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MODULATION OF WORKING MEMORY BY AN ALTERNATING MAGNETIC FIELD IN HUMANS

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INTRODUCTION

Working Memory (WM) and tACS

- transcranial Alternating Current Stimulation (tACS) is a non-invasive method using oscillating currents to modulate brain activity.
- It may enhance working memory by targeting neural oscillations.
- While theta-band stimulation is well studied, gamma-band stimulation remains less explored but shows promising effects.
- To assess its impact, we used EEG and applied a nonlinear analysis (RQA) to investigate the dynamics and complexity of brain signals.

Limitations of tACS

- Side effects: tingling, discomfort, even pain.
- Non-uniform current distribution: electrical fields are distorted by tissue properties (skin, bone, CSF).
- Limited depth: tACS currents primarily affect cortical regions, with poor penetration into deeper brain areas.

New Approach: tAMS

Transcranial Alternating Magnetic Stimulation (tAMS) uses alternating magnetic fields (sinusoidal) to induce electric currents in the brain.

- ✓ Deeper and more homogeneous penetration
- ✓ Fields orientation (orthogonal)
- ✓ Improved participant comfort

tAMS induces cortical electric fields of similar intensity to tACS (0.1-1 V/m)

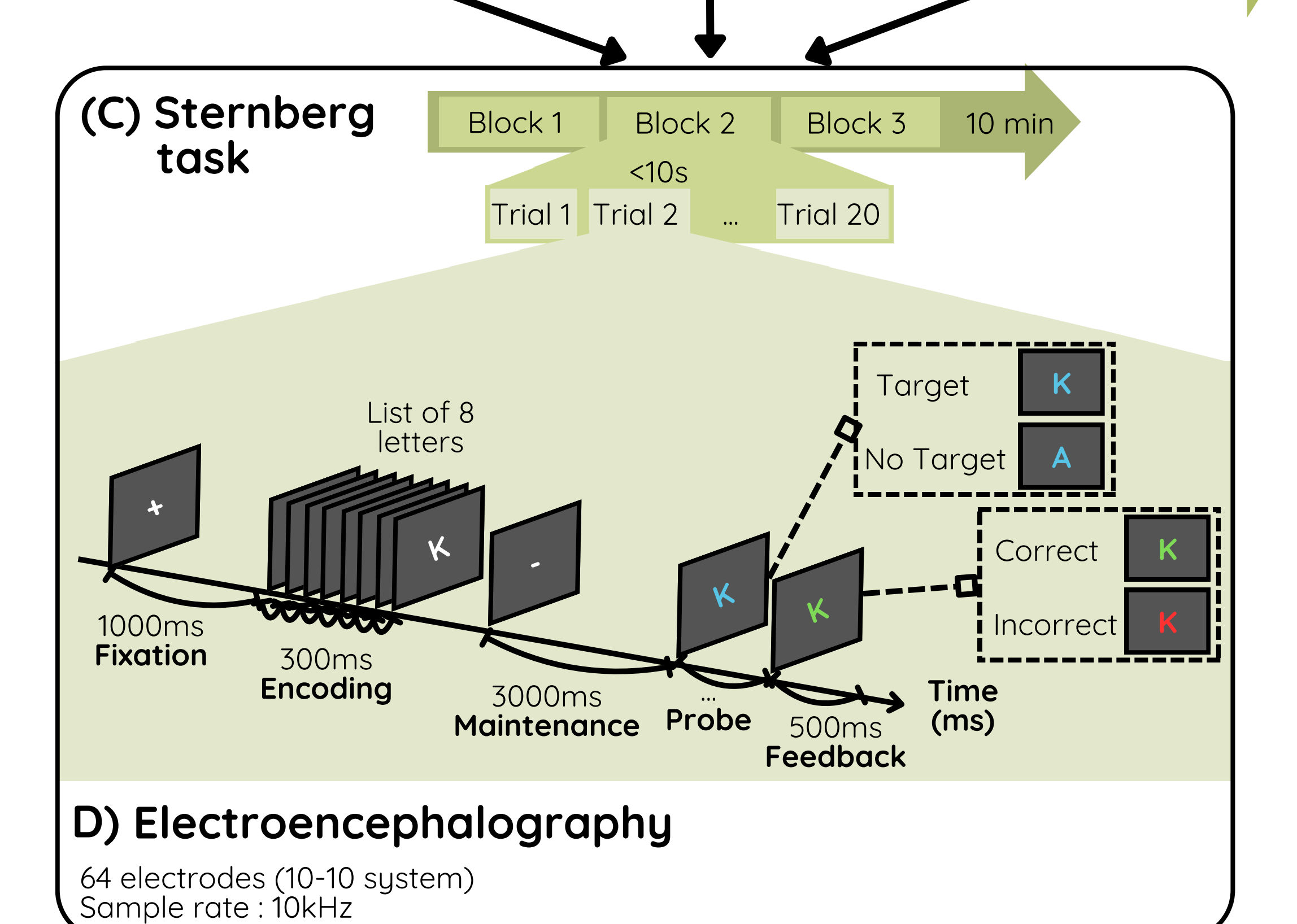
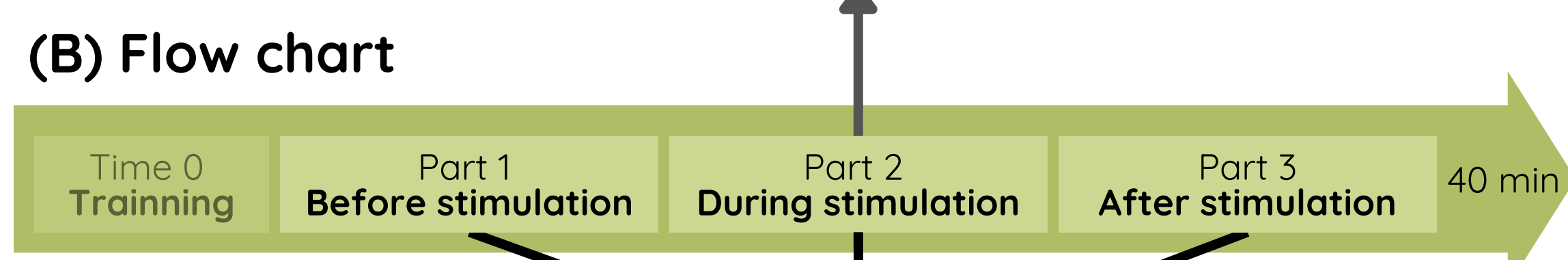
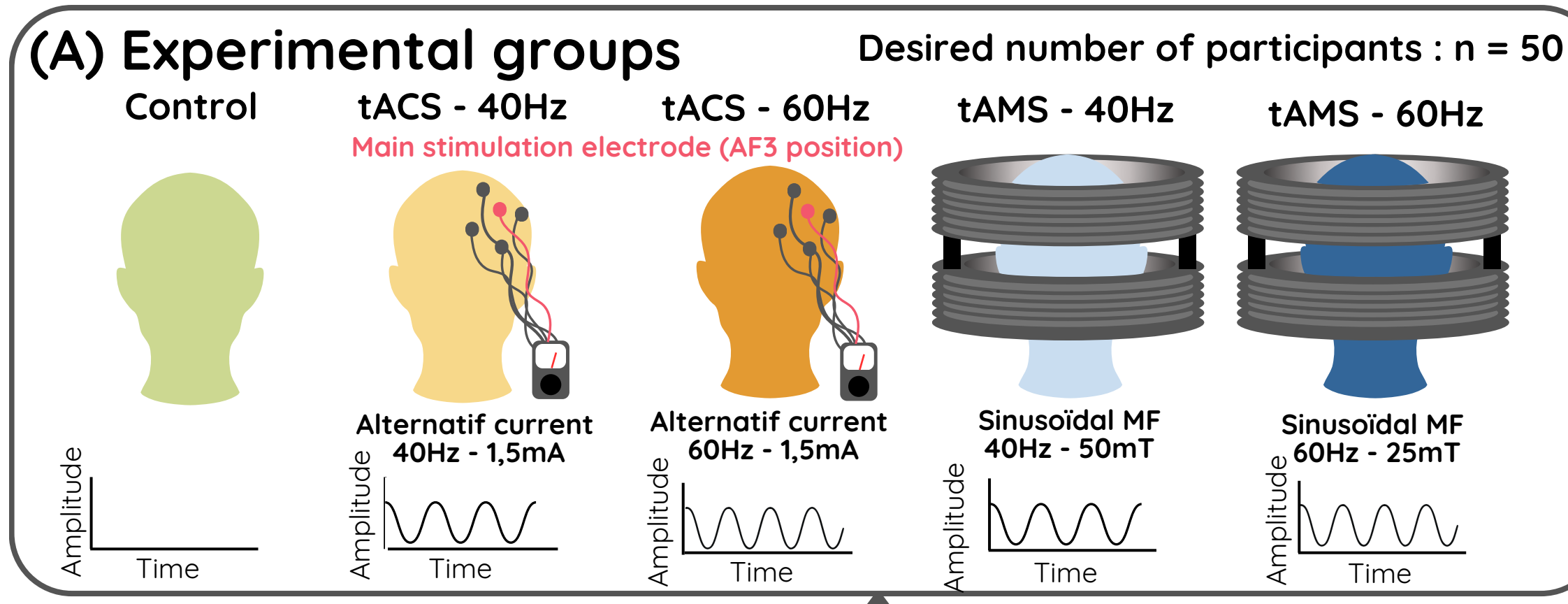
Objectives

