Texture-Dependent Sensorimotor Patterns Under Scopolamine and Nerve Block

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Overview

- Oral health issues have been associated with age-related dementias such as Alzheimer's disease (AD), a neurodegenerative disease affecting tens of millions worldwide [1].
- Changes in brain connectivity with aging and AD are linked to motor impairments such as dysphagia [2].
- Memory loss and reduced oral sensation often co-occur in Alzheimer's disease, but the connection between cognitive decline and age-related oral health changes remains poorly understood.
- The orofacial sensory motor cortex is central to guiding texture-based feeding behavior, yet how its connectivity changes with aging and memory impairment is still unclear.
- Understanding cortico-cortical interactions may aid in developing therapies for sensorimotor disorders, such as those affecting speech and feeding.
- We aim to investigate how cortical representation of texture changes under memory impairment alone and when combined with reduced sensory input.

Methods

- **Subjects:** One healthy adult non-human primate (N = 1, age 21 years).
- **Behavioral Task:** Texture discrimination task with tongue-licking and juice reward.
- **Trial Structure:** 4.5 s trials, 20 trials per texture plate.
- **Experiments:**
  1. **Scopolamine:** Scopolamine: muscarinic receptor antagonist used to model memory deficits
  2. **Scopolamine + Nerve Block:** Combines central memory impairment with peripheral sensory loss through a local trigeminal nerve block
- **Neural Recording:** Multiunit activity recorded from Utah Arrays implanted in primary motor cortex (M1), primary somatosensory cortex (S1), and prefrontal cortex (PF).
- **Region Pairs:** Intracortical and intercortical combinations across M1, S1, and PF.
- **Coherence Analysis:**
  - Computed corticocortical spectral coherence (magnitude and phase) in the theta band (2 to 6 Hz)
  - Phase coherence derived from significant peaks using shuffled controls to identify nonrandom synchronization.
- **Variables:**
  - **Independent:** Condition (Control, Scop, Scop + NB); Texture Plates 1 (fine) and 4 (coarse).
  - **Dependent:** Magnitude coherence and theta phase coherence across region pairs.

