NORTHWESTERN UNIVERSITY
FEINBERG SCHOOL OF MEDICINE

Oscillatory mechanisms for hippocampal memory encoding tested in humans

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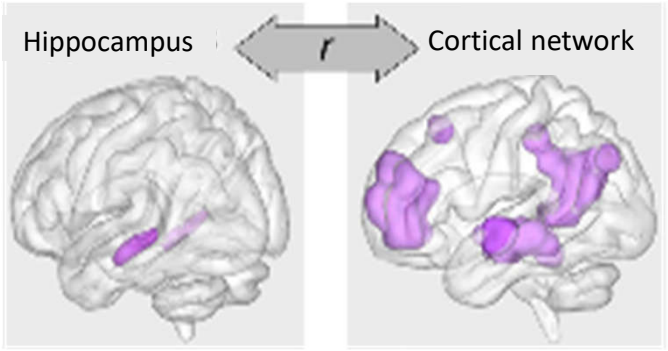
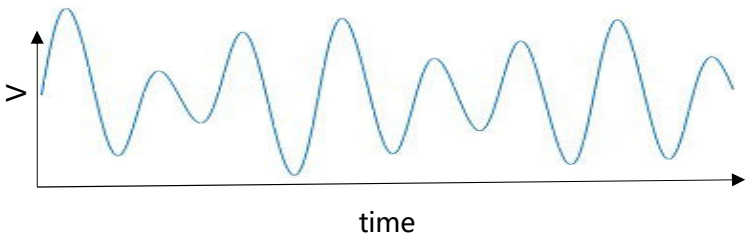
SFN 2019

Hippocampal theta and you

- Hippocampus and its network support episodic memory
- Hippocampus has prominent coherence in the theta range
  - Power relates to memory event success (e.g. Addante et. al, 2011; Fell et. al, 2011)
  - Theta phase may orchestrate binding of sensory inputs into coherent memory traces (e.g. Buzsaki, 2002; Siegle & Wilson 2012).

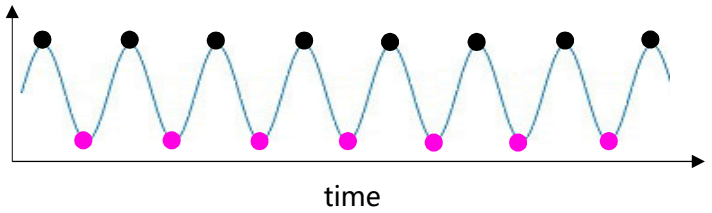


Hippocampal ensemble



theta component

optimal encoding

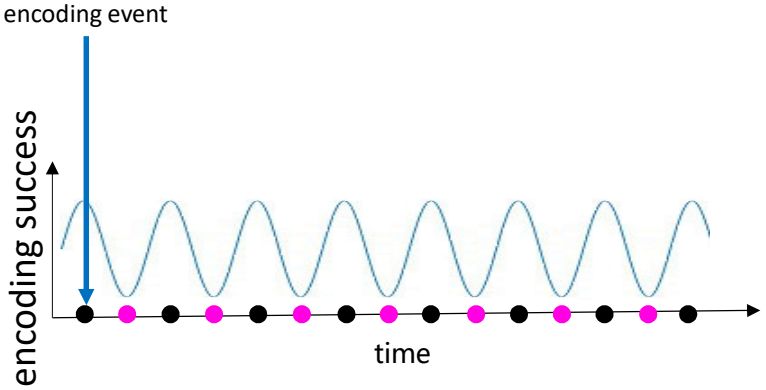


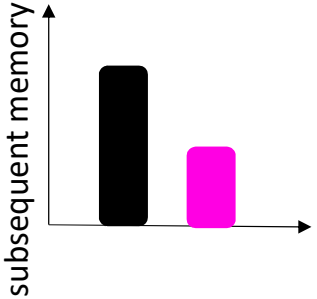
optimal retrieval

Project Goal:
Test dependence of memory encoding on hippocampal network theta phase

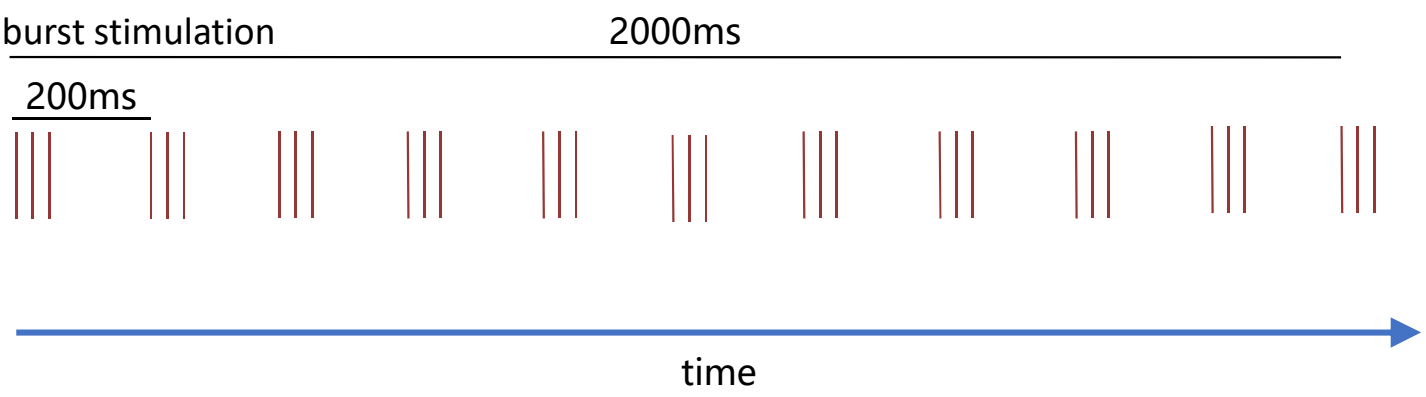
Q: How to align encoding event with theta oscillation?

