Recognition of faces expressing emotions in patients with unilateral brain damage

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Abstract. The experiment concerned the functional specialization of brain hemispheres in recognizing faces expressing emotions in patients with focal brain damage of the left and right hemispheres and in persons without damage of the central nervous system. Three types of faces were presented: happy i.e. expressing positive emotions, sad i.e. expressing negative emotions and neutral. The task of the subject was to recognize the test face exposed for 20 ms in the left or right visual field and point to the correct face on the response-card which contained three different faces. The errors made in recognizing of faces exposed in the right visual field (addressing the left hemisphere) and in the left one (addressing the right hemisphere) were analyzed. The patients with left hemisphere damage showed a similar pattern of hemispheric differences to that observed in the controls. In case of neutral and sad faces fewer errors were made in the left visual field exposures, in case of happy faces no significant differences between the two fields were stated. The results in patients with right hemispheric damage were different from both the other groups. In processing all the three types of faces, fewer errors were made in the left visual field presentations independently of the localization of the damage within the right hemisphere. Similar recognition level of different types of faces was also found in patients with left or right hemisphere damage as well as in controls. The above results suggest the crucial role of the right hemisphere in processing both positive and negative emotions expressed in faces.

Key words: patients with unilateral brain damage, hemispheric asymmetry, faces expressing emotions
INTRODUCTION

The previous psychological researches have not given a uniform answer whether the structures which analyse emotions are functionally asymmetrical in the two hemispheres. In hitherto published literature there exist two controversial viewpoints based on clinical observations of the behaviour of patients with focal brain damage and on psychological experiments on perception of stimuli expressing emotions.

The first hypothesis assumes that the structures which analyse both positive and negative emotions are localized in the right hemisphere. It has been proved that the most emotional disturbances of patients' behaviour resulted from the damage of the right hemisphere (Gainotti 1983, 1988). Moreover, the dominance of the right hemisphere in the perception of faces expressing positive and negative emotions has been found in psychological experiments on patients with unilateral focal brain lesions (Kremin 1980, Borod et al. 1983, 1986, Etcoff 1984, Gainotti and Caltagirone 1989) and on subjects without brain damage (Landis et al. 1979, Ley and Bryden 1979, Hansch and Pirozzolo 1980, Lavadas et al. 1980, Heller and Levy 1981, Safer 1981, Strauss and Moscovitch 1981, Mohoney and Salimsbury 1987, Gainotti and Caltagirone 1989).

According to the other hypothesis, the hemispheric organization pattern depends on the kind of emotion. Thus, the positive emotions are represented in the left hemisphere and the negative ones in the right hemisphere (Silberman and Weingartner 1986, Gainotti and Caltagirone 1989, Schiff and Lamon 1989, Schiff and MacDonald 1990). In patients with focal brain lesions (Goldstein 1939, Terzian 1964, Gainotti 1972, 1982) the left hemisphere damage causes a tendency to catastrophic reactions (i.e. feeling of anxiety, despair, helplessness and sometimes anger), whereas the damage of the right hemisphere causes euphoria. Likewise, following a barbiturate injection to the left or to the right hemisphere, the patients reacted either with sudden outbursts of weeping or with laughter (Terzian 1964, Kolb and Milner 1981). Likewise, Reuter-Lorenz et al. (1981, 1983) and Tucker et al. (1977) proved that faces expressing positive emotions are processed more efficiently by the left hemisphere and those expressing negative emotions, or expressing no emotions, are analysed mainly by the right hemisphere.

Thus, the role played by the right and left hemispheres in analysing emotions has not been determined so far. The present experiment is one more attempt to test the hemispheric asymmetry in processing faces expressing emotions. As we aimed to investigate the effect of left and right hemispheric lesions on processing positive and negative emotions, our experiment...
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was conducted on subjects with unilateral focal brain damage.

