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INTERHEMISPHERIC DIFFERENCES IN ATTENTION TO NOVELTY

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Riassunto. Scopo del presente lavoro era quello di determinare il ruolo giocato da ciascun emisfero in un compito di attenzione alla novità, quando lettere e linee sono presentate tachistoscopicamente al campo visivo destro e a quello sinistro. Ventiquattro soggetti destrimani hanno partecipato all'esperimento. La prestazione del soggetto era misurata sulla base dei due tipi di errori possibili: errori falsi negativi e falsi positivi. Indipendentemente dal materiale usato il totale degli errori falsi negativi era maggiore per l'emisfero destro (RH). Per poter separare la componente sensitiva e la componente decisionale della prestazione finale di ciascun soggetto, i dati sono stati anche analizzati sulla base della Signal Detection Theory (SDT). Il parametro d' è maggiore per l'emisfero sinistro nella presentazione verbale e per il destro nella presentazione di linee. Per il parametro ß esiste una differenza tra i due emisferi, in favore dell'emisfero destro, solo per il materiale verbale. I risultati sono discussi sulla base delle conoscenze sulla specializzazione emisferica.

INTRODUCTION

In spite of the frequent occurence of severe attentional disturbances following brain damage, the role of each hemisphere on tasks of sustained attention has not been completely clarified.

According to Broadbent (1952) attentional mechanisms can be seen in the light of hemispheric specialization so that, for example, verbal stimuli presented to the right hemisphere are not attended.

On the contrary, according to Kinsbourne (1970, 1972) hemispheric asymmetry in specific tasks, as superior performance of the left hemisphere in processing visual verbal stimuli, is subdued by a corresponding lateral difference in attention: the previous knowledge of the specific nature of the stimulus which is to be processed would determine a preparatory activation: it follows that when the subject is perceiving visual verbal stimuli, the left hemisphere is in a state of sustained attention in respect to the controlateral hemisphere. Berlucchi *et al.* (1974) in an experiment using random presentation of visual verbal and non verbal stimuli (letters and faces) to a single visual field failed, however, to confirm Kinsbourne's data.

As far as the auditory modality is concerned Matsumiya *et al.*

(1972) using evoked potentials, showed a left hemisphere activation prior to the processing of linguistic stimuli, due to the waiting of incoming stimuli.

In a series of works Dimond and Beaumont (1971, 1973, 1974) postulated the existence of two different vigilance systems: a primary vigilance whose main feature consists of a high initial performance followed by a rapid decrement and carried out by the left hemisphere. Conversely a second system characterized by a low but steady level of vigilance; a function of the right hemisphere. Attention would consist of an interaction of these two mechanisms, so that the right hemisphere represents « a skeleton service in vigilance, a minimum service capable of maintaining performance after decrement occurs at the left hemisphere ». The stimuli used by the latter authors were non verbal consisting of variations of brightening of signal lights directed to a single visual field.

The aim of our works is to identify the part played by each hemisphere in a task of attention to novelty, when verbal and non verbal stimuli are presented tachistoscopically.

Since the final performance of a given subject in a task of this type could be due to sensitive components or to decisional criteria, an analysis of the data according to the Signal Detection Theory (SDT) was made, in order to split sensitivity and decisional components of the performance.

Such technique has been previously used by White (1970) in a study where Ss were required to decide whether or not a probe letter was in each trial display and to rate the decision on a five point confidence scale. White's study failed to report differences in sensitivity (d′) between the left and the right visual field.

MATERIAL AND METHODS

Subjects.

Twenty-four right handed students (6 male, 18 female) ranging in age from 18 to 25 years partecipated in the experiment on a voluntary basis.

All of them had normal visual acuity.

Strength of handedness was assessed by their performance on a hand preference inventory (Oldfield, 1971), from which an index of handedness (IH) in the form of group preference scores was obtained. The mean IH of our subjects was 0.733.

Stimuli.

There were two types of stimuli, verbal and non verbal. Verbal stimuli consisted of eight couples of consonants presented in a vertical arrangement in order to prevent scanning effects.

As non-verbal material we used directional stimuli consisting of twelve pairs of lines: each line of every couple had one of the four possible orientations: horizontal, left oblique (45°), vertical, right oblique (45°).

Figure 1 shows the stimuli used in the present experiment.

Q Z	P H	M F	R N
T L	G V	B K	C S

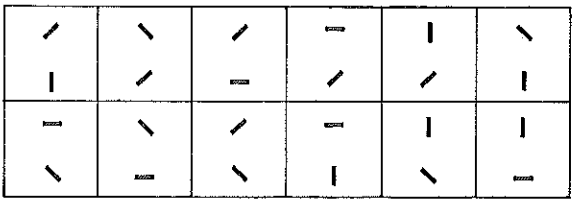

Fig. 1. Verbal and directional stimuli used in the present experiment.