A:





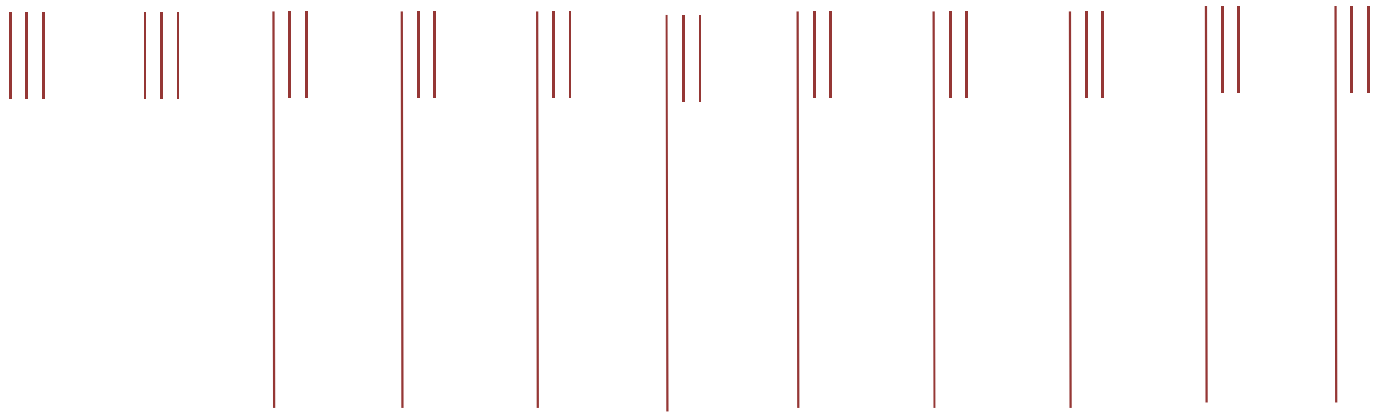
5Hz theta burst stimulation



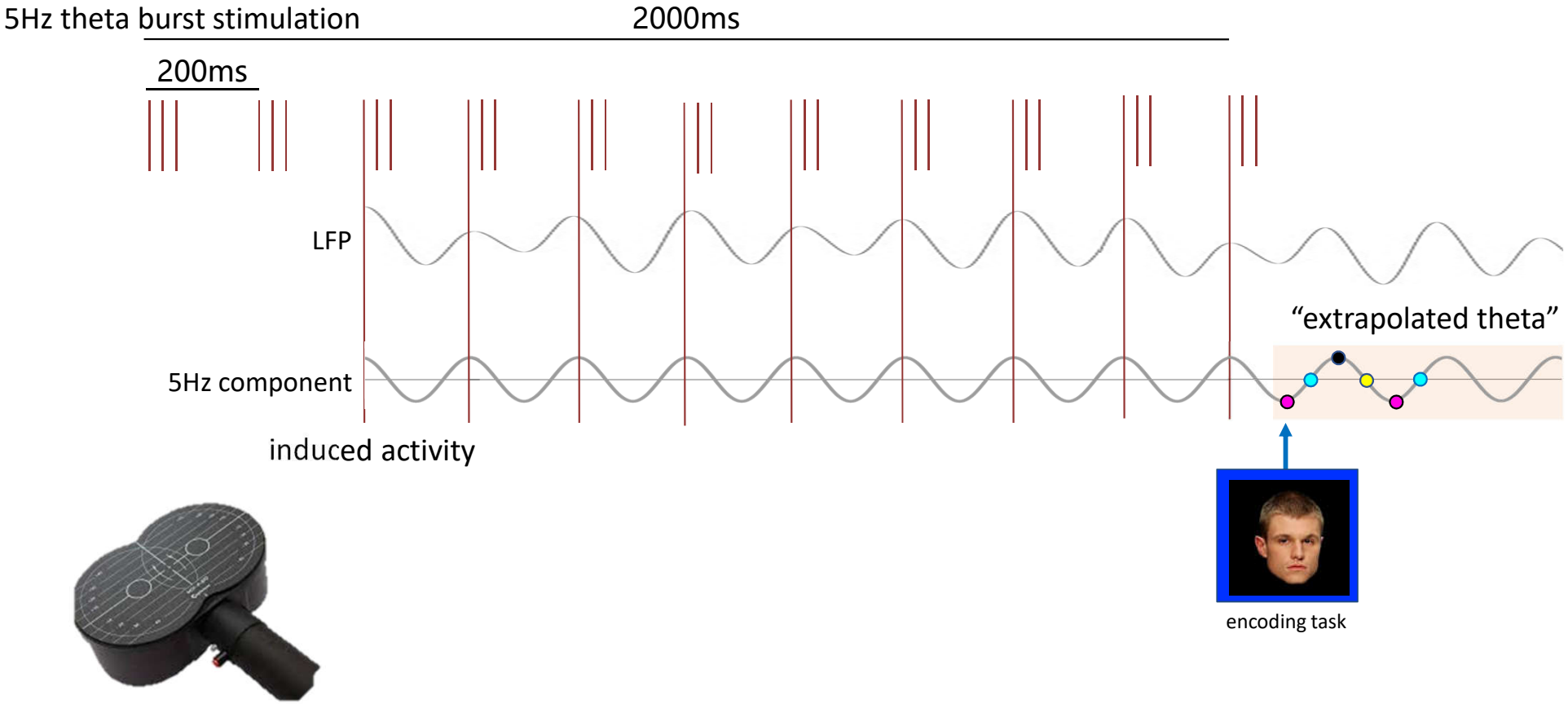
5Hz theta burst stimulation

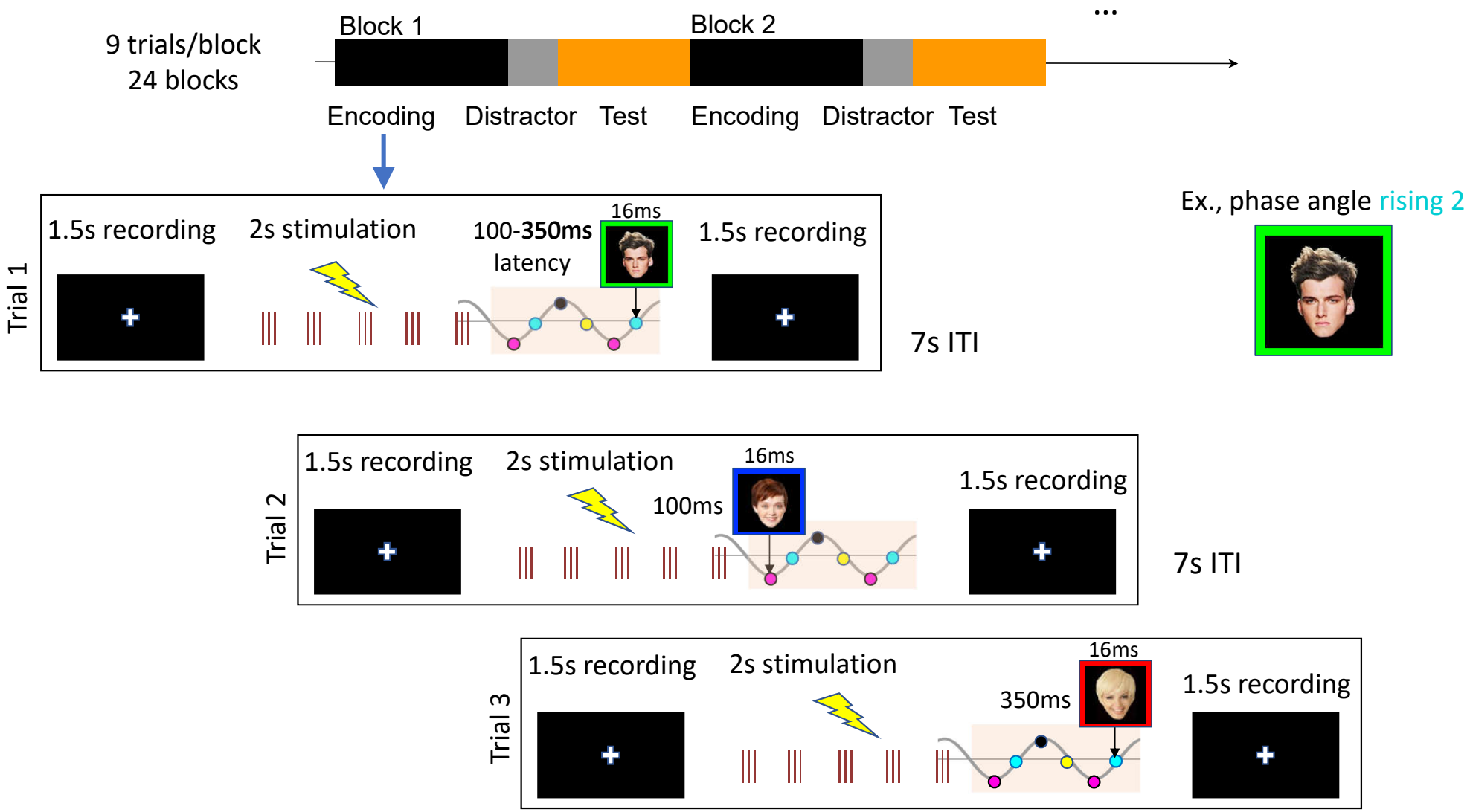
2000ms

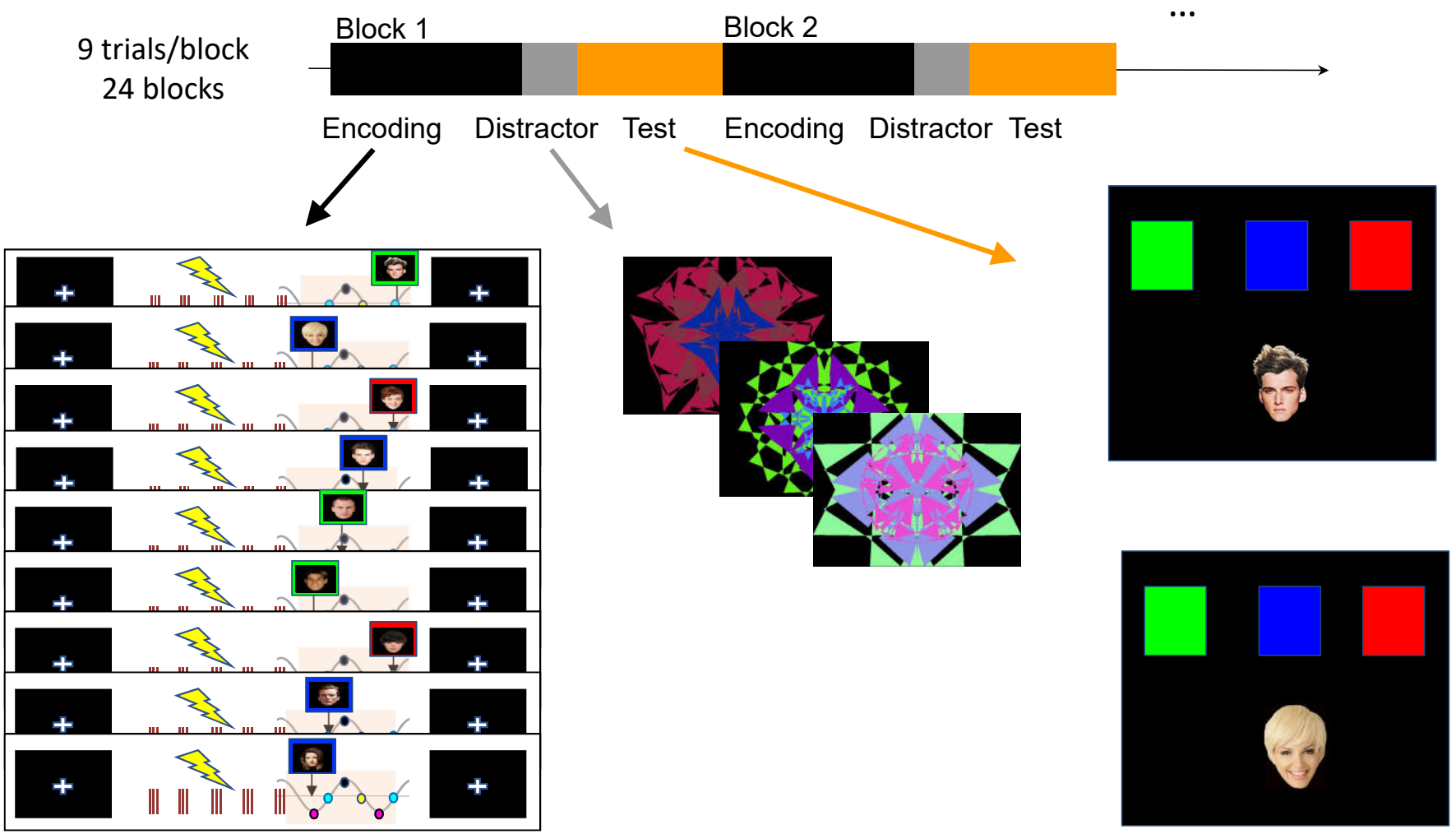
200ms



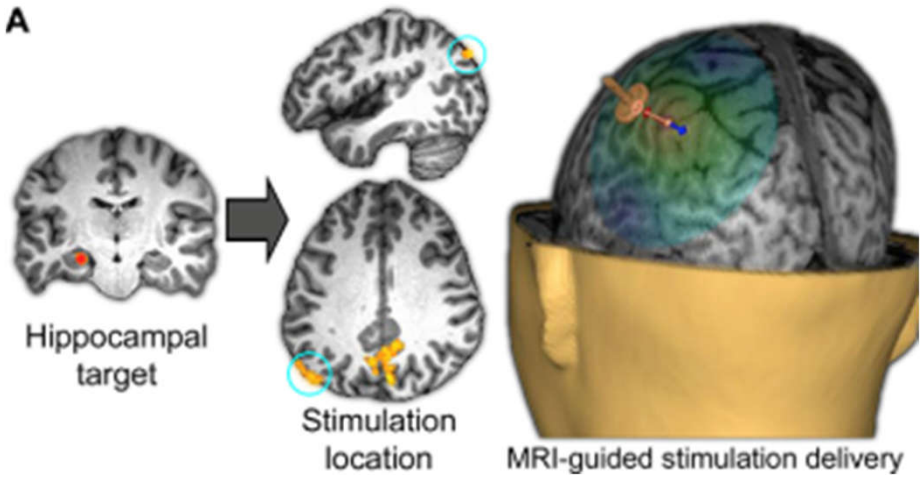
induced activity


