

Expectation And Surprise In The Sleeping Brain: Auditory prediction error response for omitted tones in NREM and REM sleep

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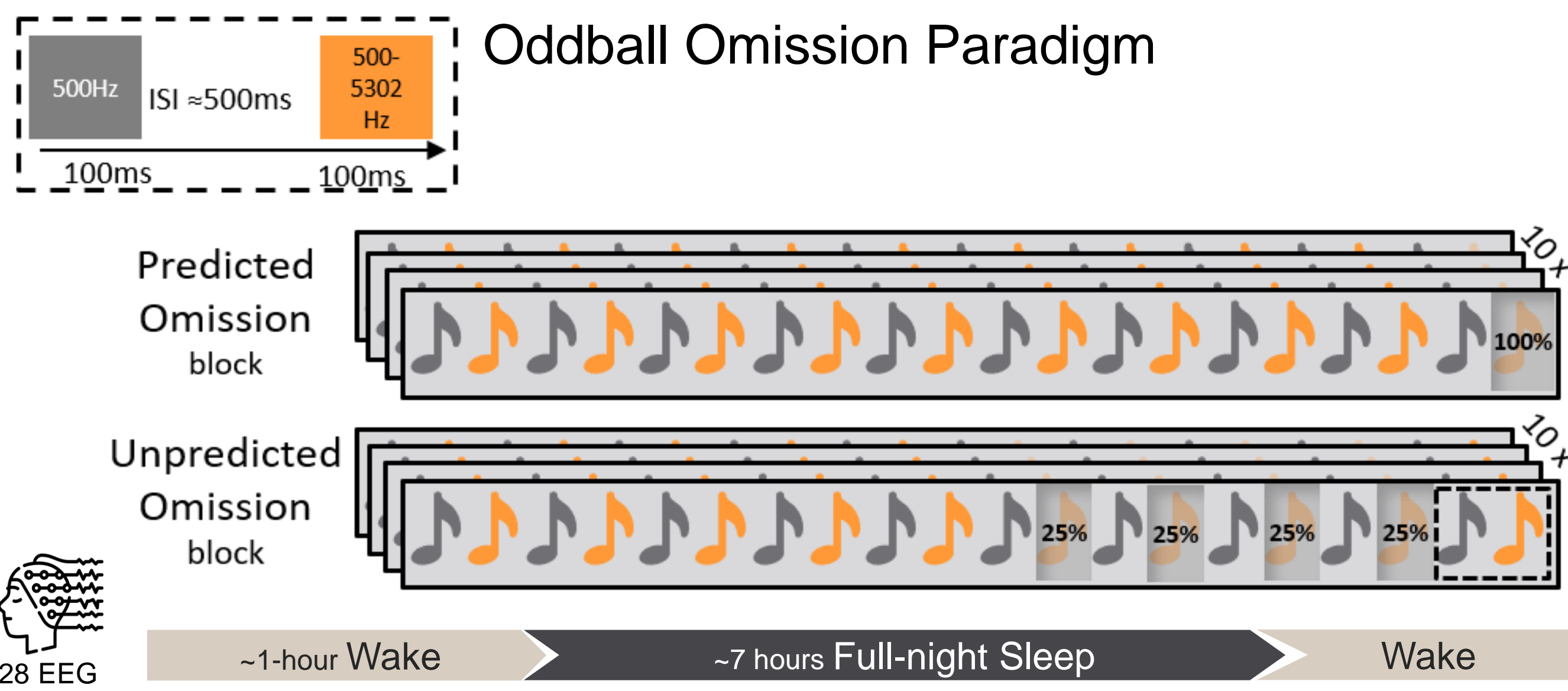
Introduction

To survive, organisms must detect regularities and their violation, even during sleep. Indeed, neural responses to regularity deviation can be observed in non-rapid eye movement (NREM) and rapid eye movement (REM) sleep. However, most research has conflated responses to unexpected events with reactions to the physical properties of the stimuli. An elegant approach to disentangle these responses involves inducing surprise through the absence of anticipated stimuli, which has yet to be studied in sleep. Here, we aim to investigate the brain's surprise response during sleep by examining neural activity in response to expected and unexpected periods of silence throughout a full-night sleep.

