Matching Top–Bottom Parts of Facial Expressions by Brain-damaged Patients

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Patients with focal brain-damage, right/left hemisphere-damage (RHD/LHD) and anterior/posterior region-damage (ARD/PRD), and normal controls (NC) were asked to match photographs of top-bottom facial parts expressing different emotions, positive (happy, surprise), negative-aroused (fear, anger), negative-nonaroused (sad, disgust). The LHD patients performed significantly worse than the RHD patients, and the ARD patients were significantly worse than the PRD patients, in the perceptual-matching task with affective stimuli. NC subjects performed significantly better than any of the brain damaged sub-groups.

Introduction

Several recent studies have shown that the right hemisphere is more efficient than the left in processing facial expressions of emotion (Leventhal and Tomarken, 1986; Tucker, 1981). Clinical studies have also revealed that patients with right hemisphere damage (RHD) were impaired in remembering emotional material (Wechsler, 1973), comprehending emotional tones of voice (Heilman *et al.*, 1984), and perceiving emotional faces (Bowers *et al.*, 1985; Borod *et al.*, 1986; Dekosky *et al.*, 1980). The role of the anterior neocortical regions in the processing of facial emotions has also been emphasized (Fox and Davidson, 1984). Studies with normal subjects have revealed that activation of the left frontal cortex is important for positive emotions (Davidson *et al.*, 1979) whereas right frontal activation is involved in negative emotions (Tucker *et al.*, 1981). In one study, both bilateral frontal lesioned patients and RHD patients were found equally poor in their judgment of facial emotions (Cicone *et al.*, 1980).

Evidence has come mainly from studies that used photographs of the whole face as affective stimuli. Although there are studies in experimental neuropsychology that employed unusual faces (for example, inverted faces, face drawings, quasi faces, strange faces) (Bruyer, 1986), little is known about the brain-damaged patients' ability to match componental parts of facial expressions of emotions. The present study investigates so with a specific aim to quantify the nature of impairment associated with lesion side (left–right) and region (anterior–posterior) of the brain. This is considered important in view of the assumption that

the component face may require a processing strategy distinct from the whole face. Although in experimental neuropsychology, there is controversy about configurational vs componential face processing (Sergent, 1984) such a debate is based upon whole face processing.

Experimental studies of facial expression of emotion utilize two kinds of facial components: left–right, top–bottom. In the present study, the top–bottom facial components have been used. We elected to do this because, left or right symmetrical facial parts depict all the features of the whole face as facial emotions are bilaterally expressed (with certain variation in intensity of expression for two hemifaces, see Leventhal and Tomarken, 1986), RHD patients systematically avoid lateral hemifaces when invited to choose among upper, lower left, and right hemifaces (Bruyer, 1986).

Method

Subjects

The study included 24 male patients with unilateral focal brain-damage who were selected from the Section of Neurosurgery, Department of Surgery, Banaras Hindu University, Varanasi. These patients were classified into equal numbers either for the cerebral hemisphere involved (RHD: $n = 12$, M age = 34.50 years, M education = 9.25 years; LHD: $n = 12$, M age = 27.25 years, M education = 7.75 years) or for the cerebral region involved (ARD: $n = 11$, M age = 30.63 years, M education = 8.10 years; PRD: $n = 11$, M age 32.00 years, M education = 8.36 years). The criterion adopted for classifying a lesion as “anterior” or “posterior” was the area in front of and behind the central sulcus, respectively. Lesion sites of all the patients were confirmed by CT scan and verified at craniotomy (Table 1) (see also Figs 1 and 2). Although four LHD patients were aphasic, they had sufficient language skills to carry out the tests. Patients with obvious bilateral damage, and those with lesions that extended across the antero–posterior boundary, were excluded. Patients with lesions not restricted to the cortex, previous psychiatric disorder, and those unable to keep the set required for carrying out the task, were also excluded.

Equal numbers of male control NC subjects were considered for comparison with the hemisphere-damaged group ($n = 12$, M age = 27.00 years, M education = 9.50 years) and with the region-damaged group ($n = 11$, M age = 26.72 years, M education = 9.36 years). All subjects were right-handed. The hand preference for each subject was assessed using a Handedness Inventory (Oldfield, 1971). Any subject with a score below +25 (maximum +100) was excluded as the subject may not be completely right-handed.

