Selective modulation of theta oscillations using rhythmic TMS boosts auditory working memory performance

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Introduction
- Brain oscillatory activity is considered as signatures of distributed cognitive processes (Jensen et al., 2007).
- Brain oscillations can be synchronized (entrained) to external stimulation using non-invasive techniques such as rTMS (Thut et al., 2011) TACS and (Helfrich et al. 2014).
- We aim to modulate brain oscillations directly during auditory task performance, and investigate consequences on behaviour and brain activity.
- We investigate the causal relationship between brain oscillation and behavior in the context of auditory working memory, first identifying a relevant oscillatory signature (Experiment 1), and then modulating it with TMS (Experiment 2).

Experiment 1

MEG/EEG Results, Experiment 1

Identification of the target region and frequency of stimulation during the retention period

Increased activity in left dorsal pathway areas for reversed as compared to simple melodies

Increased theta power in the left IPS during the retention of reversed melodies predicts participants’ behavioral performance on the reversed task

Experiment 2

Procedures

Rhythmic TMS

Stimulus 1 silence Stimulus 2

Arhythmic/TMS

Stimulus 1 silence Stimulus 2

Results Experiment 2

Task by Session interaction : F(2,32) = 3.38 p = .04; Rhythmic TMS at theta boosts working memory performance for the reversed task

Conclusion

Our MEG/EEG results revealed the emergence, during the retention period, of a parietal theta oscillation (in the left Intra Parietal Sulcus: IPS) that predicts participants’ performance on the reversed melody task. In contrast this oscillatory activity was not observed for the simple task. We then used rhythmic Transcranial Magnetic Stimulation. With TMS bursts tuned to participants’ preferred theta-frequency (θ-TMS), performance was increased as compared to baseline and to arrhythmic stimulations on the reversed melody task, which requires manipulation of auditory information in memory. In contrast such stimulations did not significantly modulate performance on the simple pitch task. Furthermore our results demonstrate that rTMS boosts ongoing oscillation as measured by EEG, and Theta power entrained with TMS predicts behavioral benefits. Our results demonstrate that the modulation of endogenous oscillations during task performance can modulate participants’ behavioral performance. This approach suggests that brain oscillations can serve as specific signal markers and targets for controlled interventions into brain activity and (dys)functions, using safe, non-invasive brain stimulation.