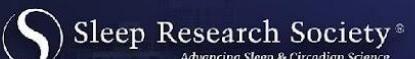




# SLEEP 2025

Seattle, WA    June 8 – 11

A JOINT MEETING



**Decoding spatiotemporal dynamics of neural oscillations during sleep and their age-related effects on emotional memory consolidation**

Thea Ng<sup>1</sup>, Lindsey Mooney<sup>2</sup>, Irina Orlovsky<sup>2</sup>, Morgan Barnes<sup>2</sup>, Cassandra Delvey<sup>2</sup>, Lena Gaudette<sup>2</sup>, Karolina Rusin<sup>2</sup>, Katrina Rodheim<sup>2</sup>, Bethany Jones<sup>2</sup>, Rebecca Spencer<sup>2</sup>

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June 9, 2025

## **Conflict of Interest Disclosures for Speakers**

To review this speaker's  
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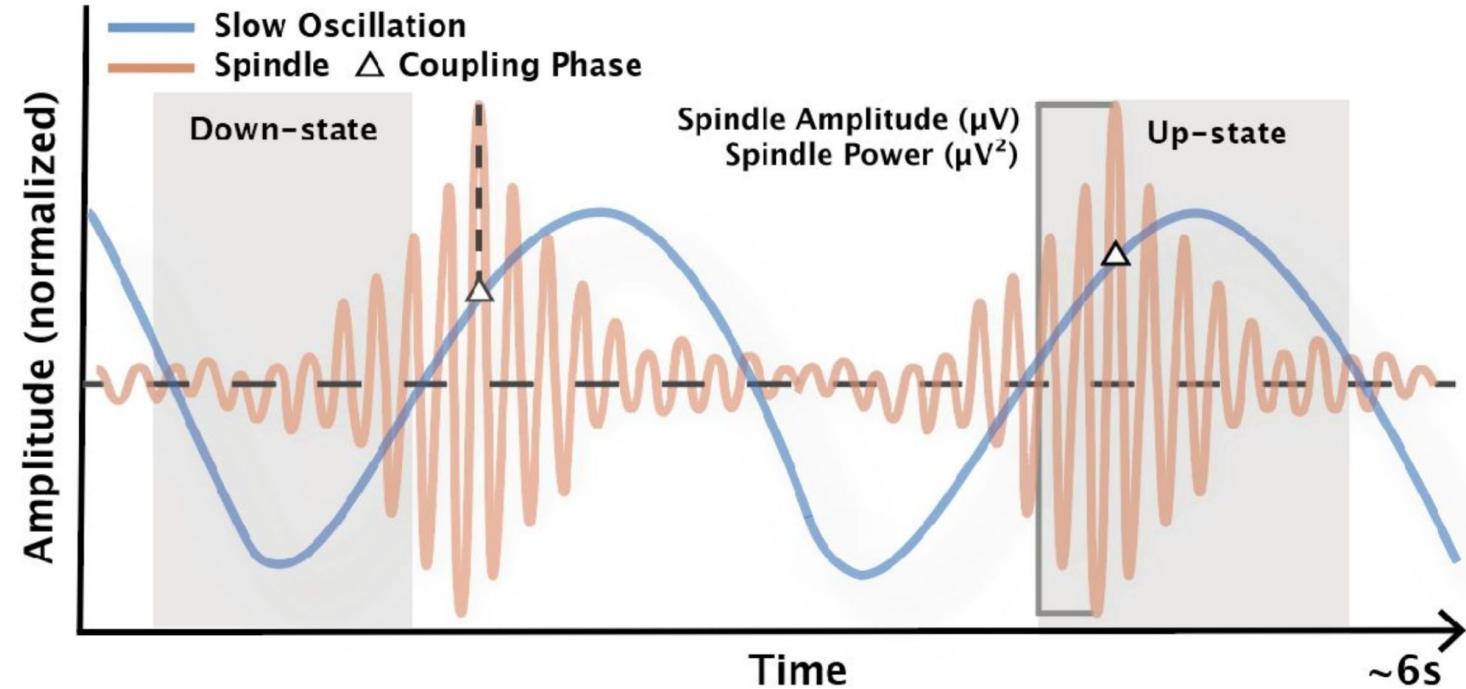
# SLEEP 2025 Photography Policy



- Photography **IS NOT** permitted during this lecture.

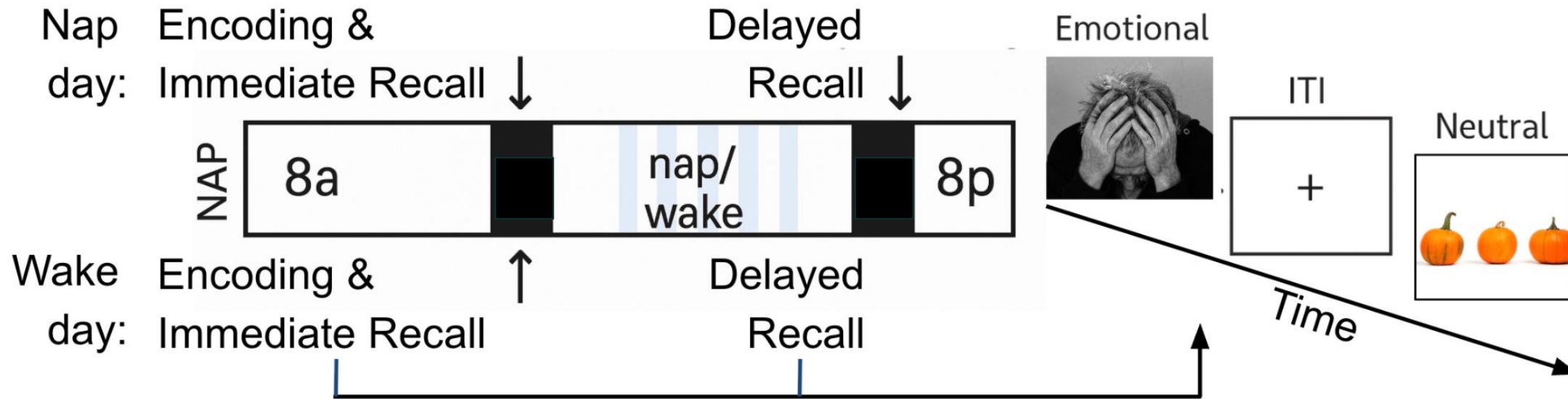
# Backgrounds

- Precise and strong slow oscillation (SO) – spindle (SP) coupling is critical for memory consolidation (Ng et al., 2024).



- Most studies detect only a few electrodes and treat oscillations and their coupling as isolated local events. **Spatiotemporal relationships remain unexplored.**
- Recent theory (e.g. Kinzling et al., 2019) proposes that wave propagation during sleep enables inter-regional communication to support **long-range memory transfer**.