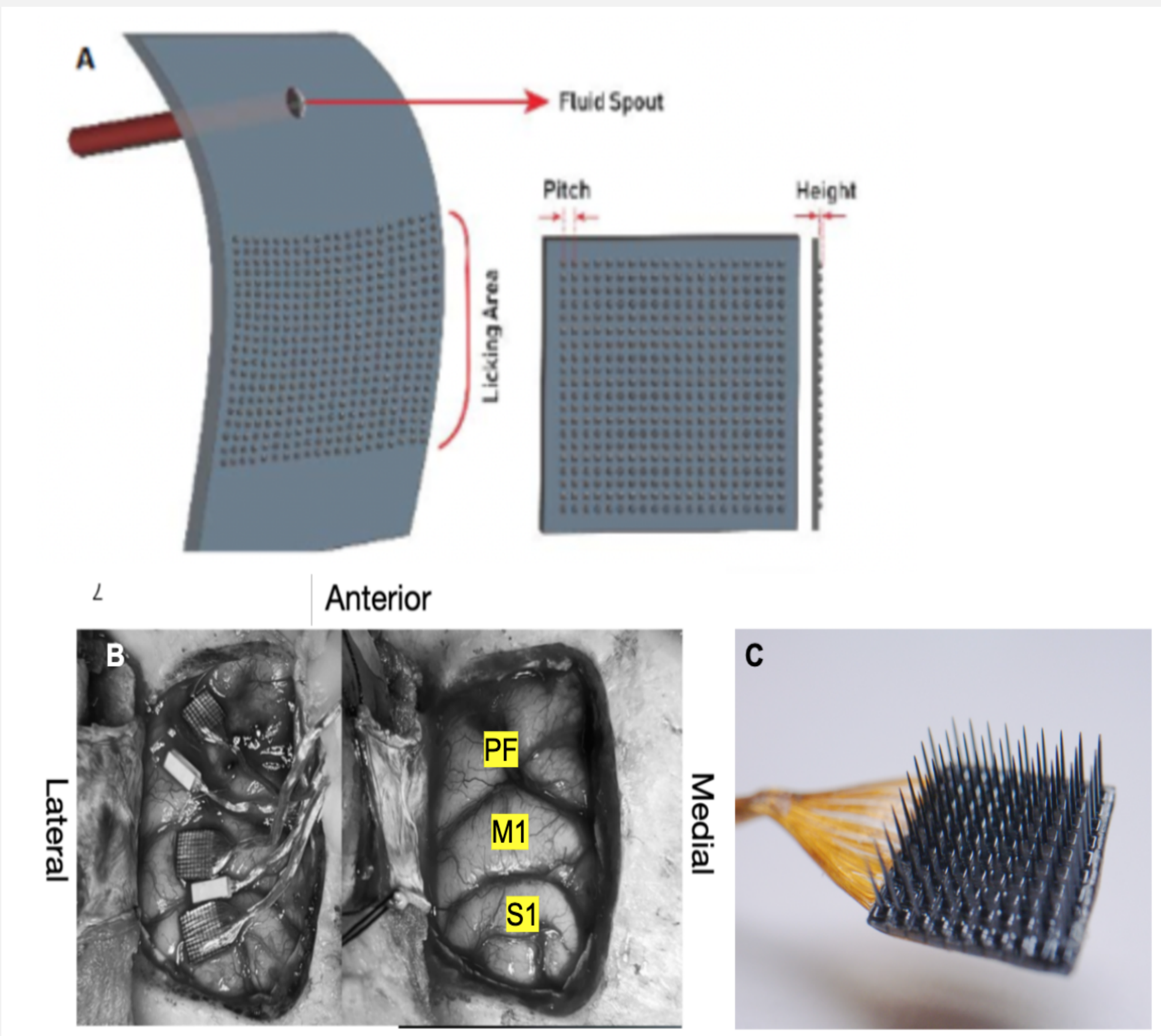

Fig. 1 (A) Texture plate (B) Array implantation setup (C) Utah Array

Results

Preliminary Analysis: Which Band Exhibits the Highest Overall Coherence?

