A Quantitative Study on the Left-Right Asymmetry of the Planum Temporale

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Summary: To determine the difference of size between the cortical speech region in the dominant hemisphere and its corresponding region in the other hemisphere, the planum temporale was measured and compared by means of a rubbed copy method using 50 brains of both sexes. The planum temporale was significantly larger in the left hemisphere than in the right.

Since the existence of the cortical speech area was reported (Broca, 1861; Wernicke, 1874) it has been thought that the area is usually located unilaterally in the so called “dominant hemisphere”, inferring a functional difference between the left and right hemispheres. A morphological difference in the planum temporale which is thought to be an important part of the speech cortex or the superior surface of the temporal lobe had been reported in the early decades of this century (Flechsig, 1908; Pfeifer, 1920; Kakeshita, 1925; Economo and Horn, 1930; Pfeifer, 1936), but this fact had not been given much attention until 1968 when Geschwind and Levitsky reported a significant difference in its size between the left and right hemispheres. Following that report, similar results were reported by several investigators such as Teszner et al. (1972). Witelson and Pallie (1973), Wada et al. (1975) and Rubens et al. (1976). In 1978 Yamadori et al. in reporting the results of the measurement of a composite region consisting of the posterior part of the superior temporal gyrus and the inferior parietal lobule, emphasized that there is no significant difference between the measured regions of both hemispheres. In the present study, the authors examined 50 brains of both sexes by using a rubbed copy method and tried to determine the left-right asymmetry of the planum temporale which is thought to be an important part of the speech cortex.
**Materials and Methods**

Twenty five brains of Japanese adults of each sex were randomly selected from among brain specimens which had been stored in 10% formalin for varying lengths of time of 1 to 18 years. These brains had not been used in any other studies. The age ranges and mean ages respectively were 30 to 92 years and 73.6 years in the male and 40 to 95 years and 74.3 years in the female. The brains were washed in running water for varying lengths of time from 1 to 5 days. The pons, cerebellum and medulla oblongata were detached from the brain by cutting the brain stem at the lower end of the midbrain. The hemispheres were carefully separated at the mid-sagittal plane. The meninges and blood vessels on the cerebral surface were removed and the water absorbed with filter paper, and then each hemisphere was weighed. To expose the planum temporale, the brain was cut along the main course of the posterior branch of the lateral sulcus at first. However, in its posterior part the brain was cut more horizontally along the line between the point where the posterior end of the posterior branch ascends as a posterior ascending branch or bifurcates and the occipital pole of the cerebrum (Fig. 1A, 1C). The dried surface of the planum was painted with a mixture of thick India ink and a small amount of starch. A rubbed copy was obtained by laying a piece of thin Japanese paper onto the painted surface of the planum temporale and pressing it gently against the surface with a cotton tampon. Thus, the exact shape of the planum and the neighbouring gyri appeared on the surface of the paper as a positive picture. The copied papers were dried and the borderline of the planum was delineated (Fig. 1B, 1D).

A planimeter was used to measure the area of the planum. The area was measured several times until the measured errors were consistently less than 0.1 cm², after which the mean area was calculated.

**Results**

Since there was a considerable difference in the fixation periods, the brain specimens used in this study were statistically evaluated to determine whether or not they belonged to the same population. The t-test was performed on brain weight and a significant difference was discovered between the weights of brains which had been fixed more than 7 years and the weights of brains fixed less than 5 years (Table 1). Therefore, it was decided not to compare the data of the measurement by absolute value. The data was examined by using non-parametric methods under the supposition that the rate of contraction during the fixation period is the same for both the left and right hemispheres.

The difference in weight between the left and right hemispheres was examined by using Wilcoxon's signed rank test. There was no significant difference between the hemispheres of the female brains but in the male brains, the right hemisphere was significantly heavier than the left (P < 0.05). However, when all 50 brains were examined as a single group, there was no significant difference between the left and right hemispheres. The difference in brain weight between the male and female specimens was also examined by using Mann-Whitney's U-test, which demonstrated that the weight of the male brain was significantly greater than that of the female (Z = 2.4254, P < 0.02).

