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Oscillatory Signatures of Prior Learning: Dissociable Roles of Theta and Alpha Oscillations in Strategy Acquisition and Exploitation

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Introduction

Recent years have witnessed growing interest in the cognitive neuroscience of prior knowledge implementation in perceptual decision-making. Previous studies emphasized the role of posterior alpha rhythms in exploiting explicit priors, showing cue-related amplitude modulations. Yet, the oscillatory mechanisms underlying prior learning remain poorly understood. In this study, we investigated the temporal dynamics of prior acquisition and exploitation, predicting that posterior alpha oscillations would underpin prior use, while mid-frontal theta would reflect the learning decision strategies.

Methods

Participants (n=78) performed a simple detection task with concurrent EEG recording. Before each stimulus, a contextual cue signaled the optimal strategy (liberal or conservative). Feedback, linked to the initial cue, guided participants in learning the appropriate strategy. This design allowed us to examine how contextual priors shaped both behavior and oscillatory activity.

Results

Behaviorally, participants adjusted their response criterion based on feedback, although strong inter-individual differences emerged. A subgroup of "good-learners" successfully optimized their behavior, while "bad-learners" failed to leverage contextual information. Neural analyses revealed distinct oscillatory patterns between groups: good-learners exhibited increased mid-frontal theta synchronization during early learning phases and posterior alpha modulation in later stages once the associations had been internalized.

Conclusions

Our findings demonstrate that learned priors critically shape decision strategies and reveal the oscillatory dynamics underpinning this process. Specifically, mid-frontal theta supports model acquisition through feedback, while posterior alpha amplitude serves as a marker for the exploitation of learned priors.

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