Human brain development

Human brain development is a complex and dynamic process that begins early in embryonic development and continues throughout life. Several key stages and processes characterize this intricate journey:

Embryonic Development:

The development of the human brain begins in the early stages of embryogenesis. The neural tube, which forms from the ectoderm, gives rise to the central nervous system, including the brain. Different regions of the brain start to develop during this phase. Fetal Development:

During the fetal period, the brain undergoes significant growth and differentiation. Neural progenitor cells proliferate, migrate to their designated areas, and differentiate into neurons and glial cells. The formation of the cerebral cortex, responsible for higher cognitive functions, occurs during this time. Postnatal Development:

After birth, the brain continues to develop and refine its structure and function. Early experiences and environmental stimuli play a crucial role in shaping neural connections through processes like synaptogenesis (formation of synapses) and myelination (the development of myelin sheaths around nerve fibers). Childhood and Adolescence:

Throughout childhood and adolescence, the brain undergoes further refinement. This period is marked by synaptic pruning, where unnecessary synapses are eliminated, and remaining connections are strengthened. Brain regions associated with higher-order thinking, emotional regulation, and social cognition continue to mature. Early Adulthood:

The brain development process continues into early adulthood, particularly in regions responsible for executive functions and decision-making. Myelination continues, enhancing the efficiency of neural communication. Cognitive abilities, including memory and problem-solving, continue to improve. Adulthood and Aging:

While certain aspects of brain development slow down in adulthood, neuroplasticity persists, allowing the brain to adapt to new experiences. Aging is associated with changes in the brain, including some degree of synaptic loss and alterations in neurotransmitter levels. Throughout these stages, genetic factors, environmental influences, and experiences shape the architecture and function of the human brain. Disruptions or abnormalities in this developmental process can contribute to neurological and neurodevelopmental disorders. Understanding the intricacies of human brain development is essential for gaining insights into normal cognitive functioning and addressing challenges associated with brain-related conditions.

Human brain development is ongoing throughout childhood, with for example, myelination of nerve fibers and refinement of synaptic connections continuing until early adulthood. 1H-Magnetic Resonance Spectroscopy (Proton magnetic resonance spectroscopic imaging) can be used to quantify the concentrations of endogenous metabolites (e.g. glutamate and γ -aminobutyric acid (GABA)) in the human brain in vivo and so can provide valuable, tractable insight into the biochemical processes that support postnatal neurodevelopment. This can feasibly provide new insight into and aid the management of neurodevelopmental disorders by providing chemical markers of atypical

development. This study aims to characterize the normative developmental trajectory of various brain metabolites, as measured by Proton magnetic resonance spectroscopic imaging from a midline posterior parietal voxel. We find significant non-linear trajectories for GABA+ (GABA plus macromolecules), Glx (glutamate + glutamine), total choline (tCho) and total creatine (tCr) concentrations. Glx and GABA+ concentrations steeply decrease across childhood, with more stable trajectories across early adulthood. tCr and tCho concentrations increase from childhood to early adulthood. Total N-acetyl aspartate (tNAA) and Myo-Inositol (mI) concentrations are relatively stable across development. Trajectories likely reflect fundamental neurodevelopmental processes (including local circuit refinement) which occur from childhood to early adulthood and can be associated with cognitive development; we find GABA+ concentrations significantly positively correlate with recognition memory scores [1)].

The type of study described is a longitudinal observational study on human brain development.In this case, the study focuses on the ongoing development of the human brain throughout childhood and early adulthood.

The study specifically uses 1H-Magnetic Resonance Spectroscopy (Proton magnetic resonance spectroscopic imaging) to quantify concentrations of endogenous metabolites in the human brain in vivo. The goal is to characterize the normative developmental trajectory of various brain metabolites, such as GABA, Glx, total choline, total creatine, total N-acetyl aspartate, and Myo-Inositol. The study aims to understand how these concentrations change over time, providing insight into biochemical processes supporting postnatal neurodevelopment.

The findings suggest significant non-linear trajectories for certain metabolites, indicating changes in their concentrations from childhood through early adulthood. The study also explores the potential associations between these metabolite trajectories and cognitive development, with a notable positive correlation between GABA+ concentrations and recognition memory scores. Overall, the study aims to contribute valuable information about the biochemical processes underlying normative brain development and potentially provide insights for managing neurodevelopmental disorders.

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Thomson AR, Hwa H, Pasanta D, Hopwood B, Powell HJ, Lawrence R, Tabuenca ZG, Arichi T, Edden RAE, Chai X, Puts NA. The developmental trajectory of Proton magnetic resonance spectroscopic imaging brain metabolites from childhood to adulthood. Cereb Cortex. 2024 Mar 1;34(3):bhae046. doi: 10.1093/cercor/bhae046. PMID: 38430105; PMCID: PMC10908220.