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ORIGINAL RESEARCH

Temporal Lobe Asymmetry: A Morphometric Analysis

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ABSTRACT

Cerebral hemispheric asymmetry is a recognized anatomical and functional property of the human brain. In the temporal lobe, asymmetry of the lateral sulcus, Heschl's gyrus and planum temporale is particularly relevant to the structural basis of auditory and language lateralization. **Objective:** To assess right-left temporal lobe asymmetry using gross anatomical measurements in cadaveric/autopsy brains and corresponding measurements on magnetic resonance imaging (MRI) brain scans. This observational morphometric study included 400 human brains/brain scans: 200 cadaveric and autopsy-derived brain specimens and 200 MRI brain scans. Each group comprised 100 males and 100 females. The age range was 2-80 years. Only brains and scans without intracranial mass lesions, head injury or recorded pathology involving either temporal lobe were included. The length of the lateral sulcus (Ls) and the distance from the posterior end of the lateral sulcus to the inferior margin of the inferior temporal gyrus (H) were measured bilaterally. Data were summarized as mean ± standard deviation, and right-left differences were evaluated using paired Student's t-test. The length of the lateral sulcus was greater on the left than on the right in both cadaveric/autopsy specimens and MRI scans. In cadaveric/autopsy brains, mean Ls was 7.80 ± 0.63 cm on the left and 7.67 ± 0.72 cm on the right, showing a highly significant difference ($t = 5.7949$, $p < 0.0001$). In MRI scans, mean Ls was 8.07 ± 0.64 cm on the left and 8.00 ± 0.73 cm on the right, showing a statistically significant difference ($t = 2.5552$, $p = 0.0114$). The H measurement showed no statistically significant right-left difference in either group. In cadaveric/autopsy brains, H was 3.83 ± 0.43 cm on the left and 3.81 ± 0.46 cm on the right ($t = 0.9049$, $p = 0.3666$). In MRI scans, H was 3.72 ± 0.41 cm on the left and 3.72 ± 0.42 cm on the right ($t = 0.0966$, $p = 0.9231$). The findings demonstrate measurable right-left differences in temporal lobe morphology, particularly a leftward predominance in lateral sulcus length. These observations support the view that the cerebral hemispheres are not anatomically identical and reinforce the relevance of temporal lobe morphometry in studies of auditory and language-related cerebral lateralization.

Keywords: Brain; Temporal lobe; Cerebral asymmetry; Lateral sulcus; Morphometry; MRI

INTRODUCTION

The two cerebral hemispheres are not exact mirror images. Both anatomical organization and functional specialization vary between the right and left hemispheres, and this lateralization is particularly evident in higher cognitive functions such as language, praxis, auditory processing and visuospatial integration. The historical association between left hemispheric lesions and impaired speech, first advanced through the work of Marc Dax and later consolidated by Broca, established the foundation for modern concepts of cerebral dominance and language lateralization [1].

Among the structural asymmetries described in the human brain, those involving the temporal lobe and perisylvian region are among the most consistently investigated. Geschwind and Levitsky demonstrated marked right-left differences in the superior temporal plane, reporting that the planum temporale was larger on the left side in most examined brains [2]. Subsequent reviews have emphasized that the planum temporale, a region located on the superior surface of the temporal lobe behind Heschl's gyrus, is anatomically linked to auditory and language-related cortical networks, although its exact boundaries and functional interpretation remain subjects of methodological debate [3].

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The lateral sulcus, also known as the Sylvian fissure, is an important surface landmark of the temporal lobe. Earlier morphometric studies have shown that the course and length of the lateral sulcus may differ between hemispheres, with leftward elongation commonly reported in humans [4,5]. These asymmetries are of interest because they may reflect structural correlates of lateralized auditory and language functions, even though anatomical asymmetry alone cannot establish functional dominance in an individual brain.

In view of this background, the present study was undertaken to examine temporal lobe asymmetry using two complementary sources of morphometric data: cadaveric/autopsy brain specimens and MRI brain scans. Particular attention was given to the length of the lateral sulcus and the vertical distance from the posterior end of the lateral sulcus to the inferior margin of the inferior temporal gyrus. The study was intended to support further anatomical consideration of the temporal lobe, Heschl's gyrus and planum temporale in investigations of auditory and language-related cerebral asymmetry.

