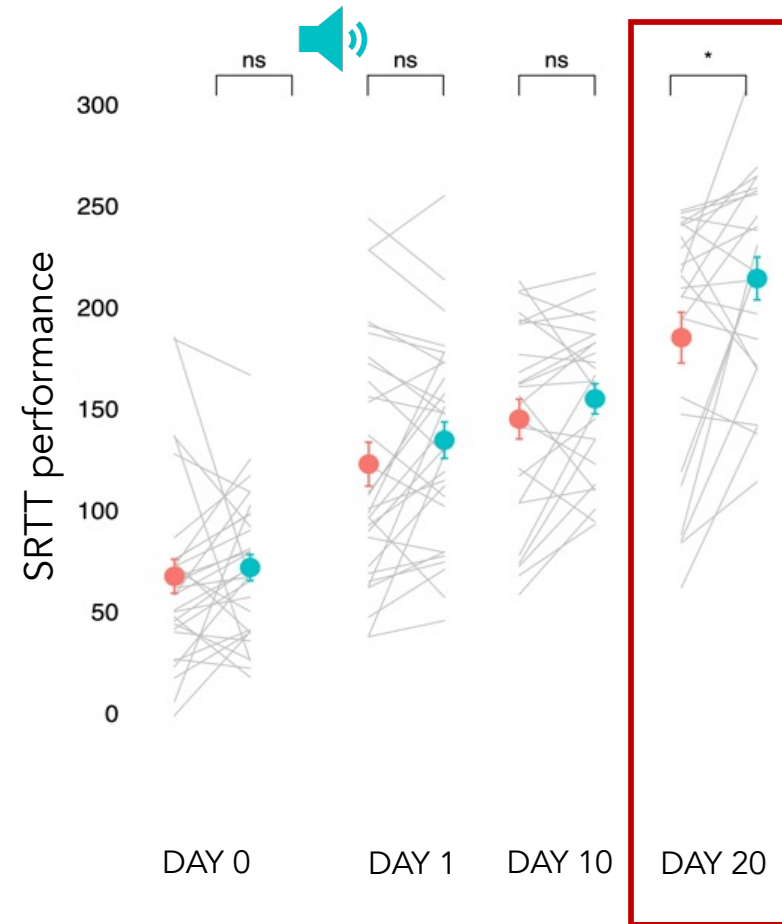


Let's have a look at the... **RESULTS**



Mind's Eye by Scott Teplin

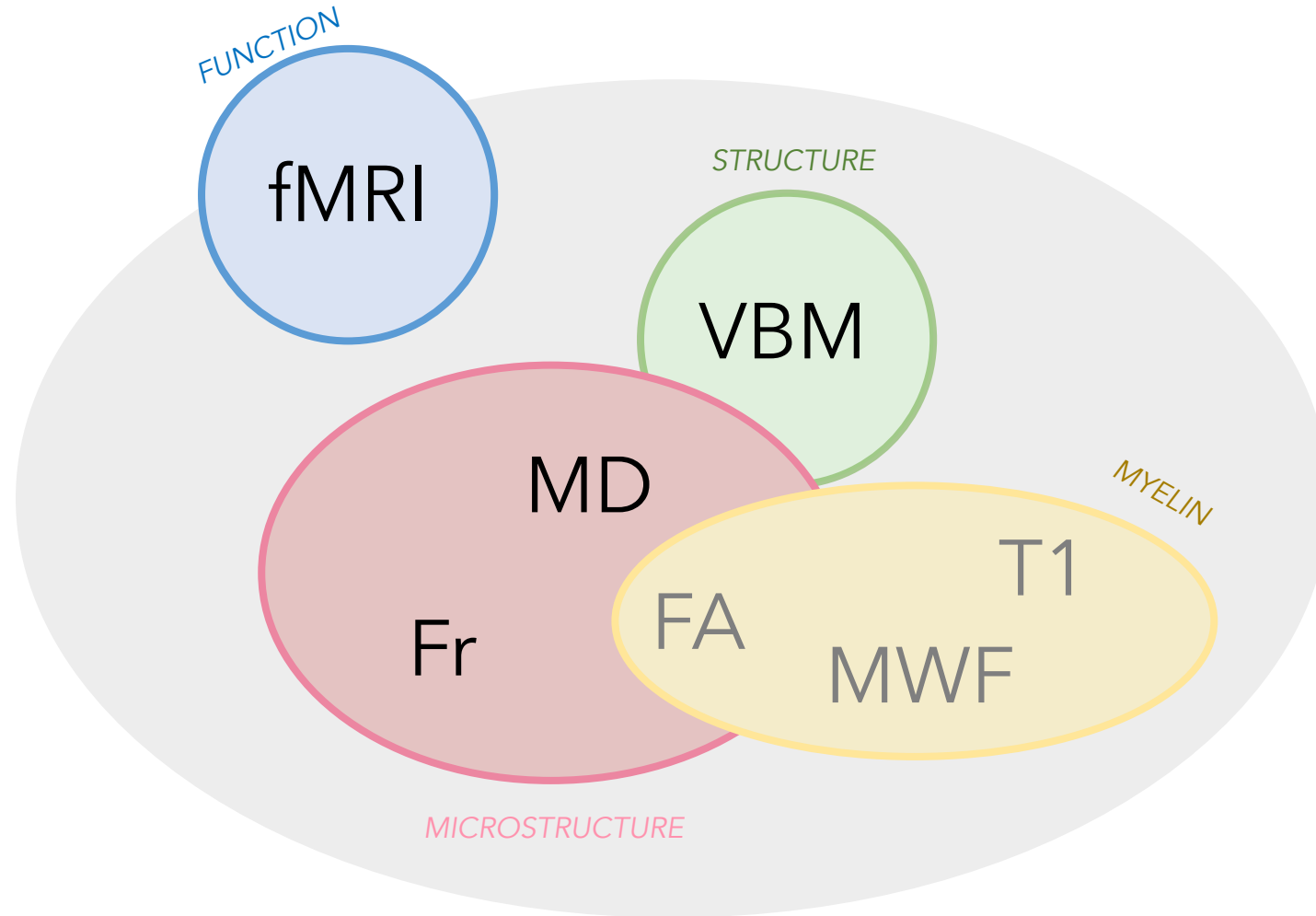