5Hz theta burst stimulation
2000ms
200ms
LFP
5Hz component
induced activity
"extrapolated theta"
encoding task

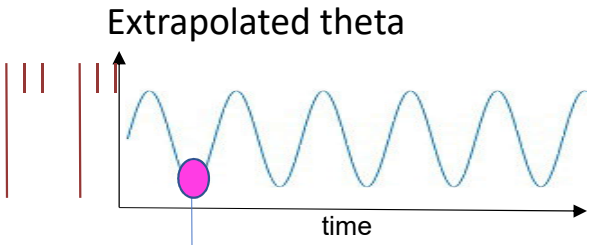

9 trials/block
24 blocks
Block 1
Block 2
...
Encoding
Distractor
Test
Encoding
Distractor
Test
Trial 1
1.5s recording
2s stimulation
100-350ms
latency
16ms
1.5s recording
7s ITI
Ex., phase angle rising 2
Trial 2
1.5s recording
2s stimulation
16ms
100ms
1.5s recording
7s ITI
Trial 3
1.5s recording
2s stimulation
16ms
350ms
1.5s recording

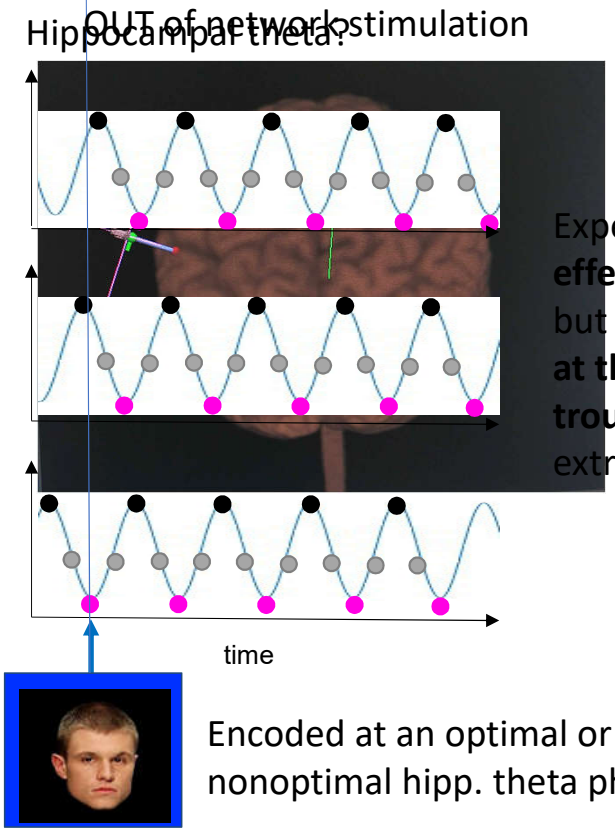

9 trials/block
24 blocks
Block 1
Block 2
...
Encoding
Distractor
Test
Encoding
Distractor
Test

Stimulation site(s)



