Perceptual and Motor Skills, 1982, 54, 859-869.

PERCEPTION AND MEMORY OF FACIAL AFFECT FOLLOWING BRAIN INJURY[1]

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Summary.—Brain-lesioned patients and controls were shown a series of happy, sad, fearful, and angry faces and asked to identify verbally the facial emotion and later freely recall the affect when shown some of the faces having neutral expressions. Greater misperception of facial affect was associated with posterior lesions when bilateral lesions were removed from data analysis. Unilateral and bilateral frontal lesions, however, were associated with memory deficits for facial affect. As a group, right versus left hemisphere-lesioned patients were not different from each other in the perception or memory of facial affect. Right frontal lesions, however, seemed especially to disrupt recall of facial emotion.

A number of studies have shown that the perception of unfamiliar faces is impaired following a right-hemisphere lesion, particularly when it is posterior in location (DeRenzi & Spennler, 1966; Yin, 1970; Hamsher, Levin, & Benton, 1979; Benton, 1980). Other studies have suggested that right cerebral hemisphere lesions might also interfere with the perception of facial affect or emotion (Cicone, Wapner, & Gardner, 1980; DeKosky, Heilman, Bowers, & Valenstein, 1980). While the same neural processes might account for both of these deficits, e.g., a visual-spatial information processing deficit, the evidence is equivocal. For example, Cicone, *et al.* (1980) reported a low and presumably nonsignificant correlation between errors in facial recognition and errors in the recognition of facial emotion. DeKosky, *et al.* (1980) reported a similar finding.

Since information about emotional or affective stimuli frequently is received by multiple modalities, the perception of emotional information most likely involves overlapping neural processes. When just facial affect is perceived, as in an artificial experimental situation, a verbal response or even the thought that "this is a happy or sad face" might evoke different encoding strategies for perceiving and remembering that affect. Galper and Costa (1980) have demonstrated, for example, that facial recognition in normals can be superior in either the right or left visual field, depending on the type of cognitive encoding strategy employed by the subject. Hansch and Pirozzolo (1980) have shown that the task demands can lead to either a right- or left-

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field advantage in perceiving "emotional" stimuli. Cicone, *et al.* (1980) found that bilateral frontal lesioned patients made essentially the same number of errors as right hemisphere-lesioned patients when asked to perceive facial affect. Different neural system deficits or different information-processing strategies, therefore, may lead to the same behavioral deficit but for different reasons.

To complicate matters further, in most studies of recognition of facial affect, the subject is asked to match a person or an emotional expression (Ley & Bryden, 1979; Suberi & McKeever, 1977; Cicone, *et al.*, 1980; DeKosky, *et al.*, 1980). In everyday life, simple matching is not the method of testing perception or recall of facial affect. The individual determines if a given person is happy, sad, fearful, angry, etc. based on the information that a person provides. Later, when confronting the person again, the individual must freely recall what the affect was the last time he encountered that person. Errors in either the initial judgment of facial affect or its later recall potentially can cause serious problems in social adjustment. In particular patient groups, e.g., with closed-head injury, this may be an extremely important source of their personal adjustment problems.

The present study attempted to assess the ability to perceive and remember facial affect using more "real-life" test characteristics. Brain-lesioned patients and controls were shown pictures of faces and asked to state verbally what emotion the face was showing. Later, they were asked to recall freely that affect when confronted with some of the same faces now having relatively neutral expressions.

Based on previous research, it was predicted that under these conditions, right-hemisphere patients may not be statistically different from left-hemisphere patients (DeKosky, *et al.*, 1980), but both should be inferior to controls. Because of the perceptual nature of the task, it was predicted that patients with posterior brain lesions should do worse than frontal lesioned patients. The study of Cicone, *et al.* (1980) points out, however, that patients with bilateral frontal cerebral lesions might also be expected to do very poorly on such a task, but possibly for different reasons (see Jouandet & Gazzaniga, 1979).

Method

Subjects

The subjects in the present study were part of a previous research project dealing with how feeling states influence episodic memory. Details regarding subjects' selection, the methods of identifying regionalization of lesions, and type and duration of brain lesions can be found in that report (Prigatano & Pribram, 1981). While some were initially aphasic, by the time of testing, all had sufficient good language skills to participate in the study.

For the purpose of the present study, 20 patients with well-documented lesions were initially classified as having either frontal ($n = 10$) versus posterior ($n = 10$) lesions. Subjects were then reclassified as having right ($n = 8$), left ($n = 7$), or bilateral ($n = 5$) cerebral lesions. A group of 10 peripheral neurologic and psychiatric patients, as well as normal volunteers, served as control subjects.

