

PLANUM TEMPORALE

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1. Core Definition and Anatomical Location

The Planum Temporale (PT) is a critically important anatomical region located within the **superior temporal cortex** of the brain, a region integral to auditory processing and language comprehension. Anatomically, the PT forms the posterior portion of the supratemporal plane, a flat area situated superior to the Sylvian fissure (lateral sulcus). It is bordered anteriorly by **Heschl's gyrus**, which functions as the primary auditory cortex (A1). This adjacency is essential, positioning the PT as a key association area that processes information relayed from the initial auditory receiving centers. While often described generically as a part of the temporal lobe, its functional significance elevates it far beyond mere anatomy, placing it at the nexus of hearing and cognition, particularly relating to the sequential and temporal processing necessary for understanding speech. The precise cytoarchitecture of the PT differs significantly from the primary cortex, suggesting its role is not merely reception, but complex interpretation and integration of acoustic input.

Functionally, the Planum Temporale constitutes a significant portion of what is classically defined as **Wernicke's area** in the dominant (typically left) hemisphere, though modern definitions recognize Wernicke's area as a broader network encompassing parts of the posterior superior temporal gyrus and adjacent parietal cortex. Its location immediately posterior to the area responsible for initial auditory reception implies its function involves higher-order analysis of complex auditory stimuli, such as phonemes, words, and musical tones. Damage to the PT, particularly in the left hemisphere, often results in varying degrees of receptive aphasia, confirming its fundamental role in decoding linguistic meaning. This anatomical and functional linkage firmly establishes the PT as one of the most studied components of the brain's language circuitry, acting as a crucial intermediary between raw sound transduction and semantic interpretation.

While the PT exists in both the left and right **cerebral hemispheres**, the functional specialization of the two sides is a defining characteristic of this structure. The PT's primary involvement in processing speech sounds and language comprehension dominates the activity of the left hemisphere, whereas the right PT appears more involved in processing non-linguistic auditory features, such as pitch, melody, and environmental sounds. This hemispheric specialization underscores the profound anatomical and functional lateralization present in the human brain. The gross morphology of the PT, particularly its striking size asymmetry, has historically served as a major piece of evidence supporting the anatomical basis of functional lateralization for language in humans, distinguishing it from comparable structures in non-human primates.

2. Anatomical Asymmetry and Laterality

One of the most remarkable and consistently observed characteristics of the Planum Temporale is its pronounced anatomical asymmetry. In the vast majority of individuals, irrespective of handedness, the PT is significantly larger, both in surface area and volume, in the left cerebral hemisphere compared to the right. This structural difference, which can manifest as a surface area ratio of up to 10:1 favoring the left side in some individuals, was first comprehensively documented in the late 1960s by Geschwind and Levitsky, providing a tangible, visible anatomical correlate for the long-observed functional specialization of the left hemisphere for language. The presence of this asymmetry is often evident even in fetal brains, suggesting a developmental process linked to fundamental genetic programming rather than purely postnatal learning or experience.

The functional significance of this asymmetry is deeply intertwined with the development of language dominance. Since the left hemisphere typically mediates language processing, including syntax and semantics, the enhanced size of the left PT is hypothesized to accommodate the complex neural circuitry required for rapid analysis of the temporal cues critical to distinguishing phonemes and understanding spoken language. Studies utilizing magnetic resonance imaging (MRI) and post-mortem analyses have sought to link variations in this structural asymmetry directly to functional outcomes, although the correlation is not always perfect. For instance, while most right-handed individuals exhibit left PT dominance and left language dominance, a small percentage may show reversed asymmetry, or symmetry, demonstrating that the relationship between gross anatomy and specific cognitive function, while strong, is not deterministic for every individual.

Conversely, the right Planum Temporale, despite being smaller, is not functionally silent. It exhibits specialization for tasks requiring the analysis of features that vary along a spectral rather than a temporal axis, such as music perception, recognizing emotional tone (prosody) in speech, and detecting subtle changes in pitch. This division of labor--temporal processing (rapid sequential analysis) being dominant in the larger left PT, and spectral/prosodic processing (pitch and timbre analysis) being dominant in the right PT--represents a fundamental principle of auditory cortical organization. Furthermore, research into individuals with developmental disorders, such as dyslexia or specific language impairment, frequently investigates whether reduced or absent anatomical asymmetry of the PT contributes to the observed cognitive deficits, suggesting that proper asymmetry is critical for typical language development.

3. Role in Complex Auditory Processing

The core function of the Planum Temporale extends beyond merely participating in Wernicke's area; it is fundamentally specialized for processing complex auditory signals, particularly those that require fine temporal resolution. Spoken language relies on the rapid succession of acoustic cues

(formant transitions, stop consonant bursts) that must be analyzed in milliseconds. The neural architecture of the left PT is exquisitely tuned to this rapid temporal analysis, acting as a critical filter that transforms basic acoustic input received from Heschl's gyrus into temporally ordered sequences that the brain can decode as speech units (phonemes). This temporal specialization contrasts sharply with the auditory processing mechanisms necessary for perceiving steady tones or slowly changing sounds, highlighting the PT's specific adaptation to the demands of human communication.

