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Faces and emotions: brain electric field sources during covert emotional processing

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Abstract—Covert brain activity related to task-free, spontaneous (i.e. unrequested), emotional evaluation of human face images was analysed in 27-channel averaged event-related potential (ERP) map series recorded from 18 healthy subjects while observing random sequences of face images without further instructions. After recording, subjects self-rated each face image on a scale from "liked" to "disliked". These ratings were used to dichotomize the face images into the affective evaluation categories of "liked" and "disliked" for each subject and the subjects into the affective attitudes of "philanthropists" and "misanthropists" (depending on their mean rating across images). Event-related map series were averaged for "liked" and "disliked" face images and for "philanthropists" and "misanthropists". The spatial configuration (landscape) of the electric field maps was assessed numerically by the electric gravity center, a conservative estimate of the mean location of all intracerebral, active, electric sources. Differences in electric gravity center location indicate activity of different neuronal populations. The electric gravity center locations of all event-related maps were averaged over the entire stimulus-on time (450 ms). The mean electric gravity center for disliked faces was located (significant across subjects) more to the right and somewhat more posterior than for liked faces. Similar differences were found between the mean electric gravity centers of misanthropists (more right and posterior) and philanthropists. Our neurophysiological findings are in line with neuropsychological findings, revealing visual emotional processing to depend on affective evaluation category and affective attitude, and extending the conclusions to a paradigm without directed task. © 1998 Elsevier Science Ltd. All rights reserved.

Key Words: brain mapping; evoked potentials; facial expression; laterality; personality; source localization.

Introduction

Facial expressions as stimuli have been used to study the spatial organization of brain mechanisms of emotions in the human brain. In neuropsychological investigations, behavioural changes were observed when the evaluation or generation of facial emotion was supposed to be predominantly generated by the left or the right hemisphere [25, 40, 41, 43, 51]. Using event-related potential (ERP) measurements, electrophysiological correlates of the outcome of forced emotional classification of faces were reported [12, 29, 32, 34, 53] but their localizing interpretations lacked methodological validation. Employing a non-ambiguous method to estimate the center location of brain activity, we investigated whether the effect of different emotional meaning on the spatial organization of brain activity also occurs spontaneously, i.e. when no emotional decision is required and it occurs automatically and when the information is available to both hemispheres.

One of the hypotheses suggested by the neuropsychological assessment of normal subjects and brain-damaged patients was that the right hemisphere is generally more efficient than the left hemisphere in the processing of emotional stimuli [3, 23]. In particular, right hemisphere advantage was observed in the perception and/or expression of facial emotion in normals (perception: [39, 41, 43, 60]; expression: [5, 43, 44]). Similarly, deficits in the perception and/or expression of facial emotion have been found more frequently in right than left hemisphere damage (perception: [2, 6, 16, 18, 40]; expression: [11, 55]). These results led to the suggestion that "the right hemisphere may contain a lexicon/representation of facial emotions" ([7], p. 2603).

This view has been challenged by the hypothesis that the quality of emotion alters hemispheric contribution [58]. Support for this assumption arose from reports on

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left hemispheric contributions to the recognition of faces and to the discrimination of facial expression [14, 25, 51, 59], thus suggesting that the left hemisphere is considerably involved in emotion [63]. In particular, some studies suggested right-hemisphere dominance for negative emotions and either left-hemisphere or bilateral involvement for positive emotions: Normals tended to prefer faces presented to the right visual field/left hemisphere and to disfavour faces presented to the left visual field/right hemisphere [45, 47–51]. Right brain damage impaired the perception of negative facial expressions but not of positive expressions [4, 13]. Conversely, when attributing emotions to neutral faces, left hemisphere damaged patients attributed sadness significantly more often and happiness significantly less often than right hemisphere damaged patients [40], suggesting that left hemisphere-damaged patients may show a bias towards negative emotions. Indeed, "catastrophic reactions" (i.e. outbursts of tears, anxiety) were more frequent in patients with left hemispheric lesions whereas "indifference reaction" (i.e. tendency to joke, anosognosia, inappropriate cheerfulness) were predominant with right hemispheric lesions [19, 20, 57]. In stroke patients, indifference reportedly was related to right anterior lesions, depression to left anterior lesions [52].