Brain-lesioned and control subjects were matched on age, education, and handedness. Brain-lesioned patients had a mean age of 39.5 yr., with mean education of 13.2 yr. Seventy-five percent were right-handers. Controls had a mean age of 31.8 yr., mean education of 14.2 yr., and 80% were right-handers. Sex ratio, however, was not matched. In the patient sample, there were 14 males and 6 females. In the control sample, there were 4 males and 6 females. Previous research, however, has not shown sex, education, or age to influence perception of facial characteristics or facial affect in this range of adult subjects; see Benton (1980) for references that support this point.

Procedures and Materials

Each subject was individually tested in a private room with no distractions. The subject was instructed to look at 16 faces and to state verbally whether the face looked happy, sad, fearful, or angry. The subject was then shown eight of the previous faces, but this time the faces had relatively neutral facial expressions. The subject was asked to try and recall the emotional expression of each face on the previous trial. This was a very difficult task for most subjects, and guessing was encouraged. After this, the entire sequence was repeated a second time. Consequently, there were 32 facial affect-recognition trials and 16 facial affect-memory trials per subject.

The stimulus pictures were taken from the commercially available facial affect slides by Ekman and Friesen (1976). These slides offer the advantage of providing reliability ratings regarding the emotion expressed by a given face. Thus, one can measure how easily a given facial affect is perceived by normals.

In the present study, four happy, four sad, four fearful, and four angry faces were used. There were two pictures of men and two pictures of women for each emotion. The commercial numbers of each and their reliability judgments are:

1. Happy:	Slide 22; rating = 96%	3. Fear:	Slide 37; rating = 96%
	Slide 29; rating = 100%		Slide 79; rating = 92%
	Slide 48; rating = 100%		Slide 88; rating = 100%
	Slide 57; rating = 100%		Slide 50; rating = 88%
2. Sad:	Slide 15; rating = 97%	4. Anger:	Slide 25; rating = 70%
	Slide 36; rating = 93%		Slide 105; rating = 100%
	Slide 2; rating = 90%		Slide 69; rating = 100%
	Slide 43; rating = 96%		Slide 96; rating = 100%

These data show that the sad and fearful faces were not identified as easily by normals. Three out of the four happy faces had 100% reliability, and three out of the four angry faces had 100% reliability. This is important since errors in perceiving sad and fearful faces for brain-injured patients would potentially reflect the difficulty level of the perception rather than the specific disability to deal with one emotion versus another. This methodological control is often not employed.

In the memory condition, one neutral male and one neutral female's face was used in each of the four affect conditions. The neutral slides used were as follows: previously happy faces: Slides 33 and 65; previously sad faces: Slides 24 and 47; previously fearful faces: Slides 83 and 92; and previously angry faces: Slides 110 and 72.

All slides were projected onto a blank screen or white wall approximately 5 ft. from the subject. Subjects who normally wore glasses were instructed to wear them during the testing procedures. Subjects who had evidence of any visual-field difficulty were positioned in such a way as to ensure stimulus material was projected to the best visual field.

Results

Frontal Versus Posterior Cerebral Lesions

Patients were initially subdivided into frontal ($n = 10$) versus posterior ($n = 10$) lesioned groups. These subjects were then compared to the controls on their perception of the four facial affects. A 3×4 analysis of variance indicated no group effect ($F = 1.82$, $df = 2/27$, $p = .18$), a strong facial emotion effect ($F = 4.83$, $df = 3/81$, $p = .004$), and a trend for an interaction ($F = 1.79$, $df = 6/81$, $p = .11$). The Duncan multiple-range test, with a probability rating set of .05, showed that the perception of happy faces were decidedly easier than perception of other facial affects for all subjects. This analysis did not show a greater perceptual deficit for posterior lesioned patients as initially predicted.

A similar analysis, using memory scores, was then conducted. A group effect was observed ($F = 3.38$, $df = 2/27$, $p = .04$) with a tendency for a facial emotion effect ($F = 2.29$, $df = 3/81$, $p = .08$) and no interaction ($F = 1.22$, $df = 6/81$, $p = .30$). A Duncan range test indicated that frontal-lesioned patients had impaired memory for facial affect but only compared to controls. There was no difference between posterior and frontal subjects' memory of facial affect.