Methods

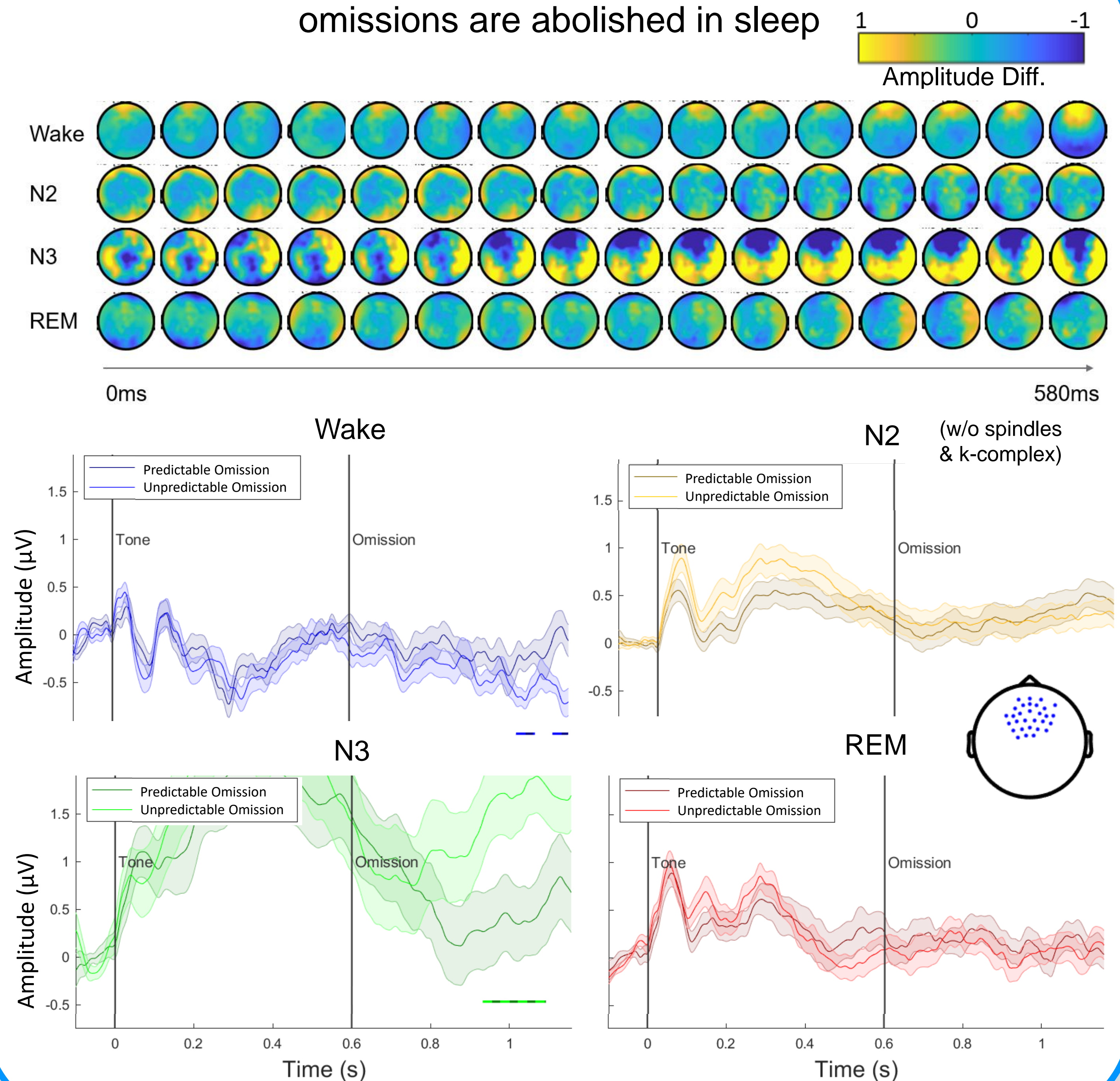
Healthy participants (N=27) were recorded with HD-EEG during wakefulness and a full night's sleep while passively hearing an auditory oddball-omission sequences.

