

Fig. 1. EEG and chin EMG tracings of one subject before awakening from an REM period. Note the predominantly horizontal eye movement pattern (R, right; L, left; P, parietal; O, occipital).

significantly different from that of fourteen expected by chance ( $P=0.14$ ; one-tailed binomial test). A qualitative analysis of the data was also performed. Each of nine reports contained very clear descriptions of visual events occurring at the end of the dream which should have been associated with distinctive patterns of eye movement according to the "scanning hypothesis". Yet only three of these nine reports were matched correctly with their associated records. In all but one of the other six cases, the EOG pattern was totally inappropriate to the dream events. One subject, for example, stated that at the end of her dream she was looking at vertical rows of buttons from a distance of about 2 feet. When asked how she looked at them, she replied, "I was looking vertically", but the EOG record was almost entirely horizontal before awakening (Fig. 1). Alternate up-and-down vertical eye movements were absent throughout the entire REM period, so that the lack of a relation between the eye movements and dream imagery could not be ascribed to faulty memory of the time when the events occurred.

Our failure to confirm the findings of Roffwarg *et al.*<sup>4</sup>, when considered together with other data on the physiological characteristics of REMs<sup>7</sup>, casts doubt on the validity of the "scanning hypothesis". REMs can be present in the absence of visual imagery in the neonate<sup>8-12</sup> or decorticate human<sup>13</sup>, and visual imagery can be present in the absence of REMs during stages of non-REM sleep<sup>14-17</sup>. The patterns, frequencies, velocities and interval distributions of the REMs have been found to be remarkably constant in cat, monkey and man<sup>18-21</sup>, while visual imagery is highly variable from one REM period to another. Taking account of this, one of us has recently proposed the hypothesis that REMs represent the functional output of mechanisms maintaining the integrity of oculomotor control throughout sleep<sup>22</sup>.

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Received April 17; revised August 18, 1969.

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## Possible Basis for the Evolution of Lateral Specialization of the Human Brain

WORK carried out during the past few years with patients whose neocortical commissures have been surgically divided for the control of epilepsy has revealed an organizational differentiation of the hemispheres for perceptual and cognitive functions<sup>1,2</sup>.

There is evidence that the minor hemisphere possesses some minimal ability to express language<sup>3,4</sup>, but it is



difficult to observe because of competition from the major hemisphere for control of the motor mechanisms for the production of language. These interference effects support a rationale for the evolution of a unilateral control of language expression, namely that such lateralization was an adaptation permitting control of the unique vocal apparatus, uncomplicated by competitive antagonism between the hemispheres.

Separate testing of each hemisphere for its ability to visualize in three dimensions<sup>2</sup> showed that not only was the right, minor hemisphere superior to the left, but it apparently used a different strategy in solving the problems. While the left hemisphere seemed to analyse the stimulus properties, the right hemisphere seemed immediately to abstract the stimulus Gestalt—that is, as an integrated whole. It was as if the speaking hemisphere processed stimulus information in such a way that the stimulus could be described in language. Gestalt appreciation seemed to be actively counteracted by a strong analytic propensity in the language hemisphere. It is therefore not illogical to suppose that during the evolution of the hominids Gestalt perception may have lateralized into the mute hemisphere as a consequence of an antagonism between functions of language and perception.

If this idea is correct, it suggests that people with bilateral language centres or even with partial language competency in both hemispheres would perform relatively poorly in tests of perceptual function. To assess this possibility, ten left handed and fifteen right handed graduate science students at the California Institute of Technology were compared with each other on the verbal and performance scales of the Wechsler Adult Intelligence Scale (WAIS)<sup>4</sup>, for sinistrals are known to have less well differentiated hemispheres with respect to linguistic capacity than dextrals<sup>5</sup>. The WAIS was used as a measure because it has been shown that the verbal scale reflects major hemisphere abilities and the performance scale reveals what are usually minor hemisphere abilities<sup>6,7</sup>. Although graduate science students constitute a select population, there is no *a priori* reason for supposing them to reveal a differentiation between left handers and right handers which would not be present in the population at large.