Results: Behaviour



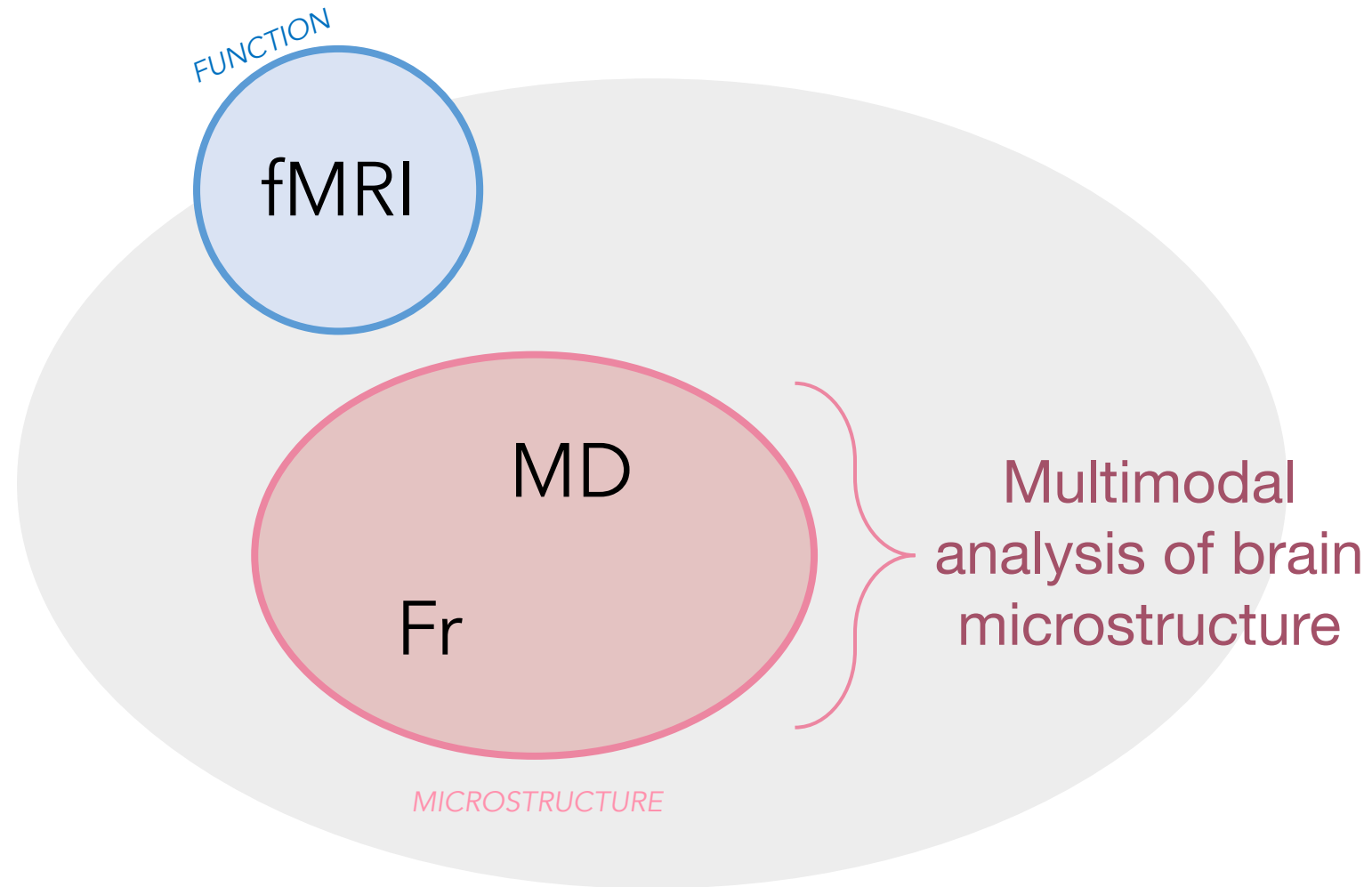
LME, main effect of TMR: $X^2_{(1)} = 11.01, p = 0.001.$

