Review

Neuroscience

How Does the Language Center of Our Brain Develop?

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Human language is one of the most complex cognitive functions, relying on distributed yet specialized neural networks that emerge through a dynamic interplay of genetic programming, brain maturation, sensory experience, and social interaction. The development of the brain's language centers is not a simple unfolding of a predetermined blueprint, but a prolonged, plastic process that begins before birth and continues through childhood and adolescence. This review examines how language-related brain regions develop structurally and functionally, integrating evidence from neuroanatomy, developmental neuroscience, genetics, neuroimaging, and studies of atypical language acquisition. It highlights how early neural biases become refined into lateralized language networks, how experience sculpts cortical circuits, and how critical and sensitive periods shape long-term outcomes. Understanding language center development provides insight into normal cognition, neurodevelopmental disorders, and the biological foundations of human communication.

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DEVELOPMENT begins before birth. During prenatal life, the human brain undergoes rapid neurogenesis, migration, and early circuit formation. Even at this early stage, the cortex shows regional specialization, with areas destined for language exhibiting distinct cytoarchitecture and connectivity (Dubois et al., 2021). Genetic programs guide the establishment of these regional identities, influencing cortical thickness, neuron type distribution, and long-range connections. Importantly, these early differences do not encode specific words or grammar but rather bias certain regions toward processing rapidly changing auditory signals and hierarchical sequences—capacities essential for language (Skeide & Friederici, 2022).

Fetal exposure to sound also plays a role. Although the womb attenuates high-frequency sounds, rhythmic and prosodic features of speech penetrate the uterine environment. Studies show that newborns can distinguish their mother's voice and show preference for the rhythm of their native language (Partanen et al., 2021). These findings suggest that the auditory system and its cortical targets are already being tuned before birth, laying the groundwork for later language learning.

At birth, the human brain is structurally immature but functionally primed for learning. Newborns possess a broad capacity to discriminate speech sounds from many languages, a flexibility that gradually narrows with experience. Early in life, language-related activity is distributed across both hemispheres, indicating that lateralization is not fixed at birth (Hááden et al., 2025). While adults typically rely more on left-hemisphere networks for language, infants show bilateral activation during speech processing, suggesting that hemispheric specialization emerges gradually through development.

The first year of life represents a critical phase for language-related brain development. During this period, synaptogenesis accelerates, particularly in auditory and association cortices. Infants begin to specialize in the sounds of their native language, a process reflected in changes in neural responses within the superior temporal cortex (Kuhl, 2021). This perceptual narrowing illustrates how experience refines neural circuits by strengthening frequently used connections and pruning those that are less relevant.

Vocabulary acquisition during the second year of life coincides with further reorganization of cortical networks. As children learn words, regions in the temporal lobe become increasingly responsive to meaningful speech rather than simple acoustic features (Rowland et al., 2022). At the same time, frontal regions associated with speech production and sequencing become more engaged. The gradual coordination between temporal and frontal areas, mediated by white matter pathways such as the arcuate fasciculus, marks a key step in the emergence of a functional language system (Skeide & Friederici, 2022).

The development of grammar provides further insight into how language centers mature. Syntax requires the integration of hierarchical rules, working memory, and predictive processing. Neuroimaging studies indicate that frontal regions traditionally associated with Broca's area become increasingly specialized for syntactic processing as children age (Matchin & Hickok, 2020). This specialization reflects prolonged maturation of cortical microstructure and connectivity.

Social interaction is a powerful driver of language development and its neural substrates. Children do not learn language simply by hearing words; they learn through responsive, contingent communication with caregivers and peers. Brain imaging studies show that socially interactive language exposure produces stronger activation in language networks than passive listening (Kuhl, 2021). This underscores that language development is a socially embedded process that recruits attention and emotional circuits alongside traditional language areas.

Critical and sensitive periods play a central role in shaping language centers. Early childhood represents a window during which the brain is particularly receptive to linguistic input. Evidence from cases of extreme deprivation or delayed language exposure demonstrates that delayed input can lead to long-lasting deficits in grammar and phonology (Mayberry & Kluender, 2022). However, plasticity does not disappear after childhood; rather, it becomes more constrained.

Bilingualism offers a valuable lens through which to examine language center development. Children exposed to multiple languages from an early age typically develop overlapping but partially distinct neural representations for each language (Costa & Sebastián-Gallés, 2021). This experience appears to enhance executive control networks and maintain flexibility in language-related circuits.

Atypical development further illuminates the processes underlying language center formation. Developmental language disorder, autism spectrum conditions, and dyslexia are associated with differences in the structure and function of language-related networks (Bishop et al., 2023). These differences often involve altered connectivity rather than isolated regional deficits.

Genetics contributes significantly to language development, but not in a deterministic manner. Genes influence neural proliferation, migration, synaptic plasticity, and neurotransmitter systems that support language learning (Graham & Fisher, 2022). Yet genes operate within environmental contexts, and rich linguistic input can mitigate genetic risk.