Since frontal patients had a greater number of bilateral lesions than the posterior patients, this variable may have confounded the results. Consequently, the perceptual and memory analyses were repeated with bilateral patients omitted. Unilateral frontals ($n = 6$), unilateral posteriors ($n = 9$), and controls ($n = 10$) were compared. This analysis did show an effect for group ($F = 3.87$, $df = 2/22$, $p = .03$), facial emotion ($F = 4.57$, $df = 3/66$, $p = .005$), and an interaction ($F = 2.59$, $df = 6/66$, $p = .02$). Posteriors were now decidedly impaired relative to controls but were no different than frontals (Table 1). Happy and angry faces were more easily perceived than fearful and sad ones. Posterior patients were inferior to frontals only in the perception of fearful faces.

TABLE 1

DUNCAN MULTIPLE-RANGE TEST FINDINGS: FRONTAL VS POSTERIOR VS CONTROL GROUPS

Subjects	M		
1. *Perception* of facial affect (bilateral lesion *included*)			
a. controls	7.7	A*	
b. posterior	7.3	A	
c. frontal	7.1	A	
2. *Perception* of facial affect (bilateral lesion *excluded*)			
a. controls	7.7	A	
b. frontal	7.6	A	B
c. posterior	7.2		B
3. *Memory* of facial affect (bilateral lesion *included*)			
a. controls	6.2	A	
b. posterior	5.6	A	B
c. frontal	5.4		B
4. *Memory* of facial affect (bilateral lesion *excluded*)			
a. controls	6.2	A	
b. posterior	5.5	A	B
c. frontal	5.3		B

*Means having same letter reflect no difference at $p = .05$. Means having different letters beside them reflect significant difference at $p = .05$.

A similar analysis with memory scores again showed a group effect ($F = 3.46$, $df = 2/22$, $p = .04$), but no effect of facial affect ($F = 1.31$, $df = 3/66$, $p = .27$), or interaction ($F = .26$, $df = 6/66$, $p = .05$). The removal of bilateral patients, therefore, did not alter the findings on the memory data. Frontals are again worse than controls, but no different from posteriors (Table 1).

Right Versus Left Cerebral Lesions

The next hypothesis under investigation was whether right- and left-hemisphere patients would be similar in their performance under the present testing conditions. Lesion patients were thus divided into right ($n = 8$), left ($n = 7$), and bilateral ($n = 5$) groups and compared to controls ($n = 10$) on the four facial affects. A 4 $\times$ 4 analysis of variance of perceptual scores indicated effects of group ($F = 2.95$, $df = 3/26$, $p = .05$) and facial emotion ($F = 4.69$, $df = 3/78$, $p = .004$), but no interaction ($F = 1.22$,

$df = 9/78$, $p = .29$). Duncan multiple-range test showed that controls, right- and left-hemisphere lesioned patients were not significantly different from one another but were all less impaired than bilateral-lesioned patients (Table 2). Again, happy faces were clearly more easily perceived than other faces. As predicted, there was no difference between right and left hemisphere-lesioned patients in this analysis.

A 4 × 4 analysis of variance was then conducted on memory scores. The results were less striking. Only trends were observed for effects of group ($F = 2.42$, $df = 3/26$, $p = .08$), facial affect ($F = 2.45$, $df = 3/78$, $p = .06$), and their interaction ($F = 1.82$, $df = 3/78$, $p = .07$). Using just the memory scores, however, the right-hemisphere-lesioned patients did show the greatest impairment but were only significantly different from controls (Table 2).

TABLE 2

DUNCAN MULTIPLE-RANGE TEST FINDINGS: RIGHT, LEFT, BILATERAL, AND CONTROL GROUPS

Subjects	M		
1. *Perception* of facial affect			
a. controls	7.7	A*	
b. right	7.7	A	
c. left	7.2	A	
d. bilateral	6.7		B
2. *Memory* of facial affect			
a. controls	6.2	A	
b. bilateral	5.8	A	B
c. left	5.5	A	B
d. right	5.4		B

*Means having same letter reflect no difference at $p = .05$. Means having different letters beside them reflect significant difference at $p = .05$.

Right Versus Left × Frontal Versus Posterior Lesions

A potential methodological problem with the present data was the unequal distribution of right- versus left-sided lesions in patients classified as frontal versus posterior. Frontal patients had more unilateral right-sided lesions ($n = 5$) than left ($n = 1$). The opposite was true for posterior patients in which unilateral left lesions ($n = 6$) outnumbered unilateral right lesions ($n = 3$). Consequently, further analyses were done.