N = 30 for S1-S2, N = 25 for S3, N = 24 for S4

MRI modalities



MRI modalities

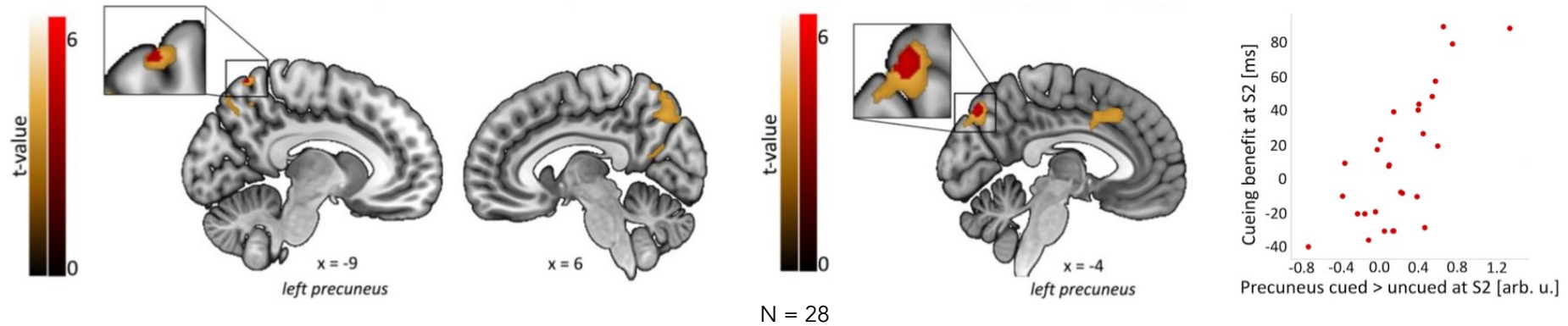


Results: MRI

FUNCTIONAL ACTIVITY

(Cued > Uncued at 24h)

