Memory and Growth in the Superior Temporal Gyri

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SUMMARY: *The superior temporal gyri were measured in 33 infants and in 33 adults. In the adults, most right superior temporal gyri were larger. This asymmetry was not found in infants, a difference which suggests greater growth of the right superior temporal gyri in the population from which our sample was taken. The asymmetry may be related to the functional asymmetry found by Penfield: some of his patients reported re-experiencing of past sensory experiences with electrical stimulation of the temporal lobe. This response was more frequently evoked from the right hemisphere.*

RÉSUMÉ: *La circonvolution temporale supérieure fut mesurée chez 33 enfants et 33 adultes. Chez les adultes, la circonvolution temporale supérieure droite était plus grosse. Cette asymétrie n'était pas retrouvée chez les enfants, une différence qui suggère une plus grande croissance de cette circonvolution. L'asymétrie peut être reliée à une asymétrie fonctionnelle décrite par Penfield: quelques-uns de ses patients notaient une réexpérimentation d'expériences sensitives passées avec stimulation électrique du lobe temporal. Cette réponse était plus fréquemment évoquée à l'hémisphère droit.*

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INTRODUCTION

Penfield (1952) described patients who reported the re-experiencing of past sensory experiences when he stimulated the lateral part of a temporal lobe. This was not the normal experience of remembering, but rather of seeing and hearing past events vividly superimposed on the present reality of the operating room. The data collected by Penfield and Perot (1963) reveal a bias of this phenomenon toward the right hemisphere. Among 248 people who received stimuli to the right temporal lobe, 25 reported hearing sounds and seeing scenes from their past lives. Among 272 who received stimuli to the left temporal lobe, only 15 reported this experience. Most points where stimuli caused the "flashback" experience were on the lateral surface of the superior temporal gyrus, more often the right. In many human adults, the lateral surfaces of the superior temporal gyri measured by Hyde, Akesson and Berinstein (1973) were wider on the right. This asymmetry was not found in infants. Herewith is reported a second series of measurements, which also indicate the frequently asymmetrical growth of the superior temporal gyri in man.

Anatomical asymmetries may reflect the dominant role of the left hemisphere in verbal function. Cunningham (1892) noted the Sylvian fissure rising more steeply in the human right cerebral hemisphere. Connolly (1950) reported longer left Sylvian fissures in man. Geschwind and Levitsky (1968) described the planum temporale, the upper surface of the temporal lobe behind the auditory cortex, as being longer in the left hemisphere. Le May and Culebras (1972) found the upper end of the Sylvian fissure higher on the right in right-handed people. Witelson and Pallie (1973) found larger areas of the left planum temporale in human infants as well as in adults. Wada, Clarke and Ham (1975) confirmed the findings of Witelson and Pallie.

Language, despite its importance in man, may not require more brain tissue than the different, but equally important, cognitive functions usually resident in the right hemisphere. Penfield's evocation of past experiences is qualitatively the same in both hemispheres, but was found more often on the right. Perhaps the phenomenon is related to data storage in the brain. If data storage is associated with increases in the sizes and numbers of brain cells, asymmetrical growth of the superior temporal gyri may be associated with the asymmetry of response found by Penfield.

METHODS

The 33 infants in this study were less than 9 months old when they died. Like the 33 adults, they had no history of brain disorders. Handedness data were not available. The brains, fixed by suspension in 10% formalin, were free from disease changes and post-mortem distortion. There were no other criteria for selection. Sex was not used as a parameter of analysis.

After the leptomeninges had been removed, the brains were placed for photography in a rack that held the lateral extent of each superior temporal gyrus, and a 4 cm module, at the same distance from the camera. The module was used as a guide in enlargement. Thus the photographs, on which widths were measured, were made to represent the sizes of the gyri. As in our previous work, 50% of the pictures were reversed in printing. Each print, which contained the autopsy number of the brain, was given a random number (Fig. 1). The autopsy numbers were concealed, and prints were arranged in the order of their random numbers.

Our measurements were limited to the lateral surfaces of the superior temporal gyri in intact brains. Whereas this approach gives data for only one part of the gyrus, it eliminates biases that might be introduced by dissection. Moreover, most points at which electrical stimuli caused re-experiencing of past experiences were located on the lateral surface of the gyrus. Removal of biases resulting from observer expectations is especially important in a search for anatomical asymmetries of an order commensurate with the rather weak bias toward the right hemisphere in Penfield's phenomenon.