Oddball Omission Paradigm



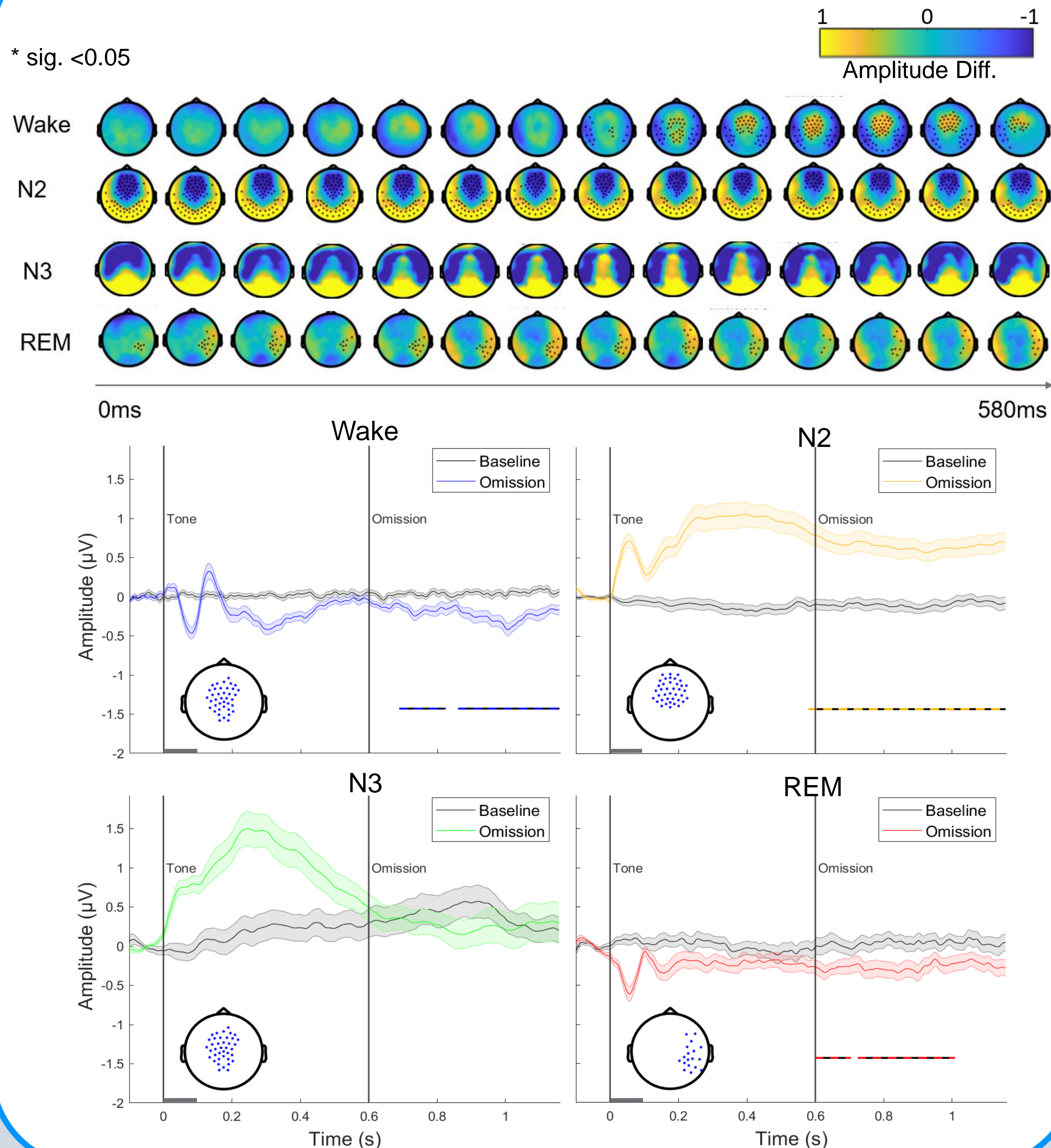
Can the sleeping brain perform complex expectations?