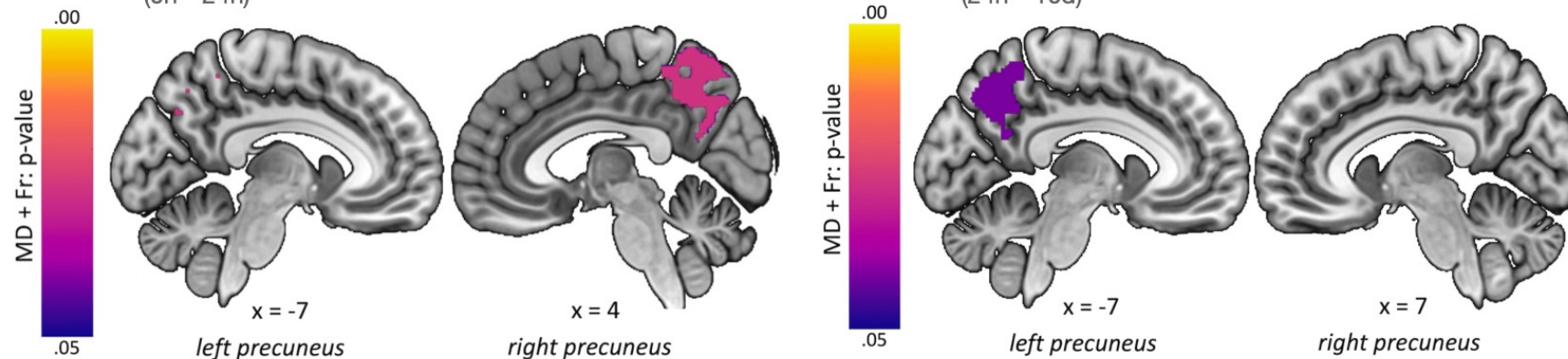
(Cued > Uncued at 24 hours) correlates with behaviour



MICROSTRUCTURAL PLASTICITY

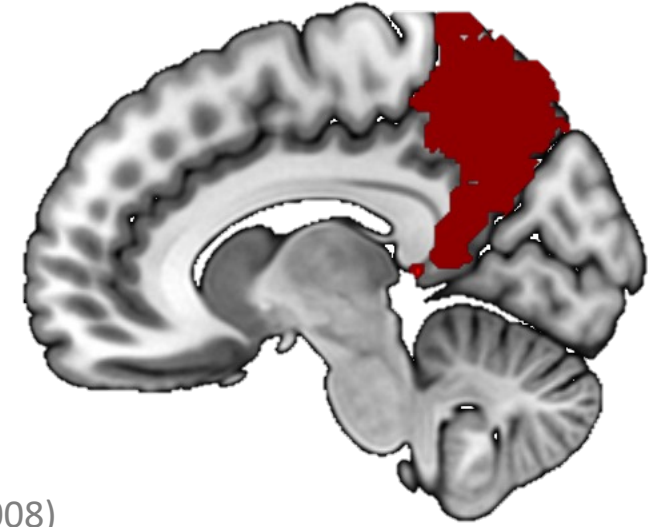
Early plasticity correlates with behaviour
(0h–24h)

Late plasticity correlates with behaviour
(24h–10d)



(left) N = 16, (right) N = 15

Why precuneus?



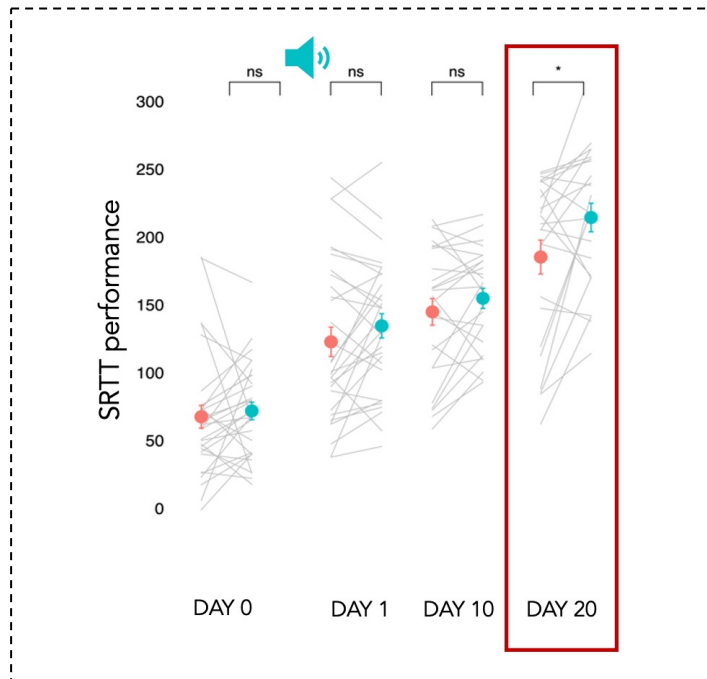
- Part of the posterior parietal cortex
 - traditionally associated with motor function (Shadmehr & Holcomb, 1997)
 - engaged in motor imagery (Zhang & Chiang-shan, 2012)
 - memory retrieval as the central function (Wagner et al., 2005; Cabeza et al., 2008)
- **Precuneus can reactivate motor memories during sleep** (Himmer et al., 2021)
- Precuneus could either hold memory representation (Vilberg & Rugg, 2008) or bind its distributed traces (Shimamura, 2011)
 1. tightly interconnected with multiple brain areas (Buckner et al., 2008; Zhang & Chiang-shan, 2012)
 2. shows microstructural plasticity (Brodt et al., 2018 & our study)