The area of the planum temporale was measured in each hemisphere and compared by using Wilcoxon's signed rank test. There was a significant difference between the left and right hemispheres not only in the brains of the male group (P < 0.02)
Table 1. Mean weights of brains according to the length of the fixation period.

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Mean ± S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>under 5 years</td>
<td>11</td>
<td>1058.6±74.12</td>
</tr>
<tr>
<td>over 7 years</td>
<td>14</td>
<td>949.0±81.37</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>under 5 years</td>
<td>7</td>
<td>990.7±71.92</td>
</tr>
<tr>
<td>over 7 years</td>
<td>18</td>
<td>901.3±85.57</td>
</tr>
</tbody>
</table>

but also in the brains of the female group (P<0.01), being larger on the left side. However, within the same hemisphere, there was no significant difference in the area of the planum between the male group and the female group (Mann-Whitney’s U-test). When one considers the comparative brain weight differences between male and female, there is the suggestion that the weight of the female brain being less, the planum temporale occupies a larger area in this group than in the male. The planum temporale was not recognized in the right hemisphere in 4 cases in the male group and in 5 cases in the female group.

Discussion

The left-right asymmetry in the planum temporale of the superior surface of the temporal lobe had been pointed out in the early decades of this century, but this fact had not been given much additional attention until the existence of a significant dimensional difference was reported (1968). In 1972 Teszner et al. measured the surface area of the planum temporale by using a mold and reported that the left planum was larger than the right. Witelson and Pallie (1973) in reporting the difference based on data obtained from photographs, indicated that the difference is already present in the brains of newborns. Wada et al. (1975) examined 100 adult brains and 100 infant brains, noting that in the majority of these specimens the planum was larger in the left hemisphere than in the right, and that this difference was larger in the adults than in the infants. Rubens et al. (1976) measured the length of the planum and reported that it was larger in the left hemisphere in 67% of the examined brains. They also reported an asymmetry of the posterior region of the lateral fissure, indicating that in 69% of the examined brains, the fissure runs more horizontally in the left hemisphere while angulating sharply upward and earlier in the right hemisphere. Using an arteriography technique, LeMay and Culebras (1972) reported a larger left parietal operculum while Hori (1976) reported a larger planum temporale in the left hemisphere. Chi et al. (1977) studied left-right asymmetries of the temporal speech areas embryologically using 207 fetuses from 10 to 44 weeks of age and found greater size and number of the right transverse temporal gyri and a larger planum on the left in 54% of the brains without a difference between the sexes.

Thus, even though a considerable number of studies have been performed on the asymmetry of the planum temporale, those who measured the area of the planum used either traced copies from molds or photographs. To measure the surface area of the planum temporale, the authors in the present study used a rubbed copy method which enabled more direct and accurate measurement of the surface. By this method, the findings of previous authors, that the planum is larger in the
left hemisphere than in the right hemisphere, was confirmed, although the difference in size between the male and female was not significant. The number of brains without a planum temporale on the right side was 9 among 50 brains (18%) showing a higher rate than the previous report (Wada, 1975) of 8 cases in 100 adult brains (8%). The planum temporale was always present in the left hemisphere.

Economo and Horn (1930) studied the left-right asymmetry of the superior surface of the temporal lobe and stated that the planum temporale was seen always on the left side but on the right side the surface was usually occupied by 2 Heschl's gyri. They further stated that the area TB, which covers the large anterior part of the planum, occupied a larger area on the left side. On the other hand, Garaburda et al. (1978) who had studied the extent of the area Tpt, which occupies the posterior part of the planum as well as a part of the posterior part of the superior temporal gyrus reported that asymmetry in the size of the planum temporale of both hemispheres possibly reflects asymmetry in the size of a cytoarchitectonic area, which on morphological grounds belongs to the auditory region and has a probable relevance to language function. Taking this report in account, it can be said that the left-right difference in the area of the planum temporale in the present study is thought to indicate the morphological asymmetry in the region which is related to an auditory function, probably the auditory language function, between the two hemispheres.

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Explanation of Figure

Plate I

Fig. 1. The left planum temporale (A) and its rubbed copy (B). The right planum temporale of the same brain (C) and its rubbed copy (D). P1: planum temporale.