

Protocol

Regression analysis utilizing subjective evaluation of emotional experience in PET studies on emotions

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Abstract

A methodological study on subject-specific regression analysis (SSRA) exploring the correlation between the neural response and the subjective evaluation of emotional experience in eleven healthy females is presented. The target emotions, i.e., amusement and sadness, were induced using validated film clips, regional cerebral blood flow (rCBF) was measured using positron emission tomography (PET), and the subjective intensity of the emotional experience during the PET scanning was measured using a category ratio (CR-10) scale. Reliability analysis of the rating data indicated that the subjects rated the intensity of their emotional experience fairly consistently on the CR-10 scale (Cronbach alphas 0.70–0.97). A two-phase random-effects analysis was performed to ensure the generalizability and inter-study comparability of the SSRA results. Random-effects SSRAs using Statistical non-Parametric Mapping 99 (SnPM99) showed that rCBF correlated with the self-rated intensity of the emotional experience mainly in the brain regions that were identified in the random-effects subtraction analyses using the same imaging data. Our results give preliminary evidence of a linear association between the neural responses related to amusement and sadness and the self-evaluated intensity of the emotional experience in several regions involved in the emotional response. SSRA utilizing subjective evaluation of emotional experience turned out a feasible and promising method of analysis. It allows versatile exploration of the neurobiology of emotions and the neural correlates of actual and individual emotional experience. Thus, SSRA might be able to catch the idiosyncratic aspects of the emotional response better than traditional subtraction analysis.

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Topic: Motivation and emotion

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1. Type of research

The statistical analyses of imaging studies on emotions have almost exclusively utilized the subtraction method (see [30]), where two conditions, typically “activation” and reference (“neutral”) states, are subtracted from each other, which is a bipolar and fairly simplistic approach. This

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approach is based on external validation of emotion induction and presumes reliable coupling between the stimulus and the response, i.e., that almost similar emotional states can be induced in the study sample as in the validation sample. However, even in controlled laboratory conditions, emotional experience varies considerably between subjects (see, e.g., [43]). Therefore, in parallel with the “traditional” subtraction approach, there is a need for methods of analysis that could capture more flexibly the inherent individuality of emotional responses.

The theoretical works by Friston et al. [10–12] have served as a basis for subject-specific regression analysis (SSRA) in a voxel-based statistical analysis of imaging data. With this method, it is possible to examine the association between regional cerebral blood flow (rCBF) reflecting neuronal activity and external variables, e.g. subjective ratings. SSRA with subjective self-evaluation of the emotional experience has several potential advantages compared to subtraction analysis in studies on emotion. Firstly, the method does not need a reference (neutral) condition or a validation procedure of dichotomous emotion induction, which are required for the subtraction method. Secondly, this approach allows individual responses to the material used for emotion induction because it is based on individual ratings of emotional experience, and the statistical model is fitted individually for each subject. Thirdly, by using a versatile rating questionnaire, it is possible to explore the different emotions or aspects of emotions induced by the stimuli using the same (multiscan) imaging data. Thus, SSRA might be able to catch more fully the idiosyncratic aspects of the emotional response, as it allows and draws on the natural variation of emotional experience. On the other hand, despite the individualistic approach and the subject-specific statistical model, the results of a multi-subject study can be generalized at the population level, using random-effects analysis (RFX). Despite its possible methodological benefits, SSRA utilizing self-evaluation of subjective emotional experience has been utilized only in a few recent fMRI studies [31,32,46]. However, to the best of our knowledge, it has been neither applied nor methodologically evaluated in positron emission tomography (PET) studies on emotions.

The aim of the study is methodological evaluation of SSRA utilizing subjective evaluation of emotional experience in imaging studies on emotion. We present a PET study utilizing SSRA and subjective evaluation of emotional experience. Two target emotions, amusement and sadness, were induced with validated film stimuli. The rCBF values were measured using PET, and the subjective intensity of the emotional experience was rated on a category ratio scale [5] after each PET scan. The correlation between rCBF and the subjective rating data was analyzed using subject-specific regression analysis with RFX to achieve results generalizable at the population level. For comparison, subject-specific subtraction analysis with RFX was performed as well. In the present study, we utilize the PET data

with eleven subjects used in our earlier study presenting the results of fixed-effects subtraction analysis [2]. The present study is mainly methodological, and the discussion focuses on the usability, benefits, and restrictions of SSRA in studies on emotions.

2. Time required

Training of subjects to use the CR-10 scale: 30 min per subject.

Manipulation check: 60 min.

Evaluation of rating data: 60 min.

Magnetic resonance imaging of the brain: 35 min per subject.

PET data acquisition: 150 min per subject.

PET data preprocessing: 10 min per subject.

Voxel-based statistical analyses: 120 min.

Total time required to run the protocol with 11 subjects: approximately 45 h.

3. Materials

3.1. Subjects

Eleven right-handed healthy female volunteers (mean age 33.4; range 18 to 44 years) participated in the study approved by the Ethics Committee of Turku University/Turku University Central Hospital. The volunteers gave written informed consent. (For a detailed description of the study sample, see [2]).

3.2. Stimulus material

The stimulus material consisted of 12 film clips, each lasting for an average of 2:30 min, with four films in each category, to induce amusement, sadness and a “neutral” state. Four of the emotional film clips (When Harry met Sally (amusement), two clips from Kramer vs. Kramer (sadness), and The Champ (sadness)) were chosen from previously validated film sets [16,33]. All the additional films were validated for the purposes of the present study with a sample of 51 university students. From this set, three episodes of the film *Bean-The Ultimate Disaster Movie* (amusement) and one episode from *Kramer vs. Kramer* (sadness) were chosen. The four neutral films were professional video material containing views of social scenes, talking people, and scenes of nature with movement and sound. The neutral films with minimal emotional content were chosen in such a way that the basic sensory properties (sound, movement, color) were similar to those of the emotional films. To eliminate potential order effects, the sequence of films was pseudo-random, but similar for all subjects. The present set of films has been previously used by Aalto et al. [2].

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