We made four sequences, two composed of verbal stimuli and two of directional stimuli. In each sequence, comprising fifty slides, twenty five images were novel and the remainder were repeat presentations of one image. The first eight slides of every sequence were a repeat presentation in order to habituate the subject to the target stimulus.

Apparatus.

A modified version of a commercial Kodak Carousel slide projector was used; the lens was equipped with a photographic shutter operated by means of an electromagnet. An electronic device permits variations of exposure duration within a range of 10 msec.-1 sec. The stimuli were projected from the rear of a translucent screen 40×40 cm., nine angular degrees to the right or to the left of, and on a level with, a central fixation dot.

During testing the subject was seated in front of the screen with the head positioned by a head and chin rest at a distance of fifty cm. One eye was occluded by a mask.

Stimuli presented to the right visual field were directed to the left hemisphere by the left temporal hemiretina, the right eye being masked. On the contrary stimuli presented to the left visual field were directed to the right hemisphere by the right temporal hemiretina, the left eye being masked.

An acoustic signal prompted the subject to fixate on the central mark. One second after the warning signal a stimulus was projected for 10 msec. The interstimulus interval was 2 sec.

Procedure.

The task was a « go-no go » discrimination: the subject was instructed to press a key with his right index finger only when he was sure that he had seen a new stimulus and not to press the key in correspondence of an old stimulus.

The order of presentation of the four sequences was balanced according to a Latin square design. Therefore none of our subjects received two sequences successively to the same hemisphere.

Conventional methods of scoring are based on the total number of correct answers, without taking into account the qualitative aspect of a defective performance: in a task like that required in our experiment an error can be due either to a lack of detection of a new stimulus or through considering an old stimulus as a new one.

In order to avoid this bias, performance was scored according to type of errors: « false positive errors » meant identifying the repeat as new; « false negative errors » meant a failure to identify a new stimulus.

Furthermore in order to separate the sensitive aspects and the decisional criteria, an analysis according to Signal Detection Theory (SDT) was made. This technique has been recently applied to neuropsychological studies (Banks, 1970; Lockhart and Murdock, 1970; Broocks, 1974) with promising results.

The starting point of every experimental condition viewed on the basis of SDT is the construction of a decisional matrix. The total number of responses (R) given by the subject is divided into two parts, which, according to SDT, are called « H » and « FA ». H means « hit » and refers to the number of a new stimuli correctly identified. FA means « false alarm » and refers to the number of old not identified stimuli or commissions.

The number of new not identified stimuli are called « M », « miss » or omissions.

The sum of old stimuli correctly identified is known as CR (correct rejection).

A decisional matrix can be easily drawn as follows:

Observers' decision		Identity of the stimulus: new	old	
Answer	New present	H	FA	R
	New absent	M	CR	50-R
				50

The four cells of the decisional matrix can be summarized in two values: P(Y/o) or HR: meaning the proportion of new items correctly identified, and P(Y/n) or FAR meaning the proportion of times that the new item is reported when the new item is not present.

The measure of the subject sensibility (d′) and his decision criteria (β) can be obtained starting from the knowledge of HR and FAR, and using Hocchhaus's formulas (1972) and Elliot's tables (1964).

RESULTS

False negative and false positive errors.

In the verbal task (VS) the mean of false negative errors is greater for the right hemisphere (RH): 3.166 vs 0.750.

On the contrary, in the directional task (DS), the mean of false negative errors is greater for the left hemisphere (LH): 0.750 vs. 1.792.

The means of false negative errors (FNE) and standard deviation (SD) for the two types of task are summarized in the following table:

	RH	LH	DIFFERENCE
VS	3.166 (2.477)	0.750 (1.450)	2.416
DS	0.750 (1.127)	1.792 (1.779)	−1.042

An analysis of variance, using a two factor repeated-measurement design (Lindquist, 1953) showed a significant interaction between type of material and hemisphere ($F=17.2867$; d.f.$=1,23$; $p<0.001$).

The difference between the means for the two hemispheres, using a two tailed t-test, proved to be highly significant: for the verbal task, $t=4.488$ ($P<0.001$); for the directional task, $t=2.347$ ($P<0.05$).

Seventeen of our 24 subjects showed, irrespective of the type of material, a number of false negative errors greater for the RH. A Sign Test for paired observations applied to these results showed that a significantly larger proportion of subjects had inferior detection of a new stimulus in the RH ($Z=2.041$; $p<0.05$).