Materials and Methods

Study design, setting and ethics

This observational morphometric study was conducted in the Department of Anatomy, Indira Gandhi Government Medical College, Nagpur. The project was approved by the Institutional Ethics Committee. The study sample consisted of 400 human brains/brain scans. Of these, 200 were cadaveric and autopsy-derived brain specimens, and 200 were MRI brain scans. Each group included 100 males and 100 females. The subjects/specimens represented an age range of 2-80 years.

Inclusion and exclusion criteria

Brains and MRI scans were included only when there was no evidence of intracranial mass lesion, head injury or recorded pathology affecting the temporal lobes of either cerebral hemisphere.

Brains and scans showing intracranial mass lesions, head injury or any documented pathology involving the temporal lobes were excluded.

Cadaveric and autopsy-derived brain specimens

A total of 200 brain specimens were obtained from the Department of Anatomy and the Department of Forensic Medicine and Toxicology. Sex, age and available medical history were recorded from institutional records. Cadaveric brains used for dissection were preserved by perfusion fixation through the femoral and carotid arteries with a solution containing 7% formaldehyde, 40% ethanol, 13% glycerine and 0.1% panacide as an antifungal agent. Brains obtained at autopsy were fixed by flotation in 10% buffered formalin.

After fixation, each brain was divided in the midsagittal plane. A sagittal section was made from anterior to posterior through the median longitudinal fissure, with an additional section at right angles through the upper midbrain using a brain knife. Bilateral temporal lobe measurements were then obtained using the same anatomical definitions for all specimens.

MRI scan measurements

MRI scans of 200 subjects were obtained from the Department of Radiodiagnosis. Routine cranial MRI examinations included sagittal images suitable for morphometric assessment. Scans were performed on a 1.5-T Philips Achieva MRI system. Measurements were taken from images stored on computer media and viewed using RadiAnt viewer. Measurements were recorded in millimetres and converted into centimetres for analysis.

The same anatomical parameters were measured in the MRI group as in the cadaveric/autopsy group, allowing comparison of right-left asymmetry across the two modalities.

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Morphometric parameters and measurement reproducibility

Two bilateral measurements were recorded for each brain or scan: (1) Ls, defined as the length of the lateral sulcus of the temporal lobe in each cerebral hemisphere; and (2) H, defined as the distance from the posterior end of the lateral sulcus to the inferior margin of the inferior temporal gyrus.

To improve reproducibility, all measurements were based on predefined anatomical landmarks and the same operational definitions were applied to cadaveric/autopsy brains and MRI scans. The available study records did not document independent repeated measurements or interobserver/intraobserver reliability testing; this limitation is explicitly acknowledged below and should be addressed in future studies.

Statistical analysis

Measurements were expressed as mean ± standard deviation. Because right and left measurements were obtained from the same brain or MRI scan, right-left comparisons were evaluated using paired Student's t-test. A p value <0.05 was considered statistically significant, and p <0.001 was considered highly significant. Statistical analysis was performed using SPSS version 20.0.

Sex-specific results were summarized descriptively where available. Inferential age-stratified, sex-stratified or multivariable analyses were not added because individual-level raw data and complete subgroup statistical outputs were not available in the study records.

RESULTS

Temporal lobe asymmetry was demonstrated primarily in the measurement of lateral sulcus length. In the cadaveric/autopsy group, the left lateral sulcus was longer than the right lateral sulcus. The difference was statistically highly significant. In MRI scans, the left lateral sulcus was also longer than the right lateral sulcus, and the difference reached statistical significance.

The H measurement, representing the distance from the posterior end of the lateral sulcus to the inferior margin of the inferior temporal gyrus, did not show a statistically significant right-left difference. In cadaveric/autopsy brains, the left-sided value was slightly greater than the right-sided value. In MRI scans, the mean H value was identical on both sides. The detailed comparative results are shown in Table 1.

Sex-specific descriptive mean values are presented in Table 2. These values are included to improve reporting transparency; however, no sex-stratified inferential analysis was performed because the required individual-level dataset and complete subgroup statistics were not available in the study records.