The results of this comparison fully confirmed the initial idea. While the groups did not differ on verbal intelligence (IQ) quotient (left = 142, right = 138,  $P > 0.10$ ), there was a large difference on the performance scale (left = 117, right = 130,  $P < 0.002$ ). More remarkable than this difference in performance scores, however, was the difference between the two groups in their discrepancy scores, that is the difference between verbal and performance IQs. The dextrals had a discrepancy of eight IQ points, but the sinistrals a discrepancy of twenty-five IQ points. A difference this large between the groups would occur by chance less than twice in 10,000.

In summary, bilateral language capacity seems to interfere with abilities usually associated with the minor hemisphere. Whether it is the presence of language *per se*, or whether it is some pre-existing brain organization which permits the development of language which is responsible for disfavoring Gestalt apprehension could not be determined from this study. In either case, it is reasonable to conclude that, given a hemisphere laterally specialized for language, the evolution of lateralized perception can be accounted for by the foregoing interpretation.

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Received July 21, 1969.

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## Fluid Mechanics of the Mitral Valve

THE exploitation of trapped vortices and flow deceleration by the aortic valve to ensure maximum efficiency and to make possible laminar flow<sup>1,2</sup> suggests a similar mechanism for the atrio-ventricular valves. These are the inlet valves to the two ventricles, the mitral valve on the left side and the tricuspid valve on the right.

A model of the left ventricle was built, incorporating an aortic valve (A in Fig. 1) and a mitral valve. The ventricle was simulated by a transparent rubber diaphragm (B) which was alternately expanded and contracted by applying external forces to simulate muscular action. This simulation was carried out by placing the ventricle in a rigid 'Perspex' box (C) which was filled with water and connected by a tube (D) to a pulsatile pump<sup>3</sup>. The base of the ventricle (E in Fig. 2) was rigid, and incorporated both the mitral and aortic valves. The mitral valve consisted of a sleeve (F) of a flexible membrane of silicone rubber reinforced with nylon mesh 0.1 mm thick and of maximum length 30 mm. The sleeve was shaped like the physiological valve, with two major cusps which were connected by inextensible chordae tendineae (G) to a fixed support (H) 48 mm from the base of the ventricle (E). In the absence of forces the cusps (F) assumed a cylindrical shape with the chordae tendineae slack. In the physiological valve the chordae tendineae (also inextensible) are connected to the papillary muscles which prevent mitral valve inversion during ventricular contraction and may assist in valve opening and cusp positioning<sup>3</sup>. In the model valve the support points of the chordae tendineae remained at a fixed distance from the base of the ventricle so that they could prevent mitral valve inversion without the help of papillary muscles. They could not, however, assist in valve opening or positioning.

When the ventricle was pulsed, fluid was displaced from the ventricle, through the aortic valve (A), into a constant-head tank which discharged through a tube of 25 mm bore into the mitral valve. The mitral orifice and

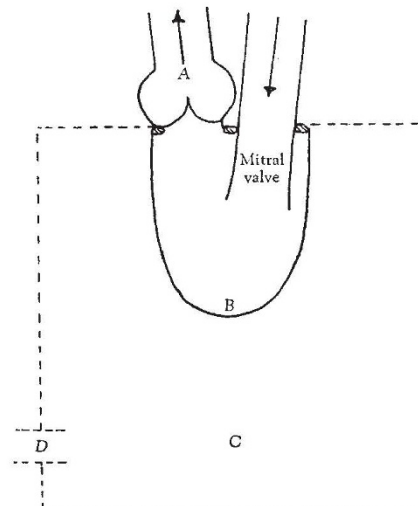


Fig. 1. Diagram for model of left ventricle, aortic and mitral valves.