Neuropsychological methods traditionally explored the capacities of brain information processing by assuming that contributions from brain regions involved in a task usually increase processing capacities and thus lead to an improved performance in terms of speed and accuracy. In order to elucidate the contribution of different brain regions, this approach must analyse the reduction of processing capacities while processing contributions are constrained in some regions; this is achieved by unilateral stimulus presentation in normals or by the presence of localized brain lesions in patients. In order to reduce needed constraints in the experimental design, the event-related field topography might be recorded because this is the direct electrical manifestation of the neural activity. Different configurations of the brain electric field must originate from differences in geometry of the active neural elements and thus are assumed to subserve different brain functions [35, 37, 38]. Brain electric field-based conclusions about the neural processes that constitute perceptual, emotional and cognitive processing can be drawn even during covert processing, i.e. when the subjects are not required to produce an overt response to the stimulus [8, 24, 30]. Avoiding directed, specific tasks offers the additional advantage that powerful brain mechanisms needed for task execution, *per se*, are not activated. If active, such mechanisms may overlay and conceal more subtle cognitive-emotional processes.

In a variety of tasks, differences in ERP waves were recorded for emotional vs neutral faces as stimuli [12, 27, 29, 32, 34, 53, 65]. Emotion-related processing tended to produce more ERP wave differences on the right side of the scalp. ERP amplitude or latency differences between positively and negatively evaluated faces were reported by some groups [29, 32] but no spatial organization could be described. Other studies failed to find ERP wave differences between these two conditions [27, 34, 65].

Our criticism of the ERP literature in this field is that conclusions about the spatial organization of emotions in the brain have been based on the assumption that the brain location of the processing site is identical to the scalp location of differences of EEG and ERP waveshapes. This is, however, only the case if the generators are oriented perpendicular to the scalp surface [9], an assumption that is unlikely, has never been validated and is proven to be wrong by the mere existence of magnetoencephalographic (MEG) measurements which can record only sources tangential to the surface. This issue is illustrated by the well-known ERP component P100 which often shows maximal scalp voltage values at locations contralateral to the active hemisphere [10, 26]. In order to obtain conclusive results about differences in neuronal activity, spatial descriptors of the brain electric field are required that offer an unambiguous distinction between the activity of different neural populations [36, 38, 42]. In particular, conclusions about changes of the location of active neuronal elements may only be drawn if they are based on adequate source modeling.

The aim of this study was to assess ERP map differences related to differences in spontaneous, covert emotional evaluation of images of human faces presented to normal subjects. These differences were assessed as a function of the subjects' affective evaluation of the single face images ("liked" vs "disliked") and as a function of the subjects' general affective attitude towards the entire set of face images (in line with the vernacular "misanthropists" vs "philanthropists"). In order to describe the most basic features of these processes, a paradigm without any directed task was used. Thus, possible interferences due to task execution were minimized by having the subjects merely look at the face images. To avoid ambiguities in the interpretation of the results, the brain electric field data were evaluated using the location of the point of gravity of the entire neuronal activity as a conservative localization approach.

Method

Subjects

Seven female and 11 male healthy volunteers (mean age 29.4, range 22–37) with normal or corrected-to-normal vision were recruited via campus advertisements and gave their informed consent to serve as subjects. No subject had any history of psychiatric disorder, alcohol or drug abuse. The subjects were informed about the experimental design (i.e. that they were going to see face images during the recordings), but not about the specific aim of the study. Handedness was assessed with the Edinburgh Handedness Inventory [46]; all were right-handed; the mean laterality index was 80.5 (S.D. = 20).