Although the superior temporal sulcus is one of the more distinct cerebral landmarks, it can be rather ambiguous. The observers therefore outlined the superior temporal gyri, as they perceived them, on separate sets of photographs. Even though 50% of the pictures had been reversed in printing, the Sylvian asymmetries noted by Cunningham and by Le May and Culebras may have given cues as to which hemisphere, right or left, appeared in a photograph.

Each observer drew widths on her set of prints. One set of widths was drawn perpendicular to the Sylvian fissure, the other set perpendicular to an approximate midline drawn along the gyrus, at intervals of 5 mm (fig. 1). These distances between the Sylvian and parallel (superior temporal) sulci were measured with dividers and read to the nearest 0.5 mm on a scale. No measurements were made by the investigator who kept the record of the data. They were begun 1 cm posterior to the temporal pole as seen in the photographs, and confined to the anterior 7 cm of the gyrus in adults, the region in both hemispheres from which Penfield elicited many reports of the re-experiencing of past experiences. In most adults, 11 widths were obtained. In most infants, only 8 widths were obtained, because the gyrus was shorter. The data, as obtained by the two methods, were treated with analysis of variance as repeated measurements on one brain. Asymmetries in individual brains were determined by the Mann-Whitney test.

TABLE I

Means and Standard Deviations for Widths of Gyri, with Three-way Analysis of Variance. Measurements in mm.

33 infants

Observer	Left	Right
EJA	9.961 ± 2.150	10.302 ± 2.090
WJD	8.786 ± 2.290	9.346 ± 2.200
Means of the above data:	9.373 ± 2.220	9.864 ± 2.140

Analysis of Variance: $F = 1.92$, $p < 0.175$

33 adults

Observer	Left	Right
EJA	11.971 ± 2.347	13.378 ± 2.315
WJD	10.821 ± 2.315	12.137 ± 2.478
Means of the above data:	10.897 ± 2.331	12.757 ± 2.397

Analysis of Variance: $F = 11.37$, $p < 0.002$

RESULTS

Observers were consistent in recording greater widths from the total sample of the right superior temporal gyrus. In adults, the difference is significant (Table 1). The asymmetry extended through the part of the gyrus lying 5 - 7 cm from the temporal pole, often included in Wernicke's speech area.

In 10 infants and 7 adults, mean widths of the left superior temporal gyrus were greater. In 17 infants and 22 adults, mean widths were greater on the right. In the infants, two significant differences favored the right gyrus. In two adults the left gyri were significantly wider, but the right gyri were wider in 11. Random variation of gyral widths would make 2.5% of gyri significantly wider on the right, and an equal number on the left, if $p < 0.05$ is used as the criterion of significance. The chi squared goodness of fit test, used to compare our findings with expected asymmetries, gave a value significant at the $p < 0.001$ level.

DISCUSSION

Penfield's electrical evocation of past experiences suggests the possibility that the lateral temporal cortex, or regions connected with it, are concerned with the retention of memory data. Velasco-Súarez (1970) evoked similar reports by stimulating structures deep in the temporal lobe, implicating the hippocampal region as a storage site. Hippocampal measurements, such as those of Gertz, Lindenberg and Piavis (1972) might reveal asymmetries like those found in the superior temporal gyri. Penfield and Milner (1958) described hippocampal lesions causing persistent retrograde amnesia. Bilateral temporal lobe excision by Terzian and Ore (1955), which included the anterior 5 cm of the superior temporal gyri, caused severe loss of past memory. Similar removal of a right temporal lobe by Dimsdale, Logue and Piercy (1964) left their patient with "a profound retrograde amnesia extending over a period of years." Such memory losses, however, have not been described fol-