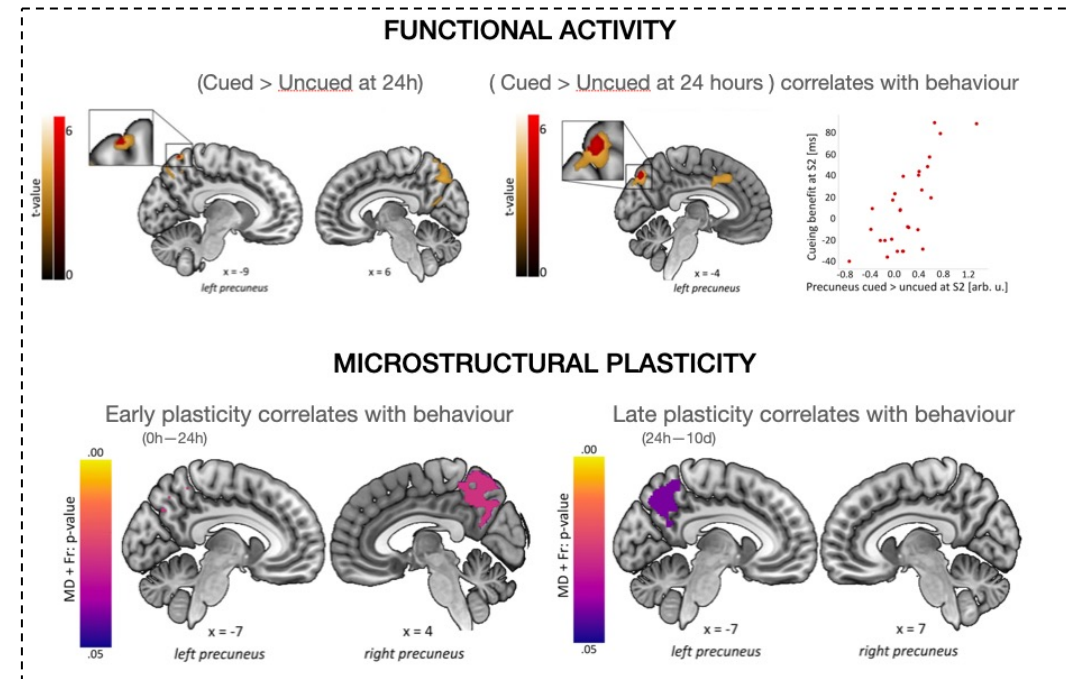
Transient storage site

Take-home message

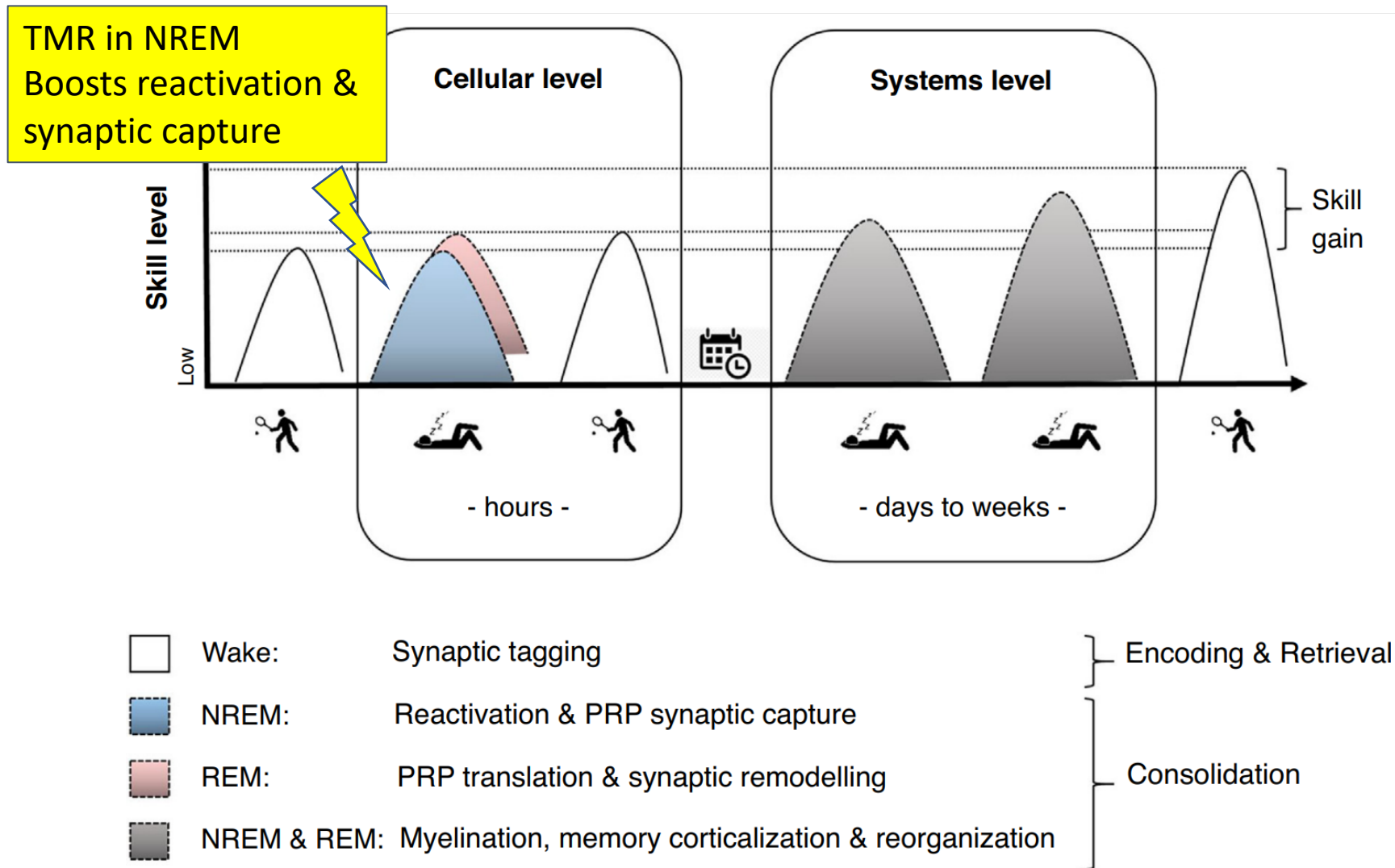
Effects of TMR can last for at least 20 days



TMR leads to ongoing functional & microstructural plasticity in precuneus



Possible mechanisms



bioRxiv preprints

[the behavioural & fMRI results](#)



bioRxiv posts many COVID19-related papers. A reminder: they have not been formally peer-reviewed and should not guide health-related behavior or be reported in the press as conclusive.

New Results

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Cueing motor memory reactivation during NREM sleep engenders learning-related changes in precuneus and sensorimotor structures

Martyna Rakowska, Paulina Bagrowska, Alberto Lazari, Miguel Navarrete, Mahmoud E.A. Abdellahi, Heidi Johansen-Berg, Penelope A. Lewis

doi: <https://doi.org/10.1101/2022.01.27.477838>

This article is a preprint and has not been certified by peer review [what does this mean?].



[the microstructural results](#)



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New Results

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Distributed and gradual microstructure changes track the emergence of behavioural benefit from memory reactivation

Martyna Rakowska, Alberto Lazari, Mara Cercignani, Paulina Bagrowska, Heidi Johansen-Berg, Penelope A. Lewis

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Thank you!



Paulina Bagrowska



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Penny Lewis