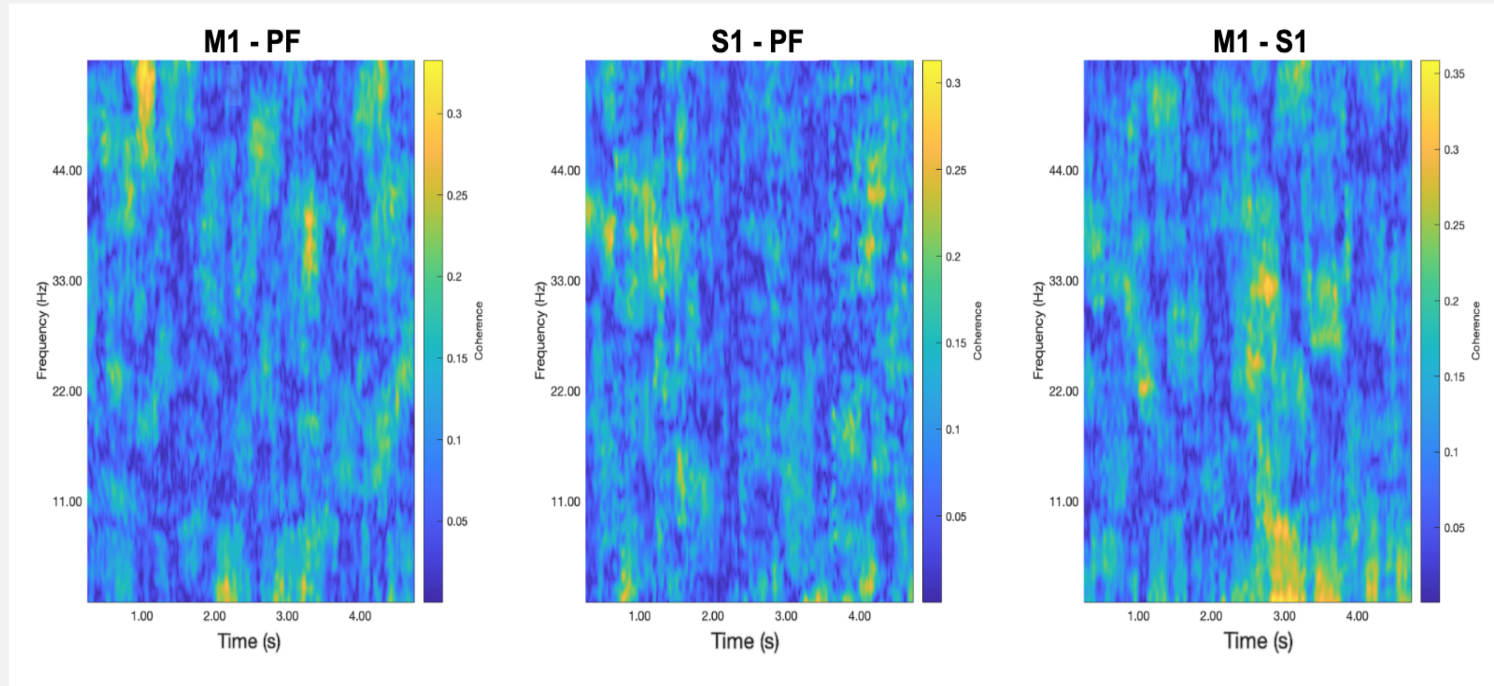

Fig 2. Coherograms of neuron pairings from brain regions during control condition. Coherence was highest in theta band, followed by gamma band. Based on this spectral profile, all subsequent magnitude and phase coherence analyses focus on the theta band.