Unilateral right versus left frontal-lesioned patients were first compared on perception and memory scores. These two groups did not differ in their perception of facial affect ($F = 1.67$, $df = 1/4$, $p = .26$). There was also no interaction of group by facial emotion ($F = .53$, $df = 3/12$, $p = .67$) or facial emotion ($F = 1.43$, $df = 3/3$, $p = .28$) for perception scores. Comparison of memory scores, however, showed a trend for right frontals to have a more difficult time recalling facial emotion than the single left frontal patient ($F = 4.59$, $df = 1/3$, $p = .09$). There was no interaction ($F = .42$, $df = 3/12$, $p = .74$) or effect of facial emotion ($F = .45$, $df = 3/3$, $p = .72$).

Comparison of right versus left posterior-lesioned patients on perception scores gave no effect of group ($F = .05$, $df = 1/7$, $p = .83$), but there was a decided effect of facial emotion ($F = 6.98$, $df = 3/3$, $p = .002$) and an interaction ($F = .478$, $df = 3/21$, $p = .01$). Right posterior-lesioned patients were decidedly worse than left posterior-lesioned patients in the perception of fearful faces. Happy and angry faces were again statistically easier to perceive than sad or fearful ones.

Analysis of memory scores for right versus left posterior-lesioned patients yielded no effect of group ($F = .88$, $df = 1/7$, $p = .37$), no facial emotion ($F = .70$, $df = 3/3$, $p = .56$), or their interaction ($F = .3$, $df = 3/21$, $p = .93$).

These latter findings suggest that the right frontal-lesioned group had the most trouble with memory of facial affect. Both right and left posterior-lesioned groups tended to have difficulty perceiving facial affect. The right posterior-lesioned patients, however, performed worse than left posterior-lesioned patients when perceiving fearful faces. These were the more difficult stimuli to perceive based on the normative data listed in the method section.

Post Hoc *Analyses*

In addition to these analyses, two *post hoc* analyses were done. The first investigated whether the type of brain lesion influenced the results. The literature indicates that closed head-injured patients with brain stem and cerebral contusion typically did more poorly on perceiving unfamiliar faces than patients with only cerebral contusion (Levin, Grossman, & Kelly, 1977). Also, the possible effect of the acuteness of the lesion on test results was considered. Frequently, when patients are acutely impaired, there is a general disruption in all higher cerebral function and consequently, this might have accounted for the less clear findings.

Closed Head Injury Versus CVA and Tumor

Patients were divided into two major types of brain lesions. One group consisted of patients with closed-head injury ($n = 10$) and the second group consisted of patients who had either CVAs ($n = 7$) or tumors ($n = 3$). The CVA and tumor patients were combined into one group since there were only three tumor patients. A 3×4 analysis of variance compared CHI patients versus the combined CVA and tumor group versus controls over the four conditions of facial affect. A clear effect for group ($F = 5.75$, $df = 2/27$, $p = .008$) and facial emotion ($F = 4.84$, $df = 3/81$, $p = .003$) and a tendency for these to interact ($F = 1.81$, $df = 3/81$, $p = .10$) were observed. Duncan multiple-range test indicated that CHI patients were decidedly inferior to controls and other brain-injured patients in the perception of facial affect. Again, happy and angry faces were much more easily perceived than sad and fearful ones.

Analysis of memory scores using this same patient grouping also yielded significant effects. An effect for group was significant ($F = 4.11$, $df = 2/27$, $p = .02$) with a trend for facial affect ($F = 2.36$, $df = 3/81$, $p = .07$). There was, however, no interaction ($F = 1.66$, $df = 6/81$, $p = .14$; see Table 3). It may be of some clinical significance that CHI patients had considerable difficulty in both perception and later memory of facial affect since these individuals frequently have serious problems of social adjustment (Levin & Grossman, 1978).

TABLE 3

DUNCAN MULTIPLE-RANGE TEST FINDINGS: CHI VS CVA AND TUMOR VS CONTROL GROUPS

Subjects	*M*		
1. *Perception* of facial affect			
a. controls	7.7	A[a]	
b. CVA and tumor	7.5	A	
c. Closed head injury	6.7		B
2. *Memory* of facial affect			
a. controls	6.2	A	
b. CVA and tumor	5.6	A	B
c. Closed head injury	5.3		B

[a]Means having same letter reflect no difference at $p = .05$. Means having different letters beside them reflect significant difference at $p = .05$.