Neural differences between predicted and unpredicted tone omissions are abolished in sleep

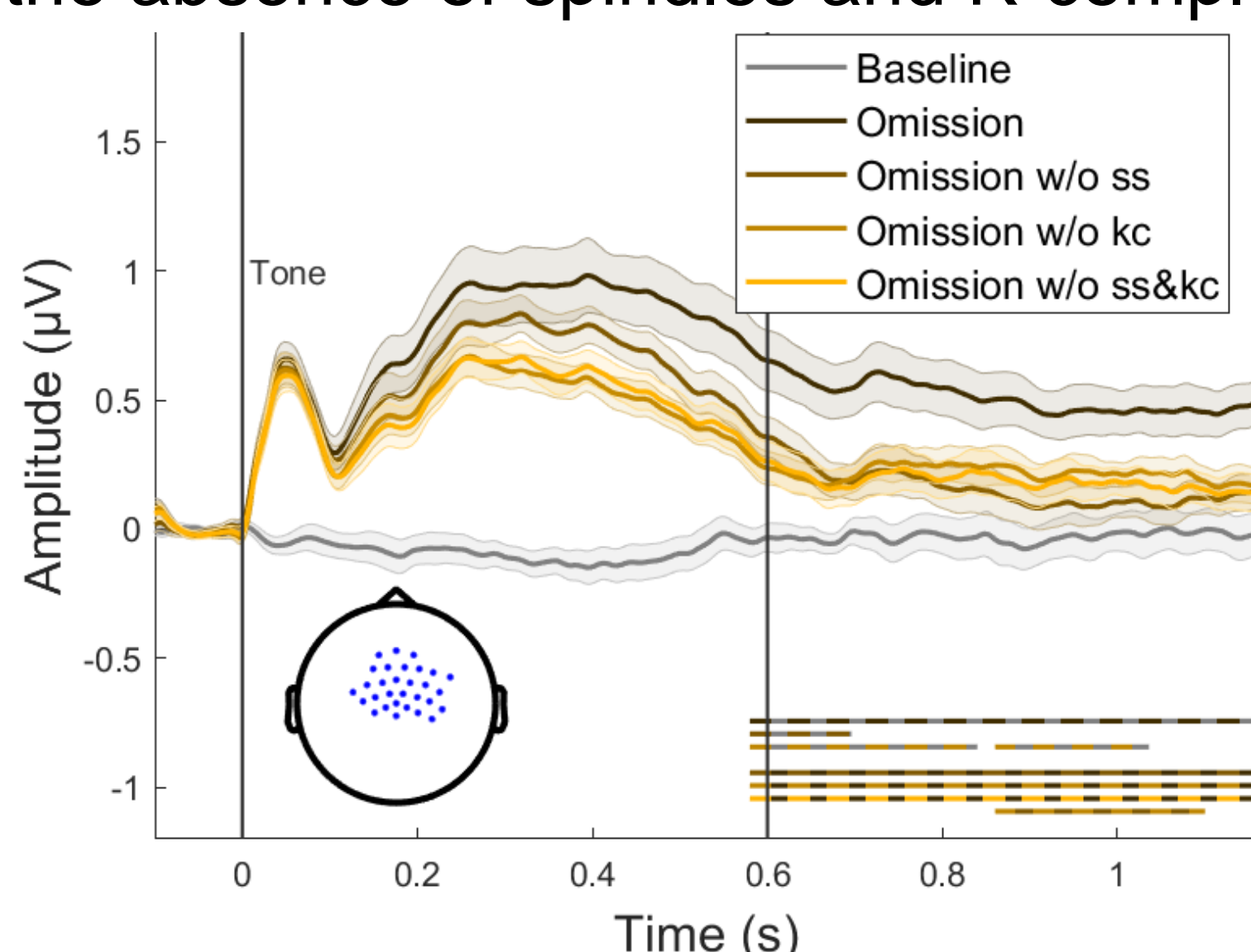


Is the sleeping brain sensitive to stimulus omission?

