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# HUMOR AND EPISODIC MEMORY FOLLOWING FRONTAL VERSUS POSTERIOR BRAIN LESIONS[1]

GEORGE P. PRIGATANO[2,3] AND KARL H. PRIBRAM
*Stanford University*

*Summary.*—10 frontal versus 10 posterior brain-lesioned patients were studied as to their capacity to use feelings (a humor response) to aid episodic memory. Both groups were inferior to 10 controls, and frontal-lesioned patients were inferior to those with posterior lesions. However, the former had more trouble using visual cues to aid memory. Consequently, the differences between frontal- and posterior-lesioned patients may not be specifically related to differences in using "feeling" cues to facilitate memory.

The present study is concerned with the question of how feelings influence memory. Specifically, it examines the hypothesis that frontal brain lesions which disrupt the frontolimbic system interfere with the capacity to involve feelings in memory of a specific sort. As a result of human cognitive studies, memory mechanisms have been divided into "episodic" when specific episodes are recalled, in contrast to "semantic" which remains invariant over most situations (Tulving, 1972). In non-human primate research a similar distinction has been made between context-sensitive processes when the appropriate response varies as a function of contingent cues or the consequences of immediately prior behavior, as in the delayed response and delayed alternation tasks (Pribram, 1954, 1961, 1971, 1973) and processes that are essentially context free, i.e., invariant. Pribram (1977a, 1977b) and Wood and Kinsbourne (1977) have adduced evidence that the frontal cortex of both human and non-human primates is involved in such context sensitive, episodic processing.

Gardner, *et al.* (1975) have suggested that the study of humor is especially suited to investigating the natural relationship between cognitive and affective components of behavior. They studied the effect of various brain lesions (in primarily aphasic patients) on the comprehension and appreciation of humorous material. They compared aphasic patients with primarily anterior versus those with posterior lesions and found that these groups did not differ in their ability to identify humorous cartoons. They did not attempt, however, to use humor as an independent variable to influence learning and memory. The present study was initiated to examine just this possibility: Does the appreciation of humor influence the encoding of the episode which evoked the humor?

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[1]An earlier version of this paper was presented at the International Neuropsychological Society Meeting in San Francisco, California, January 31 to February 2, 1980.
[2]This research was conducted while the first author was a Visiting Scholar at the Department of Psychology, Stanford University, Palo Alto, California.
[3]Reprint requests should be sent to George P. Prigatano, Ph.D., Section of Neuropsychology, Department of Neurosurgery, Presbyterian Hospital, Northeast 13th and Lincoln Boulevard, Oklahoma City, Oklahoma 73104.

It was predicted that patients with frontal brain lesions would show poorer recall of sentences associated with humorous pictures when compared to patients with posterior brain lesions. The hypothesis being tested is that such a selective effect of frontal lesions would derive from an impaired ability to use feelings (in this case a humor response) to aid encoding and later retrieval of context-sensitive, episodic verbal information.

## METHOD

Over 60 patients were screened at the Palo Alto and Menlo Park VA Hospitals in California, the Oklahoma City VA Hospital, and the Presbyterian Hospital of Oklahoma City, to select 10 patients with primarily frontal brain lesions and 10 patients with primarily posterior brain lesions. Frontal lesions were defined as lesions occurring anterior to sensory-motor (Rolandic) cortex. Posterior lesions were defined as lesions involving part of or being posterior to the sensory-motor cortex as documented by the same methods. Composite data gleaned from the medical records were used to classify patients. Records typically included detailed information on neurological examinations, CAT scan findings, surgical intervention reports, and other diagnostic techniques including EEG and skull X-rays. All frontal lesions consisted of tissue destruction except for one patient who had the polar portion of the right temporal lobe surgically removed as part of excising a tumor. Posterior patients had parietal,

TABLE 1
DEMOGRAPHIC AND MEDICAL CHARACTERISTICS OF SUBJECTS

| | Frontal Brain Lesion | Posterior Brain Lesion | Controls |
|---|---|---|---|
| Demographic | | | |
| Mean Age | 41.2 yr. | 36.9 yr. | 31.8 yr. |
| Mean Education | 13.4 yr. | 13.0 yr. | 14.2 yr. |
| No. Right Handers | 7 of 10 | 8 of 10 | 8 of 10 |
| Sex Ratio | 9 males, 2 females | 6 males, 4 females | 4 males, 6 females |
| Race | 9 Caucasians, 1 other | 10 Caucasians | 10 Caucasians |
| Medical | | | |
| Injury | 3 CVA | 7 CVA | 2 Peripheral neuropathy |
| | 2 Tumors (2 meningiomas and 1 astrocytoma) | 0 Tumors | 1 Dystonia |
| | | | 3 Psychiatric disturbance |
| | 4 Traumatic head injuries | 3 Traumatic head injuries | 4 Normal volunteers |
| Chronicity of Lesion | 5 < 6 mo.<br>5 > 6 mo. | 4 < 6 mo.<br>6 > 6 mo. | |
| Lateralization of Lesion | | | |
| Right | 5 | 3 | |
| Left | 1 | 6 | |
| Bilateral | 4 | 1 | |

