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ROLE OF THE FRONTAL LOBES ON AN ATTENTION TASK: A SIGNAL DETECTION ANALYSIS[1]

DARIO SALMASO AND GIANFRANCO DENES
Istituto di Psicologia del C.N.R. and Clinica delle Malattie Nervose e Mentali dell' Università di Padova

Summary.—Sensitivity and criterion were studied on an attention task requiring detection of new stimuli for a group of 20 patients with unilateral hemispheric damage restricted to the anterior or posterior areas. Patients performed a simple attention task, in which the presence of a novel stimulus had to be detected against the repetition of the same stimulus repeated. Only the site of the lesion (anterior vs posterior damage) influenced the performance of the task. In fact, frontal patients had both lower capacity to discriminate between signals and nonsignals and lower confidence in their responses.

Despite the great importance of attention in human behaviour, particularly for cognitive processes (Luria, 1973), very few studies considered how the two hemispheres work and how a local brain lesion affects this performance. Recently, it has been proposed that the two cerebral hemispheres hold two different attention systems: one, whose function is the sustained attention or vigilance, carried out by the right hemisphere, and the other, performed by the left hemisphere, whose task is a selective attentive performance (Dimond, 1978; Jerison, 1977). Today we have very few data to say when one or the other mechanism is involved and so to specify the different hemispheric mechanisms at work.

The use of the signal detection theory in research on sustained attention has made possible the distinction of two possible factors implied in an attention task, that is, sensitivity and criterion or response bias. Sensitivity refers to the subject's capacity to distinguish between signal and nonsignal events, while the criterion is an evaluation of the decision strategy or the degree of caution adopted in the experiment. Whether these factors have different neurological bases is not at present known, but many data are now available that show a difference in the behaviour of the two measures during sustained attention tasks; see reviews by Swets (1973, 1977). Some recent experiments (Salmaso, *et al.*, 1976; Salmaso, 1980) have also indicated that sensitivity and criterion may have a different hemispheric basis. It should be reasonable to expect that patients with unilateral damage will show different behavioural effects according to the side of the lesion. However, as suggested by Luria (1973) different areas of the brain may, for an attention task, hold different roles. In fact, although not directly implied in sensory processes, anterior areas seem to keep the main role every time a discrimination and a decision process are

[1]Address requests for reprints to Dr. Dario Salmaso, Istituto di Psicologia C.N.R., Via dei Monti Tiburtini 509, 00157 Roma, Italia.

necessary to respond correctly (Luria, 1973). Our aim was to see how the site and the side of the lesion might affect attention performance of brain-damaged patients and whether the same or a different pattern could be found between sensitivity and criterion.

METHOD

Twenty right-handed patients admitted to the Neurological and Neurosurgery Department of the University of Padua for evaluation of unilateral hemispheric damage of vascular origin served as subjects. They were further divided in four even-sized groups according to the side (right vs left) and the site (frontal vs temporal, parietal and occipital) of lesion. Etiology and location of lesion were assessed by clinical, neuroradiological, electroencephalographic, and Brain Scan data. Subjects' average age was 54.4 yr. ($SD = 7.4$), and no significant differences were observed among the four groups. Twelve patients, of comparable age, admitted to the same Department for lesions below the cervical spine, provided a control group.

Two tachistoscopic tests were presented to the patients, one with pairs of letters and the other with pairs of lines, as previously used with normal subjects (Salmaso, *et al.*, 1976; Salmaso, 1980). To prevent or reduce possible scanning effects, the two elements of both letter and line pairs were vertically arranged. One of these pairs was used as a nonsignal stimulus, the habituating one, and all the others as signals. Every pair was rear-projected on the centre of a grey translucent screen for 100 msec. Two sequences of 160 pairs were presented to every subject. In every sequence, divided in two equal periods, 32 stimuli were signals, for which an overt response was required, and the remainder were repeated presentations of the same pair. To make the test more sensitive to possible differences among the four groups, a very fast event rate (1 stimulus every 2 sec.) was used. When projected, the size of every stimulus was about 1×0.5. To habituate the subject every sequence began with the repeated presentation of the same pair (the nonsignal stimulus) and the task was to detect and report, by pressing a switch with the hand homolateral to the lesion, the presence of a novel stimulus. To see whether the relative superiority of each hemisphere to handle particular type of stimuli could also affect attention, each patient was tested with a letter and a line sequence. Half of the subjects began with the first one and the others with the second one. Before starting the patients received a brief training in which the maximum attention was given to the appropriate understanding of the instructions of the task. The performance was scored according to non-parametric estimates of sensitivity [$P(\bar{A})$] (McNichol, 1972) and criterion (false positive rates = FPR) (Richardson, 1972). The larger is the value of $P(\bar{A})$ the greater is the sensitivity of the subject. A larger FPR means a more liberal criterion in identifying the repetitive stimulus or that the observer is more willing to guess.