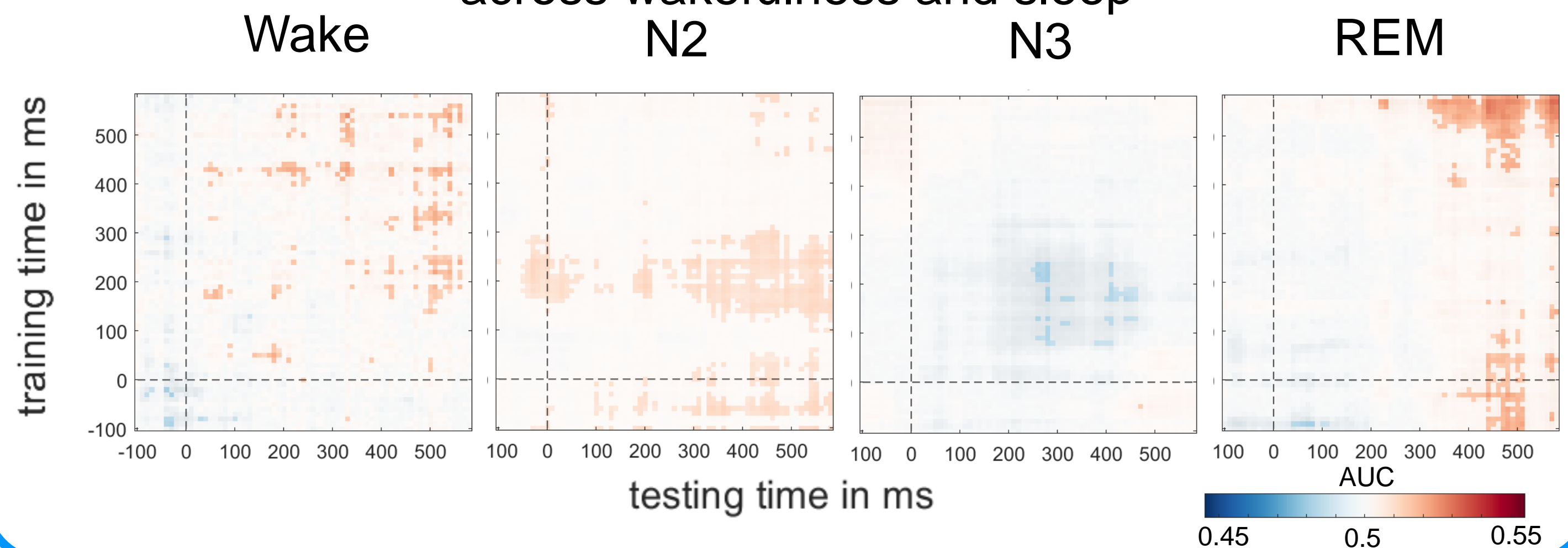
Neural responses to tone omission are state-dependent



No omission response is observed in N2 in the absence of spindles and K-complexes