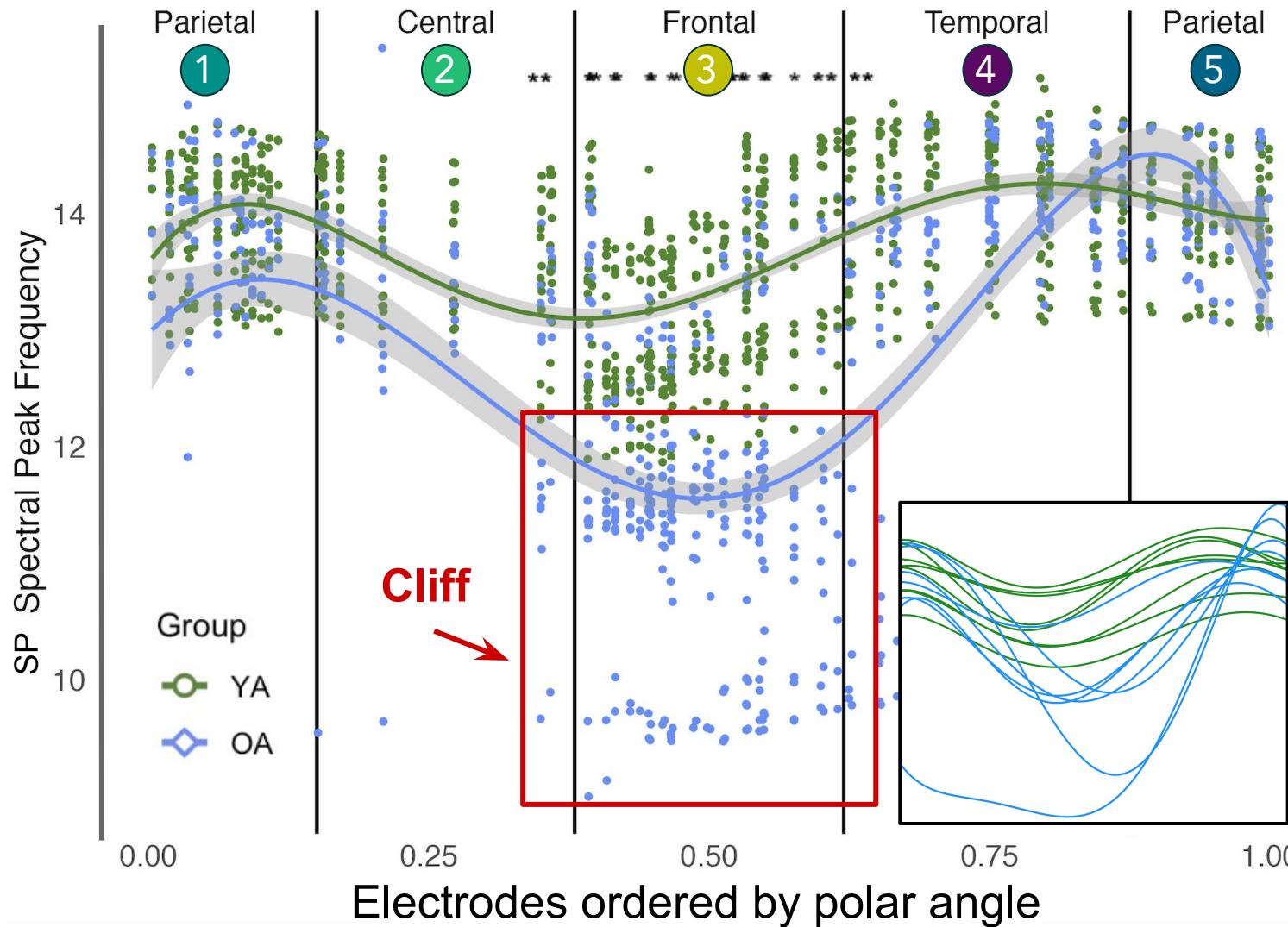
# Experimental Paradigm



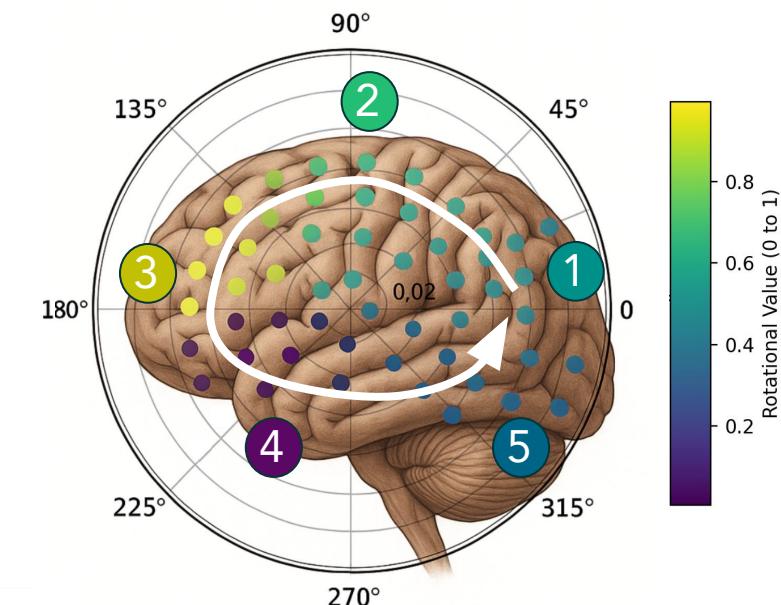
- Young adults (YA, n = 15) and older adults (OA, n = 15) were included in the analysis
- High-density EEG (122 channels, Fs = 500 Hz) were used



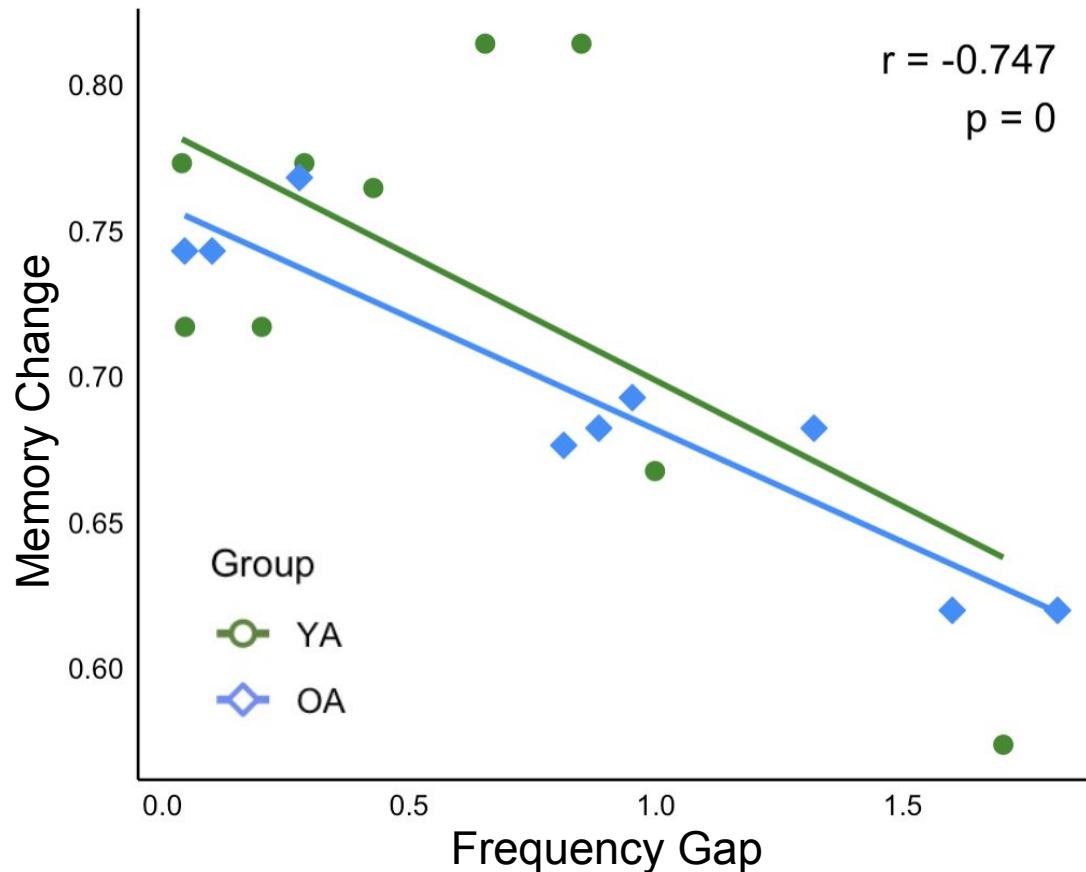
# Abrupt frequency gradient shifts across cortical areas in OA



- OA exhibits a discontinuity in spindle peak frequency
- Disrupted long-range communication and isolated activities within each region



