



Dissimilar spatiotemporal activation patterns for multiple attention tasks revealed by multivariate representational similarity analysis of EEG and fMRI data

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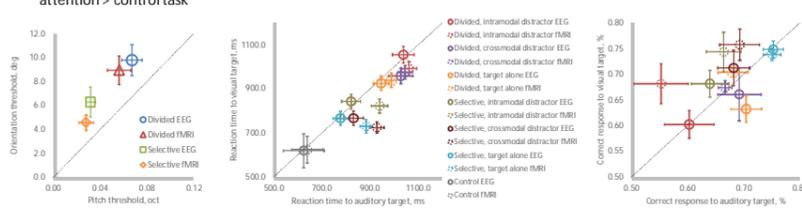
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Introduction

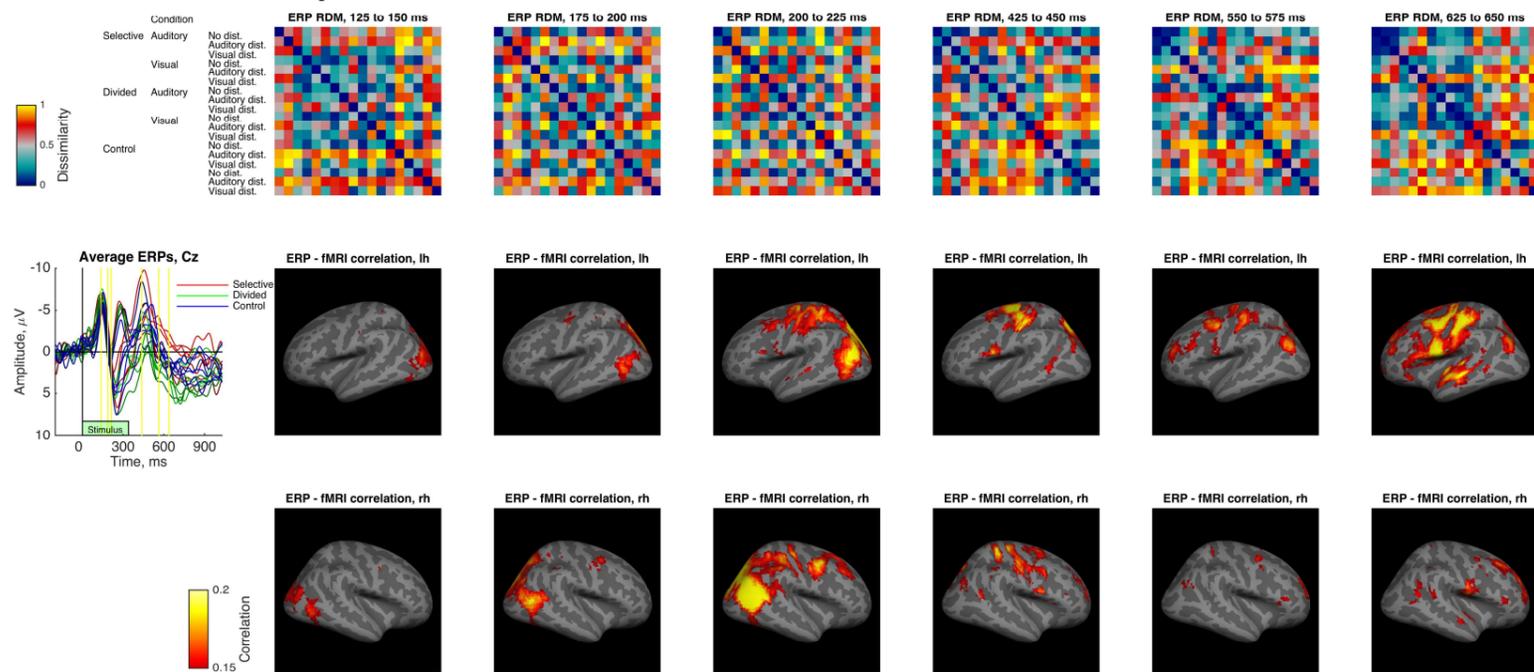
- Attention modulates brain function at multiple time scales and in distributed brain networks. However, there is a lack of studies characterizing the spatiotemporal dynamics of specific attention-related modulations. We conducted identical experiments with EEG and fMRI in order to examine the spatiotemporal dissimilarities in neuronal representations associated with auditory-visual attention and distractor stimuli.
- Our experiment consisted of 1) auditory and visual 1-back discrimination tasks 2) in selective and divided attention conditions 3) without or with auditory or visual distractor stimuli. The dissimilarities of activity patterns across different trial types were analyzed with multivariate representational similarity analysis (RSA) by combining EEG and fMRI data (Fig. 2) and separately for EEG and fMRI (Fig. 3).