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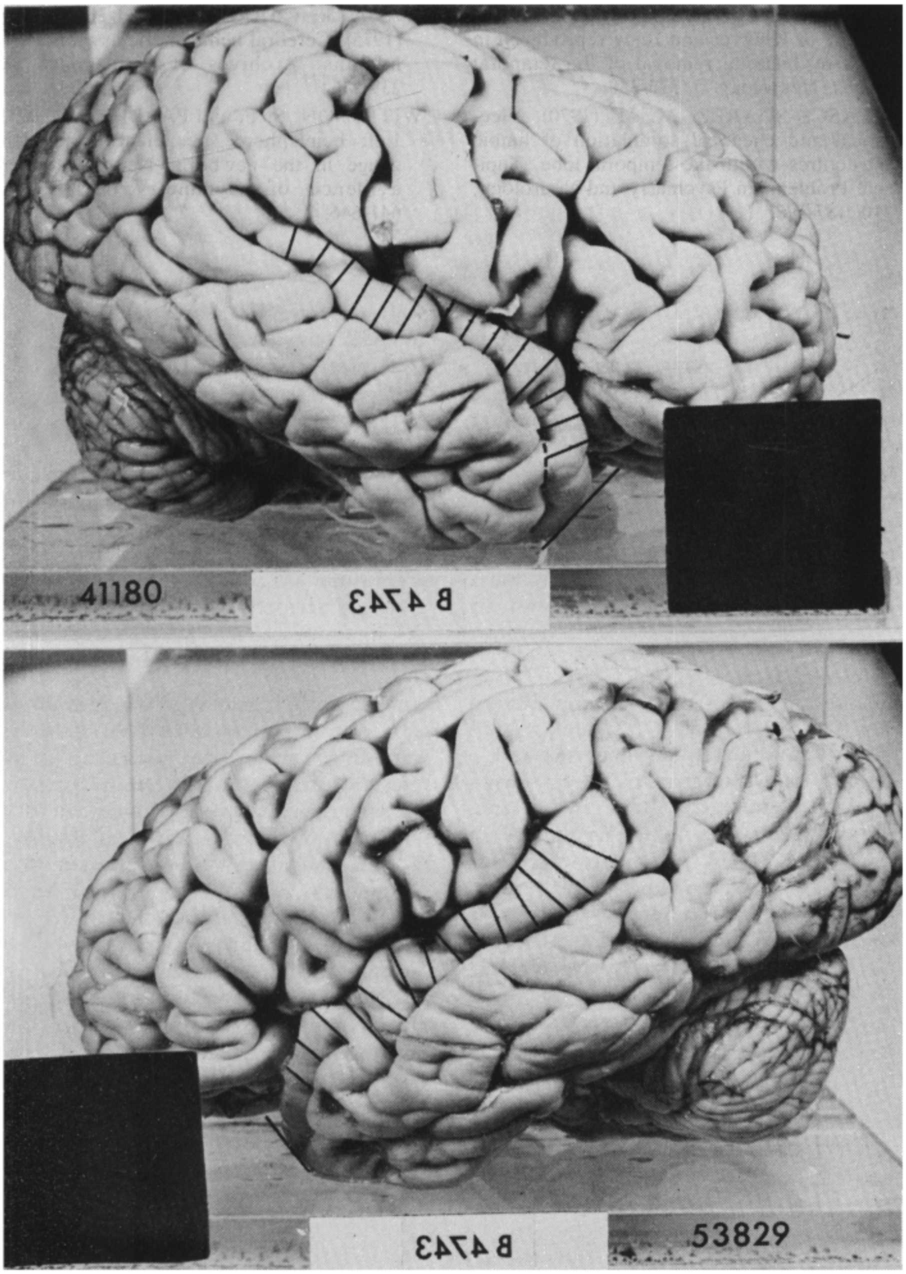

Figure 1 — Widths of gyri drawn on photographs. Black 4 cm square was used as a guide in enlarging. As with 50% of the specimens, the photographs of brain with autopsy number B 4743 were reversed in printing, and labelled with random numbers 41180 and 53429. The most anterior parts of the gyri were not measured.

lowing Penfield's less extensive removals of superior temporal gyri.

Penetrating wounds of the cerebrum reported by Russell and Espir (1961) frequnetly caused temporary amnesia and dysphasia. Among the few lesions causing loss of long-standing memories were those that also caused lower quadrantanopsia by damaging the upper part of the visual radiation in the temporal lobe (Cases 37 and 38). One might expect the collected data of memory to be stored in many parts of the brain rather than in a small part of each temporal lobe. The cases reported by Russell and Espir, however, suggest the more restricted site as a possibility. Although Dawkins (1971) proposed that memories may be formed by the elimination of neurons, Greenough (1975) described enlargement of dendrites as a concomitant of learning. Neuronal growth of this type may occur in man as well as in experimental animals. In some human brains, marked asymmetries appear in the posterior parts of the superior temporal gyri (Fig. 1). Such gross asymmetries in structure may reflect asymmetrical storage of memory data, and may be correlated with differences visible at the microscopic level.

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