METHOD

Subjects

Three groups of subjects were studied: the first formed of five patients with left hemispheric damage, the second of seven patients with right hemispheric damage and the third of eighteen persons without damage of the central nervous system. Patients were hospitalized at the Neurosurgery Unit of Experimental Clinical Medicine Centre of Polish Academy of Sciences. In all cases, the damage was focal in character and relatively well localized by CT scan and neurosurgical data (see Fig. 1 presenting the tomography localization of brain damage). Only those patients whose tumour was histologically classified as mild and removed completely were chosen for the experiment. In all cases a routine ophthalmological test excluded hemianopsia and scotomas as well as a diminished acuity of vision. Possible imperfections in vision were corrected by glasses. All the patients were right-handed. Handedness was checked on Briggs and Nebes (1975) 12-point questionnaire. Moreover, no distinct neurological or neuropsychological disturbances were found in the tested patients. Additionally, a neuropsychological examination we performed to exclude visual agnosia, in particular, prosopagnosia, i.e. disturbances in recognizing faces, a neglect of some parts of visual field, as well as speech production or reception disorders. Other disturbances which might affect the performance of the task were not present either. The detailed data concerning localization of the damage for each patient are presented in Tables I and II.

The control group consisted of subjects without any damage of the central nervous system, also right-handed and with correct vision.

Material

The material consisted of three kinds of faces expressing positive and negative emotions and neural. Positive emotions were expressed by happy faces and negative ones by sad faces (see Fig. 2). We used photographs of six male faces in black-and-white without characteristic features such as beard, moustache or glasses. Each of these faces expressed three kinds of emotions. Thus 18 test faces were used in our experiment.

The synonymity of the evaluation of emotions expressed in those faces was confirmed by the method of competent judges. Five students were to classify the photographs of faces in the three groups: ones without any emotion and those expressing positive and negative emotions. The subjects univocally evaluated three kinds of emotion expressed in the faces. Thus classified, the test faces were then exposed in the proper experiment in the form of slides projected on a screen with a Kodak-Carousel projector with an electronic shutter. The stimuli were presented right or left of the fixation point which was a black spot (38' in diameter) fixed in the centre of the screen. The distance between the point of fixation and the inner border of the stimulus was 2'. The height of the exposed face was 3', its width 2'. The time of exposition of each stimulus was 20 ms.

Procedure

The experiment was conducted in a sound-proof room. The subject was seated at a distance of 1.7 m from the screen on which the faces were presented.

The subject’s task was to concentrate vision on the fixation point and to recognize the exposed test face. As some patients could have difficulty in concentrating, the subjects were taught to press the button to expose each face in the moment of their best concentration. The answer was given by pointing to the chosen test face on a response-card containing three faces situated vertically. Each response-card contained one face identical with a test face. All the faces on the respon-
TABLE I

Basic data concerning the patients with left hemispheric damage

<table>
<thead>
<tr>
<th>No.</th>
<th>Initials, education, sex</th>
<th>Age at the time of surgery</th>
<th>Lapse of time between surgery and experiment</th>
<th>Localization and type of damage</th>
<th>EEG (after surgery)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H.P. secondary female</td>
<td>31</td>
<td>10 years</td>
<td>meningioma in the parietal region</td>
<td>discrete disturbances in the left parietal region</td>
</tr>
<tr>
<td>2</td>
<td>R.O. secondary female</td>
<td>40</td>
<td>10 years</td>
<td>meningioma in the temporal region</td>
<td>discrete disturbances in the left frontotemporal region</td>
</tr>
<tr>
<td>3</td>
<td>W.W. university education male</td>
<td>26</td>
<td>12 years</td>
<td>meningioma in the frontal region</td>
<td>discrete disturbances in the left frontal region</td>
</tr>
<tr>
<td>4</td>
<td>M.R. university education male</td>
<td>35</td>
<td>3 months</td>
<td>intracerebral hematoma in the temporal region</td>
<td>norm</td>
</tr>
<tr>
<td>5</td>
<td>T.Sz. secondary female</td>
<td>54</td>
<td>3 months</td>
<td>meningioma in the frontal region</td>
<td>focal disturbances in the left frontotemporal region</td>
</tr>
</tbody>
</table>

se-card expressed the same emotions as that shown by the test face. Thirty six cards were used (two different cards were prepared for each of 18 test faces). Each face was placed twice in the top position of the card, twice in the middle position and twice at the bottom. Thus the position of faces on the cards was fully balanced. The effectiveness of perception of the material exposed in the left and right visual fields was measured
### TABLE II

