Identifying sequential memory reactivation during sleep in humans

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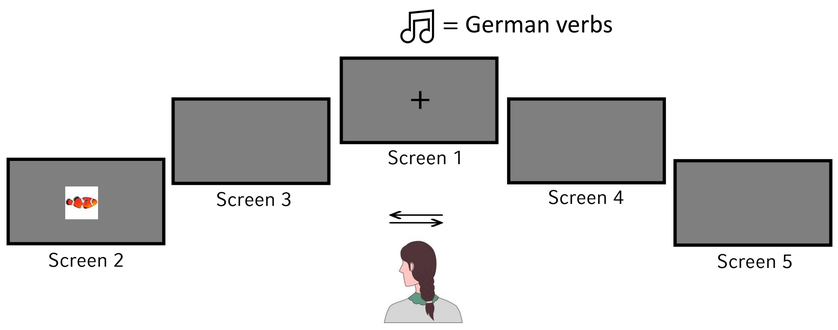
INTRODUCTION

- Sleep benefits memory consolidation by reactivating previous experiences[1,2]
- Sequences of learned spatial trajectories replayed during sleep in rodents[3,4]
- Human research usually lacks the combination of sequential and spatial features

Goals of this study:

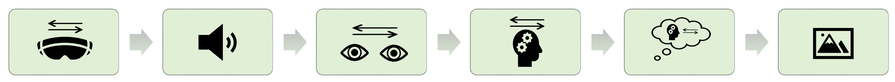
- Implement a sequential spatial-learning paradigm during wake and targeted memory reactivation (TMR) during sleep
- Investigate the reactivation of sequential memories during NREM sleep in humans

DESIGN



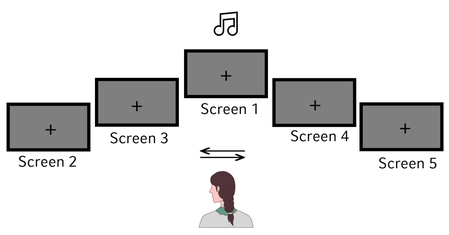
- 24 participants (15 female, age range: 19-35 years)
- Measurements: EEG (during wake & sleep), head motion tracking, eye tracking

Localizers & Controls



Memory Task

- Encoding 24 sequences of images that are associated with specific head directions
- 4 images per sequence (3 sec. each): objects, houses, animals, famous faces
- 3 blocks: 8 sequences in each block



Head Directions

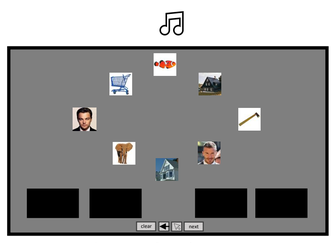
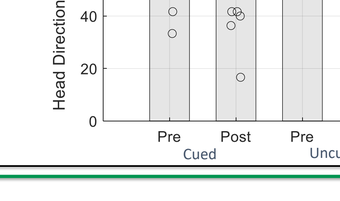


Image Sorting

- Memory performance: Post-sleep & 24h delay retrieval
- All 24 sequences are tested after sleep and 24 hours later

Targeted Memory Reactivation (TMR)

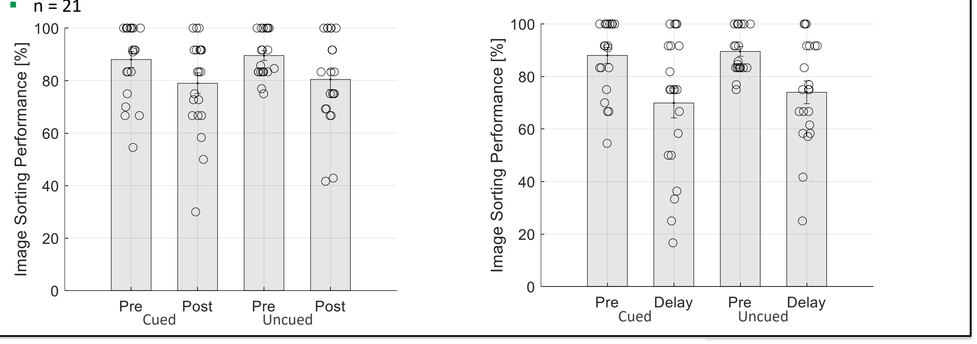


- ~8h of night sleep in the sleep lab: TMR during NREM
- Half of the previously learned sequences are cued.
- Cues are balanced for memory performance and starting screens of each sequence
- 12 experimental sounds & 1 control sound

