EEG Decoding of Emotional States: Neural Substrate Revealed by Simultaneous EEG-fMRI

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Multivariate pattern analysis (MVPA) has been applied to both EEG and fMRI data. Relative to MVPA decoding of fMRI data, MVPA decoding of EEG data offers the advantage of being able to temporally resolve the formation and evolution of different brain states, but it has the limitation of not being able to provide information on the relevant neuroanatomical substrate. We hypothesized that appropriate fusion of the two recording modalities holds the key to solving this problem. Simultaneous EEG-fMRI was recorded from healthy human subjects viewing unpleasant (mutilation, human violence, attacking animals) and neutral (house hold scenes, people) pictures selected from the International Affective Picture System (IAPS). On each trial the picture was shown for 3000ms. The inter-trial interval (ITI) varied randomly from 2800 to 4300ms. Applying the support vector machine (SVM) technique to single-trial EEG and BOLD responses, we spatially and temporally decoded unpleasant versus neutral brain states. The following results were found. First, starting at ~200ms after picture onset, EEG decoding became significantly above chance level, which lasted until ~1800ms. Second, pleasant pictures are decoded earlier than unpleasant pictures. Third, the decoded neural pattern can generalize over a long time interval. Fourth, the generalization ability can predict the decoding of visual cortex from fMRI data. These results suggest that emotional states elicited by affective pictures can be decoded from EEG data and the formation and development of the neural representations of these emotional states could relate to the sustained enhancement effect on visual cortex.

Keywords: emotion processing; simultaneously EEG-fMRI; multivariate pattern analysis; visual cortex; Temporal generalization.