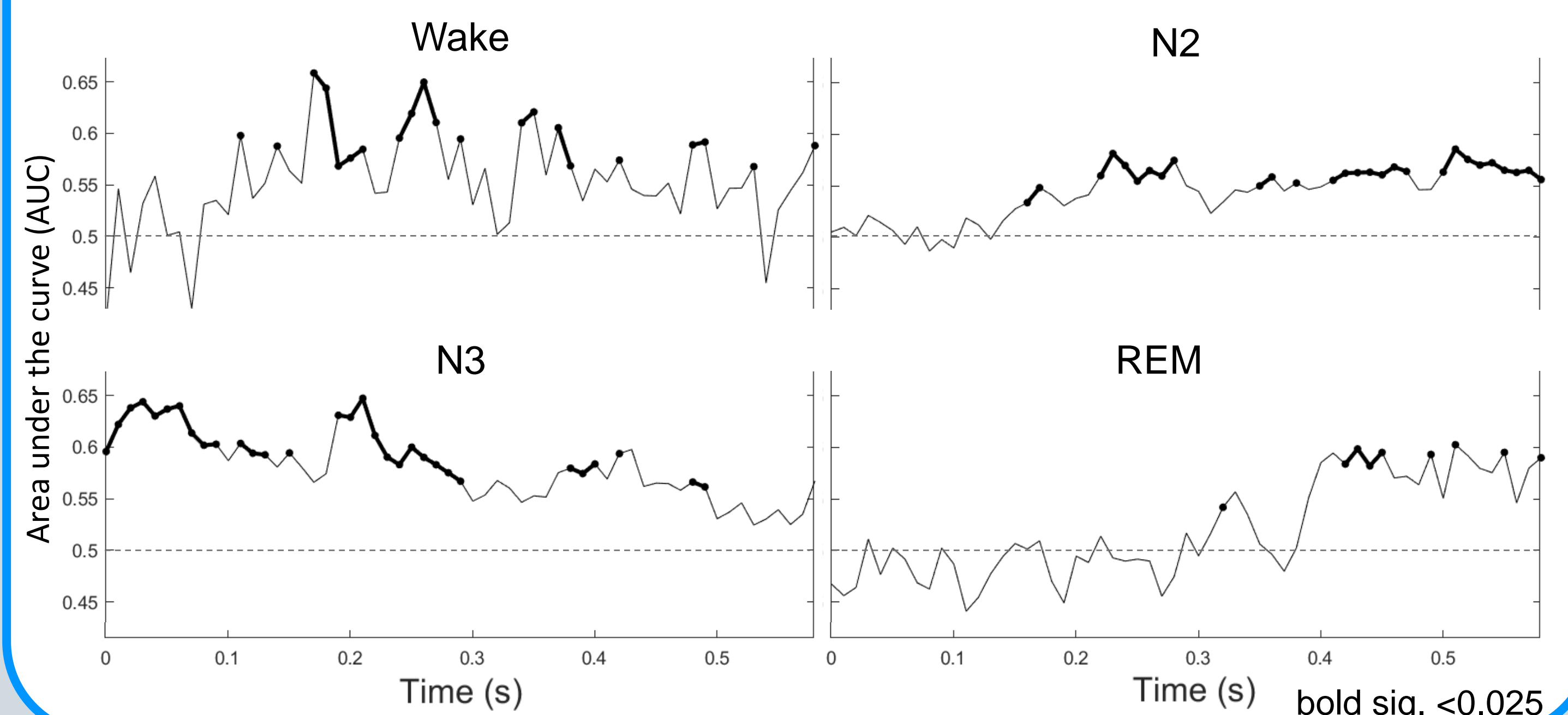
No classification of neural responses by omission predictability across wakefulness and sleep



Limited within-subject decodability of omission predictability across wakefulness and sleep

Only two participants showed sustained classification of omission predictability during wakefulness and sleep.

Participants #35 classification performance



Discussion

We found that the brain responds to the cessation of regular auditory stimuli during wakefulness, N2, and REM sleep. However, the observed omission response during sleep may reflect prolonged neural activity following auditory stimulation attributed to the paradigm's design, which does not provide sufficient time for the neural activity to return to baseline. Additionally, differences in response to predictable versus unpredictable omissions are observed in wakefulness but not in N2 or REM sleep. In N3, differences in response to predictable versus unpredictable omissions may potentially be related to slow-wave entrainment rather than predictive processing. Overall, our findings suggest a diminished capacity for auditory omission detection during sleep.