How Auditory Temporal Structure Shapes Neural Entrainment and Selective Attention

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INTRODUCTION

When our brains are engaged in particular activities, characteristic patterns of rhythmic neural synchronization emerge — measurable as power in particular frequency bands (e.g., delta = deep sleep; alpha = relaxed wakefulness and selective attention; beta = active concentration).

In particular, the act of selective attention — focusing on one thing while ignoring others — is associated with increased alpha band synchronization, which reflects the active suppression of task-irrelevant neural processing (Foxe & Snyder, 2011).

At the same time, we know that these rhythmic patterns can be externally driven via neural entrainment — the synchronization of brain oscillations to rhythmic auditory stimuli.

Research Question: Can externally induced alpha synchronization via neural entrainment engage the brain's selective attention mechanisms — effectively using sound to put the brain into an attentional state?

MEASURES

The PLV is a measure that quantifies the consistency of a phase relationship between two signals. In this study, we calculated the PLV by comparing the phase of the EEG signal with the phase of the rhythmic auditory stimulus over time (Lachaux et al., 1999).

The Flanker task is an established paradigm for measuring selective attention. It requires the participant to respond as quickly and accurately as possible to the direction of a central arrow in a row of arrows. The central arrow either faces the same direction as the other arrows (congruent), or the opposite direction (incongruent).

>>>>> or <<><<

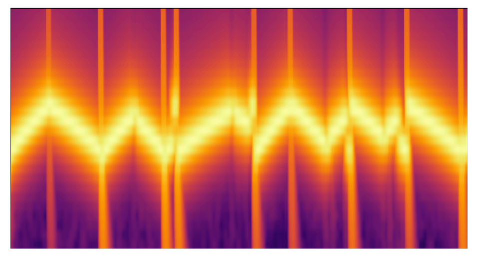
congruent | incongruent

HYPOTHESIS

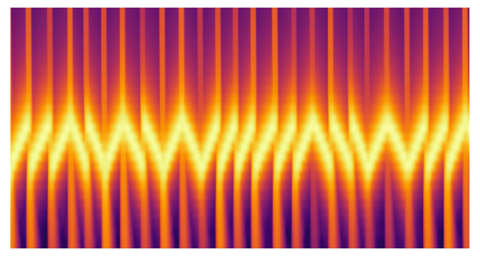
We hypothesized that participants assigned to the alpha stimulus condition will show greater improvements in selective attention following auditory entrainment than participants assigned to the beta2 stimulus condition.

METHODS

N = 8, ages 19-38 years old (M - 23.5)



alpha



beta2

There were two types of auditory stimuli taken from Teng & Poeppel, 2020 for our study: alpha and beta2 as experimental conditions. These auditory stimuli are designed to create entrainment in the alpha and beta2 frequency ranges (8-12 Hz and 21-30 Hz respectively), and consist of frequency modulated sweeps concatenated on each other. These stimuli included attention checks for participants to listen for.