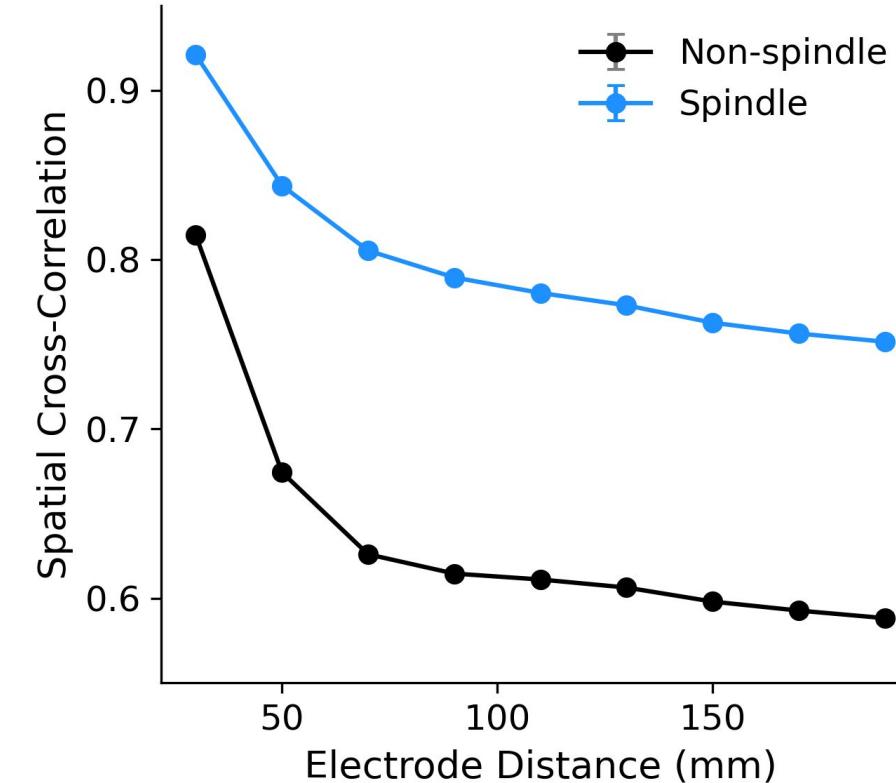
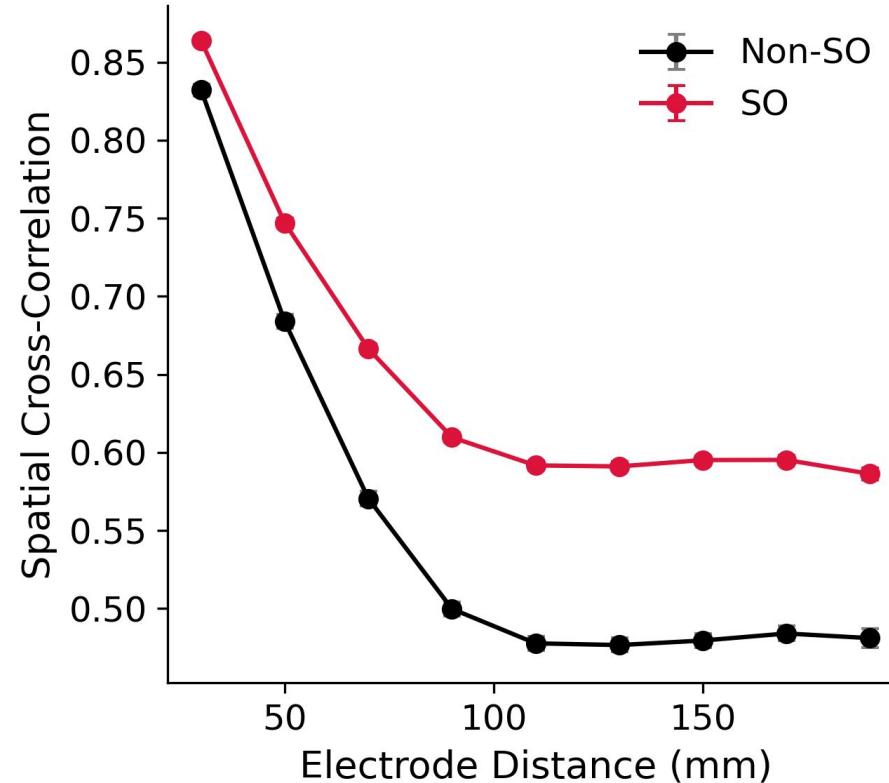
# Wider SP Frequency Gaps Predict Poorer Memory Performance



- An increased frequency gap between frontal-temporal and centro-parietal spindles predicts poorer memory performance in both YA and OA
- Similar results found in SO frequency

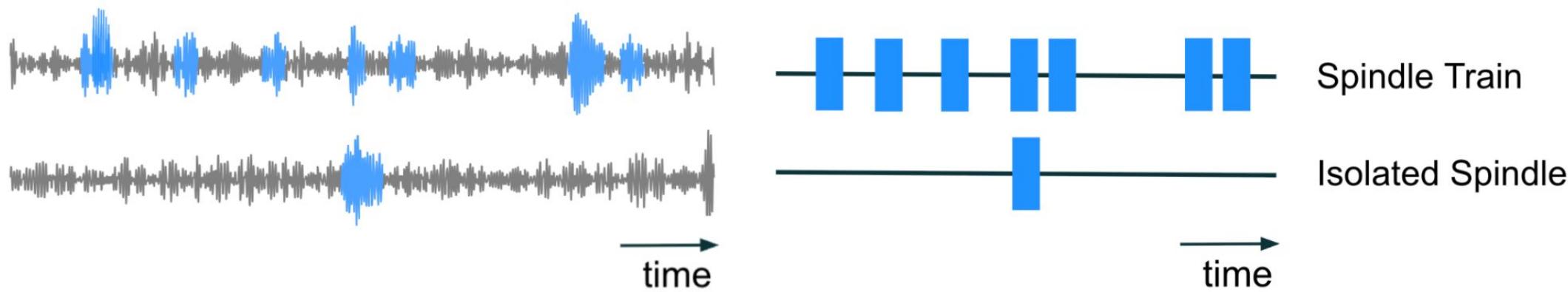
**What does the link between inter-area consistency and memory imply about cortical connectivity?**

# Cortical connectivity increases during oscillation events



- Cortical connectivity significantly increases during SO and/or spindle events.
- What is the benefit of having multiple events repeated within a short timeframe?

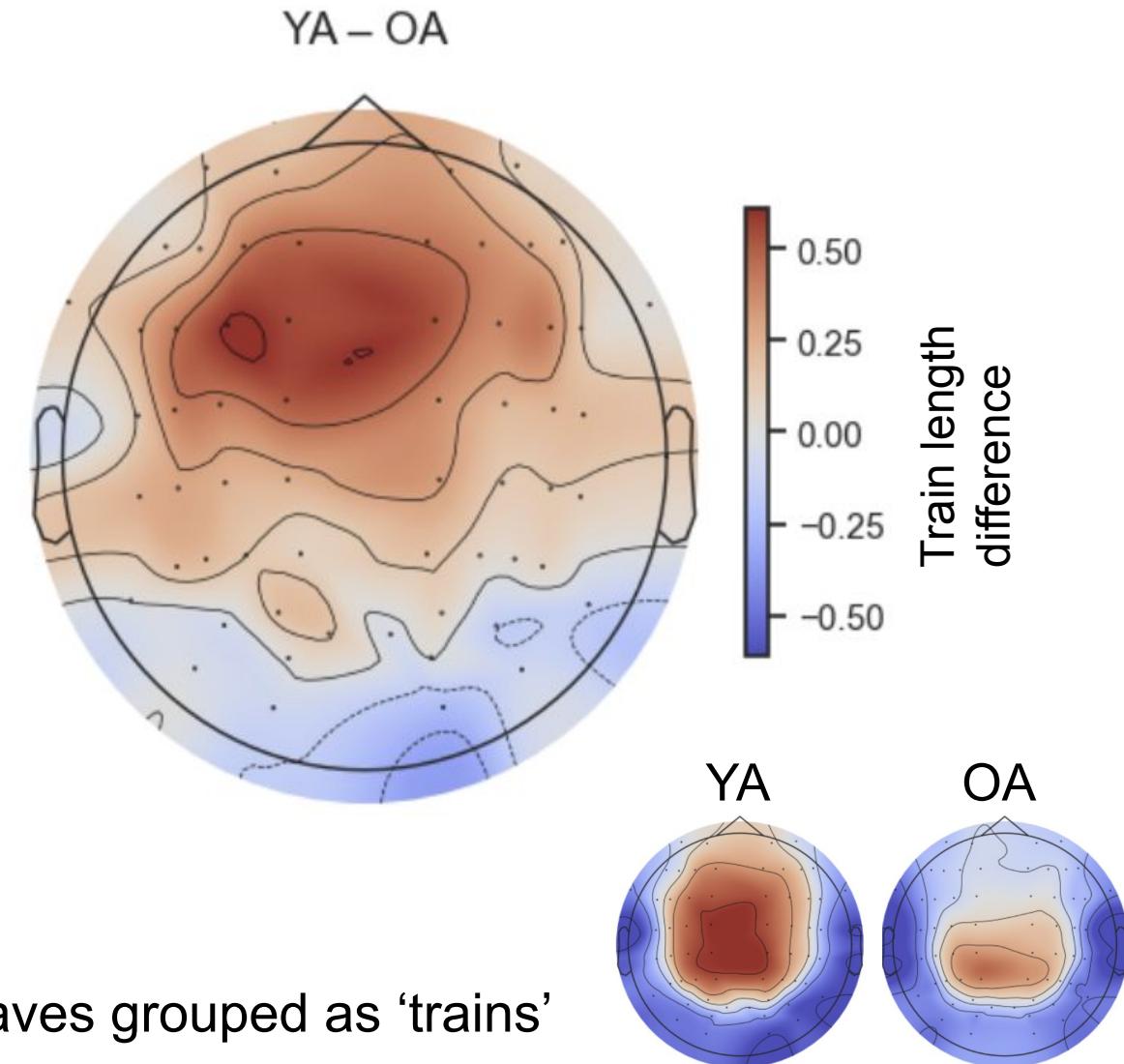
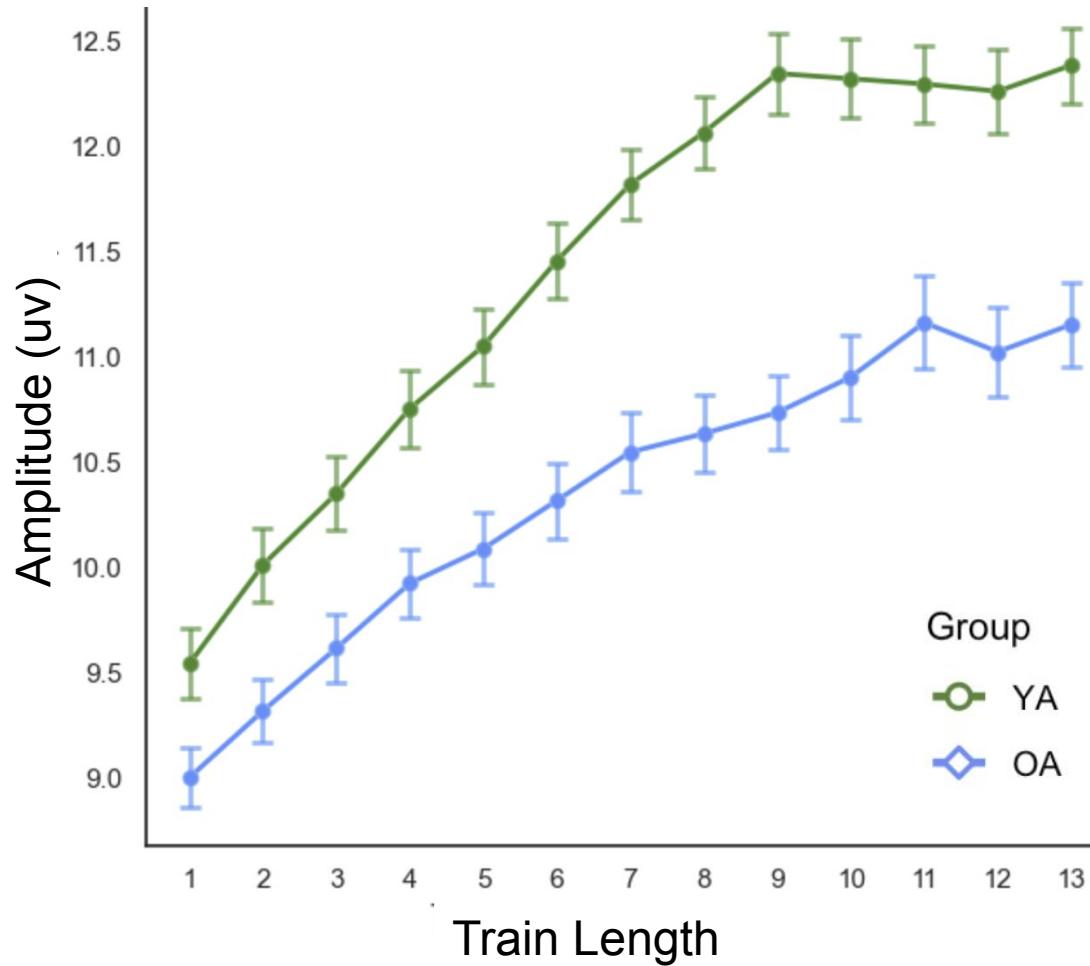
## Sleep spindles are organized as repeated events