Table 1. Comparison of temporal lobe measurements in cadaveric/autopsy brains and MRI brain scans

Measure	Modality	Left temporal lobe	Right temporal lobe	t value	p value
Ls	Cadaveric/autopsy	7.80 ± 0.63	7.67 ± 0.72	5.7949	<0.0001; highly significant
Ls	MRI	8.07 ± 0.64	8.00 ± 0.73	2.5552	0.0114; significant
H	Cadaveric/autopsy	3.83 ± 0.43	3.81 ± 0.46	0.9049	0.3666; not significant
H	MRI	3.72 ± 0.41	3.72 ± 0.42	0.0966	0.9231; not significant

Values are expressed as mean ± SD in centimetres. Ls = length of lateral sulcus; H = distance from the posterior end of the lateral sulcus to the inferior margin of the inferior temporal gyrus.

Table 2. Sex-specific descriptive mean values for Ls and H measurements

Modality	Parameter	Sex	Left temporal lobe	Right temporal lobe	Comment
Cadaveric/autopsy	Ls	Male	7.82	7.72	Descriptive mean
Cadaveric/autopsy	Ls	Female	7.78	7.63	Descriptive mean
Cadaveric/autopsy	H	Male	3.86	3.86	Descriptive mean

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Modality	Parameter	Sex	Left temporal lobe	Right temporal lobe	Comment
Cadaveric/autopsy	H	Female	3.79	3.77	Descriptive mean
MRI	Ls	Male	8.03	7.94	Descriptive mean
MRI	Ls	Female	8.10	8.06	Descriptive mean
MRI	H	Male	3.77	3.75	Descriptive mean
MRI	H	Female	3.67	3.68	Descriptive mean

Values are expressed in centimetres. These data are descriptive because full subgroup inferential statistics were not available in the study records.

Discussion

The present morphometric study demonstrates measurable right-left differences in the temporal lobe, with the most consistent asymmetry observed in the length of the lateral sulcus. In both cadaveric/autopsy specimens and MRI scans, the lateral sulcus was longer on the left than on the right. This finding is consistent with the broader literature describing leftward asymmetry in the temporal and perisylvian regions, especially in relation to the planum temporale and lateral sulcus [2-5].

Geschwind and Levitsky reported marked anatomical asymmetry of the superior temporal plane, with a larger left planum temporale in a majority of adult brains [2]. Witelson and Pallie also provided neuroanatomical evidence for left hemispheric specialization for language in the newborn, suggesting that some asymmetries related to language networks are present early in life [6]. Wada, Clarke and Hamm further documented asymmetry of cortical speech zones in adult and infant brains, supporting the concept that temporal and frontal opercular asymmetries may have developmental significance [7].

The present result for lateral sulcus length also agrees with the study by Boni et al., who measured 40 adult post-mortem brains and reported that the lateral sulcus was larger in the left hemisphere, whereas other measurements, including distance from the lateral sulcus to the inferior temporal margin, were larger on the right in their sample [4]. In the present study, the H measurement was not significantly different between hemispheres. This suggests that lateral sulcus length may be a more sensitive gross anatomical marker of temporal lobe asymmetry than the vertical distance to the inferior temporal gyrus.

Rubens, Mahowald and Hutton described asymmetry in the course of the lateral Sylvian fissures, noting that the right lateral fissure often angulates upward into the inferior parietal region while the left fissure continues more posteriorly. This pattern is associated with a smaller right parietal operculum, a shorter right planum temporale and a higher right Sylvian point [8]. Yeni-Komshian and Benson similarly showed that the human Sylvian fissure is longer on the left than on the right, and that comparable but less marked asymmetry may be present in chimpanzee brains, whereas rhesus monkeys do not show the same degree of asymmetry [9]. These observations support the view that perisylvian asymmetry is a prominent feature of the human brain and may be related to the evolution of language-related cortical organization.

Developmental evidence also supports the relevance of temporal lobe asymmetry. Chi, Dooling and Gilles reported that left-right asymmetries of the transverse temporal gyri and temporal plane become recognizable during fetal development, indicating that these anatomical differences may emerge before full postnatal language acquisition [10]. Other anatomical studies of hemispheric asymmetry and auditory cortical regions have similarly emphasized the need to evaluate temporal lobe structures, Heschl's gyrus and the planum temporale in relation to cerebral dominance and auditory processing [11,12].