Wang et al., 2014



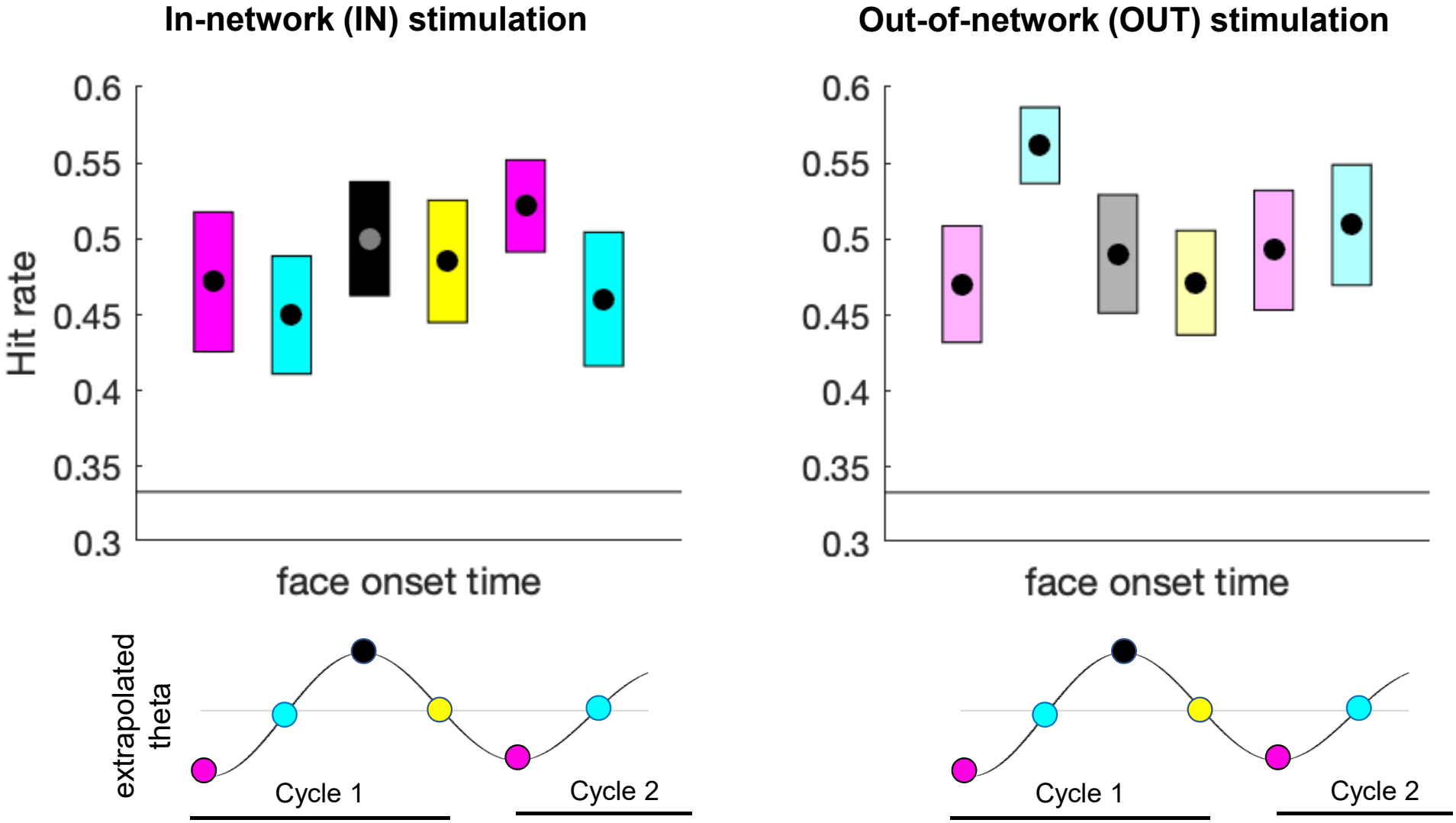


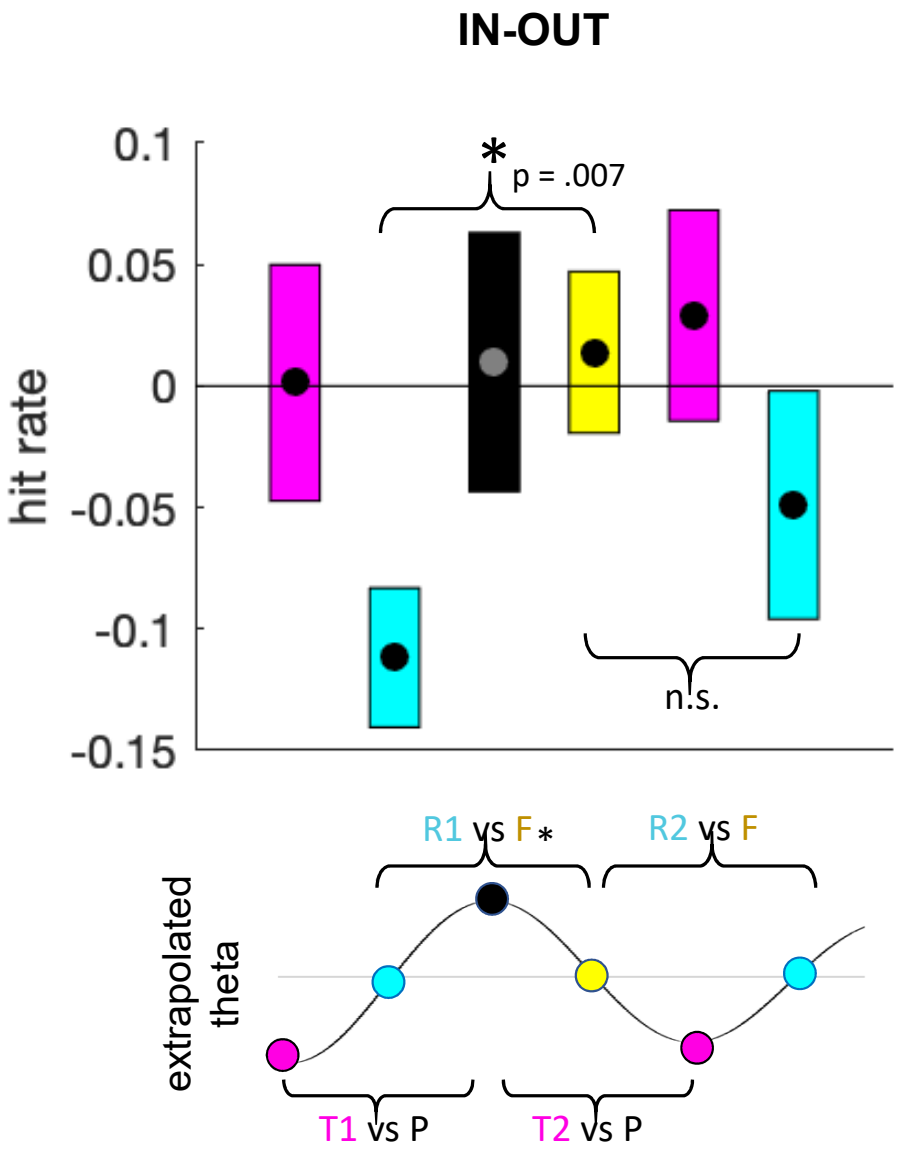
Expect a **periodic effect** on memory, but **not necessarily at the peaks and troughs** of extrapolated theta

Encoded at an optimal or nonoptimal hipp. theta phase?

Results

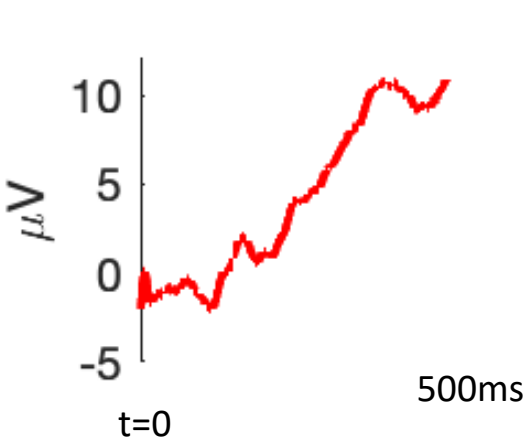
Behavioral data: n = 15
EEG data: n = 12

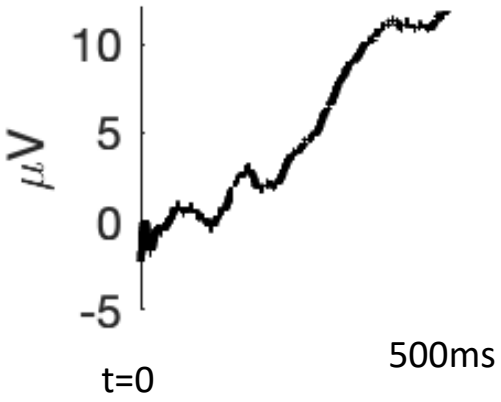

In-network (IN) stimulation
Out-of-network (OUT) stimulation
Hit rate
0.6
0.55
0.5
0.45
0.4
0.35
0.3
face onset time
extrapolated theta
Cycle 1
Cycle 2
Cycle 1
Cycle 2

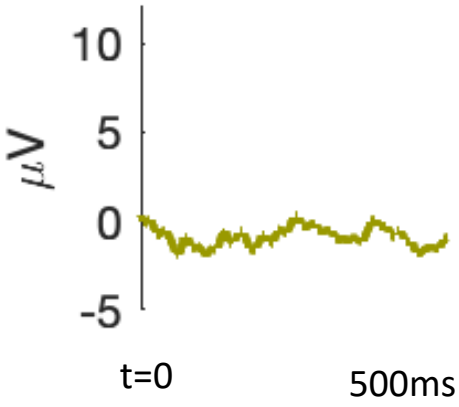


Do neural correlates of encoding vary with stim. network, phase?