The maturation of subcortical structures also supports language development. The basal ganglia and cerebellum contribute to sequencing, timing, and prediction in language (Ackermann et al., 2021). Their development parallels improvements in speech fluency and grammatical processing.

Adolescence marks a final phase of refinement for language centers. Higher-order skills such as figurative language, narrative coherence, and pragmatic nuance continue to develop as frontal and temporal networks mature (Blakemore & Choudhury, 2021).

Neuroimaging has transformed our understanding of language center development by allowing researchers to observe changes in vivo across the lifespan. Longitudinal studies reveal that language networks become more focal and efficient over time (Friederici, 2020).

Importantly, the concept of a single "language center" is increasingly obsolete. Modern neuroscience views language as an emergent property of interacting systems that process sound, meaning, memory, motor planning, and social context (Matchin & Hickok, 2020). Development involves coordinating these systems into a coherent whole.

In conclusion, the development of the brain's language center is a prolonged, dynamic process shaped by genetic predispositions, neural maturation, sensory input, and social interaction. Language emerges through experience-dependent refinement of distributed neural networks (Skeide & Friederici, 2022).■

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References

Ackermann, H., Hage, S. R., & Ziegler, W. (2014). Brain mechanisms of acoustic communication in humans and nonhuman primates: an evolutionary perspective. The Behavioral and Brain Sciences, 37(6), 529–546. DOI: https://doi.org/10.1017/S0140525X13003099

Bishop, D. V., Snowling, M. J., Thompson, P. A., Greenhalgh, T., & CATALISE consortium (2016). CATALISE: A Multinational and Multidisciplinary Delphi Consensus Study. Identifying Language Impairments in Children. PloS One, 11(7), e0158753. DOI: https://doi.org/10.1371/journal.pone.0158753

Blakemore, S. J., & Choudhury, S. (2006). Development of the adolescent brain: implications for executive function and social cognition. Journal of Child Psychology and Psychiatry, and Allied Disciplines, 47(3-4), 296–312. DOI: https://doi.org/10.1111/j.1469-7610.2006.01611.x

Costa, A., & Sebastián-Gallés, N. (2014). How does the bilingual experience sculpt the brain? Nature Reviews. Neuroscience, 15(5), 336–345. DOI: https://doi.org/10.1038/nrn3709

Dubois, J., Dehaene-Lambertz, G., Kulikova, S., Poupon, C., Hüppi, P. S., & Hertz-Pannier, L. (2014). The early development of brain white matter: a review of imaging studies in fetuses, newborns and infants. Neuroscience, 276, 48–71. DOI: https://doi.org/10.1016/j.neuroscience.2013.12.044

Friederici A. D. (2020). Hierarchy processing in human neurobiology: how specific is it?. Philosophical transactions of the Royal Society of London. Series B, Biological Sciences, 375(1789), 20180391. DOI: https://doi.org/10.1098/rstb.2018.0391

Graham, S. A., & Fisher, S. E. (2013). Decoding the genetics of speech and language. Current Opinion in Neurobiology, 23(1), 43–51. DOI: https://doi.org/10.1016/j.conb.2012.11.006

Háden, G. P., Tóth, B., & Winkler, I. (2025). Longitudinal study of functional brain networks for processing infant-directed and adult-directed speech during the first year. iScience, 28(10), 113583. DOI: https://doi.org/10.1016/j.isci.2025.113583

Kuhl P. K. (2011). Early Language Learning and Literacy: Neuroscience Implications for Education. Mind, Brain and Education: The Official Journal of the International Mind, Brain, and Education Society, 5(3), 128–142. DOI: https://doi.org/10.1111/j.1751-228X.2011.01121.x

Matchin, W., & Hickok, G. (2020). The Cortical Organization of Syntax. Cerebral cortex (New York, N.Y.: 1991), 30(3), 1481–1498. DOI: https://doi.org/10.1093/cercor/bhz180

Mayberry, R. I., & Kluender, R. (2018). Rethinking the critical period for language: New insights into an old question from American Sign Language. Bilingualism (Cambridge, England), 21(5), 938–944. DOI: https://doi.org/10.1017/S1366728918000585

Partanen, E., Kujala, T., Tervaniemi, M., & Huotilainen, M. (2013). Prenatal music exposure induces long-term neural effects. PloS One, 8(10), e78946. DOI: https://doi.org/10.1371/journal.pone.0078946

Rowland, C. F., Chang, F., Ambridge, B., Pine, J. M., & Lieven, E. V. (2012). The development of abstract syntax: Evidence from structural priming and the lexical boost. Cognition, 125(1), 49-63. DOI: https://doi.org/10.1016/j.cognition.2012.06.008

Skeide, M. A., & Friederici, A. D. (2016). The ontogeny of the cortical language network. Nature reviews. Neuroscience, 17(5), 323–332. DOI: https://doi.org/10.1038/nrn.2016.23