Pre-Entrainment Flanker → Entrainment → Post-Entrainment Flanker

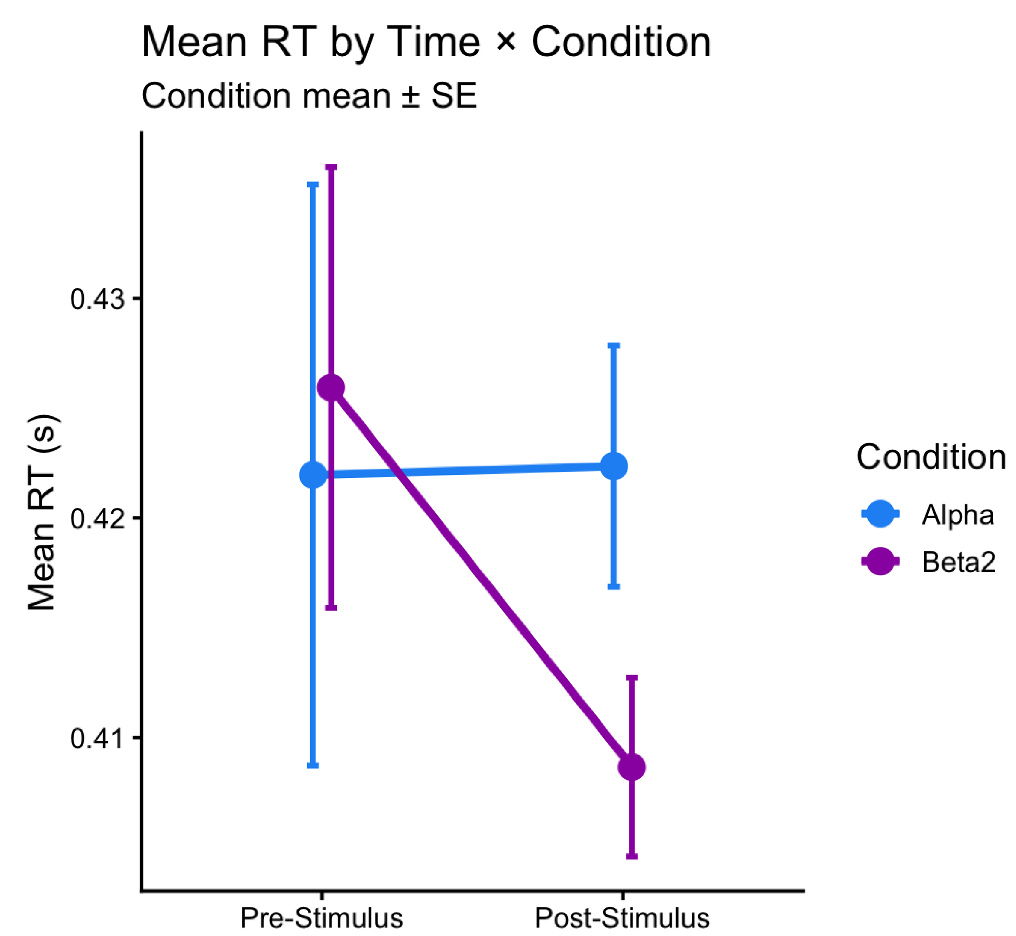
ANALYSIS

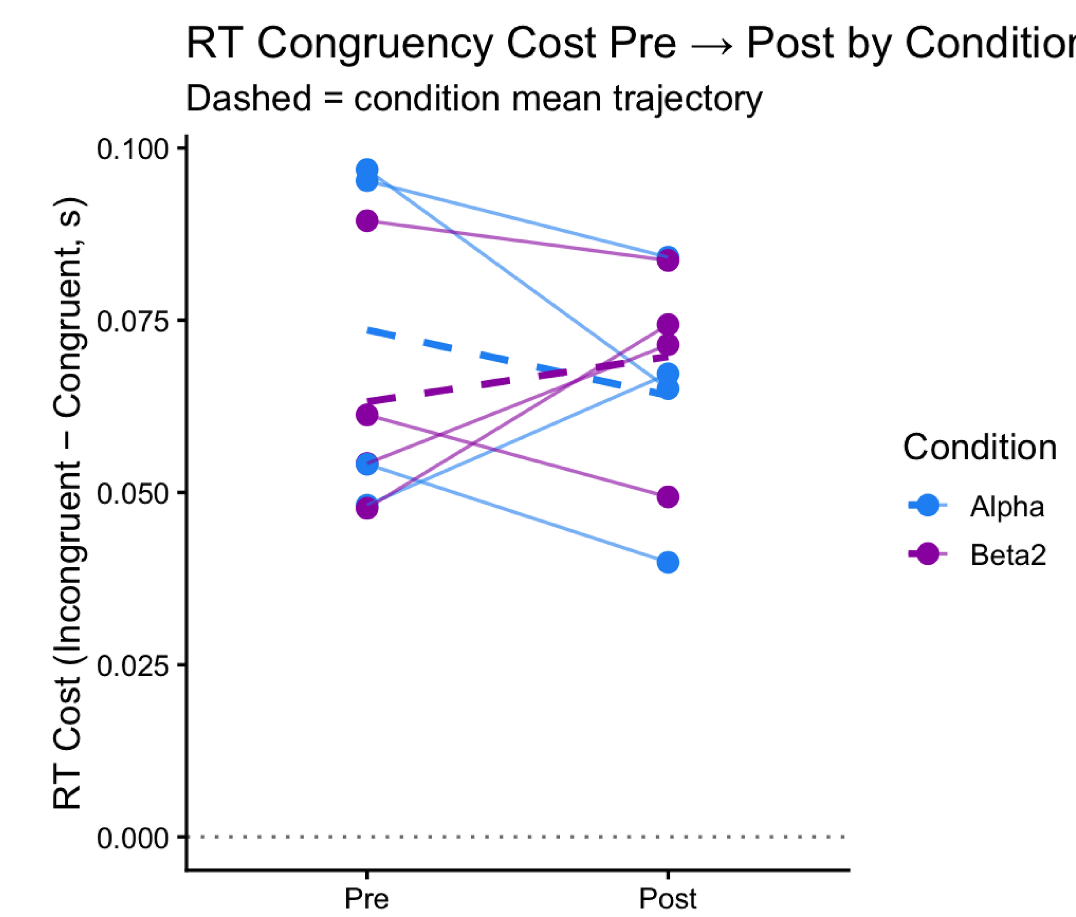
Linear mixed effects model

Fixed effects:
- Congruency
- Time
- Condition

Critical interactions:
Time × Condition
Congruency × Time × Condition

PRELIMINARY RESULTS





Analyses shown are based on the first 8 participants.
Solid lines represent individual participants; dashed lines represent condition means.

DISCUSSION

Preliminary behavioral results showed that participants assigned to the beta2 condition exhibited larger improvements in mean reaction time than those assigned to the alpha condition. Changes in RT congruency cost were comparatively small and variable across participants, suggesting that entrainment may primarily influence general response speed rather than selective attention or conflict processing.

REFERENCES

Foxe, J. J., & Snyder, A. C. (2011). The Role of Alpha-Band Brain Oscillations as a Sensory Suppression Mechanism during Selective Attention. Frontiers in Psychology, 2. https://doi.org/10.3389/fpsyg.2011.00154

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