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

Dario Salmaso and Gianfranco Denes

Fifth INS European Conference :
Deauville, June 15-18 1982

Istituto di Psicologia del CNR
Via dei Monti Tiburtini 509
00157 Roma - ITALY

Clinica Neurologica dell'Universita' di Padova
Via Giustiniani
35100 Padova - ITALY

Abstract :

Sensitivity and criterion were studied in a novelty attention task, for a group of patients with unilateral brain damage, restricted to the anterior or posterior areas. It was found that only the site of the lesion had influence on the performance of the task. In fact frontal patients had both a lower capacity to discriminate between signals and nonsignals and a lower confidence of their responses.

Introduction

Despite the great importance of attention in human behaviour, particularly for cognitive processes [1], very few studies have been made to see how the two hemispheres work and how a local brain lesion affects this performance. Recently, it has been proposed that the two cerebral hemipsheres 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 attention performance [2, 3]. 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 (S.D.T.) in sustained attention researches, has made possible the distinction of two possible factors implied in an attention task, that is, the sensitivity and criterion, or response bias. Whether these factors have different neurological bases it is not at present known, but many data are now available that show a difference between the behaviour of the two measures in sustained attention tasks (see reviews in Swets [4, 5]. Some recent experiments [6, 7] have also proved that sensitivity and criterion may have a different hemispheric basis. So, it is reasonable to expect that patients with unilateral damage will show different behaviour effects according to the side of the lesion. However, as suggested by Luria [1] different zones of the brain may, in 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 necessary to respond correctly [1].

Then 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

Subjects

Twenty patients of the Neurological and Neurosurgery Department of the University of Padua were tested. All the subjects had unilateral cortical damage (left or right) restricted to the anterior (frontal areas) or posterior (temporal, parietal, and occipital areas) parts of the brain, as assessed by clinical, neuroradiological, electroencephalographic and Brain Scan data. Their average age was 54.4 and no differences were proved among the four groups. Twelve patients, of comparable age, admitted to the same Department for a lesion below the cervical spine, were also used as controls.

Procedure

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 people [6,7]. In order to prevent or to reduce possible scanning effects, the two elements of both letter and line pairs, were vertically arranged. One of these pairs was used as non-signal 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 remainders were repeated presentations of the same pair. In order to make the test more sensitive to possible differences among the four groups, a very fast event rate (1 stimulus every 2 seconds) was used.

When projected, the size of every stimulus was about 1x0.5 degrees. To habituate the subject every sequence began with the repeated presentation of the same pair and the task was to detect and report, by pressing a switch, the presence of a novel stimulus. In order to see whether the relative superiority of each hemisphere to handle particular type of stimuli could also affect attention performance, each patient was tested with a letter sequence 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 and 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 [$P(\bar{A})$] and criterion [FPR] [9].

Results

The data of the controls and of the patients were analysed by means of two analyses of variance, one for $P(\bar{A})$ and one for FPR. No differences were proved in the control group, for the two measures, in the main factors or in the interactions.

For the patient group only one important result was found to reach significance. Both measures show a significant effect for the site of the lesion (anterior, posterior). In the $P(\bar{A})$ measure [$F(1,16)$

= 6.731; P<.025) the patients with a posterior damage have a greater sensitivity than the anterior (0.948 vs 0.807). On the contrary, the FPR measure shows that the criterion adopted by the anteriors is larger than that used by posteriors [F(1,16)=5.833; P<.05](0.127 vs 0.054). Both results, together with those of control patients, are printed in the Table 1. No effect of hemisphere damage and no interaction "hemisphere by material" was found. Also, in the first and in the second period the performance of the patients was the same.

DISCUSSION

As suggested by previous works [6,7,10] it was expected that the side of the lesion would have the major effect in this task. On the contrary, the damaged hemisphere seems not to have as much importance as the site of the lesion and the relative superiority of each hemisphere for a particular kind of process does not modify the performance on this attention task. So, the absence of any interaction between side and site eliminates the possibility to use hemispheric findings and theories to explain such differences.