Photographs

Photographs of six facial emotions (happy, sad, fear, anger, surprise, disgust), expressed by the same (2 sets) and different (2 sets) posers (4 sets $\times$ 6 emotions = 24 photographs), were chosen for the study (Mandel, 1987). The photographs were all black and white glossy prints, and each was a full face photograph of an

TABLE 1. *Characteristics of brain-damaged patients*

<i>Patient</i>	<i>Hemisphere damage</i>	<i>Region damage</i>	<i>Lesion site*</i>	<i>Lesion size*</i>	<i>Etiology</i>
1	RHD	ARD	Fronto-temporal	3×4×3	Glioma
2	RHD	ARD	Temporal	3×5×3	Glioma
3	RHD	ARD	Frontal	3×4×2	Extradural haematoma
4	RHD	PRD	Parietal	2×2×1	Compound depressed fractive
5	RHD	ARD	Fronto-temporal	4×3×3	Extradural haematoma
6	RHD	PRD	Parietal	4×3×2	Extradural haematoma
7	RHD	ARD	Frontal	3×2×2	Extradural haematoma
8	RHD	PRD	Parietal	4×3×2	Glioma
9	RHD	—	Parietal	3×2×2	Extradural haematoma
10	RHD	PRD	Parietal	3×3×2	Extradural haematoma
11	RHD	PRD	Parietal	3×2×3	Glioma
12	RHD	ARD	Frontal	4×2×2	Glioma
13	LHD	PRD	Parietal	3×2×2	Abscess
14	LHD	PRD	Parieto-occipital	2×2×1	Proencephalic cyst
15	LHD	PRD	Parieto-occipital	4×2×2	Glioma
16	LHD	ARD	Frontal	4×5×3	Abscess
17	LHD	ARD	Temporal	3×3×3	Glioma
18	LHD	PRD	Parietal	2×2×3	Proencephalic cyst
19	LHD	ARD	Frontal	4×3×2	Glioma
20	LHD	PRD	Parietal	2×2×3	Glioma
21	LHD	ARD	Frontal	2×2×2	Glioma
22	LHD	ARD	Temporal	2×3×2	Abscess
23	LHD	—	Parietal	3×2×2	Extradural haematoma
24	LHD	PRD	Parietal	2×2×3	Extradural haematoma

*Length, breadth and depth.

adult Indian subject. These photographs were then split down the horizontal midlines for top (forehead, eyebrows, eyes, and upper part of cheeks and nose), and bottom (lower part of cheeks and nose, mouth, chin) componental parts.

Procedure

Each subject was asked to perform two tasks with facial componental preparations of an emotion expression. In the first, a (target) facial part (for example, top) expressing an emotion was shown and the subject's task was to select the

FIG. 1. Location and size of lesions based on CT and operation findings (refer Table 1 for subject number shown in parenthesis); RHD (right hemisphere damage), LHD (left hemisphere damage), ARD (anterior regional damage), PRD (posterior region damage). Two patients (no. 9 in RHD group and no. 23 in LHD group) were dropped from the region-wise analysis.

facial counter-part (for example bottom) from a set of (test) facial parts expressing six different emotions. Photographs used in this task depicted the same face with differing expressions. In the second, the subject was asked to perform a similar task with a difference in the experimental set up, that is, the test photographs depicted expressions of different faces, other than the one depicted in the target

FIG. 2. Actual lesion site (CT) in representative cases (refer Table 1 for subject number shown in parenthesis). (a) Right fronto-temporal damage (5); (b) left parietal damage (20).

facial part. In any task, all the six emotions were considered target, one by one, in a random order determined pre-experimentally, and the test–target facial orientations were counter-balanced for each componental preparation.

Results

The percentage of correct judgments by each group is shown in Table 2. Data were analysed separately for hemisphere-damaged (LHD–RHD) and region-damaged (ARD–PRD) groups.

A 3 (groups: LHD, RHD, NC) $\times$ 2 (expressors: same–different) $\times$ 2 (facial parts: top–bottom) $\times$ 3 (emotions: positive = happy, surprise, negative-aroused = fear, anger, negative-nonaroused = sad, disgust), split-plot factorial analysis of variance with repeated measures in the last three factors yielded significant main effects of group ($F = 15.10$, $df = 2,33$, $p < 0.005$) and emotion ($F = 11.29$, $df = 2,66$, $p < 0.005$). NC subjects demonstrated superior performance to RHD patients (Scheffe test = $p < 0.05$) who in turn, were superior to LHD patients (Scheffe test = $p < 0.05$). Positive emotions were matched with greater accuracy than negative-aroused and negative-nonaroused emotions (Scheffe test = $p < 0.05$). Although the main effects of expressor (same–different) and facial part (top–bottom) were nonsignificant, the interaction of group $\times$ expressor $\times$ facial part was significant ($F = 3.85$, $df = 2,33$, $p < 0.05$). The significant interaction of group $\times$ expressor $\times$ facial parts revealed that the bottom facial parts (as target) of the same expressor were most accurately matched by NC subjects while these were matched with least accuracy by either of the hemisphere-damaged patients ($p < 0.05$). All other interaction effects were nonsignificant.