- Validate tAMS the effectiveness in modulating WM.
- Assess how 40 Hz and 60 Hz stimulations differentially affect WM performances.
- Evaluate Recurrence Quantification Analysis against traditional linear methods to improve EEG signal analysis following stimulation.

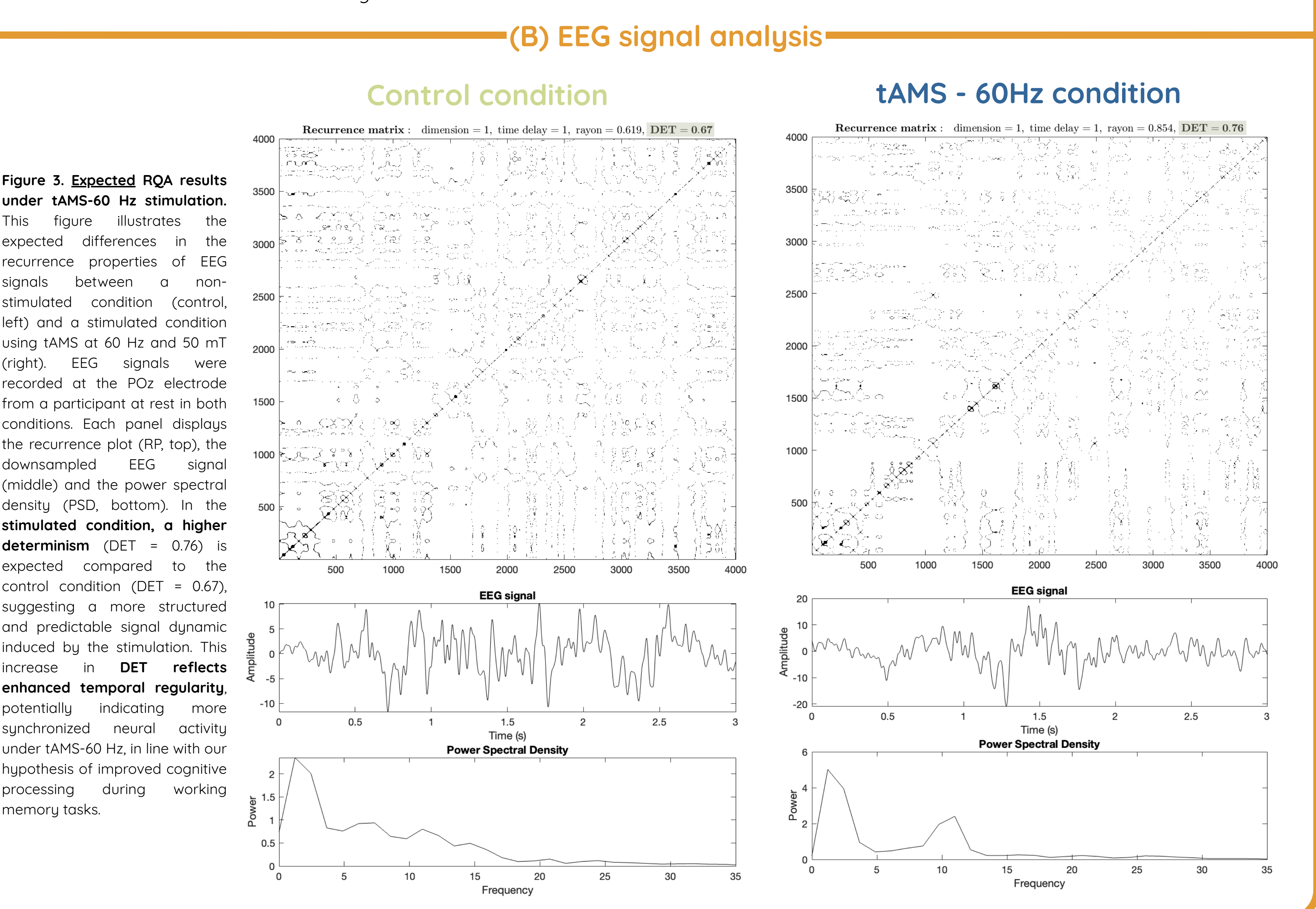
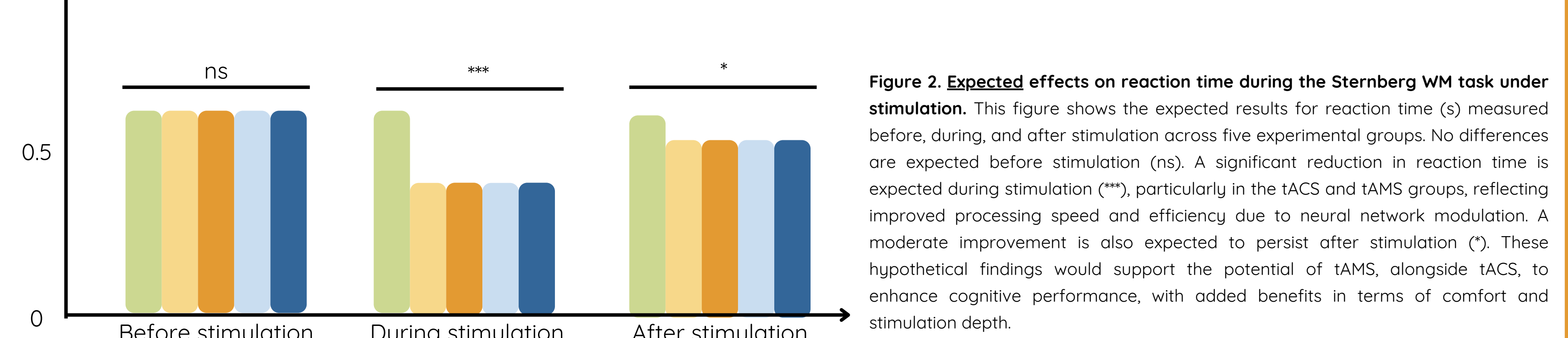
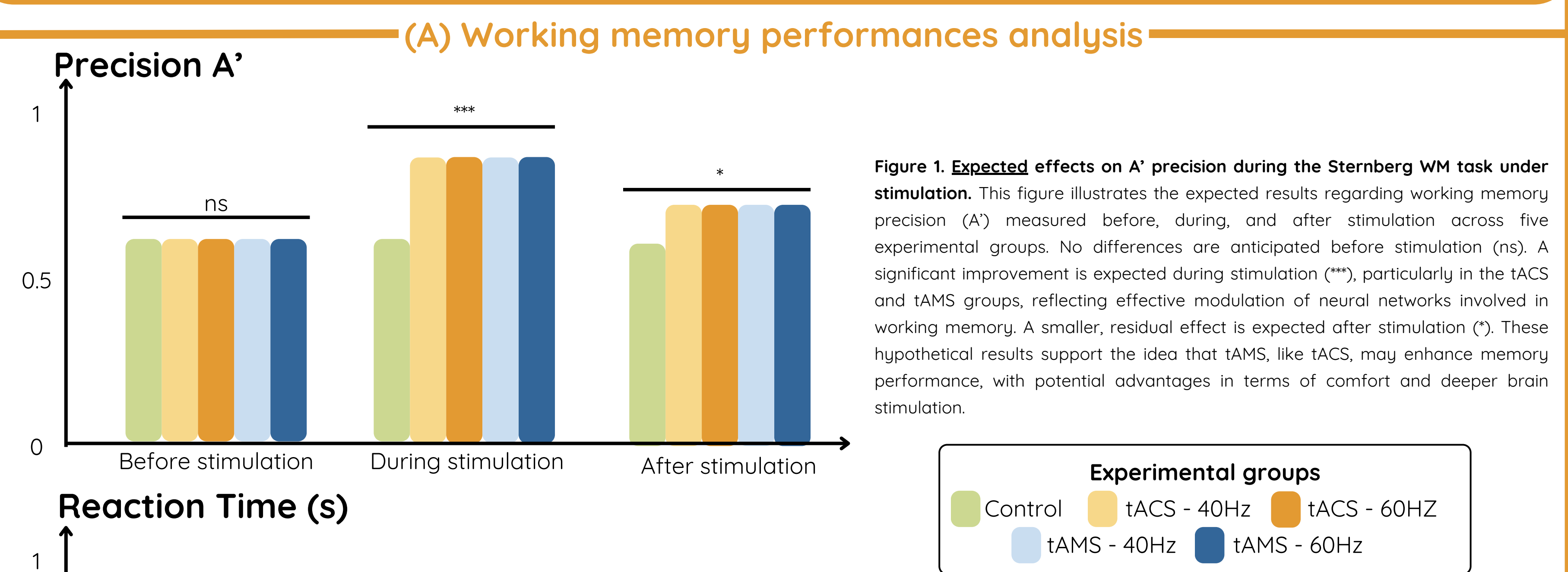
Hypothesis