<table>
<thead>
<tr>
<th>No.</th>
<th>Initials, education, sex</th>
<th>Age at the time of surgery</th>
<th>Lapse of time between surgery and experiment</th>
<th>Localization and type of damage</th>
<th>EEG (after surgery)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B.P. secondary female</td>
<td>39</td>
<td>1 year and 5 months</td>
<td>astrocytoma in the frontotemporal region</td>
<td>discrete disturbances in the right frontal region</td>
</tr>
<tr>
<td>2</td>
<td>N.W. vocational training male</td>
<td>24</td>
<td>1 year and 2 months</td>
<td>intracerebral hematoma in the parietotemporal region</td>
<td>norm</td>
</tr>
<tr>
<td>3</td>
<td>M.P. secondary male</td>
<td>32</td>
<td>1 year</td>
<td>astrocytoma in the frontal region</td>
<td>discrete focal disturbances in the right frontal region</td>
</tr>
<tr>
<td>4</td>
<td>Cz.M. secondary male</td>
<td>51</td>
<td>5 months</td>
<td>sarcoma in the temporal region</td>
<td>discrete focal disturbances in the right temporal region</td>
</tr>
<tr>
<td>5</td>
<td>A.S. secondary female</td>
<td>50</td>
<td>10 years</td>
<td>meningioma in the frontotemporal region</td>
<td>norm</td>
</tr>
<tr>
<td>6</td>
<td>M.P. vocational training female</td>
<td>28</td>
<td>3 months</td>
<td>intracerebral hematoma in the parietooccipital region</td>
<td>norm</td>
</tr>
<tr>
<td>7</td>
<td>A.K. secondary female</td>
<td>56</td>
<td>3 months</td>
<td>meningioma in the frontal region</td>
<td>discrete disturbances in the right frontal region</td>
</tr>
</tbody>
</table>

N.B. The main areas of damage are underlined.
by the number of errors. The brightness of stimuli was adjusted individually for each subject in order to obtain 20-30% of errors. This level of errors created a fairly easy situation for the subjects. That is why the experiment was preceded by a long preliminary series of tests adjusting the conditions of stimuli exposition. At the start, all the faces which were to be exposed in the session were shown in full light for an unlimited period of time; next, in order to prepare the subject for a short presentation of stimuli, the time of exposition was shortened to 100, 40, 20 ms using the above procedure. The next step of the preliminary series was a gradual reduction of intensity of the brightness until 20-30% of errors was reached. Then the experiment was started. It consisted of three sessions lasting approximately 30 min, separated by 15-min breaks. The only difference between the sessions was in the kind of emotions expressed in the exposed faces. In the first session the faces expressed positive emotions (happy) were presented; in the second one negative emotions (sad) and in the third session-neutral. The order of sessions was random. All faces were presented six times in each session. Each session consisted of 72 trials, of which half were exposed in the right visual field and half in the left visual field. The order of expositions was random. In the sessions, the stimuli were exposed in series of 18 elements separated by 2-min rest breaks.

Before each session, the subjects were informed of the kind of emotion contained in faces to be recognized. Throughout the experiment, one of the researches monitored the subject’s behaviour, especially his eye movements. Trials where eye movements occurred were dismissed. If eyes moved at the moment of the stimulus presentation, the trial was repeated at the end of the series.

RESULTS

A four-factor analysis of variance was applied to the mean percent of errors. The following factors were analyzed: Stimuli (happy, sad, neutral faces) and Visual Fields (left, right) as the within-subjects variables; Groups of subjects (patients with left hemispheric damage, patients with right hemispheric damage, controls) and Sex (male, female) as the between-subjects variables.

The analysis of variance proved statistical significance of one main factor only - sex ($P<0.01$, $F=7.55$, $df=1.24$). Females made fewer errors than males. Moreover, the interaction between stimuli, visual fields and groups of tested subjects ($P<0.01$, $F=3.25$, $df=4.48$) also proved to be significant. Apart from those, no additional interactions involving the sex of subjects as well as stimuli approached statistical significance.

In order to explain the interaction between stimuli, visual fields and groups of subjects, three separate 3-factor analyses of variance (2 Visual Fields x 3 Groups of subjects x Sex) were performed for each kind of stimuli, i.e. happy, sad and neutral faces. Interaction between visual fields and groups was significant for each kind of emotion expressed in the exposed faces, $P<0.05$, $F=4.29$, $df=2.24$ for happy faces, $P<0.05$, $F=4.8$, $df=2.24$ for sad faces and $P<0.001$, $F=50.2$, $df=2.24$ for neutral ones. The above interactions resulted from different pattern of hemispheric asymmetry in three investigated groups of subjects (see Figs. 3, 4 and 5). The pattern of asymmetry in patients with right hemisphere damage differed both from the pattern in the control group and from that found in patients with left hemisphere damage. It was valid for each kind of emotions expressed in the exposed faces.

