Chandrakumar L., Reman S.

METHODOLOGY OF MEASURING BROCA'S AREA: PHYSICAL MEASUREMENT ANALYSIS

Tutors: MD, Professor Natalia Alekseevna Trushel

Department of Normal Anatomy
Belarusian state medical university, Minsk

Senior Lecturer, Dr. Jayampathy Kumari Dissanayake

Department of Anatomy
Faculty of Medicine Peradeniya, Sri Lanka

Resume. Broca's area in females shows up to 20 % larger surface area, suggesting structural advantages in verbal ability and brain connectivity.

Keywords: *Broca's area, Anatomical variability, Measurement methodology, Neuroanatomical differences, Language function*

Actuality. Broca's area, located in the left inferior frontal gyrus, plays a crucial role in speech production and language processing. This brain region encompasses two main parts: the pars opercularis (Brodmann area 44) and the pars triangularis (Brodmann area 45), positioned anterior to the precentral sulcus near the motor cortex. Its importance in facilitating verbal communication has been widely studied, with recent research highlighting notable sex-based anatomical differences.

Aim: This thesis seeks to critically assess the methodologies used for measuring Broca's area, supporting prior research on gender-specific variations in its surface area relative to total brain size, observed laterally. The objective is to strengthen the link between brain anatomy and neurofunctional capabilities across genders.

Objectives:

1. To accurately measure the size and location of Broca's area in the brain, despite its complex and uneven surface.
2. To use different tools (measuring tapes, vernier callipers, and augmented reality) to reduce errors during the measurements.
3. To establish basic data on Broca's area dimensions based on the study of ten brain specimens, even without demographic information about the donors.

Material and Methods. The methodology employed measuring tapes, vernier callipers, and augmented reality tools to reduce errors from the brain's complex surfaces. These tools provided a preliminary framework, despite anatomical variability. Ten brain specimens from BSMU's Anatomy Department, without demographic data, were studied. Broca's area, in the frontal lobes inferior frontal gyrus (pars opercularis, Brodmann area 44; pars triangularis, Brodmann area 45), was identified anterior to the precentral sulcus, near the motor cortex. Seven measurements assessed Broca's area: vertical length from its top to the parietal lobe's top (V1); top to lower border, perpendicular to the lateral sulcus (V2); horizontal distance from frontal lobe's tip to central sulcus (H1); tip to Broca's lateral border (H2); lateral border to central sulcus, toward temporal lobe (H3); total brain length (Hmax) and height (Vmax).

Results and Discussion. The present study employed a combination of manual and augmented reality tools to quantify the dimensions of Broca's area across ten human brain specimens obtained from the BSMU Anatomy Department. Given the inherently complex and convoluted surfaces of the cerebral cortex, traditional measurement methods often face challenges due to anatomical variability and curvature-related distortions. To mitigate these limitations, measuring tapes, vernier callipers, and augmented reality technologies were utilized to establish a preliminary yet systematic framework for capturing key morphometric parameters of Broca's area, located in the inferior frontal gyrus of the frontal lobe (pars opercularis and pars triangularis corresponding to Brodmann areas 44 and 45).

Seven distinct measurements were recorded to comprehensively characterize Broca's area and its spatial relationships: two vertical distances (V1 and V2), three horizontal distances (H1, H2, H3), along with total brain length (Hmax) and height (Vmax). Analysis revealed substantial inter-specimen variability in these parameters, with V1 ranging from 2.97 to 5.92 cm and V2 from 2.88 to 3.64 cm, indicating differences in the superior and vertical extent of Broca's area. Horizontal measurements (H1-H3) also displayed notable heterogeneity, reflecting positional differences relative to adjacent frontal and temporal lobe landmarks. The total brain dimensions (Hmax and Vmax) provided essential context for scaling these regional measurements and are consistent with prior reports of sexual dimorphism in Broca's area proportionality.