- Cognitive Effects of Stimulation: tAMS aims to enhance working memory by precisely modulating neural networks
- EEG Signal Analysis: RQA offers insights into neural effects of stimulation by detecting subtle changes in signal complexity and dynamics

MATERIAL & METHODS



EXPECTED MAIN RESULTS



DISCUSSION

- ✓ **Validation of magnetic stimulation (tAMS)** - Expected to enhance working memory performance similarly to tACS during the Sternberg task.
- ⚡ **EEG signal analysis method** - RQA provides deeper insights into brain rhythm dynamics, potentially modulated by magnetic field exposure
- 🧠 **Neuroscientific implications** - Both tAMS and tACS modulate neural circuits involved in working memory, likely through effects on synaptic plasticity and, in particular, by altering the amplitude and phase of endogenous neural oscillations.
- 🧬 **Neurophysics advantage** - Unlike tACS, which delivers current directly through the scalp and is affected by tissue conductivity, tAMS induces perpendicular electric fields via time-varying magnetic fields. This allows for greater control over the orientation of the induced current, which may result in more efficient alignment with dendritic-somatic axes in cortical neurons (enhancing stimulation specificity and effectiveness).
- ⚡ **Perspective in therapeutic advance** - These findings may lead to improved working memory performance, especially relevant for addressing therapeutic challenges in the elderly population, where cognitive decline and dementia are growing concerns.
- ⚡ **Overcoming therapeutic problems of tACS with the use of MF** - tAMS overcomes several limitations of tACS, including limited field penetration, inhomogeneous distribution, and user discomfort — offering a more precise and comfortable neuromodulation approach.

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