Acute Versus Chronic Lesions

Patients were classified as having either acute, i.e., 6 mo. or less, or chronic (greater than 6 mo.) lesions. This breakdown produced 10 patients in each condition. A 3×4 analysis of variance comparing acute versus chronic versus control subjects on perceptual scores gave no effect of group ($F = 1.70$, $df = 2/27$, $p = .20$) or interaction ($F = .88$, $df = 6/81$, $p = .5$), but an effect for facial emotion ($F = 4.54$, $df = 3/81$, $p = .005$). Once again, happy and angry faces were much easier perceived than fearful or sad ones.

The 3×4 analysis of variance on memory scores yielded, however, an effect for group ($F = 3.35$, $df = 2/27$, $p = .05$), an interaction ($F = 2.20$, $df = 6/81$, $p = .04$), and a tendency for an effect for facial emotion

($F = 2.46$, $df = 3/81$, $p = .06$). The Duncan multiple-range test indicated that patients who had chronic lesions actually performed worse than controls but were equally impaired with acute patients. The interaction showed, however, that acute patients had a more difficult time remembering sad faces than other patients or control subjects.

Discussion

Excluding patients with bilateral cerebral lesions, posterior-lesioned patients misperceived facial affect significantly more than controls. In contrast, frontal-lesioned patients demonstrated significantly poorer recall of facial emotion compared to controls. These two lesioned groups, however, did not differ consistently from each other in the over-all perception and memory of facial affect. Only in the most difficult perceptions, i.e., fearful faces, did posterior-lesioned patients do worse than frontals. This finding appears to be produced primarily by right posterior-lesioned patients. The convex, posterior regions of the human brain are especially equipped to deal with the discrimination of visual-spatial stimuli and consequently facial emotions should be impaired following lesions in this brain region (Pribram & Barry, 1956; Wilson, 1968).

Frontal-lesioned patients did not have major difficulty in perceiving facial emotion. The study by Cicone, *et al.* (1980) showed, however, that bilateral frontal-lesioned patients had difficulty in perception of facial affect. Bilateral regions of the frontal cortex do not produce impairment in visual discrimination *per se* (Pribram, 1971); however, they can produce deficits in visual scanning (Jouandet & Gazzaniga, 1979). Such deficits may lead to failures in sampling important sources of visual information necessary for perceptual judgments about emotion and thereby produce the present results.

In the present study, frontal-lesioned patients consistently had the greatest trouble recalling facial affect. This was true when bilateral or unilateral lesioned patients were studied. The right frontal group, however, seems to account for this affect. Problems in using "emotional" information to aid initial learning may account for these results (Prigatano & Pribram, 1981).

A second major finding was that under the present test conditions, as a group, right cerebral-lesioned patients performed essentially as left cerebral-lesioned patients in the perception of facial affect. When the task demands a verbal response, the expected right-hemisphere effects are frequently reduced (Hansch & Pirozzola, 1980). Curiously, however, right-hemisphere patients, like frontal-lesioned patients, had trouble remembering facial affect. Suberi and McKeever (1977) have argued that the right hemisphere has a special role in the recall of facial emotion. Other studies have shown impaired nonverbal memory following right-hemisphere lesions (Butters, 1979). While it cannot be fully evaluated in this study, the present data are compatible with the notion that right frontal-lesioned patients have difficulty remembering facial emotion because of problems of inattention (Jouandet & Gazzaniga, 1979). Right posterior-lesioned patients, however, may not remember facial emotion because of initial problems in perception. This should be investigated.

In addition to the theoretical considerations, the present findings have potential clinical relevance. They raise the question of whether or not problems in perceiving and remembering facial affect contribute substantially to problems in social adjustment. The patients in this study who had closed head injuries did decidedly worse than the CVA and tumor patients on the perceptions and memory of facial affect. Patients with closed head injuries are especially at risk for dealing with individuals in a socially inappropriate manner (Levin & Grossman, 1978). If they cannot properly perceive facial affect or remember such emotional information, their social responses might well be more likely to become inappropriate. The chronicity of the closed head injury may even add to this problem as witnessed by the findings in this study. This needs to be evaluated. Patients with closed head injuries who show poor social adjustment should be evaluated for their ability to perceive and remember emotional stimuli. If there were a high positive correlation between these two dimensions, this may prove to be a valuable clinical aid in the diagnostic assessment and eventual retraining of such patients.

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Accepted February 2, 1982.