It seems to us that the only way to discuss the data comes along with the work of Luria and Homskaya [11] on the role of the 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. Due to the lesion, that may increase the neurological noise [12] and perhaps, to the experimental situation, that would cause an habituation to nonsignals

events [13], 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 [1] with frontal patients, where a greater number of responses to irrelevant stimuli than any other type of patient was recorded. In this experiment, the false positive responses are responses given to the habituating stimulus, or nonsignals events, which did not require a response, or better, they are misclassifications of the same repeated stimulus. We can therefore conclude that the anterior parts of the brain are directly implicated in the information processing analyses requested by an apparently simple task like a novelty detection. A similar pattern of results has recently been found by Shallice and Evans [14] in a Cognitive Estimation Task and by Capitani et al. [15] in a colour discrimination, despite that in the latter one a difference between left and right frontal patients was also proved. However, in both cases posterior patients perform better than anterior ones. Unfortunately, no other experimental data are today available showing a difference between the site of the lesion, irrespective of the side, and, of course, the relationship among areas of the same hemisphere cannot be studied that in brain damaged patients. So, nothing else may be said about the specific role of the frontal areas as compared to that of the others and, in particular, about the mecha-

nisms by which human beings respond to new stimuli and do not respond to the old ones.

TABLE 1 : $P(\bar{A})$ and FPR for control, posterior and anterior patients.

	Controls	Posteriors	Anteriors
$P(\bar{A})$	0.989	0.948	0.807
FPR	0.007	0.054	0.127

References

1. Luria, A.R. The working brain. Penguin Books. Harmondsworth, 1973.
2. Dimond, S.J. Disconnection and psychopathology. In Hemisphere asymmetries of function and psychopathology, J.H. Gruzelier and P. Flor-Henry (Eds). Charing Cross Hospital Medical school, 1978.
3. Jerison, H.J. Vigilance: biology, psychology, theory and practice. In Vigilance, R.R. Mackie (Ed). Nato Conference Series, Plenum Press, 1977.
4. Swets, J.A. The relative operating characteristic in psychology. Science, 182, 990-1000. 1973.
5. Swets, J.A. Signal Detection Theory applied to vigilance. In Vigilance, R.R. Mackie (Ed), Nato Conference Series, Plenum Press, 1977.
6. Salmaso, D., Denes, G., De Stavola, G. Interhemispheric differences in attention to novelty. It. J. Psychol., 3, 273-283, 1976.
7. Salmaso, D. Hemispheric differences in a novelty attention task. Not published,. 1979.
8. McNichol, D. A primer of signal detection theory. George Allen and Unwin, London, 1972.
9. Richardson, J.T.G. Nonparametric indexes of sensitivity and response bias. Psychol. Bull., 78, 429-432, 1972.
10. Dimond, S.J. Vigilance and split-brain research. In Vigilance, R. R. Mackie (Ed). Nato Conference Series, Plenum Press, 1977.
11. Luria, A.R., Homskaya, E.D. Frontal lobes and the regulation of arousal processes. In Attention: contemporary theory and analysis D.I. Mostofsky (Ed). Appleton Century Crofts, New York, 1970.
12. Gregory, R.L. Increase in neurological noise as a factor in aging.

Proceedings of the Fourth International Congress on Gerontology, 1959.

13. Mackworth, J.F. Vigilance and habituation. Penguin Books, Harmondsworth, 1969.

14. Shallice, T., Evans, M.E. The involvement of the frontal lobes in cognitive estimation. Cortex, 14, 294-303, 1978.

15. Capitani, E., Scotti, G., Spinnler, H. Colour imperception in patients with focal excisions of the cerebral hemispheres. Neuropsychologia, 16, 491-496, 1978.

Resume' :

Ce travail a ete consacré a l'étude de la "sensitivity" et des "criteria" par lesquels un groupe de malades avec de lésions unilatérales cerebrales, limitées a la partie antérieure ou postérieure, ont réagi pendant la tâche qui leur fut donnée de prêter attention à la nouveauté. Les resultats demontrent que seulement la position de la lésion a une influence sur la performance de la tâche: les malades avec une lésion frontale se révélèrent soit moins capables de discerner entre signaux et non-signaux, soit ayants moins de confiance dans leurs reponses.

Zusammenfassung :

In einer Gruppe von Patienten mit einseitiger Hirnschadigung, in anterialen oder posterrialen Bereich, wurden. Sensitivitat und Kriterium in einer Aufmerksamskeitaufgabe untersucht. Dabei wurde herausgefunden, dass nur die Lage der Lesion auf die Ausfuhrung der Aufgabe einen Einfluss hat. Patienten mit frontalen Lesionen zeigten eine geschwachte Fahigkeit zwischen Signalen und nicht-Signalen zu unterscheiden und sie zeigten eine verringerte Sicherheit in ihren Antworten.