- “Spindle trains” are repeated SP events within a short timeframe
- Possibly encode or synchronize with the pattern of memory reply

# Repeated wave propagation increases the strength of oscillation

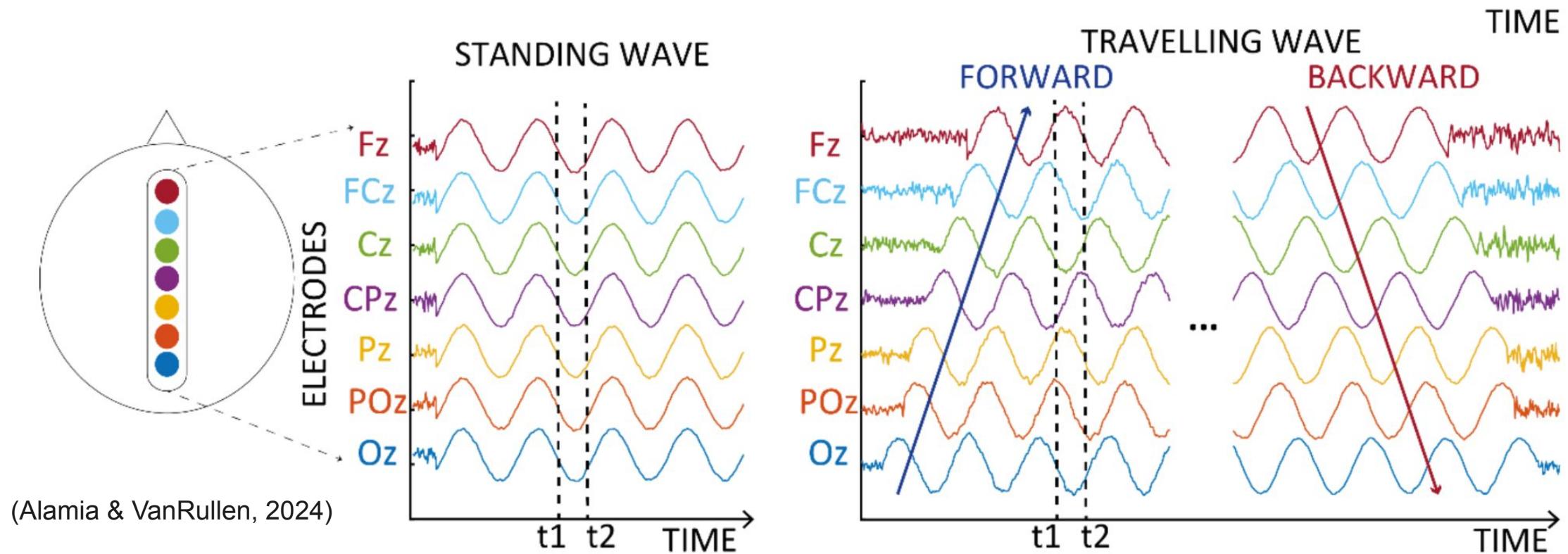
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- YA benefits more from repeated traveling waves grouped as 'trains'

**Connectivity increases and plays an important role during oscillations, but how are different areas connected?**

# Types of oscillation connectivity in the cortex



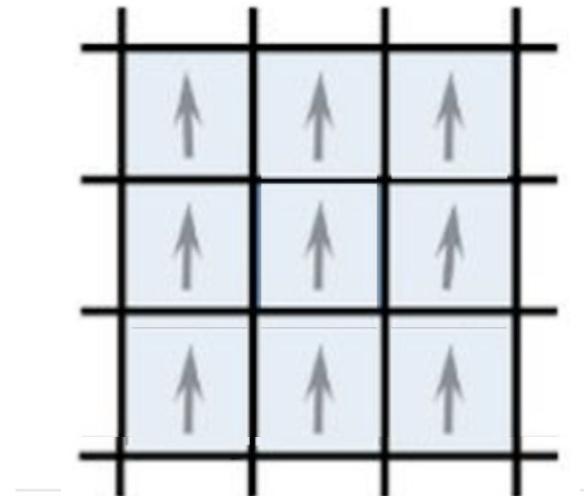
- Simultaneous connectivity vs Unidirectional propagation

# Synchronized Directionality (SD)

- Quantifies if wave propagation directions are synchronized and unidirectional across electrodes.

