

Foreground and background at the cocktail party: Interaction between attention and auditory pop-out

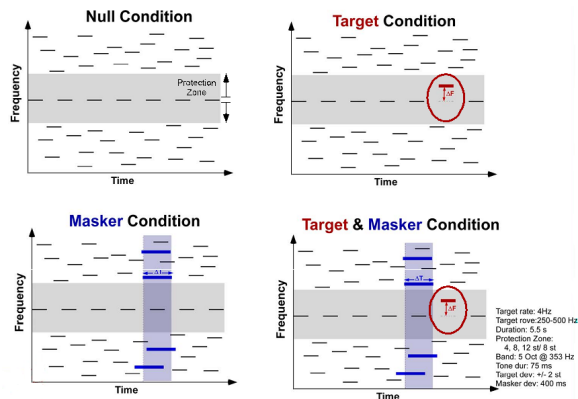
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Introduction

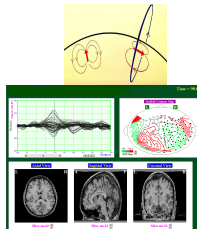
- Attention is the cognitive process underlying our ability to focus on specific components of the environment while ignoring others. It plays a key role in defining what foreground is, i.e. an object of attention, and differentiating it from irrelevant unattended clutter or background.
- Attention can be bottom-up (stimulus-driven) or top-down (task-driven). The interaction between them is investigated in a simultaneous behavioral-neurophysiological study where subjects attend to different features of an auditory scene.

Methods

- Cocktail party setting
- Modified informational masking paradigm
- Target task: detect a frequency shifted (ΔF) deviant in the repeating target signal
- Masker task: detect a sudden temporal elongation (ΔT) of the masker notes
- Comparable performance (d -prime: ~ 3) between two tasks is achieved at 8 semitone

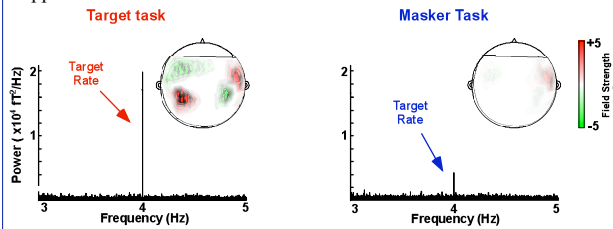


- Magnetoencephalography (MEG)
- Non-invasive technique with excellent temporal resolution (~ 1 ms)
- Neural response: magnitude of the spectrum component at presentation rate (4 Hz), normalized against responses at neighboring frequencies
- Phase coherence at the presentation rate between long range channel pairs

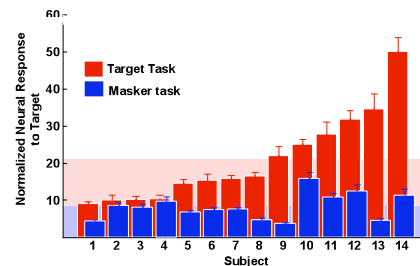


Effects of top-down attention

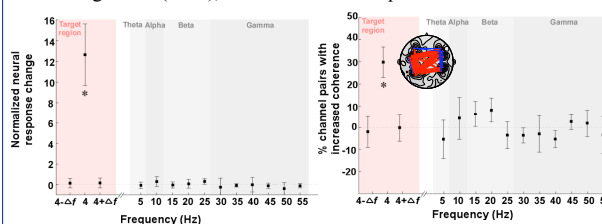
- In the target task, the target rhythm emerges as a strong 4 Hz component, while in the masker task, the cortical response is noticeably suppressed



- Attentional effect is confirmed in the population of 14 subjects



- Significant power and phase coherence enhancement is found only at the target rate (4 Hz), but not at other frequencies



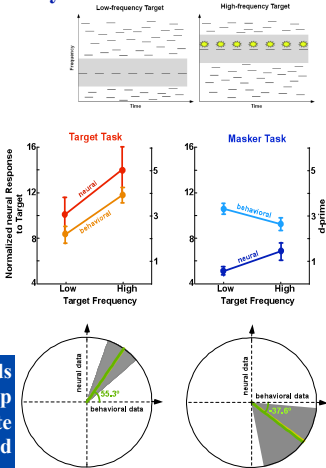
Depending on listeners' attentional focus, the percept of an auditory target in a complex scene is *differentially mirrored* by the responses of neurons in auditory cortex.

Reference

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- [3] Hillyard SA, Hink RF, Schwent VL, Picton TW, Electrical Signs of Selective Attention in Human Brain. Science 182:171-180.1973.
- [4] Michey C, Tian B, Carlyon RP, Rauschecker JP, Perceptual organization of tone sequences in the auditory cortex of awake macaques. Neuron 48:139-148.2005.

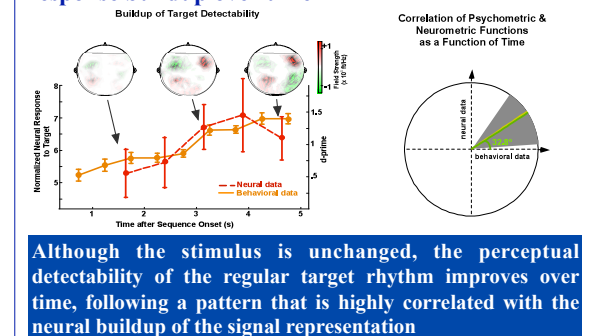
Effects of bottom-up saliency

- In the target task, behavioral performance is easier for higher frequency targets, correlating with an increased neural signal at the target rate.
- In the masker task, neural response is increased for high-frequency target, reflecting their increased audibility and distraction effect, resulting in worse behavioral performance



Together with the demands of the task, the bottom-up saliency of the target note shapes both neural and behavioral responses.

Response buildup over time



Although the stimulus is unchanged, the perceptual detectability of the regular target rhythm improves over time, following a pattern that is highly correlated with the neural buildup of the signal representation

Conclusion

- Attention modulates neural representations of target in a sustained manner, by boosting both power and phase coherence
- Bottom-up attention (auditory pop-out)
 - Target pop-out correlates with neural representation
 - Target pop-out interferes with masker task
- Similar buildup for behavior & neural representations

Note: Enhanced power in single MEG channel associates with increased synchronization within neuron populations, while enhanced phase coherence between long-range channels associates increased synchronization between distinct neuron populations