BRAIN	V1 (cm)	V2 (cm)	Vmax (cm)	H1 (cm)	H2 (cm)	H3 (cm)	Hmax (cm)
N/A1	3.84	3.16	8.07	10.23	2.33	4.14	17.14
N/A2	2.97	3.64	6.82	9.85	2.31	4.21	16.34
N/A3	3.31	3.18	8.63	10.32	2.62	3.97	15.56
N/A4	5.92	2.98	10.92	10.16	2.84	3.12	14.67
N/A5	3.83	3.23	7.87	10.71	3.13	4.18	15.67
N/A6	3.14	3.44	7.93	9.87	2.45	3.96	15.12
N/A7	4.64	2.95	8.21	11.12	3.22	3.44	14.97
N/A8	3.53	3.04	8.34	9.94	2.7	4.07	16.14
N/A9	4.43	3.13	8.74	10.56	2.53	3.63	14.83
N/A10	3.71	2.88	7.65	9.33	2.69	2.94	13.94

Fig 1: Distribution of measurements in the methodology of measuring broca's area in physical methods

While manual tools enabled foundational two-dimensional data collection, inherent constraints such as landmark identification subjectivity and inability to fully account for cortical curvature limit their precision. These shortcomings highlight the advantages of advanced imaging modalities such as MRI and CT, which afford volumetric and three-dimensional analyses critical for detailed structure-function correlation studies. Although the absence of demographic data precluded direct exploration of gender or age-related differences, the observed morphological variability aligns with existing literature linking Broca's area anatomy to individual language function variability.

Conclusion: These measurements estimate Broca's area surface area, enabling comparisons with averages. The data supports gender-based research, linking size variations to neurological functions. Low-cost tools aid preliminary assessments, but MRI/CT excels for volumetric precision in studying language processing structure-function relationships.

In Addition, the surface area ratio of Broca to total brain also analysed ranging from 7 %–11 %. Which correlates with the data collected all over the world from advance techniques stating to the near accuracy of the physical measurements for brain being in an unproportional shape. The relation of vertical and anteroposterior dimensions of Broca's area is not correlating as we could observe the biggest surface area, and the lowest surface area are not influencing on the total brain area as the results were vice-versa and different outcomes.

Fig 7: Images of the specimens from Medical Faculty of Peradeniya's Anatomy and Histology Lab, In the right corner picture the image of Temporary Lectures who assited in the research were attached

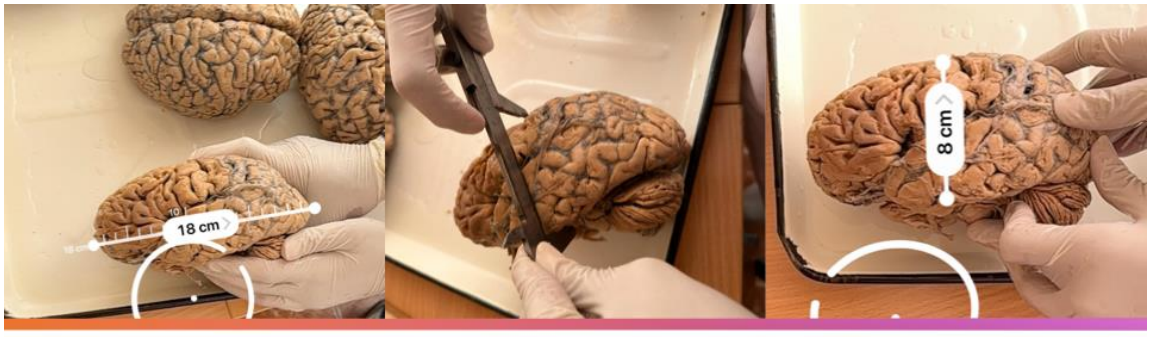

Fig 8: Images of the measurement of Brains with the basic physical measurement methods

Literature

1. Stinnett TJ, Reddy V, Zabel MK. Neuroanatomy, Broca Area. 2023 Aug 8. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. PMID: 30252352.

2. Fedorenko E, Blank IA. Broca's Area Is Not a Natural Kind. Trends Cogn Sci. 2020 Apr;24(4):270-284. doi: 10.1016/j.tics.2020.01.001. Epub 2020 Feb 20. PMID: 32160565; PMCID: PMC7211504.

3. Bohsali AA, Triplett W, Sudhyadhom A, Gullett JM, McGregor K, FitzGerald DB, Mareci T, White K, Crosson B. Broca's area - thalamic connectivity. Brain Lang. 2015 Feb; 141:80-8. doi: 10.1016/j.bandl.2014.12.001. Epub 2014 Dec 30. PMID: 25555132; PMCID: PMC10839943.