Intracortical Coherence Magnitude Across Conditions

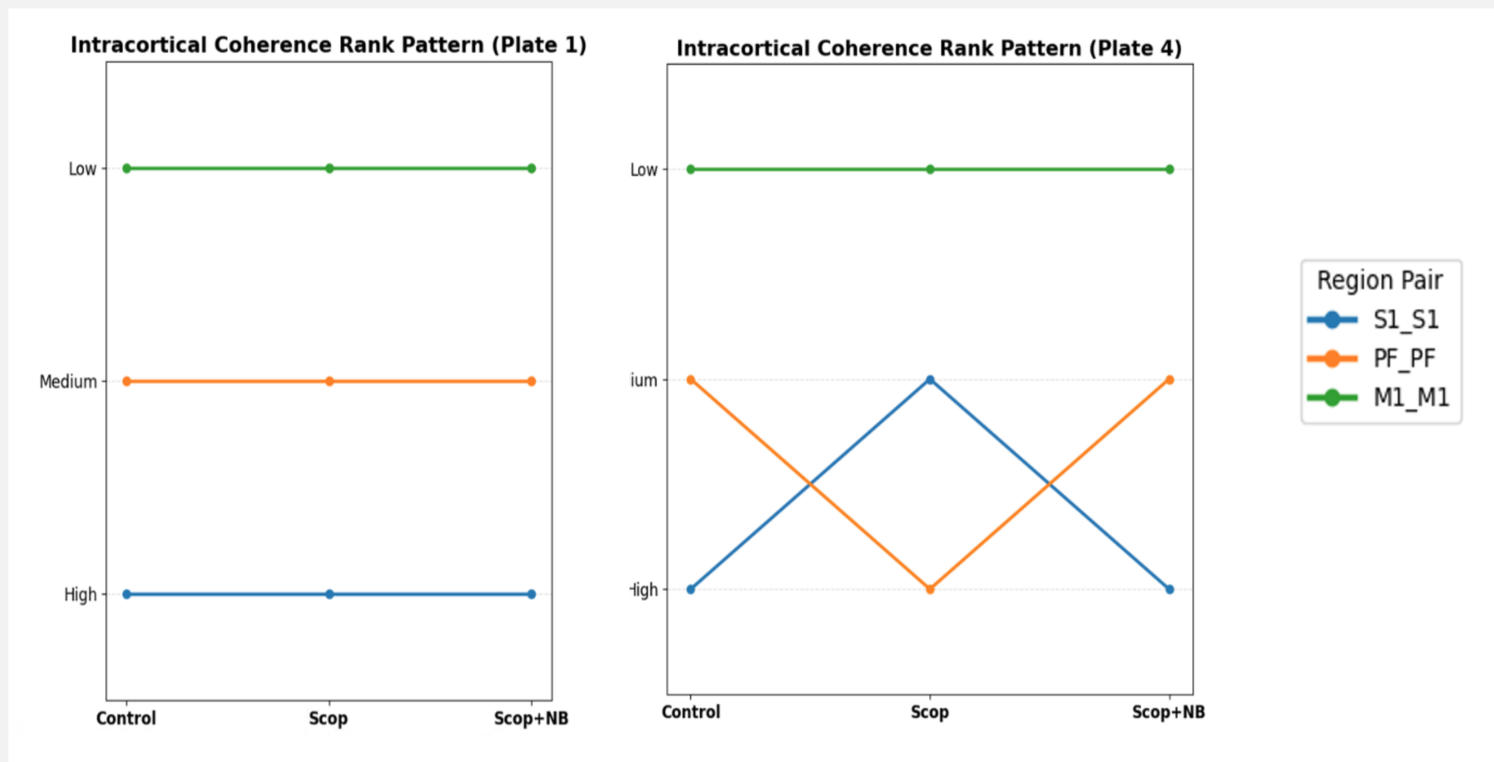

Fig 3. Intracortical peak coherence rankings were largely stable across conditions, with only a minor texture-specific shift under scopolamine that reverted under scopolamine plus nerve block. Rankings showed significant differences across pairs (Kruskal-Wallis, *, $P < 0.05$).