Correct trial ERP - Incorrect trial ERP = Encoding signal

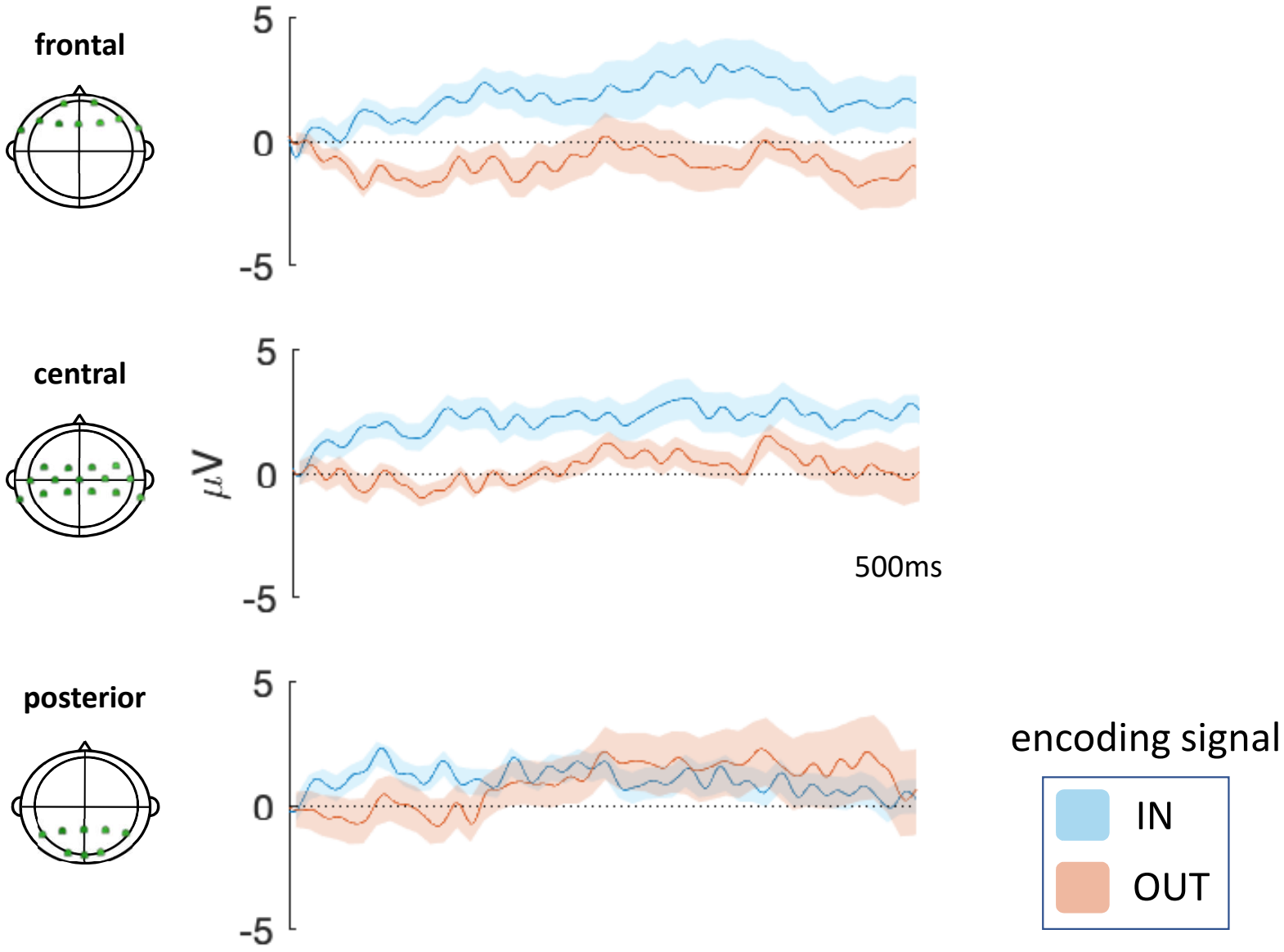




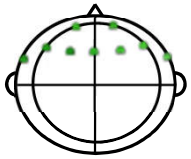


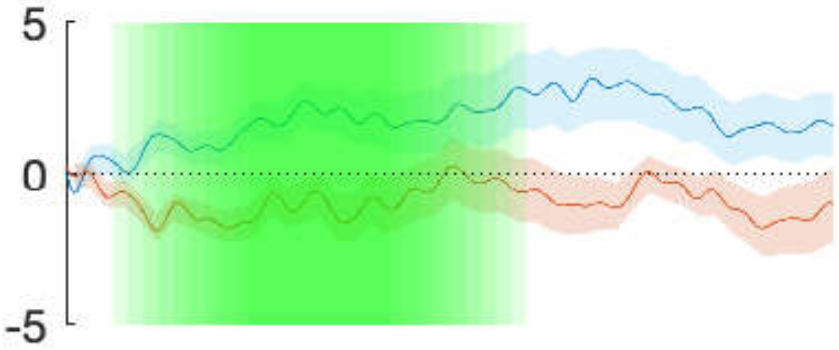
ERPs aligned to
visual stimulus

Observe effect of IN vs OUT of network stimulation:
1) Across all encoding trials
2) According to extrapolated phase angle at t=0