In the verbal task the mean of false positive errors is greater for the RH: 2.458 vs. 1.291.

In the directional task the mean of false positive errors is greater for the LH: 1.250 vs. 2.125.

The means of false positive errors (FPE) and SD for the two types of tasks are summarized in the following table:

	RH	LH	DIFFERENCE
VS	2.458 (3.905)	1.291 (1.670)	1.167
DS	1.250 (2.385)	2.125 (3.358)	−0.875

An analysis of variance showed that neither hemisphere, nor material, nor the interaction between hemisphere and material had any significant effect on false positive errors.

Two t-test for correlated scores confirmed that there was no significant difference in number of errors between left and right hemisphere: for the verbal task, $t=1.012$ ($p=0.2$); for the directional task, $t=1.021$ ($p=0.2$).

Figure 2 summarizes these results.

SDT analysis.

On the verbal task mean values for the d′ are 2.946 for the RH and 3.816 for the LH. In the directional task mean values for d′ are 3.841 for the RH and 3.302 for the LH.

The following table summarizes these results, according to hemisphere and type of task:

	RH	LH	DIFFERENCE
VS	2.946	3.816	−0.87
DS	3.841	3.302	0.539

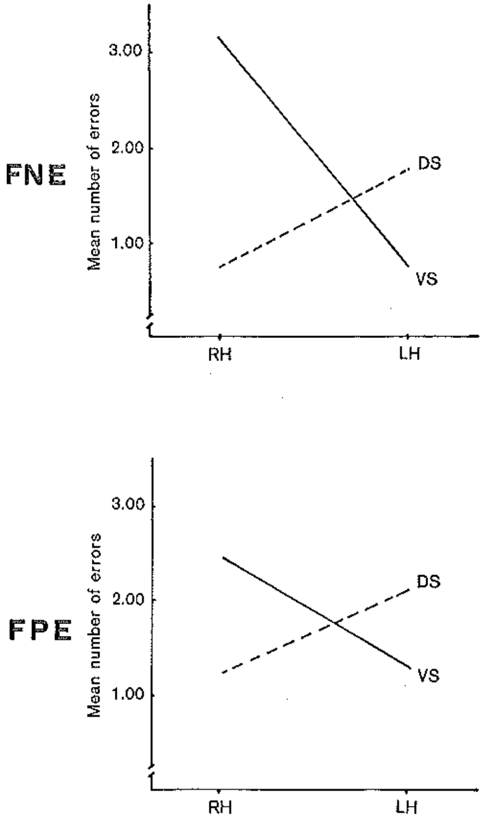

Fig. 2. Mean values of false negative errors (FNE) and of false positive errors (FPE).
(Abbreviations: RH = right hemisphere; LH = left hemisphere; VS = verbal stimuli; DS = directional stimuli).

An analysis of variance showed a highly significant interaction between the type material and hemisphere ($F=22.9836$; $d.f.=1,23$); $p<0.001$). Two t-test (two tailed) for correlated scores showed significant differences of the mean valued both for verbal ($t=3.872$; $p<0.001$) and non verbal material ($t=2.161$; $p<0.05$).

On the verbal task the mean values for β are 2.944 for the RH and 1.563 for the LH. In the non verbal task the mean values for β are 1.488 for the RH and 2.259 for the LH.

The next table summarizes these results.

	RH	LH	DIFFERENCE
VS	2.944	1.563	1.581
DS	1.488	2.259	−0.771

An analysis of variance showed a significant interaction between type of material and hemisphere ($F=8.51$; d.f.$=1,23$; $p<0.01$).

A two tailed t-test for correlated scores failed however to show a significant difference for the mean value in non verbal task ($t=0.81$; $p=$n.s.).

For the verbal material $t=2.485$ ($p<0.05$).

Figure 3 summarizes these results.