The lack of significant right-left difference in H in the present study should be interpreted cautiously. The H measurement is a gross linear dimension and may be influenced by brain size, tissue fixation, orientation of the specimen, MRI slice selection and individual variation in sulcal anatomy. In contrast, the length and course of the lateral sulcus may more directly reflect the configuration of the perisylvian region. The findings therefore support temporal lobe asymmetry but do not by themselves establish functional language dominance. Functional lateralization requires correlation with behavioural, neuropsychological or functional imaging data.

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Limitations

The study relied on linear gross morphometric measurements rather than volumetric or surface-area analysis of specific language-related regions such as Heschl's gyrus and the planum temporal. The cadaveric/autopsy specimens may have been affected by fixation-related dimensional changes, and MRI measurements may have been influenced by image resolution and slice orientation. Total brain volume and interobserver/intraobserver reliability were not documented and the wide age range was not analysed in detailed developmental or age-stratified subgroups. Although sex-specific mean values were available descriptively, complete subgroup inferential statistics were not available. Finally, the cross-sectional anatomical design cannot establish the functional dominance of language or auditory processing in individual subjects.

CONCLUSION

This study demonstrates anatomical differences between the right and left temporal lobes, most notably a longer lateral sulcus on the left side in both cadaveric/autopsy brains and MRI brain scans. The distance from the lateral sulcus to the inferior margin of the inferior temporal gyrus did not differ significantly between hemispheres. Overall, the findings reinforce the principle that the cerebral hemispheres are not identical from anatomical or functional perspectives. Temporal lobe morphometry, especially assessment of the lateral sulcus and related perisylvian structures, remains important for understanding the anatomical basis of auditory and language-related cerebral asymmetry.

Declarations

Consent/waiver: The study used cadaveric/autopsy-derived brain specimens and anonymized MRI scans.

Funding: Nil

Conflicts of interest: Nil

References

1. Manning L, Thomas-Antérion C. Marc Dax and the discovery of the lateralisation of language in the left cerebral hemisphere. Rev Neurol (Paris). 2011;167(12):868-872
2. Geschwind N, Levitsky W. Human brain: left-right asymmetries in temporal speech region. Science. 1968;161(3837):186-187
3. Shapleske J, Rossell SL, Woodruff PW, David AS. The planum temporale: a systematic, quantitative review of its structural, functional and clinical significance. Brain Res Brain Res Rev. 1999;29(1):26-49
4. Boni RC, Prosdócimi FC, Bonsi AB, Almeida TM, Ribeiro LAM. Asymmetries of the left and right temporal lobes. Int J Morphol. 2007;25(1):117-120.
5. Aboitiz F, Scheibel AB, Zaidel E. Morphometry of the Sylvian fissure and the corpus callosum, with emphasis on sex differences. Brain. 1992;115(Pt 5):1521-1541
6. Witelson SF, Pallie W. Left hemisphere specialization for language in the newborn: neuroanatomical evidence of asymmetry. Brain. 1973;96(3):641-646
7. Wada JA, Clarke R, Hamm A. Cerebral hemispheric asymmetry in humans: cortical speech zones in 100 adult and 100 infant brains. Arch Neurol. 1975;32(4):239-246
8. Rubens AB, Mahowald MW, Hutton JT. Asymmetry of the lateral (Sylvian) fissures in man. Neurology. 1976;26(7):620-624
9. Yeni-Komshian GH, Benson DA. Anatomical study of cerebral asymmetry in the temporal lobe of humans, chimpanzees and rhesus monkeys. Science. 1976;192(4237):387-389
10. Chi JG, Dooling EC, Gilles FH. Left-right asymmetries of the temporal speech areas of the human fetus. Arch Neurol. 1977;34(6):346-348
11. Kopp N, Michel F, Carrier H, Biron A, Duvillard P. Étude de certaines asymétries hémisphériques du cerveau humain. J Neurol Sci. 1977;34(3):349-363.
12. Musiek FE, Reeves AG. Asymmetries of the auditory areas of the cerebrum. J Am Acad Audiol. 1990;1(4):240-245.

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