posterior temporal, and/or occipital brain lesions. In addition, 10 subjects (some with peripheral neurologic lesions, psychiatric disturbance, or attendants working in the hospital settings) were recruited from the same institutions to serve as controls. Given the relatively small size of the sample, an attempt was made to equate groups for age, education, sex, race, handedness, type and duration (acute versus chronic) of brain lesion, as well as lateralization of brain lesion. Table 1 summarizes the demographic and medical characteristics of these groups.

Groups did not differ significantly in age ($F = 1.15$, $df = 2/27$) or in education ($F = .51$, $df = 2/27$), but sex was not completely matched between the groups. Also, frontal patients tended to have a greater incidence of right and bilateral brain involvement than the posterior patients who tended to have primarily left-hemisphere lesions (none of these patients, however, were aphasic at the time of testing). These variables were taken into account in the data analysis.

Each subject was individually tested in the following manner. The subject was first shown and asked to read aloud eight sentences separately projected on a screen or blank wall. The sentences were:

1. Next time I am driving.
2. Where to, mister?
3. Happy Valentine's Day.
4. I love sipping soda from a straw.
5. You hum and I'll fake it.
6. Anything you can read I can read better.
7. My boss gave me too much to type
8. I can't last another round, I am a terrior, not a boxer.

Without warning, the subject was then asked to recall verbatim as many of the sentences as possible. This was the incidental learning procedure. If the subject could not recall all of the sentence, he was encouraged to recall bits and pieces of the sentences. Partial credit was given for each sentence as being 3/4, 1/2, or 1/4 correctly recalled.

Second, the subject was shown eight separate humorous pictures with one of the preceding sentences as a caption to each picture.[4] The pictures and sentences were again projected on the blank wall or screen (in the order listed above), and the subject was asked to look at the picture and read aloud the sentence that went with it. Immediately after this, the subject was asked again to freely recall the eight sentences or parts of them. The same scoring procedures were used. This was the humor-evoked response procedure.

Third, the subject was then shown the eight pictures, one at a time without the sentences present. While looking at the pictures, the subject

[4]Copies of the pictures are available upon request. They depicted animals carrying on humanoid activities corresponding to the sentence it was paired with. For example, the picture that went with the sentence "My boss gave me too much to type" was a picture of a cocker spaniel with glasses, slumped over a typewriter.

was asked to recall the sentence that was associated with it. This was the visually-cued memory procedure.

It should be noted that the humor response trial was designed to evoke some type of humor response or reaction in patients and controls. While no specific measure was taken of this dimension, it generally appeared that subjects were, at least in part, amused by the condition. Several smiled, laughed, or commented about the humorous quality of the stimuli. The pictures and captions were chosen so that no "high degree" of abstraction was necessary in order to evoke a humorous reaction in these patients and controls.

After the three experimental trials were administered, the subjects were read two short narratives: "The King Story" and the "Cowboy Story" used by Wechsler (1973) and asked to recall as much of each story as possible. The stories were presented in counterbalanced order and subjects' recollections scored. Each story is equated on degree of difficulty, having 20 scorable ideas apiece. The "King Story," however, is considered an emotionally charged story for neurological patients and the second to be neutral. Memory performance on these stories was used to assess short-term verbal memory capacity.

It should be noted that subjects were forced to read the sentences aloud prior to the incidental memory condition and the humor-evoked condition *to ensure* that both the posterior and frontal subjects attended equally to the stimulus. Also, this made it clear that all subjects had sufficiently good vision and language skills to read the sentences aloud correctly. They also had sufficient auditory and language skills to listen to the stories read to them and to attempt recalling them.

## Results

An analysis of variance was performed on the recall of the sentences for the three groups (frontal brain lesion versus posterior brain lesion versus controls) over the three memory conditions (incidental learning versus humor versus visual cuing). A $3 \times 3$ analysis indicated significant differences among lesioned groups ($F = 21.8$, $df = 2/27$, $p < .001$), also over memory conditions ($F = 73.3$, $df = 2/54$, $p < .001$), and a moderate interaction ($F = 3.20$, $df = 4/54$, $p = .01$).

