Temporal cues and modulation rate interplay with attention to detect a target sound embedded in background noise

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Introduction

To parse a complex auditory scene, perceptual cues are extracted in an interplay of bottom-up saliency and top-down attentional modulation. Most modulation rates (2–12 Hz) are essential to integrate these different cues (Xiang et al., 2002). Close rates (4 and 7 Hz) were expected to behave quite similar, but showed significantly different characteristics in previous studies (Kang et al., Wang et al., 2011). We investigate these differences more closely using psychophysical and magnetoencephalographic (MEG) data in humans. The subject’s attention was drawn to different features of an auditory scene, composed of a rhythm (7 Hz) target buried in a random, irregular background, which complements an earlier study using a 4 Hz rhythm (Elhilali et al., 2006).

These differences are possibly related to the low-pass characteristic of neurons, and the functional role that the different frequencies play in global brain interactions (Let’s low theta, 7 Hz high theta).

Stimulus Design

The stimulus is a rhythm: 7 Hz, regular target embedded in a random, irregular background. The target frequency is chosen randomly in the range of 250–500 Hz with a 2 semitone interval. The target is within protection zones of 4, 8 or 12 semitones.

Tasks

Target Task: Detection of a frequency-shifted deviant, randomly placed in the target sequence.

Masker task: Detection of an irregular masked tone, in a single 500 ms time window, randomly chosen for each trial.

Procedure

Psychophysicists part A: n=12

Psychophysicists part B: n=11

MEG: n=12

Psychophysicists were performing a task in a sound-proof room. MEG recordings were conducted in a dimly lit magnetically shielded room (Hokkaido Electric Corporation) using a 168-channel whole-head system (Kanazawa Inst. of Tech.).

References


Part A

Protection Zone effect,  Target frequency effect

Part B

Protection Zone Investigation

Target Rate Investigation

Discussion

No significant lateralization found (in contrast to strong lateralization to the right for 40 Hz exp., Elhilali et al. 2006). Possibly caused by faster buildup of higher rates leading to a flat buildup after an early sharp increase in response.

Psychoacoustics

Brain interactions (4 Hz is low theta, 7 Hz is high theta).

Neural Analysis

Task-Dependent Neural Response

Neural Response

Power Enhancement

Neural Build-Up Investigation