For happy faces (Fig. 3) in the control group mean levels of errors in left and right visual fields were similar. Eight subjects committed fewer errors in the left visual field, five in the right visual field, the
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The right than in the left visual field. This tendency occurred in four patients, one (with parietotemporal lesion) showed the opposite tendency (fewer errors in the left visual field than in the right one), while two patients (with frontal or frontotemporal lesions) committed the same number of errors in both visual fields.

For neutral faces (Fig. 5) in the control group the mean percent of errors in the left visual field was lower than in the right one. This tendency occurred in 17 subjects; only in one subject the level of errors was found to be identical in both visual fields. In patients with left hemispheric damage, similarly as in controls, the level of errors in the left visual field was lower than in the right one. This tendency occurred in all tested subjects. Patients with right hemispheric damage showed an opposite tendency to that found in the two former groups. All patients with the right hemispheric damage made fewer errors in the right visual field than in the left one.

DISCUSSION

The results of the present experiment showed that, in patients with left hemisphere damage, the pattern of
hemispheric asymmetry was similar to that found in the control group. Thus in recognition of neutral and sad faces the right hemisphere prevailed; in recognition of happy face, on the other hand, there were no marked hemispheric differences. Hence, we suppose that the damage of the left hemisphere caused no marked disturbances in processing neutral as well as emotional faces.

On the contrary, in patients with right hemispheric damage the pattern of hemispheric organization differed both from that in patients with left hemisphere damage and from that in controls. Patients with right hemisphere damage performed better when the faces were presented to their left hemisphere, independently of the kind of emotions expressed by the stimuli. Such dominance resulted from the worsened processing in the damaged right hemisphere, accompanied by its certain improvement in the left undamaged one (Figs. 3, 4 and 5). The above would suggest that the left hemisphere takes over the functions of the right damaged one.

Thus, the results of our experiment show that the damage of the right hemisphere disturbs the recognition of neutral and emotional faces. These disturbances point to the crucial role played by the right hemisphere in the processing of faces, independently of emotions they express. It is worth mentioning that these relationships were found both in patients with frontal and occipital brain damage. Thus our findings would suggest that not only frontal (as shown in some previous studies e.g. Gainotti 1972, Borod et al. 1983) but also parietal, temporal and occipital regions of the right hemisphere are involved in the processing of emotions. Similar relationship, pointing to emotional disturbances both in patients with frontal brain damage and in those with posterior one, were reported by Kinsbourne (1989). We found also no interdependence between the results observed, subjects’ age and time interval between surgery and our experiment.

The results of the present study could also have same implications for another problem commonly discussed in literature on hemispheric asymmetry in processing human faces. The question is whether faces are processed better by the right hemisphere because of emotional information contained in them (Suberi and McKeever 1977, Ley and Bryden 1979, Gainotti and Caltagirone 1989) or because of their nonverbal, visuo-spatial complex character (Safer 1981). There is evidence both from clinical observations and experiments on normal subjects showing that visuo-spatial, nonverbal stimuli are analyzed more effectively by the right hemisphere (Goodglass and Kaplan 1979, Mowszowycz 1979, Hecaen 1981, Beaumont 1982, Szela and Czachowska-Sieszycka 1986). In our study, similar relationships were found for both neutral and emotional faces. In control group and in patients with left hemisphere damage the left visual field presentations resulted in better recognition scores for all types of faces. On the other hand, the right hemisphere damage produced the disturbances in the processing of all faces presented in the left visual field. Thus, our results show a distinct dominance of right hemisphere in processing faces, independently of the emotions they express. This might suggest that the visuo-spatial character of the stimuli was a crucial factor in the observed hemispheric asymmetry. Faces expressing emotions are one of the most commonly used material in investigation on lateralization of emotions. Our results suggest that investigators should be more cautious in using that type of stimuli. The reason is that such stimuli contain features other than emotional expression which are processed more effectively by one of two hemispheres.

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