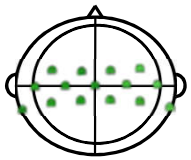

frontal
central
posterior
5
0
-5
μV
500ms
encoding signal
IN
OUT

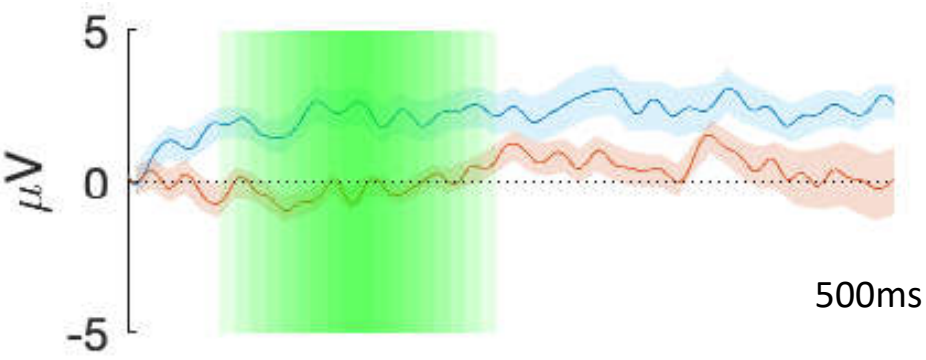
frontal



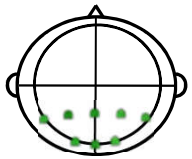


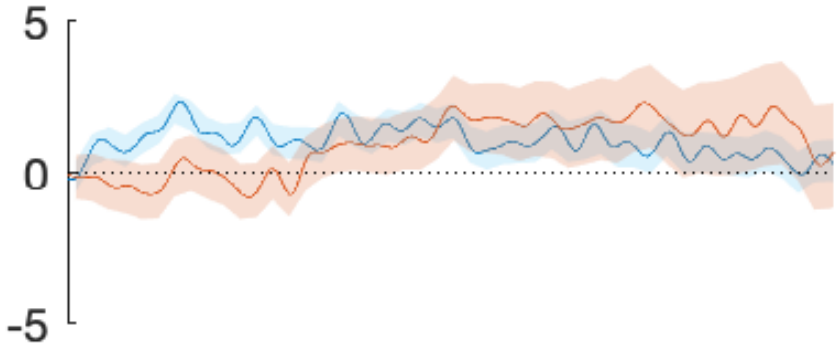
central





posterior

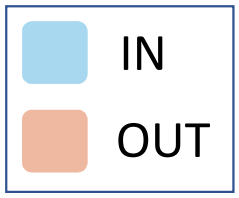




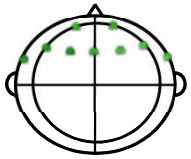
IN-network stimulation results in a more positive encoding signal after the visual stimulus

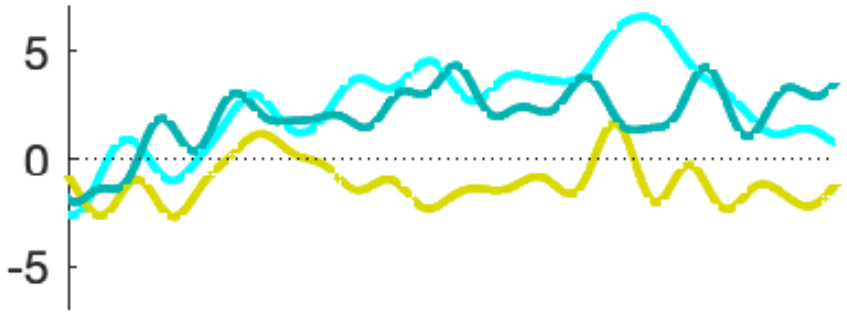
Which phase angles are contributing to that positivity?

encoding signal

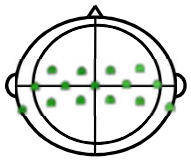


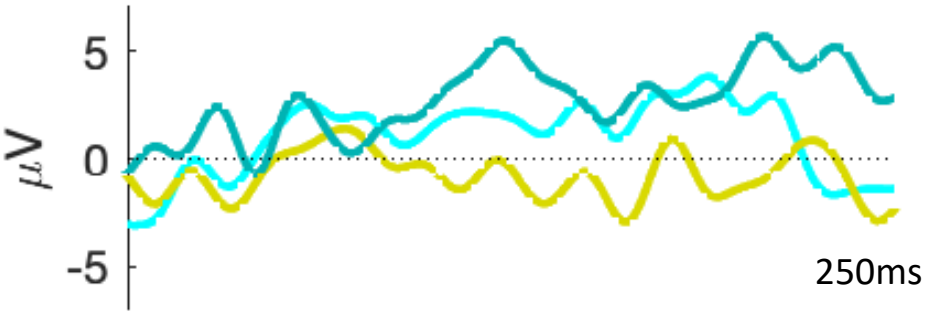
frontal



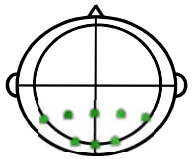


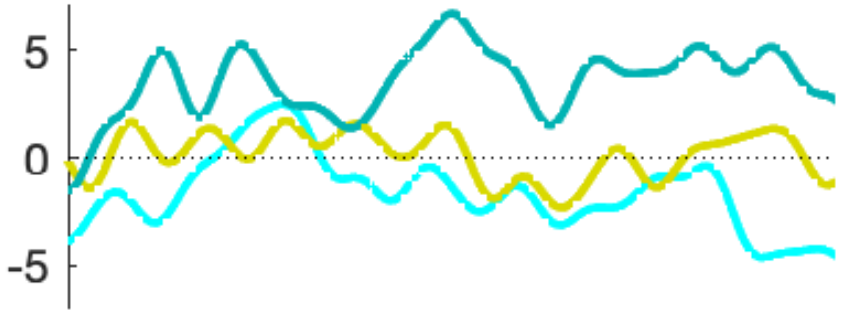
central





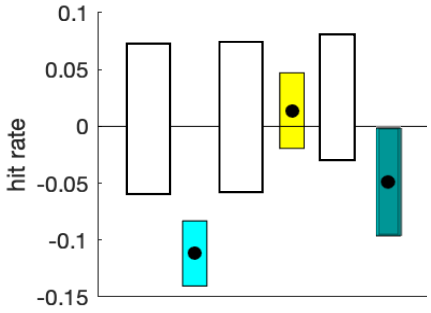
posterior



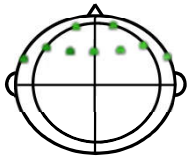


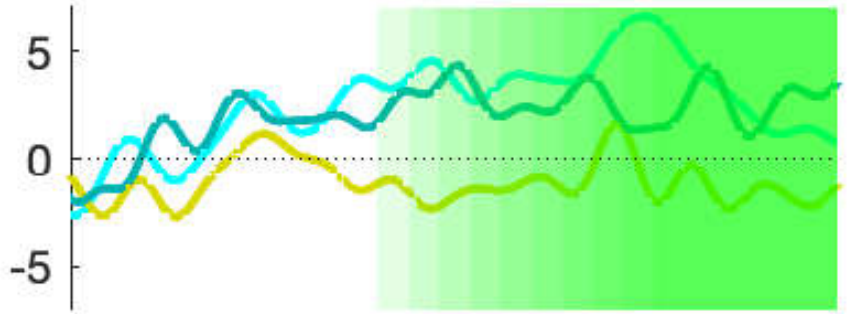
Rising phase of both cycles, but not falling phase, contribute to the enhanced IN positivity

