Crossmodal cortical responses revealed by single-trial wavelet-packet-enhanced ICA

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Introduction

In spite of numerous studies available to date, including electroencephalographic (EEG) studies [1], the exact time course of the polymodal interplay between the sensor-specific, the parietal and the prefrontal cortices still remains a significant challenge. The goal of the present study was to uncover more information on the dynamic interactions taking place during single-trial cross-modal stimulations.

Methods

A 64-channel electroencephalographic (EEG) system (NeuroScan Inc.) was used to measure evoked responses to simultaneous cross-modal auditory and visual stimuli presented to human subjects repeatedly (200 times), in addition to uni-modal auditory and visual stimuli for control. All EEG epochs were processed using independent component analysis (ICA) [2]. In this study we applied TSVD-ICA [3], a mixed 2nd and 4th order thin SVD factorizations algorithm for ICA with simultaneous extraction. Components were processed with soft-threshold denoising using the wavelet packet transformation (WPT). The crossmodal data was compared with the two unimodal conditions using a cross-cumulant similarity measure for pattern matching between the components of a learning uni-modal control template and of cross-modal single trials. Selected common independent components from the cross-modal data represented the extracted uni-modal visual or auditory responses which were used for the reconstruction of all sensory cross-modality-related interactions.

Results and Discussion

Although the reconstructed data had originated entirely from responses to cross-modal stimulations, we demonstrated rapid, balanced modulations of single-modality-specific cortices, as well as of some cortical areas, which are considered polymodal. Even though some middle-latency responses after visual and auditory stimulation exhibit overlapping uni-modal time courses, our method using ICA and wavelet-packet denoising was able to extract and separate these modality components for further precise tracking of the electrical brain activity associated with them.

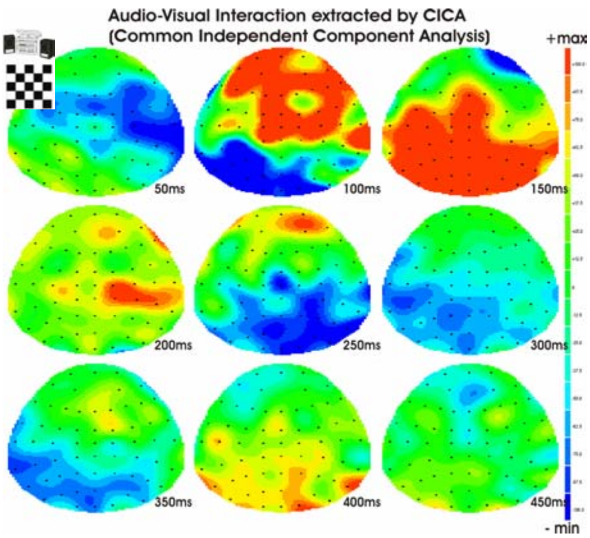

Fig. 1. Whole-head time course (50-450ms) of cross-modality effects for auditory and visual stimuli. Each map represents a 50ms step in time. Visual cortex was enhanced by sound at 50 ms, 150ms and 850ms, but inhibited at 100ms and 250ms, while the opposite pattern (although much weaker) was observed for the auditory cortex. Prefrontal and intraparietal interactions were more intensive in the intervals 100-400ms and 600-700ms.

References

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