Behavioral results

- Thresholds increased to two-fold in the divided-attention condition in comparison to selective-attention condition.
- Reaction times: divided attention condition > selective attention > control task
- Distractors increased reaction times, especially when distractors within the attended modality.
- Distractors decreased number of correct responses.
- No differences between EEG & fMRI.



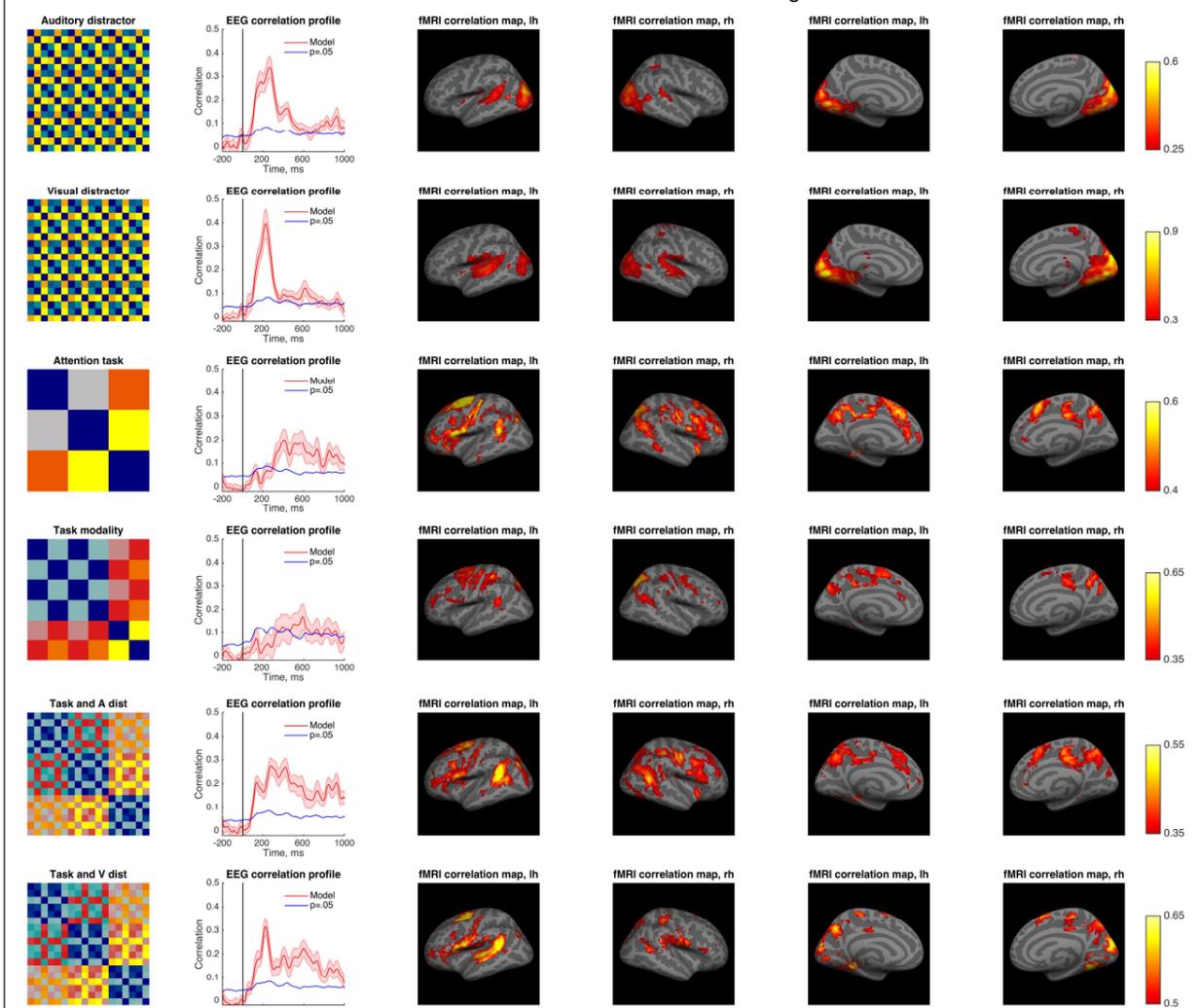
Combined EEG and fMRI analysis



Model RDM

ERP RSA

fMRI searchlight RSA

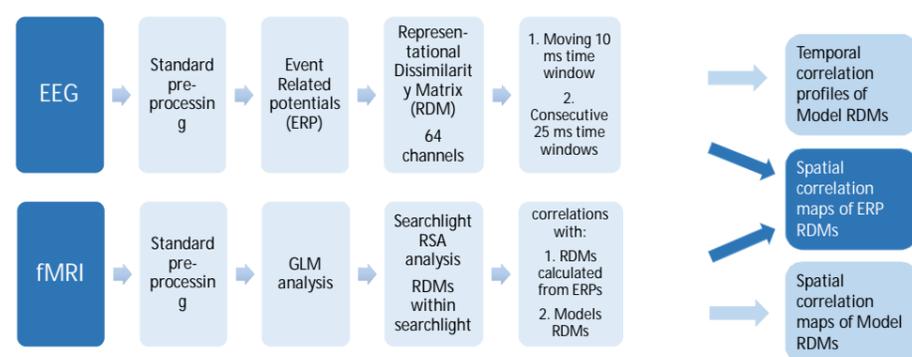


EEG & fMRI results

- Spatial correlation maps of ERP RDMs (Fig. 2)**
- No dissimilarities of responses during first 125 ms after stimulus onset.
 - Early dissimilarities (at 125-225 ms) in primary and ventral visual areas, parietal areas as well as motor areas and frontal eye field.
 - Late dissimilarities (400 - 650 ms) in parietal and temporal areas, and in ventral and dorsal frontal areas.
- Temporal correlation profiles (Fig. 3)**
- Strong distractor-related correlation peak at 200-300 ms after stimulus onset (corresponding to P3 ERP-component).
 - Sustained, attention task - related response dissimilarities 300 ms after stimulus onset.
 - Several dissimilarity peaks (e.g., 200, 300 & 400 ms) for interaction of auditory distractors and attention tasks.
 - Several dissimilarity peaks (e.g., 250 & 600 ms) for interaction of visual distractors and attention tasks.
- Spatial correlation maps (Fig. 3)**
- Distractor-related dissimilarities mainly in primary auditory and visual cortices.
 - Attention task - related dissimilarities in ventral and dorsal frontal areas as well as in temporoparietal junction.