IN-OUT encoding signal

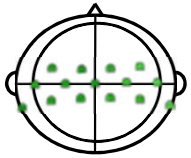


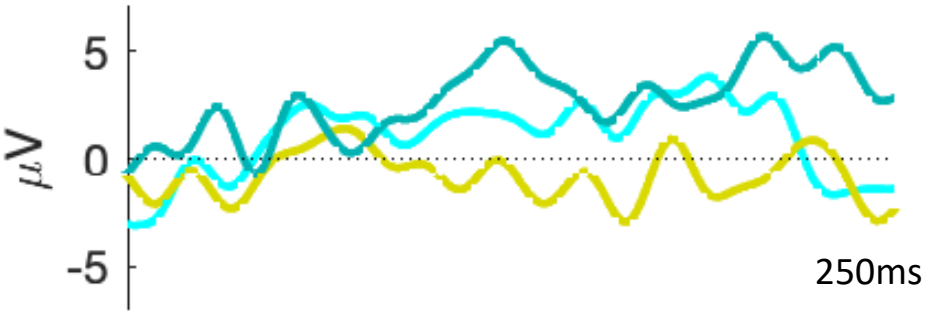
frontal



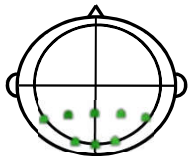


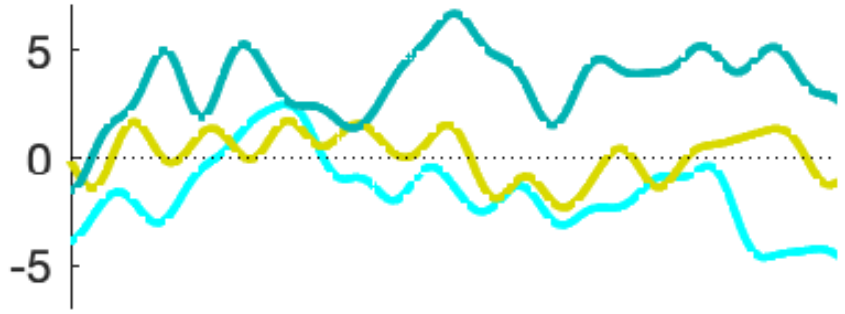
central





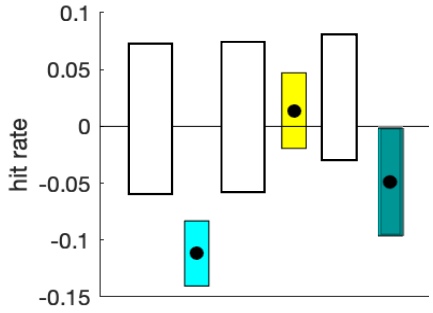
posterior



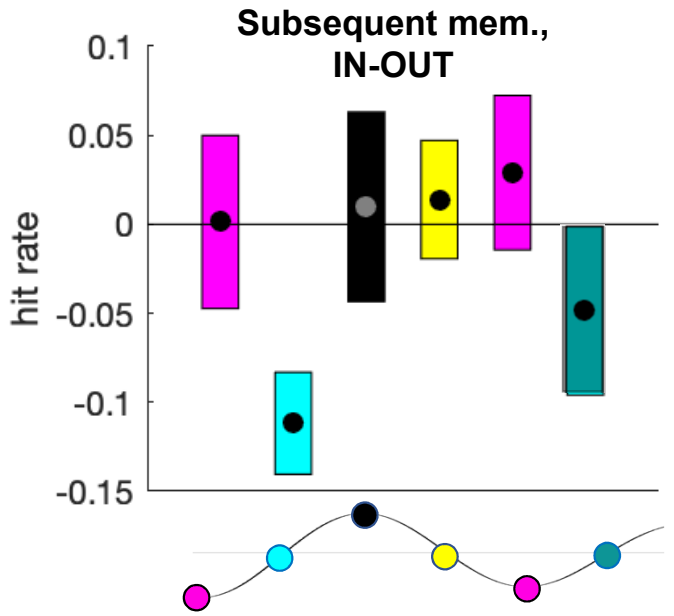


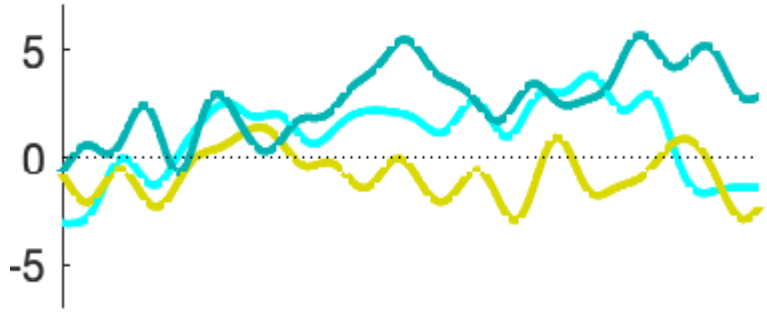
Rising phase of both cycles, but not falling phase, contribute to the enhanced IN positivity

IN-OUT encoding signal



- Parietal stimulation periodically influenced encoding relative to vertex, affecting rising phases of both cycles compared to falling phase.
- ERP encoding signals were also modulated by phase of stimulus onset, with rising phases of both cycles generating the maximal encoding signal for parietal stimulation versus vertex.
- These findings suggest an influence of stimulation on encoding-related theta signals and support the role of theta phase in encoding.





Thanks!

NORTHWESTERN UNIVERSITY
FEINBERG SCHOOL OF MEDICINE

Laboratory for Human Neuroscience

Joel Voss
Shruti Dave
Brannan Durr
Melissa Hebscher
Molly Hermiller
Erica Karp
Jim Kragel
Dan O'Young
Mary Penckofer
Kristen Warren
Stephanie Wert

This research is supported by NIMH grants **T32-MH067564** and **R01-MH111790.**