Intercortical Coherence Magnitude Across Conditions

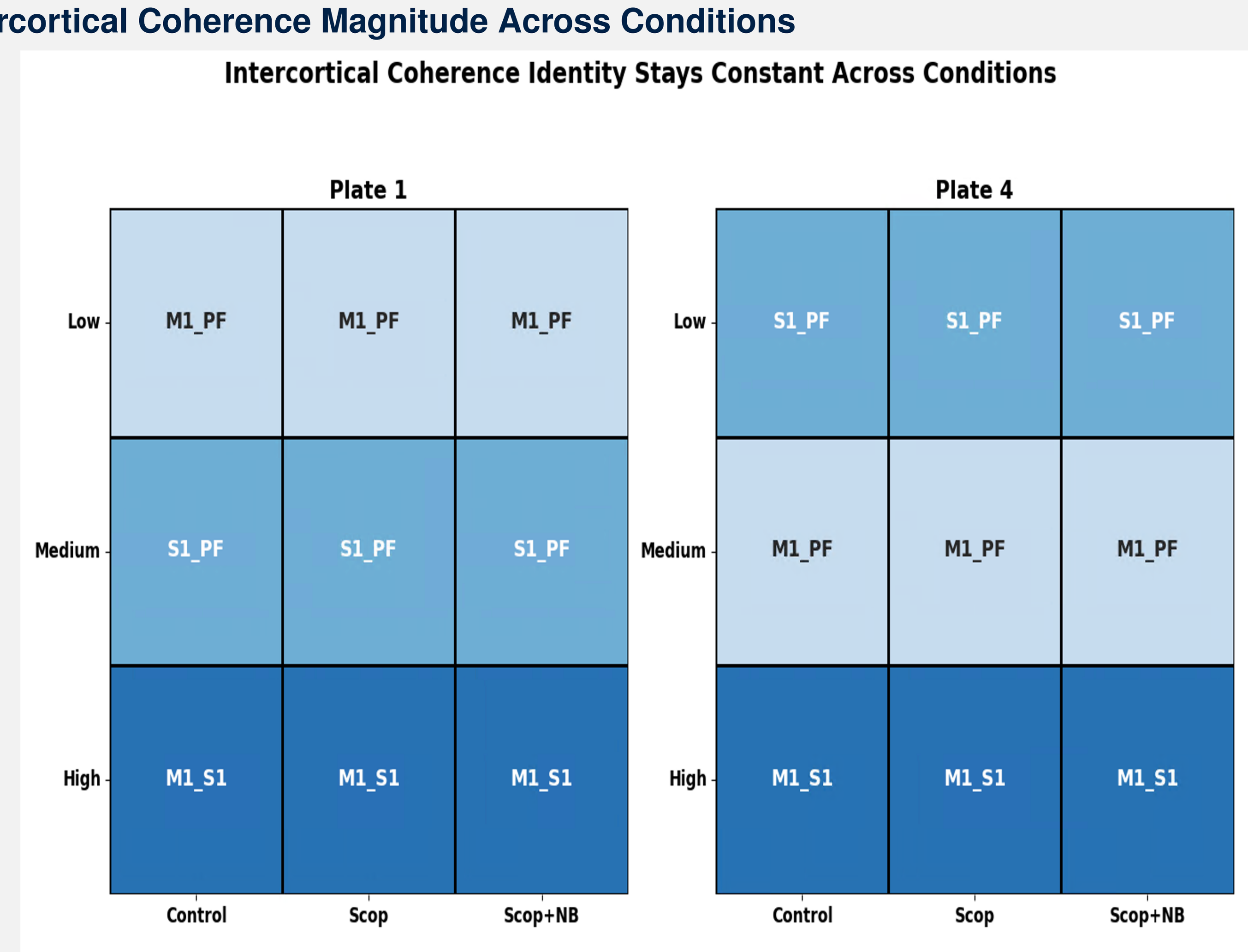

Fig 4. Coherence values were rank-ordered within each plate (Low = lowest coherence among the three pairs, Medium = middle, High = highest). Rank orders only changed as a function of texture plate. This pattern contrasts with intracortical circuits, which showed condition-dependent reorganization (Kruskal-Wallis, *, $P < 0.05$)