BEHAVIORAL RESULTS

Image Sorting Performance

- n = 21



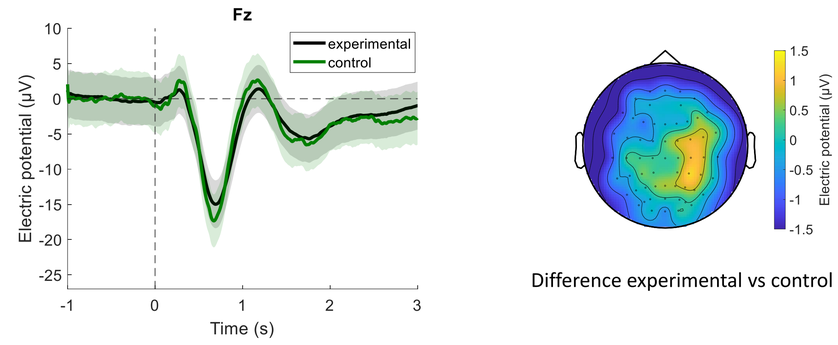
Head Direction Performance

- n = 19

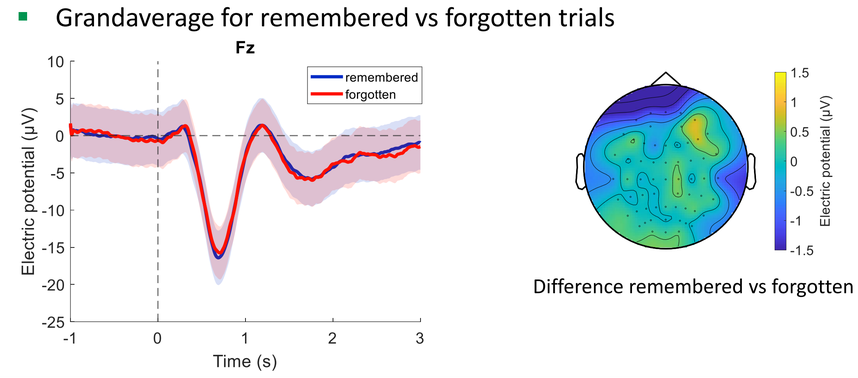
SLEEP EEG RESULTS

ERPs

- ERPs are locked to the TMR cues during NREM sleep
- Grandaverage for experimental vs control trials

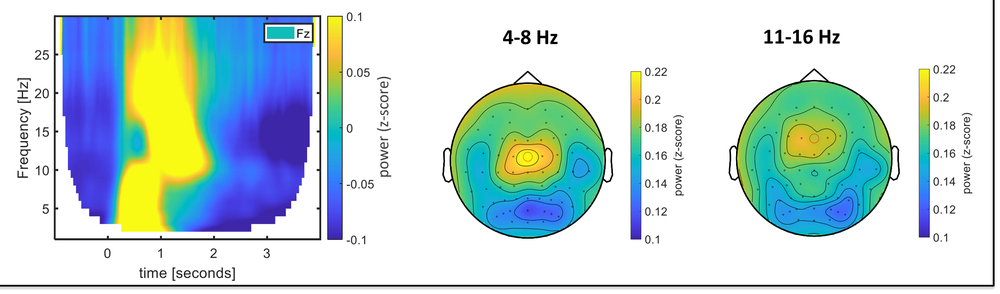


- Grandaverage for remembered vs forgotten trials



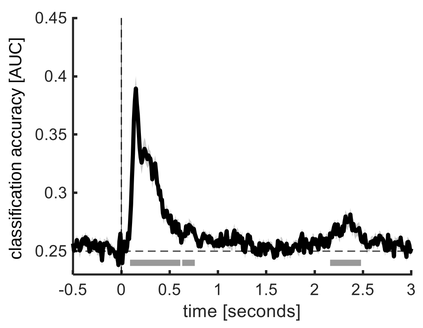
Time-frequency Analyses

- Trials with experimental sounds

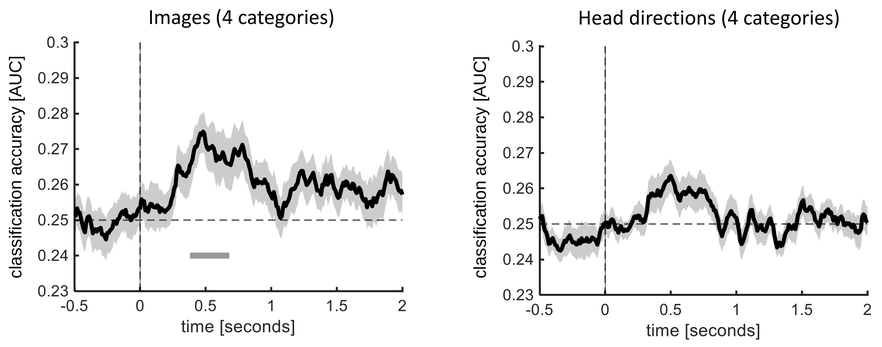


Decoding

- Multivariate EEG Analysis, multiclass LDA (4 categories), 5-kfold cross-validation
- EEG data Image Localizer Task



- Above chance classification of image categories within localizer
- EEG data after the TMR cue during NREM sleep



- Above chance classification within sleep

DISCUSSION & OUTLOOK

- No beneficial effect of cueing on both types of memory performance
- Observation of ERPs following TMR cues and cue-related increase on theta and sleep spindle power: processing of auditory stimuli
- Decoding: image category-related information can be decoded within the image localizer.
- Decoding: item-related information of the first element in a sequence can be reliably decoded from brain activity during NREM sleep
  -> assumed to benefit consolidation processes[5]

Next steps:

- Identify image and HD related sequential memories using multivariate decoding approaches[6]
- Investigating wake-related memory reactivation in the sleep-EEG
- Relating memory reactivation to sleep oscillations

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