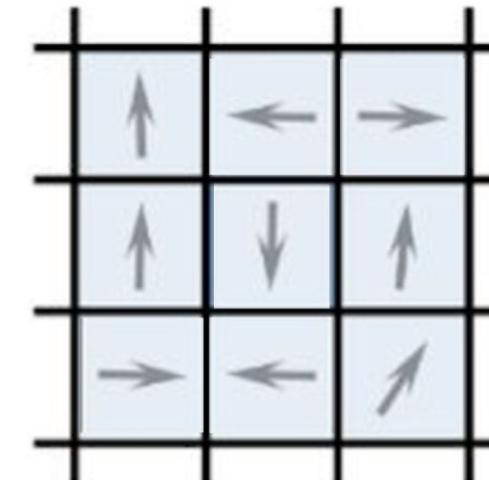
**SD → 1**

**Gradient vectors**



**SD → 0**

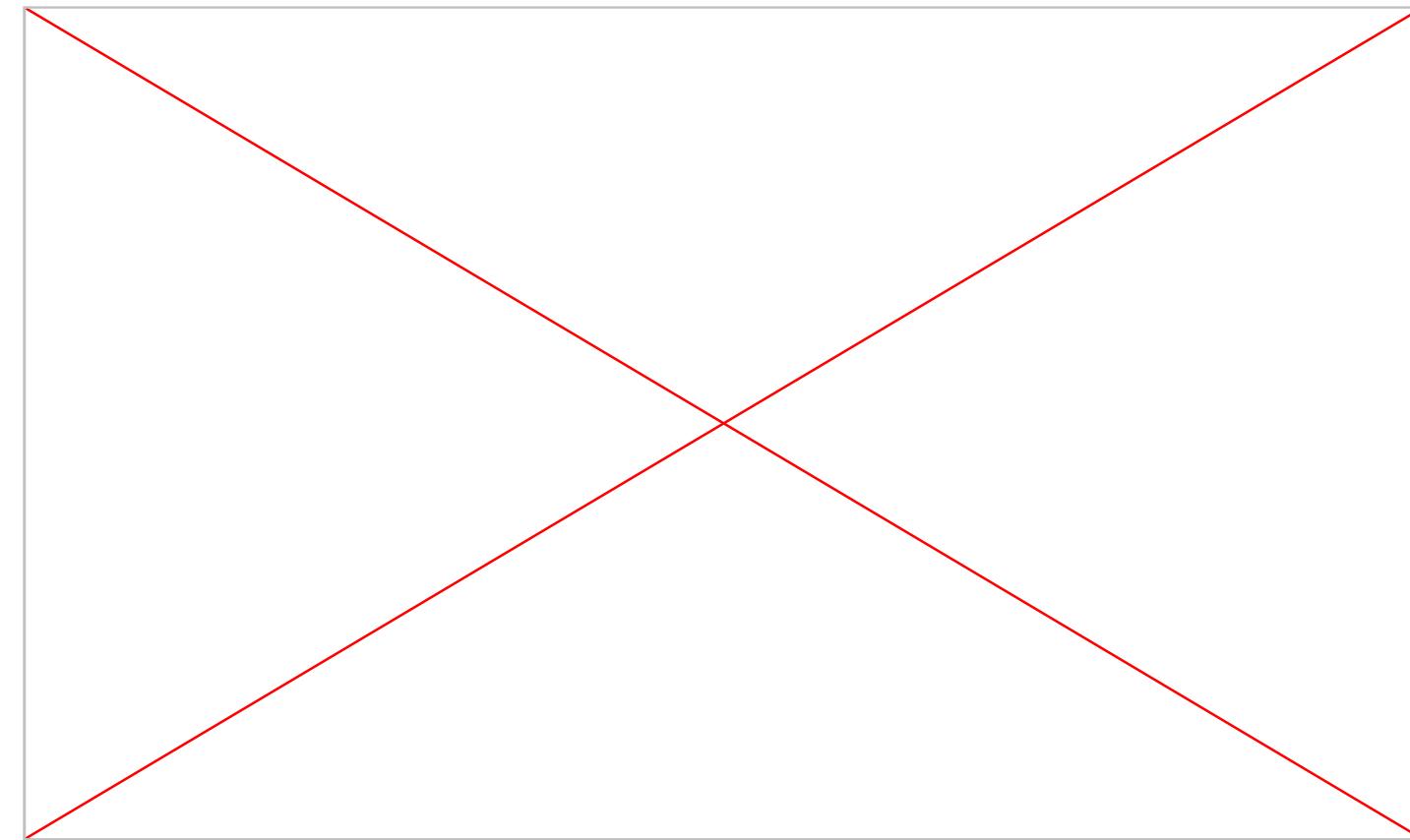
**Gradient vectors**



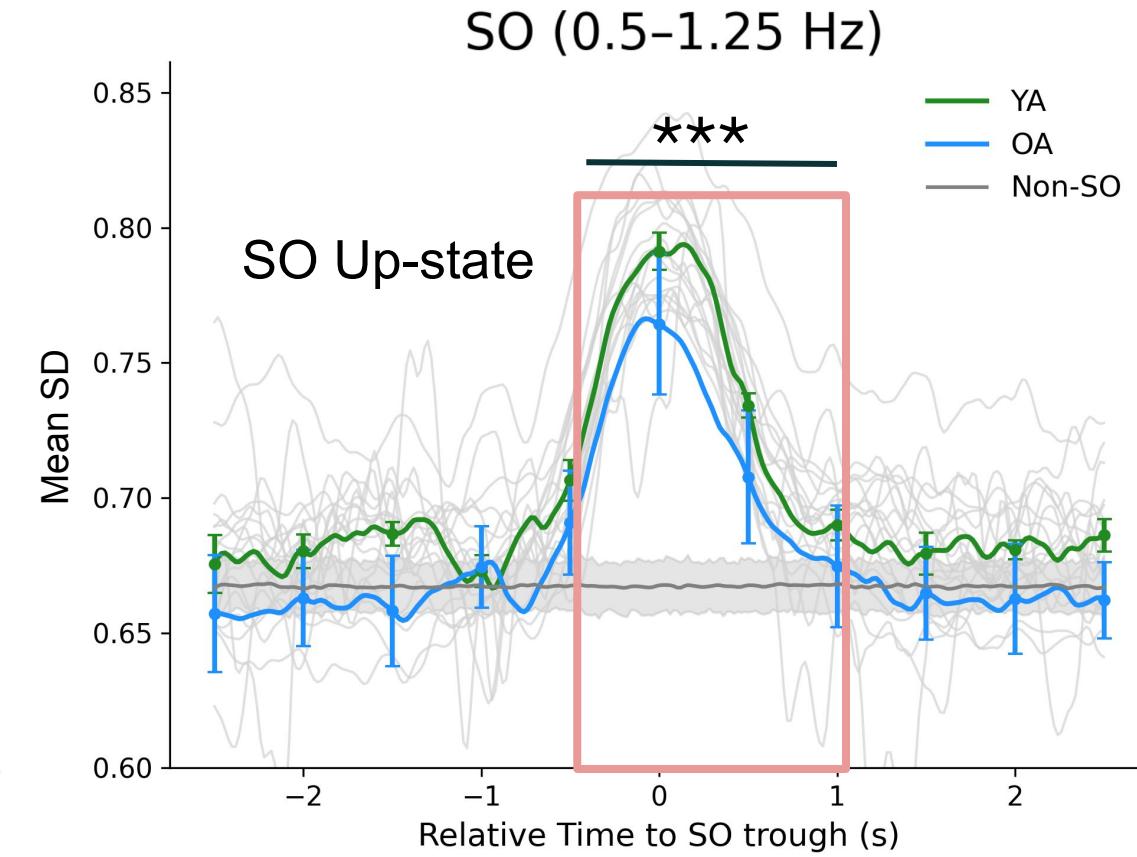
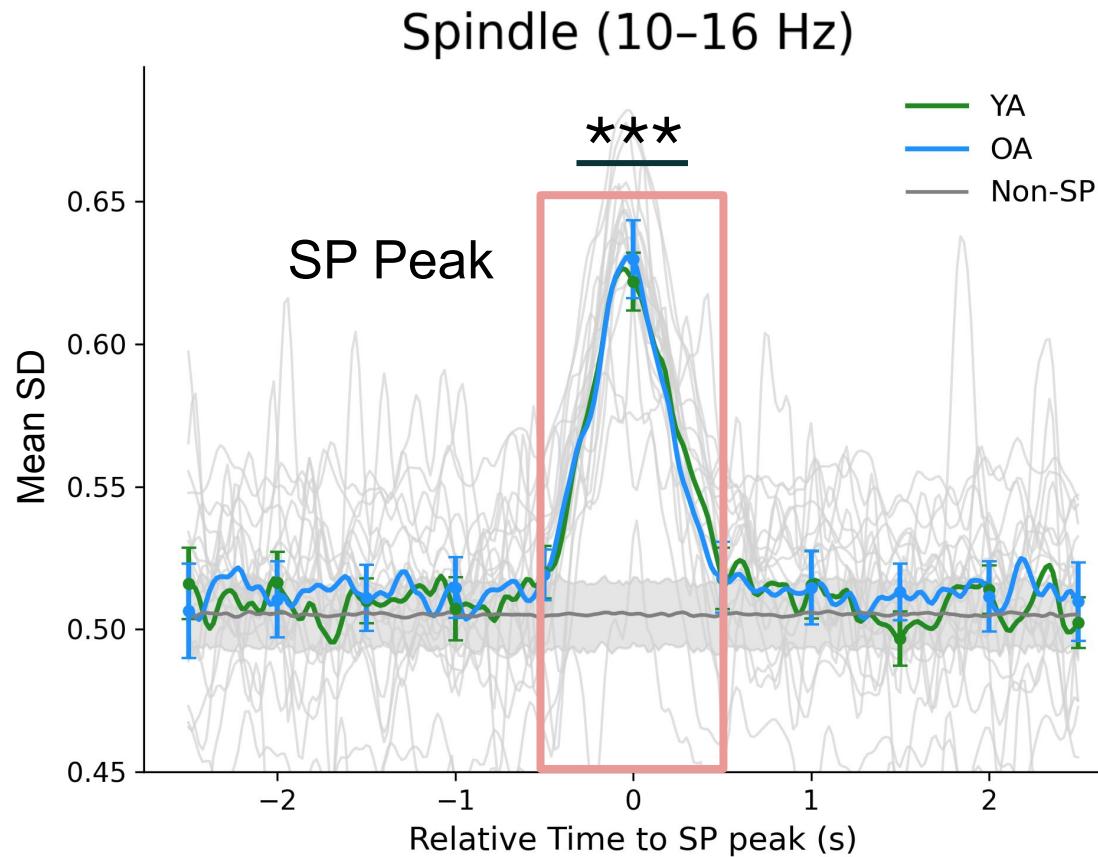
# Synchronized Directionality: Examples

- SOs & SPs exhibit organized, large-scale directional phase propagation across the cortex, reflecting coherent network-level coordination.