Identical analysis (split-plot ANOVA) for region-damaged groups yielded significant main effect of groups ($F = 9.64$, $df = 2,30$, $p < 0.01$) and emotions ($F = 15.21$, $df = 2,60$, $p < 0.005$). NC subjects demonstrated superior performance to PRD patients (Scheffe test = $p < 0.05$) who in turn, were superior to ARD

TABLE 2. *Percent of correct matching for componental parts of facial emotions*

Group	Facial part	Positive		Negative aroused		Negative nonaroused	
		Happy	Surprise	Fear	Anger	Sad	Disgust
NC	Top	66.66	41.66	54.16	8.33	54.16	16.66
	bottom	62.50	50.00	16.66	41.66	45.83	33.33
RHD	Top	54.10	33.33	25.00	20.83	29.16	29.16
	Bottom	37.50	45.83	16.66	12.50	33.33	16.66
LHD	Top	29.16	20.83	8.33	12.50	8.33	33.33
	Bottom	16.66	37.50	12.50	12.50	12.50	12.50
NC	Top	63.63	45.45	54.54	4.54	54.54	18.18
	Bottom	68.18	45.45	18.18	40.90	0.50	36.36
ARD	Top	31.81	31.81	27.27	18.18	13.63	22.72
	Bottom	27.27	31.81	9.09	4.54	22.72	13.63
PRD	Top	59.09	27.27	4.54	13.63	27.27	40.90
	Bottom	31.81	54.54	13.63	13.63	27.27	13.63

patients (Scheffe test = $p < 0.05$). Positive emotions (happy, surprise) were more accurately matched than either negative-aroused (fear, anger) or negative-non-aroused (sad, disgust) emotions (Scheffe test = $p < 0.05$). Except for the interaction of group $\times$ expressor $\times$ facial part ($F = 4.18$, $df = 2,30$, $p < 0.025$), all other interaction effects were nonsignificant. The significant interaction of group $\times$ expressor $\times$ facial parts indicated that ARD patients had demonstrated significant difficulty in matching bottom parts of the same expressor (as target) compared to PRD patients.

Discussion

Contrary to expectations, the RHD patients performed significantly better than the LHD Patients in matching top-bottom parts of facial emotions. In an earlier study (Mandal *et al.*, 1991) these patients were asked to judge (whole) facial emotions by matching/labelling response mode, and the RHD patients by matching/labelling response mode, and the RHD patients were found significantly inferior in their judgment compared to the LHD patients or NCs. It is generally accepted that the right hemisphere is more efficient than the left hemisphere in normal right-handed subjects in processing information necessary for the understanding of facial emotions (see review by Leventhal and Tomarken, 1986), and damage to the right hemisphere results in impairment in the judgment of facial emotions (Borod *et al.*, 1986; Cicone *et al.*, 1980). Although some studies have reported poor emotional sensitivity, in LHD patients compared to matched NC subjects (for example, Dekosky *et al.*, 1980; Mandal *et al.*, 1991). No previous studies have demonstrated superiority of RHD patients over LHD patients in facial emotion judgment task. However, unlike other studies that used whole face as the affective stimuli, the present study used componental facial parts. Subjects had to conceive an emotional expression by using a cognitive strategy that required componental processing of faces. A whole face perhaps is processed when both componental and configurational processes function in parallel (Sergent, 1984). The literature suggests that the right hemisphere contributes to configurational processing, "a process that generates an unitary percept of a complex stimulus rather than separate percepts of its various components" (Sergent and Bindra, 1981) whereas the left hemisphere "specializes in analysing complex stimulus configurations into discrete features" (Moscovitch, 1979), and the two hemispheres interact in both an opposing and complementary manner (Tucker, 1981). In the present perceptual-matching task with facial affective stimuli, subjects had to rely largely upon componental processing. This is because both target and test photographs were presented in parts, and instead of asking whether a top-bottom combined face was chimeric or congruous to an emotional expression, subjects were required to sequentially process a number of facial features depicted in part (test) photographs. Sequential information, linguistic or nonverbal, is primarily mediated by the left-hemisphere (Carmon and Nachson, 1971; Lackner and Teuber, 1973). LHD patients cannot process emotional information as efficiently as RHD patients due to its component-specific task structure. The left-hemisphere may also play a crucial role in the early stages of facial affective processing by subserving important analytical functions. These func-

tions however would not be assessed in tasks that use the whole face.

ARD patients performed significantly poorer than PRD patients in matching top–bottom facial parts of emotion expressions. Fox and Davidson (1984) postulated that the left and right frontal regions of the brain are differentially related to positive and negative emotions respectively. Neurophysiological evidences also support this notion (Davidson *et al.*, 1979; Tucker *et al.*, 1981). Clinical studies have shown that individuals with frontal lobe damage become emotionally labile (Teuber, 1972; Warren and Akert, 1964), and may exhibit motor and cognitive perseveration (Luria, 1973; Milner, 1964), depending upon the locus and extent of the lesion (Moscovitch, 1979).

Since “the correlation between a specific impairment and a focal brain injury is not sufficient to infer the normal function of cerebral structure” (Sergent, 1988), the inferences to be drawn from the present study cannot be considered conclusive. LHD patients, however, had specific deficits in matching top–bottom facial parts, and besides overall impairment, the ARD patients had specific deficit in matching bottom facial parts of the same expressor, in any emotional expression.

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