RESULTS AND DISCUSSION

The data of the controls and of the patients were analyzed by means of two analyses of variance, one for $P(\bar{A})$ and one for FPR. In both measures, no differences were proved in the control group for main factors or interactions. For the patient group only one important result reached significance. Both measures show a significant effect for the site of the lesion (anterior, posterior). On the $P(\bar{A})$ measure ($F = 6.73$, $df = 1/16$, $p < .025$) the patients with a posterior damage show greater sensitivity than anterior ones

TABLE 1

MEAN P(Ā) AND FPR FOR CONTROL, POSTERIOR AND ANTERIOR PATIENTS

Measures and Groups		Controls	Lesioned	
			Posteriors	Anteriors
N		12	10	10
P(Ā)	*M*	0.989	0.948	0.807
	SD	0.041	0.049	0.179
FPR	*M*	0.007	0.055	0.127
	SD	0.005	0.090	0.194

(0.948, $SD = .049$ vs 0.807, $SD = .179$). On the contrary, the FPR measure shows that the criterion adopted by the anteriorly damaged is larger than that used by posterior ones ($F = 5.83$, $df = 1/16$, $p < .05$; 0.127, $SD = .194$ vs 0.055, $SD = .09$). Both results, together with those of control patients, are summarized in Table 1. No effect of hemispheric damage and no interaction of hemisphere by material were found. Also, in the first and in the second period, the performance of the patients was the same.

As suggested by previous works (Dimond, 1977; Salmaso, *et al.*, 1976; Salmaso, 1980), it was expected that the side of the lesion would have the major effect for performance on this task. On the contrary, the damaged hemisphere seems not to have as much importance as the site of the lesion. The relative superiority of each hemisphere for a particular kind of process did not modify performance on this attention task. The absence of any interaction between side and site eliminates the possibility of using hemispheric findings and theories to explain such differences.

It seems to us that the only way to discuss the data may be found in the work of Luria and Homskaya (1970) concerning the role of frontal lobes in the control of the orienting reactions. The part played by these structures in an attention task is an active one, with a fine control of the arousal level, perhaps tonic and phasic, making possible the discrimination and selection of the incoming stimuli, that is, an appropriate level of sensitivity. Given the lesion that may increase the neurological noise (Gregory, 1959) and perhaps, the experimental situation that would produce habituation to nonsignal events (Mackworth, 1969), the ability of the subject to detect the signals from noise is diminished. However, this effect seems to depend only on the anterior structures, because the sensitivity of the posterior brain-damaged patients is quite similar to that of the control group (0.948 vs 0.989).

This hypothesis seems also confirmed by the FPR results. The anterior patients use a more liberal criterion to decide if a novel stimulus has been presented, that is, their responses have a lower confidence than those of the posteriors. This is the similar pattern reported by Luria (1973) with frontal

patients for whom a greater number of responses to irrelevant stimuli than by any other kind of patient were recorded. In this experiment, the false positive responses are responses given to the habituating stimulus or nonsignal event, which did not require a response, or better, they are misclassifications of the same stimulus repeated. We may therefore conclude that anterior parts of the brain are directly implicated in the information-processing analyses requested by an apparently simple task like detection of novelty. This result could appear a bit puzzling since the cortical analysis of the incoming information is made in the posterior parts of the brain. It must be, however, remembered that recently another work by Capitani, *et al.* (1978) showed that a frontal lesion could impair colour discrimination much more than occipital lesions. Unfortunately, no other experimental data, except those obtained from brain-damaged patients, are today available to help verify the role of the frontal lobes in attention tasks. Nothing else may be said now about the specific role of the frontal areas on the mechanisms involved in tasks of sustained attention.

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