Mapping the time course of brain activation in affective picture processing

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Introduction

- Viewing emotionally engaging scenes activates a large-scale brain network that includes both cortical and subcortical regions. Mapping the time course of activation of these regions is a key step toward developing a theoretical account of affective scene processing.
- For aversive scenes, past work has suggested rapid processing along the subcortical visual pathway (low road), superior colliculus → pulvinar → amygdala, the function of which is to provide context for the more deliberate processing along the cortical visual pathway (high road). Less is known about the neural processing of pictures displaying neutral and pleasant contents.
- In humans, mapping the time course of brain activation is difficult, because EEG and fMRI, the two commonly applied techniques, each have inherent limitations.
- We addressed the problem by recording simultaneous EEG-fMRI data in humans during viewing of IAPS pictures. By fusing EEG and fMRI via representational similarity analysis (RSA), we obtained spatiotemporal profiles of brain activation for each category of affective pictures.

Methods

Paradigm, data acquisition, and data analysis

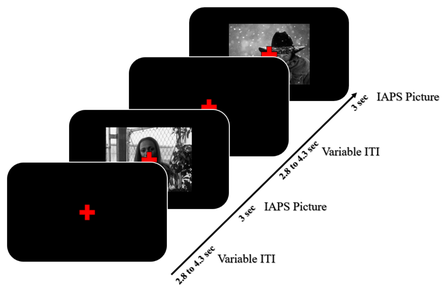

Figure 1. Timeline of affective picture viewing paradigm. 60 IAPS pictures (20 Pleasant, 20 Neutral, 20 Unpleasant) were used. 300 trials total divided into 5 sessions of 60 each.

EEG and fMRI data were recorded simultaneously from 20 healthy human subjects. MRI data were collected on a 3T Philips Achieva scanner (Philips Medical Systems) whereas EEG data were recorded using a 32-channel MR-compatible EEG system (Brain Products GmbH).

MRI gradient artifacts and cardioballistic artifacts were removed from acquired EEG signal using BrainVision Analyzer 2 (Brain Products, GmbH). The processed data was 50 Hz low-passed and downsampled to 250Hz and rereferenced. Subsequently, SOBI ICA was introduced to remove eye blinks and other noises as well as residual MRI artifacts. The preprocessed EEG signal were epoched from -0.3s to 2s relative to picture onset. FMRI BOLD activation and ERP were computed using conventional methods.

Representational similarity analysis (RSA)

Following data preprocessing, representational dissimilarity matrices (RDMs) were obtained from fMRI in 5 regions of interest (ROIs): pulvinar, amygdala, early visual cortex, ventral visual cortex, and dorsal visual cortex for each of the three picture categories, as well as from EEG at each time point. RDMs from EEG at each time point were correlated with that from fMRI in each ROI. We averaged RSA correlation functions from 20 subjects to yield a single RSA correlation function for each ROI. The maximum of the RSA correlation function was identified, and the peak latency was estimated.

Statistical significance test of difference in peak latencies

To assess whether the peak latencies of different ROIs are significantly different, we bootstrapped the subject-averaged time series 1000 times and performed pairwise T-test between peak latencies from different ROIs.

Results

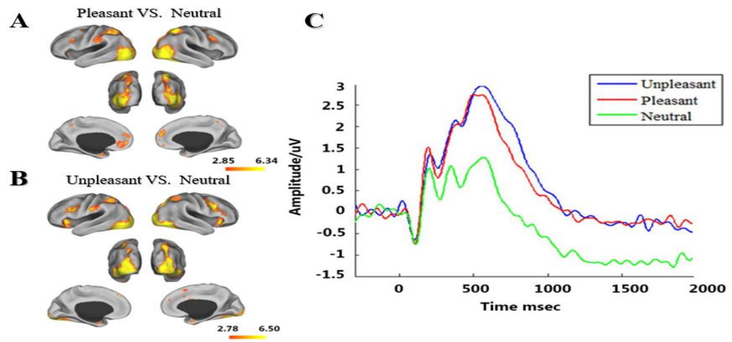

Figure 2. BOLD and ERP analysis. **A**) Activation map based on BOLD contrast between pleasant versus neutral conditions. **B**) Activation map based on BOLD contrast between unpleasant versus neutral conditions. **C**) Grand average ERP showing elevated LPP for affective scenes.