In addition to linguistic processing, the PT is involved in the perception of other complex auditory phenomena, particularly those involving sequential ordering. For instance, in musicians, the PT, and potentially the surrounding planum polare, demonstrates activity during the reading and comprehension of musical notation and the analysis of complex harmonic sequences. This suggests a more generalized function related to the sequential mapping of auditory events into a meaningful cognitive structure, whether that structure is linguistic, musical, or spatial. The ability to localize sounds in space, which relies heavily on comparing the temporal differences between sounds arriving at the two ears (interaural time differences), also engages the PT, demonstrating its role in integrating time-based cues for spatial awareness within the auditory environment.

The hierarchical processing model places the PT immediately following the primary sensory input. Signals traverse from the cochlea to the auditory brainstem, thalamus, and finally Heschl's gyrus (A1). The PT then serves as the critical transition zone between primary sensation and complex cognition. It integrates incoming information with prior knowledge, memory, and contextual cues, allowing the listener to segment continuous speech into discrete words and match those acoustic patterns to stored lexical representations. This integrative capacity is paramount for tasks such as listening in noisy environments (the "cocktail party effect"), where the PT must actively suppress irrelevant noise while focusing on the temporally complex speech signal of interest. Failure in this filtering or temporal analysis mechanism, often linked to PT dysfunction, can severely impair language comprehension even when hearing acuity remains normal.

4. Clinical Relevance: Language Disorders and Psychopathology

The clinical significance of the Planum Temporale is profound, particularly in the study of neurodevelopmental and psychiatric disorders where language and auditory processing are compromised. The most direct clinical relevance involves receptive aphasia. As the original source content noted, damage to the left PT, typically due to stroke, trauma, or ischemia affecting the middle cerebral artery territory, often results in **Wernicke's aphasia**, characterized by severely impaired language comprehension, though speech production may remain fluent (albeit often nonsensical or paraphasic). The extent and nature of the damage to the PT strongly correlate with the severity of the receptive deficit, illustrating the structure's non-negotiable role in semantic decoding.

Beyond acquired injury, anomalous PT structure is frequently observed in individuals with developmental language disorders. A substantial body of research has demonstrated that many individuals diagnosed with **developmental dyslexia** exhibit reduced or reversed Planum Temporale asymmetry. Instead of the typical left-larger-than-right pattern, the PTs may be symmetrical or, in some cases, the right side may be marginally larger. This anatomical deviation is hypothesized to underlie the core deficit in dyslexia: impaired rapid auditory temporal processing, which prevents the accurate segmentation of phonemes necessary for reading and spelling acquisition. While the causality remains complex, the structural difference in the PT provides a strong neurobiological marker for susceptibility to language learning difficulties.

Furthermore, aberrations in PT morphology and function are consistently implicated in major psychiatric disorders, most notably **schizophrenia**. Patients with schizophrenia often report auditory hallucinations, which are believed to stem from disrupted processing in the auditory association cortex. Post-mortem studies and advanced neuroimaging have frequently identified reduced PT volume, particularly in the left hemisphere, and a loss of normal asymmetry in schizophrenic populations. These structural abnormalities are often linked to specific symptoms, such as thought disorder and difficulty distinguishing between internal speech and external auditory stimuli, reinforcing the PT's critical role in self-monitoring and reality testing based on complex temporal auditory inputs.

5. Debates and Criticisms Regarding Functional Specificity

Despite decades of intensive research confirming the centrality of the Planum Temporale to language, significant debates persist regarding its precise functional specificity. Early localizationist views suggested the PT was strictly a language area, but modern cognitive neuroscience critiques this narrow interpretation. One major debate revolves around whether the PT's primary role is specific to speech sounds or whether it is a domain-general mechanism optimized for **rapid temporal processing**, regardless of the stimulus type (linguistic, musical, or environmental). Evidence supporting the domain-general view includes the finding that the left PT activates strongly when subjects are asked to discriminate between non-speech sounds that differ only by brief temporal delays, suggesting it is a 'temporal analysis machine' that language systems subsequently utilize.

A second key area of controversy involves the exact boundaries of the Planum Temporale and its overlap with other functional regions. Defining the PT using purely anatomical landmarks (the Sylvian fissure, Heschl's sulcus) does not perfectly align with the functional areas identified through fMRI or electrophysiological mapping. Some research suggests that the PT is highly heterogeneous, containing sub-regions specialized for different types of acoustic processing, complicating its designation as a single functional unit. Furthermore, the concept of Wernicke's area itself has been significantly revised, moving from a strict anatomical region to a distributed

network, diluting the concept that the PT is the sole anatomical substrate for comprehension. Critics argue that focusing too heavily on the PT's size asymmetry might overlook the compensatory roles played by other structures, or the microstructural differences (e.g., neuronal density or connectivity) that might be more crucial than gross size alone.

Finally, there is an ongoing discussion regarding the phylogenetic origins of PT asymmetry. While humans exhibit profound leftward asymmetry linked to language, studies in non-human primates, particularly chimpanzees and rhesus monkeys, have shown mild, though inconsistent, asymmetries in homologous structures. This leads to the debate whether human PT asymmetry is a relatively recent evolutionary adaptation co-opted for language, or if the underlying structural preference for left dominance in temporal processing predates the evolution of complex human language. Resolving this debate requires sophisticated comparative anatomy and imaging techniques to determine if the fundamental specialization for rapid temporal analysis is a primitive feature of the primate auditory system or a unique signature of the human language brain.

Further Reading

[Planum Temporale \(Wikipedia\)](#)

[Wernicke's Area and Language Processing](#)

[Anatomy of the Superior Temporal Gyrus](#)

[Cerebral Hemispheric Specialization](#)