Results

Distribution of Intercortical and Intracortical Theta Phase Coherence

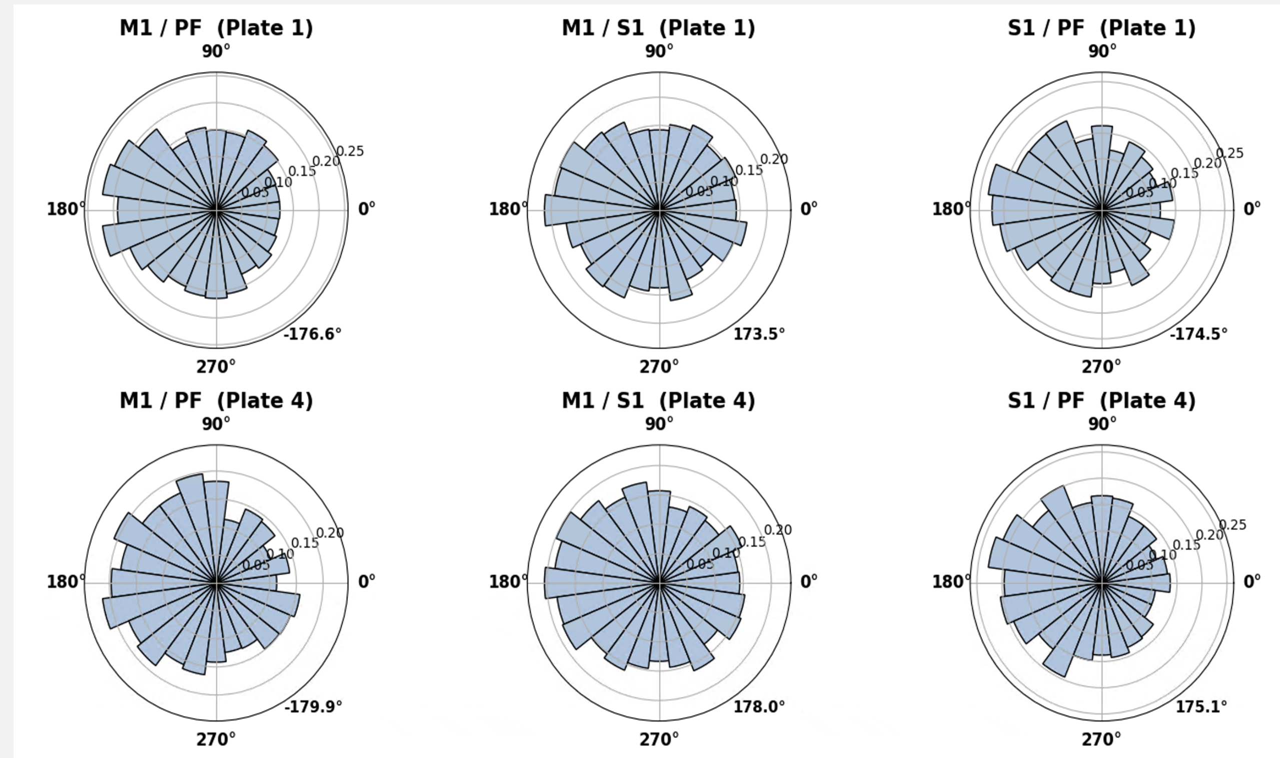

Fig 5. All *intercortical* region pairs showed significantly non-uniform theta phase distributions (Rayleigh, ***, $P < 0.05$), indicating reliable preferred phase structure in every condition. Some *intracortical* circuits showed uniform distributions (Rayleigh, $P > 0.1$), indicating absent preferred phase structure. Significant phase organization was present only in select intracortical circuits.

Intercortical Theta Phase Differences Across Conditions

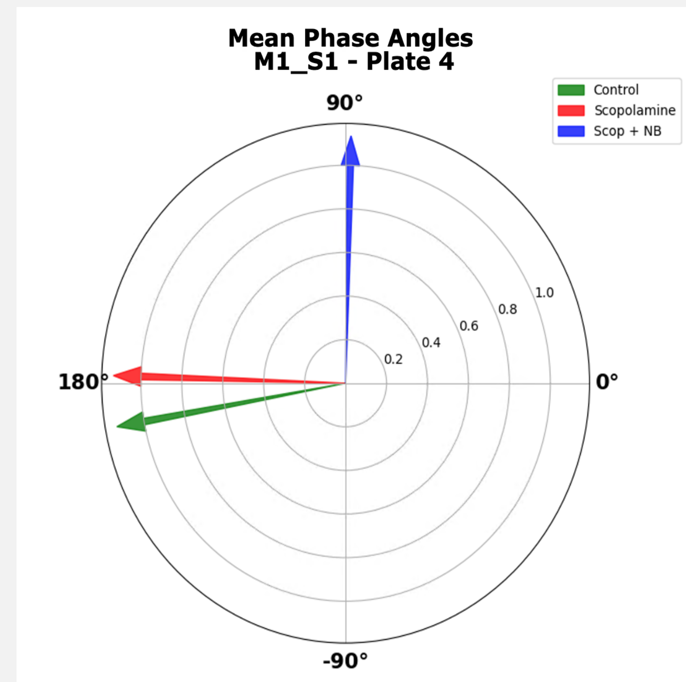

Fig 6. Theta-band phase timing significantly differed across experimental conditions, revealing strong condition-dependent phase shifts (Mardia-Watson-Wheeler, ***, $p < 0.001$), indicating that scopolamine alone and in combination with nerve block alters the timing of intercortical synchronization during texture-guided sensorimotor behavior.

Conclusions

- Intracortical peak coherence rankings had a minor shift in texture-dependent patterns under scopolamine that reversed after nerve block.
- Intercortical peak coherence rankings displayed no changes in texture-dependent dynamics, regardless of condition.
- Intercortical theta-band circuits consistently displayed strong and non-uniform theta phase preferences for all pairs and conditions.
- Intracortical theta circuits demonstrated weaker or absent preferred phase organization.
- Phase timing differences for intercortical circuits showed robust condition-dependent shifts, demonstrating that scopolamine, with or without nerve block, disrupts the normal timing of intercortical synchronization during texture-guided sensorimotor behavior. conditions

Acknowledgments

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