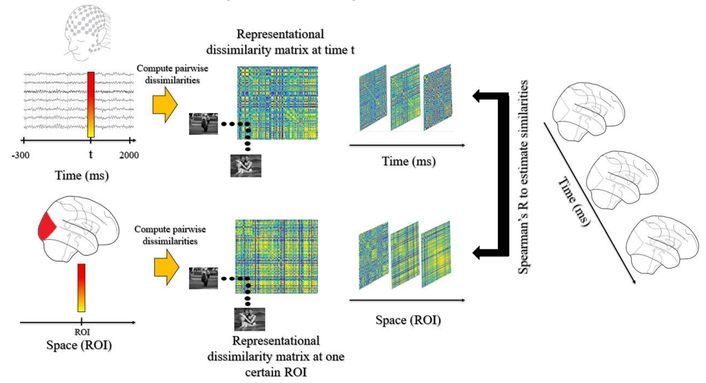

Figure 3. Fusing EEG and fMRI via representational similarity analysis.

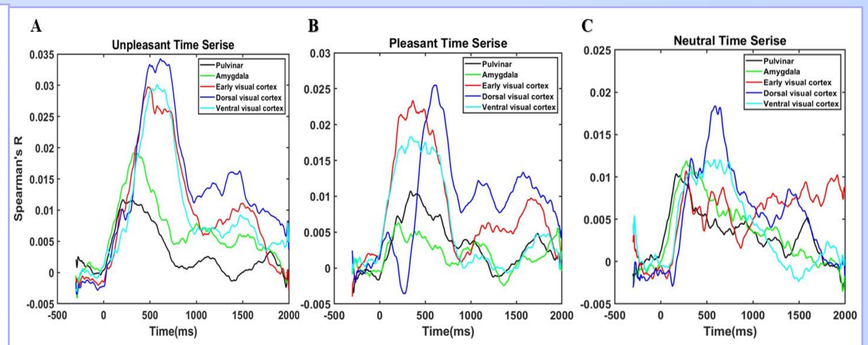

Figure 4. RSA correlation functions for the 5 ROIs. **A**) RSA correlation function for the unpleasant pictures. **B**) RSA correlation function for the pleasant pictures. **C**) RSA correlation function for the neutral pictures.

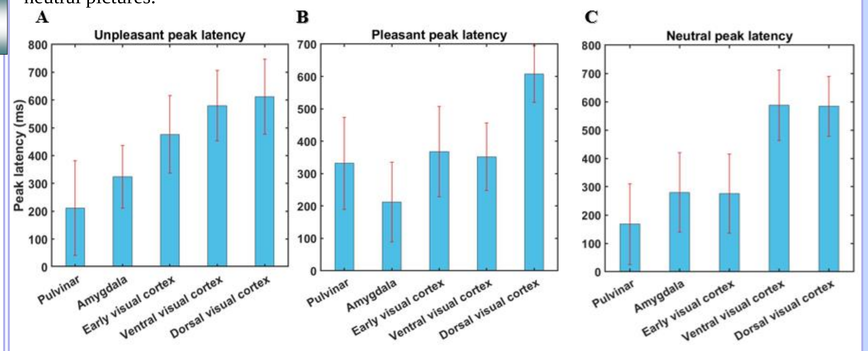

Figure 5. Peak latency analysis. A) Peak latencies of the five ROIs in unpleasant pictures. B) Peak latencies of the five ROIs for pleasant pictures. C) Peak latencies of the five ROIs for neutral pictures.

Summary and Discussion

- Consistent with previous reports, univariate BOLD analysis reveals that in addition to limbic-frontal structures, occipital-temporal visual areas were more activated for unpleasant and pleasant pictures relative to neutral pictures, and LPP was similarly enhanced for the affective pictures.
- EEG and fMRI data were combined using RSA analysis. From the RSA correlation functions peak latencies were estimated. The peak latency data suggested the following sequence of activation for the unpleasant pictures: pulvinar→amygdala→early visual cortex→ventral/dorsal visual cortex, which is in approximate agreement with the low road theory of affective picture processing.
- We also uncovered activation sequence for neutral pictures: pulvinar→amygdala/early visual cortex→ventral/dorsal visual cortex, and for pleasant pictures: amygdala→pulvinar→early/ventral visual cortex→dorsal visual cortex.

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