One-way analyses of variance were then conducted for each memory condition and differences between groups tested by Duncan's multiple-range test. Using an alpha level of .05, the frontal and posterior patients did not significantly differ from one another on the incidental learning condition. Comparable attention to stimulus materials was apparently achieved. Both groups, however, were significantly inferior to controls.

By contrast, all lesion groups significantly differed from each other in their recall of sentences on the humor-evoked trials. As predicted, subjects with frontal lesions performed significantly worse than those with posterior

damage. However, those with posterior damage were also significantly worse than controls. On the other hand, during the visually cued memory task, subjects with posterior damage and controls performed similarly, while patients with frontal lesions were significantly worse. Thus, frontally damaged subjects showed the worst performance of all groups in this condition as well as on the humor-evoked condition.

Since it might be argued that these findings are attributed not to the region of the lesion, but size of the brain lesion, a further analysis was done. All bilaterally lesioned patients were excluded from data analysis. Unilateral frontal ($n = 6$) and unilateral posterior ($n = 9$) patients were compared to one another and controls ($n = 10$). The same effects previously found were observed when bilateral patients were excluded from the data analysis. Findings of the Duncan's multiple-range test for these data are listed in Table 2.

Also, since side of lesion might conceivably influence results, two additional analyses were done. Unilateral right ($n = 5$) versus unilateral left ($n = 1$) frontal lesions were compared on the three memory trials. Side of lesion did not influence results. There was no group (i.e., lesion side) effect ($F = 0.52$, $df = 1/4$, $p = .51$) or interaction of group $\times$ memory condition ($F = .09$, $df = 1/8$, $p = .91$). Of course, there was the expected effect of memory condition ($F = 9.29$, $df = 2/4$, $p = .008$). A second analysis comparing unilateral right ($n = 6$) posterior lesions gave virtually the same findings. The effect of group ($F = 2.06$, $df = 1/7$, $p = .19$) and interaction of group by memory condition ($F = .62$, $df = 2/14$, $p = .55$) were nonsignificant. The memory condition was significant ($F = 23.97$, $df = 2/7$, $p < .001$).

The possible confounding effects of age and education were ruled out by correlating these variables with the scores on the three memory conditions. The obtained correlations were: age versus incidental learning, —.21, age versus

TABLE 2

DUNCAN MULTIPLE-RANGE TEST FINDINGS WHEN BILATERAL LESION PATIENTS ARE REMOVED FROM DATA ANALYSIS

| Condition | Group | Correct | |
|---|---|---|---|
| Incidental Learning | Controls | 4.8 | A* |
| | Posteriors | 2.7 | B |
| | Anteriors | 1.4 | B |
| Humor | Controls | 6.7 | A |
| | Posteriors | 5.2 | B |
| | Anteriors | 2.4 | C |
| Visual Cues | Controls | 7.1 | A |
| | Posteriors | 6.6 | A |
| | Anteriors | 4.2 | B |

*Means having the same letter reflect no between-group differences at $p = .05$; means having different letters beside them reflect significant differences at $p = .05$.

humor-evoked condition, —.32, age versus visually cued condition, .24, education versus humor-evoked condition, .10, education versus visually cued condition, .004. None of these correlations were significant ($p < .05$).

To assess the possible importance of chronicity of the lesion, the patients were classified as having acute ($n = 9$) or chronic ($n = 11$) brain lesions. Acute brain lesions were defined as those being less than 6 months old; a chronic lesion was deined as being 6 months or greater in duration. The effects of chronicity on sentence recall were assessed by three, one-way analyses of variance. There were no significant effects on incidental memory ($F = .15$, $df = 1/18$), memory during the humor-evoked condition ($F = .12$, $df = 1/18$), or the visually cued condition ($F = .18$, $df = 1/18$).

Laterality of brain lesion *per se* did not exert a significant effect on recall of sentences over the three memory conditions. Right ($n = 8$), left ($n = 7$), and bilateral ($n = 5$) brain-lesioned patients were again comparable over the three-sentences memory condition. There was no effect on incidental memory ($F = .58$, $df = 2/17$), humor-evoked condition ($F = 1.63$, $df = 2/17$), or the visual cued condition ($F = .17$, $df = 2/17$).