 - Interaction of distractors and attention tasks both in sensory, frontal and temporoparietal areas.

Methods

- 13 healthy adult participants.
- All target and distractor stimuli identical in all experimental conditions, only the task and the attended modality was manipulated.
- Three conditions (separate blocks)
 - Selective attention:** Auditory: "Did the pitch of the tone increase or decrease relative to previous tone?" Visual: "Did the grating rotate clockwise or counter-clockwise relative to the previous grating?"
 - Divided attention:** "In which modality target changed? In which direction the change was?"
 - Control task,** stimulus detection: "Press button when any stimulus presented."
- On 1/3 of trials *distractors* were presented. Spectrally complex sounds and textures, coincided with the target stimuli. Spatially and spectrally non-overlapping.
- Task difficulty and stimulus discriminability controlled with adaptive 2-1 staircase.
- Statistical significance tested with permutation tests
- 18 trial types in total: target modality (vis vs. aud) x distractor (no vs. vis vs. aud) x attention task (select vs. divide vs. control)



Discussion & Conclusions

- EEG and fMRI data can be combined with representational similarity analysis.
- The combined RSA analysis:
 - reveals ERP sources without any assumptions on the location or number of sources
 - increases the temporal resolution of fMRI to tens of milliseconds
- Results revealed complex spatiotemporal attention network spanning from early latencies and sensory areas to parietal and frontal areas at later times.
 - Early dissimilarities were mainly related to distractor stimuli
 - Late dissimilarities were related to attention tasks and interaction between tasks and distractors.