Anterior  
Left + Right  
Posterior

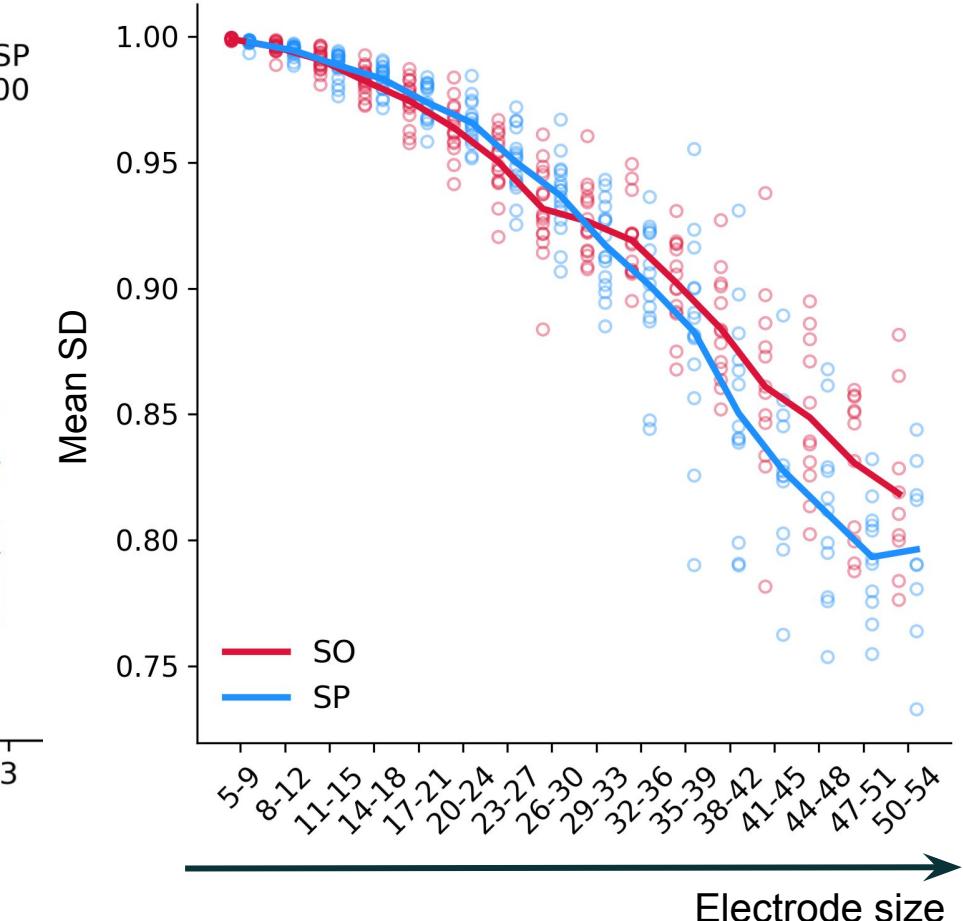
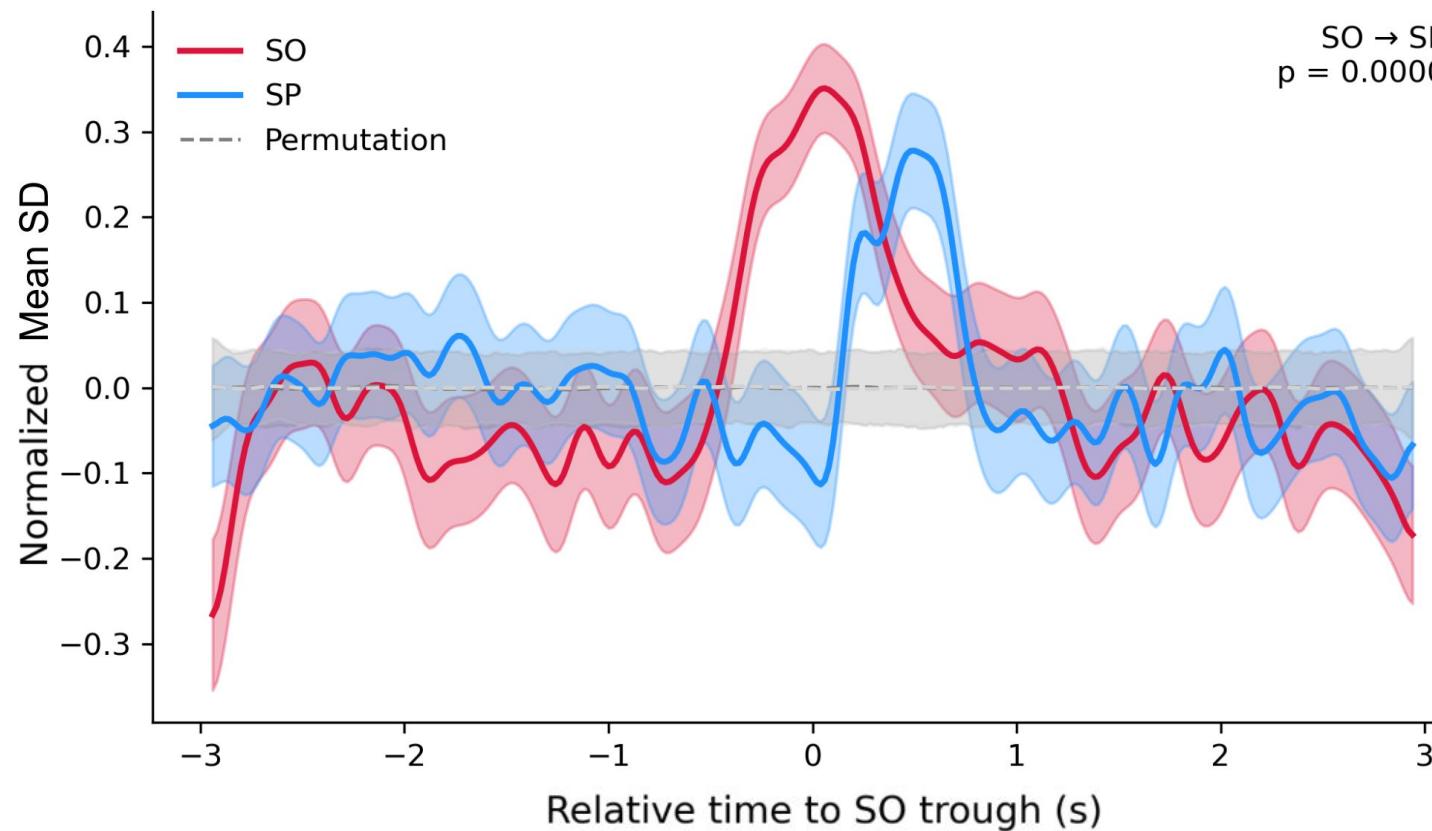