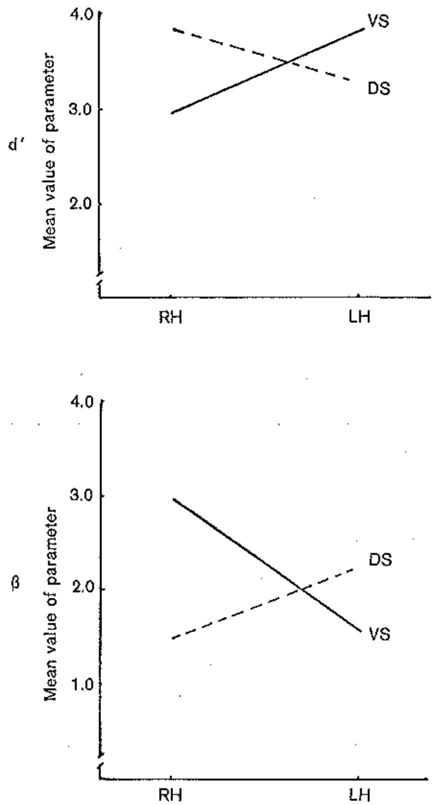

Fig. 3. Mean values of d′ and of β.
(Abbreviations: RH = right emisphere; LH = left hemisphere; VS = verbal stimuli; DS = directional stimuli).

DISCUSSION

The results show different hemispheric attentional mechanisms at work.

Irrespective of the type of material to be processed, the RH performs worse than the contralateral.

Considering the specific nature of the task which demands a relatively short period of sustained attention for every presented sequence, it seems reasonable to postulate, according to Dimond and Beaumont, that the major role should be played by a high performance vigilance system sustained mainly by the LH. However the shortness of every sequence failed to show a decrement of performance in relation to time.

Our research showed a clear cut superiority of the LH for the detection of verbal stimuli and of the RH for directional material.

Thus we can suppose that there is a difference between hemispheres even in the detectability of a new stimulus.

This does not agree with Kimura's studies (1969) which failed to demonstrate a difference between the hemispheres in the simple detection of a dot.

Worthy of note is the fact that our results showed a higher significance for verbal material over directional stimuli. Such results need to be interpreted with a certain caution.

It could be thought that directional stimuli used in the present experiment are easier, reaching in this way a « ceiling effect » which does not allow any interhemispheric difference to show. Such an hypothesis however can be easily ruled out because there is a significant difference, although less than that for verbal material, in favour of the right hemisphere.

Another way to interpret our data derives from De Renzi's studies (1968) concerning non verbal memory and the studies of Umiltà *et al.* (1974) who postulated different cerebral mechanisms for the processing of non verbal stimuli: a system, carried out by the RH, working on a purely perceptive basis, and a system carried out by the LH, which tends to apply a verbal label to the stimuli. Such a system, however, in view of the strong non verbal nature of the material to be processed and the shortness of exposure time, does not reach the same level achieved by the RH.

As far as the type of errors is concerned some considerations are to be made.

False negative error means a lack of detection of a new stimulus, while a false positive error means a failure to recognize an old stimulus.

Our results showing a higher number of false negative errors by the LH for directional material, seem not to agree with Dimond and Beaumont (1973), who, on the contrary, showed a significantly higher rate of false positives by the RH.

Worthy of note however is the fact that Dimond and Beaumont rate a delayed answer as false positive.

In the analysis of false positive errors we did not find interhemispheric difference.

This is an important point of our experiment, because it rules out the possibility that the interhemispheric differences found in the present study are attributable to recognition factors.

The SDT analysis enables us to split the sensitivity and the decision criterion of both hemispheres.

The larger is the measure of sensitivity (d′), the greater is the discriminative process.

For the decision parameter (β), on the contrary, the larger it is, the stricter the criterion.

In our work d′ was found to be greater for the LH in the verbal task and for the RH in the directional material.

Our results indicate therefore that interhemispheric differences in the sensitivity or in the discriminative process, depend upon the type of material presented.

For the decision criterion there is a significant interhemispheric difference for verbal material, but not for non verbal stimuli.

Thus the criterion adopted by the RH seems to be more stringent in the verbal task, i.e., it is more « conservative » (Swets, 1973) in deciding to report the presence of a new stimulus.

The failure to reach significance in the non verbal task can be related to the less definite hemispheric dominance for the processing of such stimuli.

It follows that when stimuli can be analyzed by both hemispheres, the same decisional criteria can be adopted by both hemispheres, irrespective of the specific nature of the stimuli presented.

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Abstract. The goal of this study was do determine the part played by each hemisphere in a task of attention to novelty, when verbal and directional stimuli are presented tachistoscopically. Twenty-four normal right-handed students took part in the experiment. Performance was scored according to type of errors: false positive and false negative errors. The total of false negative errors was greater for right hemisphere presentations, regardless of the material used. In order to separate sensitivity (d') and decisional components (β) of the final performance, an analysis of the data according to the Signal Detection Theory was made. d' measure is greater for the left hemisphere in the verbal task and for right in the directional material. For β there is a significant interhemispheric difference, in the favour of the right hemisphere, only in the verbal material. These results are discussed in terms of reciprocal specializations of functions in the cerebral hemispheres.

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