Also, type of brain lesion did not influence test results. Patients with CVA and tumors ($n = 13$) versus traumatic head injuries ($n = 7$) were compared over the three memory trials. Again, there was no incidental memory effect ($F = .28$, $df = 1/18$), humor-evoked effect ($F = .02$, $df = 1/18$), or visually cued effect ($F = .04$, $df = 1/18$) when the data were analyzed in this way. Because numbers of males and females in the patient group were unequal (fewer females) no adequate comparisons according to sex could be established.

In contrast to the significant differences between frontal and posterior brain-lesioned patients in sentence memory during humor and visually cued conditions, the recall of short narratives read to patients indicated no significant differences. A 3 × 3 analysis of variance (frontal versus posterior versus controls × King Story versus Cowboy Story) yielded no main effect of group ($F = .99$, $df = 2/26$), or story ($F = .88$, $df = 1/26$), and no interaction ($F = .64$, $df = 2/26$). The mean score for the King Story was 12.89 and for the Cowboy Story was 13.48. These scores are quite similar to what Wechsler (1973) reported for psychiatric and neurological control subjects but are higher than the norms for brain-damaged patients.

## Discussion

The results of this study are clear-cut. All brain-lesioned groups were inferior to controls in retaining incidental information and recalling sentences in the humor-evoked condition. However, in the present study, the frontal group was significantly more impaired on the humor trial and was the *only* group defective when visual cueing was instituted. This held when bilaterally or unilaterally lesioned patienrs were studied. These results were also inde-

pendent of age, education, type of lesion, or whether the right or the left hemispheres were primarily involved.

Thus, the findings obtained in the current study support in part the hypothesis which initiated the study. The impairment of patients with frontal lesions on the humor-cued tasks is not completely location-specific. Patients with posterior lesions were also inferior to controls on the humor condition. Frontals, however, showed the worst performance of all groups.

The more marked failure of the frontal patients cannot be simply attributed to defective operation of the retrieval process since failure was not alleviated by pictorial cueing. There remains, therefore, the possibility that associative learning through pictorial reinforcement of any sort (devoid of any special feeling) might produce the results obtained in the experiment (Paivio, 1971). This possibility is made more likely by the failure to find the frontally lesioned group defective on the "King Story" which is considered to be more emotionally charged than the "Cowboy Story." Thus, the possibility that frontal lesions interfere with associative learning through pictorial reinforcements needs to be further explored.

Alternatively, the difference between the effects on memory of evoking humor versus other feeling states needs to be examined. The failure to find group differences in recall of stories indicates that verbal memory is intact in these patients. Furthermore, the failure to find differences between the frontal and posterior lesioned groups in the incidental memory condition for recall of sentences indicates that attentional and short-term memory processers were not selectively influenced by the frontal lesions. What then might be the basis for the selective defect shown by patients with frontal lesions in the pictorially cued humor condition?

An answer to this question comes from the analysis of humor provided by Arthur Koestler (1964), who suggests that humor occurs when two frames of reference, two contexts, become suddenly associated. He calls this "bisociation." As noted in the introduction to this paper, the frontal cortex of human and non-human primates has been shown to be related to a type of memory processing in which "episodes" become constructed through association (bisociation?) and that the memory is therefore episode- and context-specific. Further, frontal lesions in man and monkey have been shown drastically to impair the visceroautonomic components of the orienting reaction to novelty (Luria, Pribram, & Homskaya, 1964; Kimble, Bagshaw, & Pribram, 1965), and this is assumed to account for the failure in habituation of the behavioral components of orienting in the same subjects. Could this impaired visceroautonomic reactivity-impaired arousal (Pribram & McGuinness, 1975) account not only for defective habituation, but also for the impaired associative (episodic) learning (pictorially cued humor recall) found in the present experiment? If so, the frontal associative (bisociative) impairment seen in

the current study can be attributed to defective emotional arousal—a specific, brief, phasic visceroautonomic response to humor to be distinguished from other feeling states (Pribram & McGuinness, 1975).

The findings of the present study also have some practical implications. Since patients with frontal lesions appear to be impaired in effectively using what would ordinarily be "arousing" cues to enhance memory, rehabilitation approaches with these patients will have to be significantly different from traditional methods. Expecting such patients to use visceroautonomically arousing cues to aid encoding and retrieval of information and thereby modify behavior is unrealistic in light of their neuropsychological deficits. In contrast, work with patients who have primarily posterior cerebral lesions might well be more efficient if tasks exploited their intact arousal-memory bond, as was done in the present experiments by using pictorial cues. Such patients potentially could be helped to remember information when arousing stimuli are used as retrieval cues.

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