# Unidirectional propagation increases at oscillation rising states



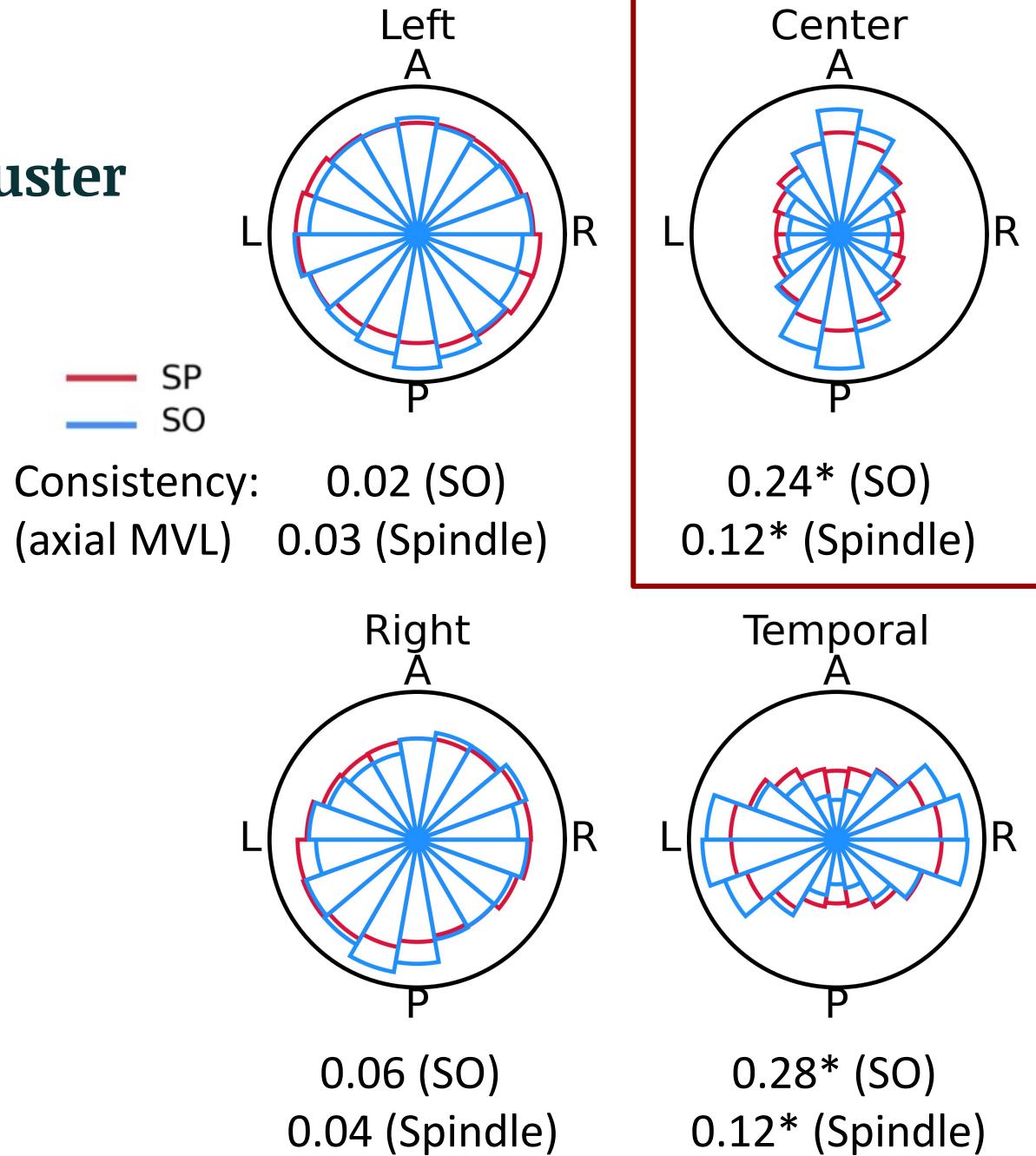
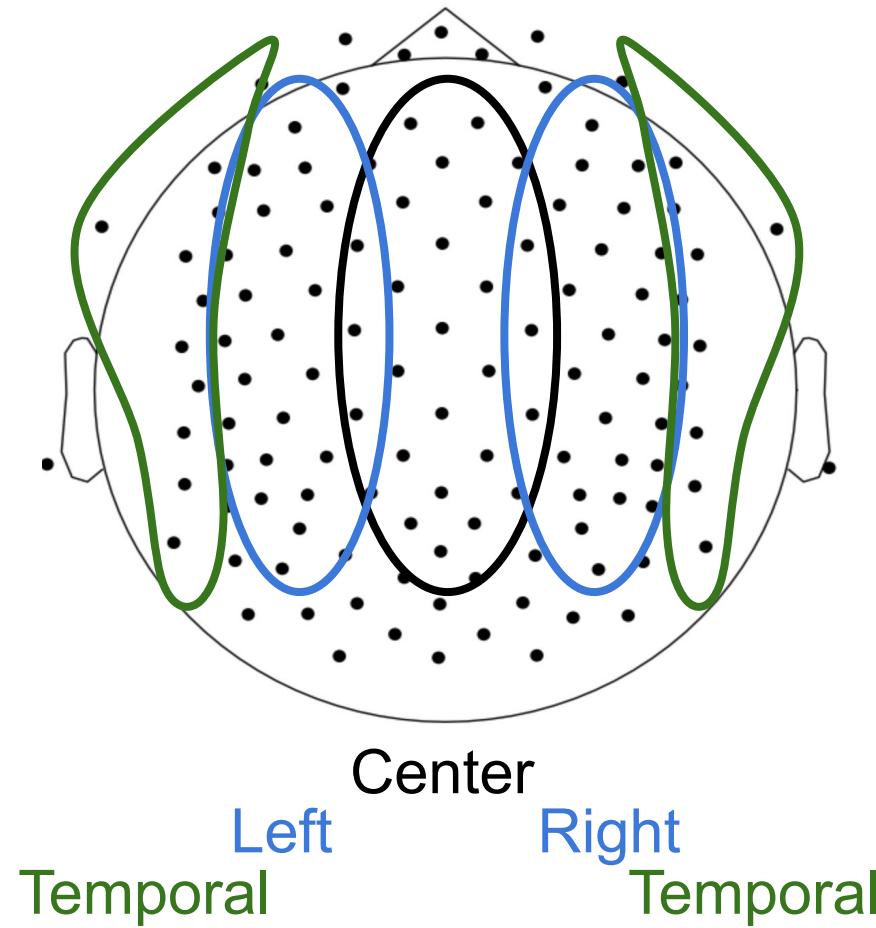
- Unidirectional connectivity of SP signals (10–16 Hz) peaks at the SP amplitude peak.
- Unidirectional connectivity of SO signals (0.5–1.25 Hz) peaks at the SO trough.

