

DETECTING TMR CUED REPLAY OF NEGATIVE MEMEORIES IN REM WITH EEG CLASSIFIERS: A PLANNED STUDY

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BACKGROUND

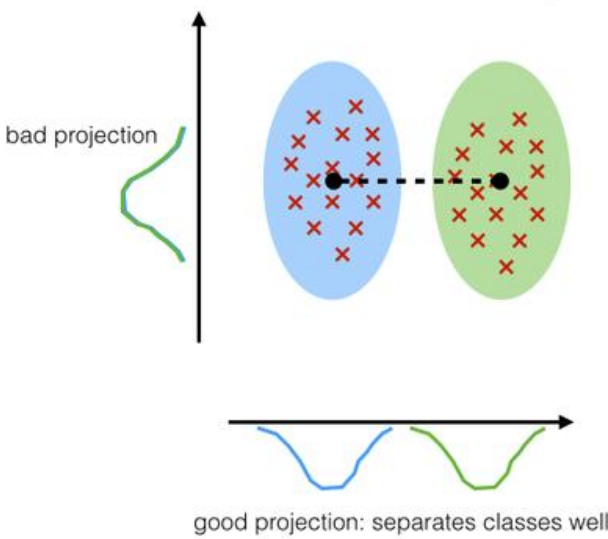
- Targeted Memory Reactivation (TMR) during sleep can cue specific memories and enhance consolidation (Rasch & Born, 2013).
- In Slow-Wave Sleep (SWS), TMR has been shown to strengthen memory traces, particularly when cues align with sleep spindles (Cairney et al., 2018). EEG-based classifiers have successfully decoded such TMR-related reactivation events (Belal et al., 2018; Tsimpanouli et al., 2017).
- Abdellahi et al. (2023) demonstrated that TMR in REM sleep also produces decodable neural reactivation, and that reactivation strength predicts post-sleep behavioural improvements.
- Recent work at the NaPS Lab applied an EEG classification pipeline to emotionally valenced motor sequences during NREM sleep, showing that negative and neutral sequences could be distinguished using theta-band power and LDA (Abdellahi, Tsimpanouli & Lewis, poster presented at Replay@CUBRIC 2025).

HYPOTHESIS

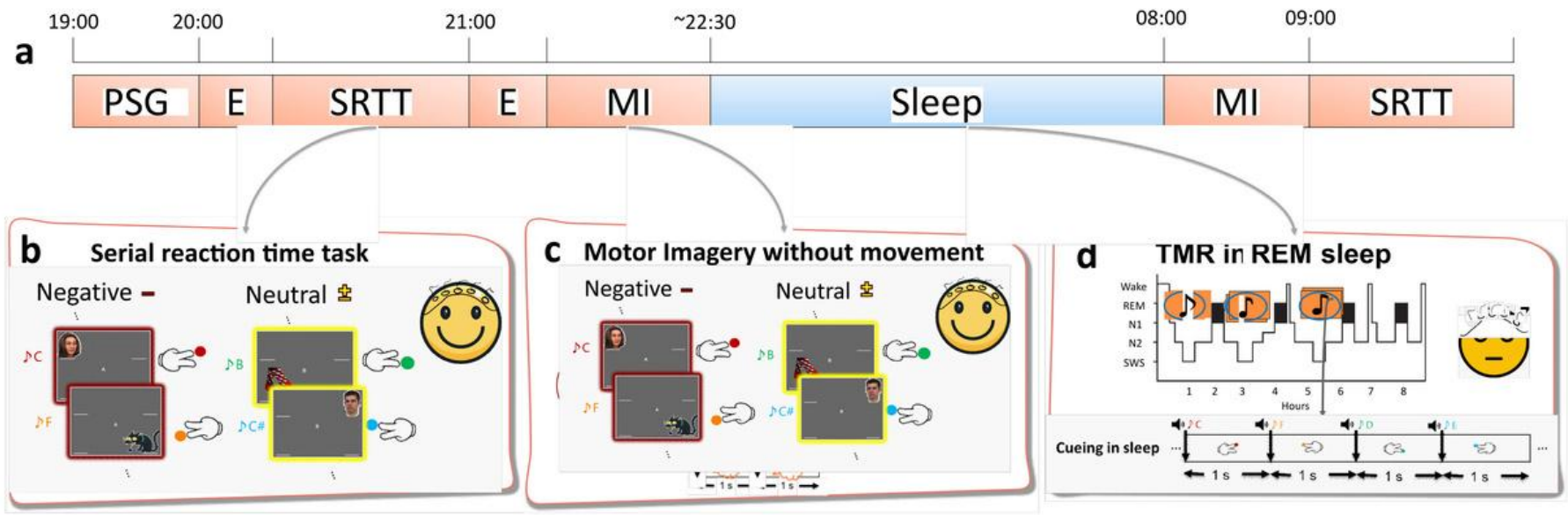
- Building on previous work showing that emotional memory traces can be decoded during NREM sleep, we now ask:
 - Can a classification model, trained on data across participants, accurately identify reactivations of emotionally cued sequences during REM sleep?
- This approach extends existing pipelines from NREM to REM, aiming to test whether emotion-specific reactivation can be detected in the more desynchronised neural dynamics of REM.

LDA:

maximizing the component axes for class-separation



PROTOCOL



BLOCK CONTAINS 3 REPETITIONS OF THE SEQUENCE.
15-SECOND GAP BETWEEN BLOCKS.
24 BLOCKS OF EACH SEQUENCE IN TOTAL AND 4 RANDOM BLOCKS.

METHODOLOGY

Participants and Design

- Data will be collected from participants performing a Serial Reaction Time Task (SRTT) paired with auditory cues and emotionally-valenced images (negative or neutral).
- Participants will then sleep overnight, with TMR cues presented during REM sleep in interleaved blocks.

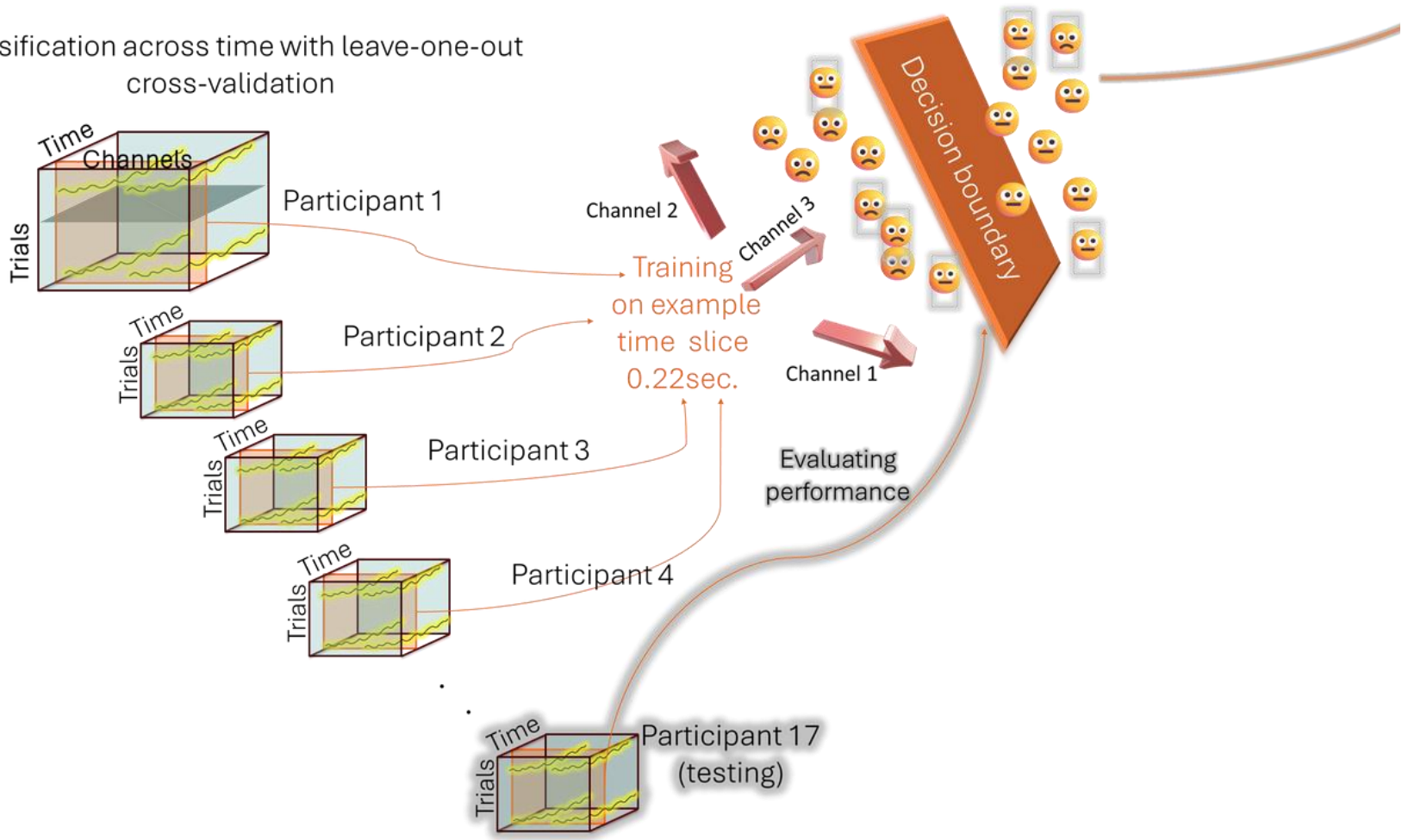
EEG Feature Extraction

- EEG data will be recorded from 32 channels and preprocessed using standard filtering and artefact rejection.
- A Hilbert transform will be applied to extract instantaneous theta-band power (4–8 Hz) from each channel following cue onset.

Classification Pipeline

- A Linear Discriminant Analysis (LDA) classifier will be trained on pre-sleep wake imagery EEG, distinguishing negative vs neutral cue sequences.
- Classification will be performed across time, and accuracy will be assessed using leave-one-out cross-validation.
- Performance will be compared to chance-level baselines using permutation tests.

Classification across time with leave-one-out cross-validation



EXPECTED RESULTS

- We expect that the classifier will achieve above-chance accuracy in distinguishing emotionally valenced TMR cues (negative vs neutral) during REM sleep, indicating successful detection of memory reactivation.
- However, classification performance may be lower than that observed in SWS, due to the more desynchronised and dynamic EEG activity characteristic of REM.
- Identifying reactivation in REM would not only extend the validated NREM classification pipeline to a new sleep stage, but also provide insights into how emotional memories are processed and re-expressed in REM sleep; a stage traditionally associated with affective regulation and dream-related reorganisation.
- This study may help clarify the functional role of REM sleep in emotional memory consolidation and reactivation dynamics.

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