# Directionality of SOs modulates directionality of coupled SPs

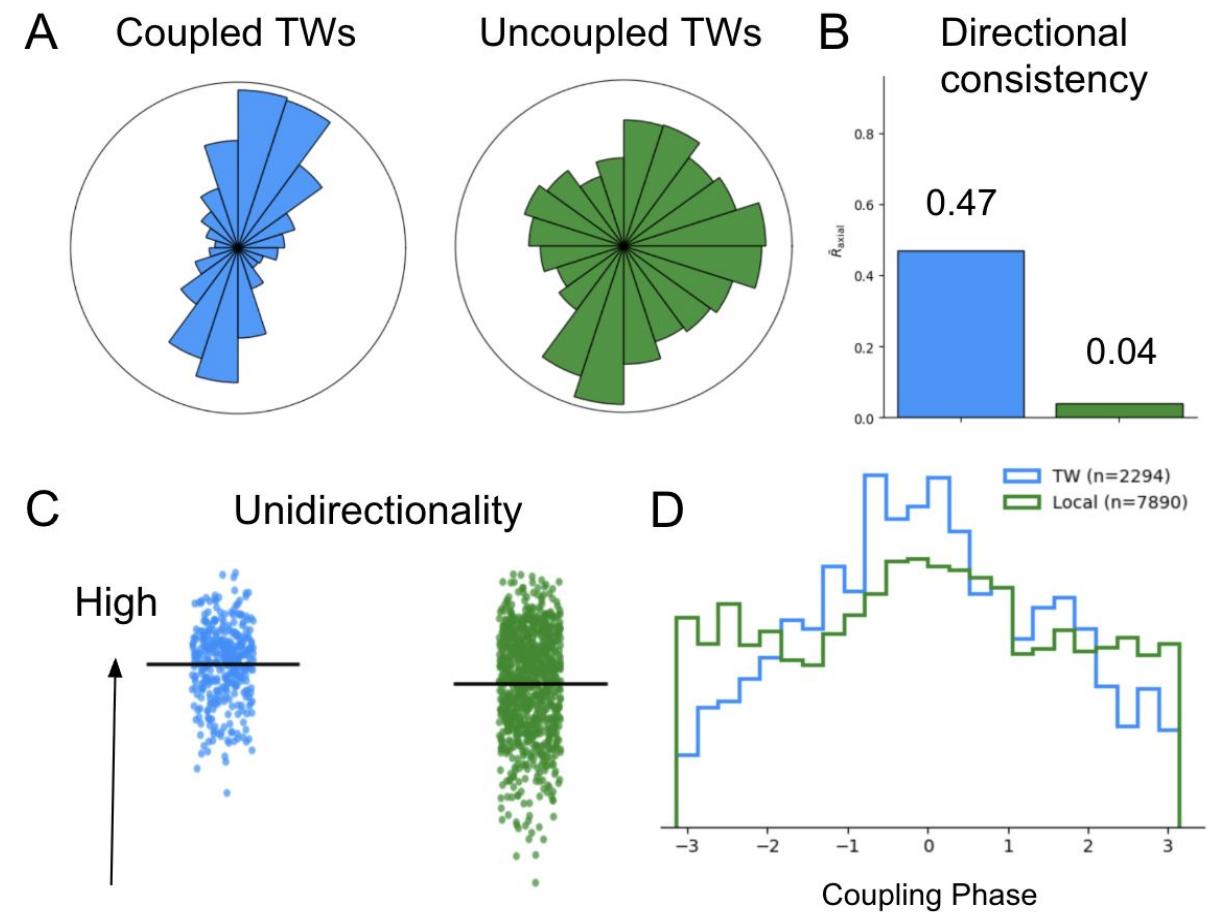
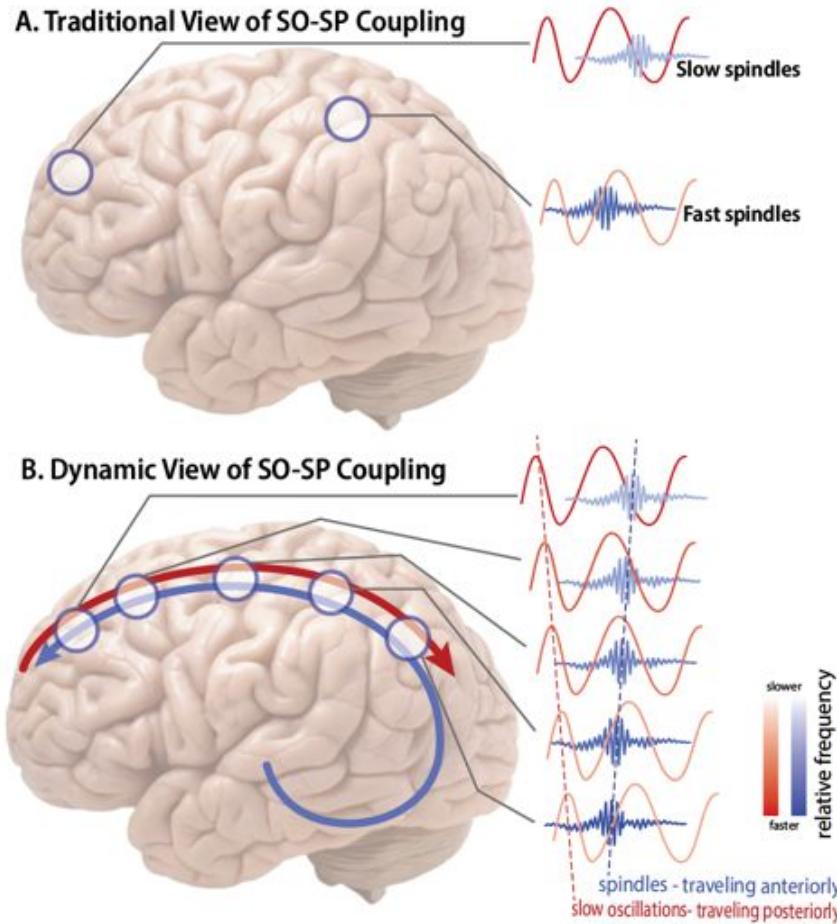


- SD over time for SO–SP coupling events
- Increased unidirectional movement in SOs drives that in SPs

## Consistency of propagation directions at each electrode cluster

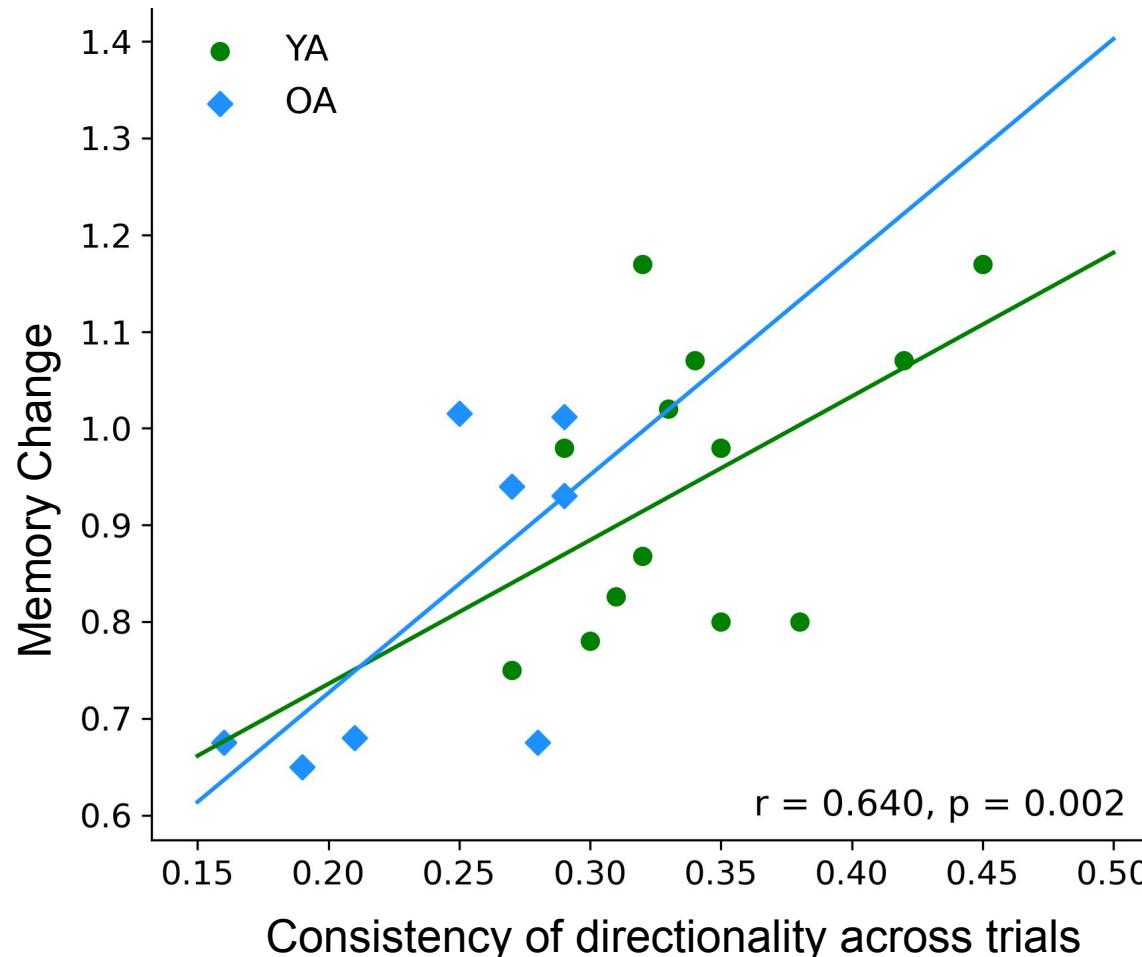


# Bidirectional reinforcement between Traveling Waves and SO-SP coupling



**Does the consistency of traveling wave direction predict memory performance? Does it vary with age?**

# Consistency of propagation predicts memory performance



- Higher directional consistency of SO propagation predicts better memory performance in YA and OA.
- Precise spatiotemporal coordination during wave propagation are crucial for effective memory consolidation.

## Conclusion

- Repeated SO and SP events across the cortex enables maximal coordinated, unidirectional wave propagation, supporting long-range information transfer and integration.
- Their propagation gradients, consistency, and cortical involvement can predict memory change oversleep, and its disruption is related to impaired memory performance.
- Traditional definitions of “fast” and “slow” SPs are often subjective. SP frequency varies by age and cortical region following a continuous scale.
- Future sleep-memory studies **should** include spatiotemporal structures in their analysis.

# Thank you!



**SOMNEUROLAB**  
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AT THE UNIVERSITY OF MASSACHUSETTS AMHERST

Poster Presentation

Session: P-21

Date and Time: **6/10/2025 10:00 - 10:45 AM**

Poster Board Number: **37**

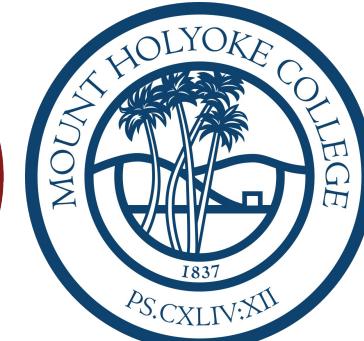
## Acknowledgements (2019-2025)

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Irina Orlovsky	Katrina Rodheim <b>187</b>
Morgan Barnes	Bethany Jones
Cassandra Delvey	Undergrad RAs

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<https://github.com/somneuro-lab-umass>

## SO-SP Coupling Meta-analysis:



## References:

