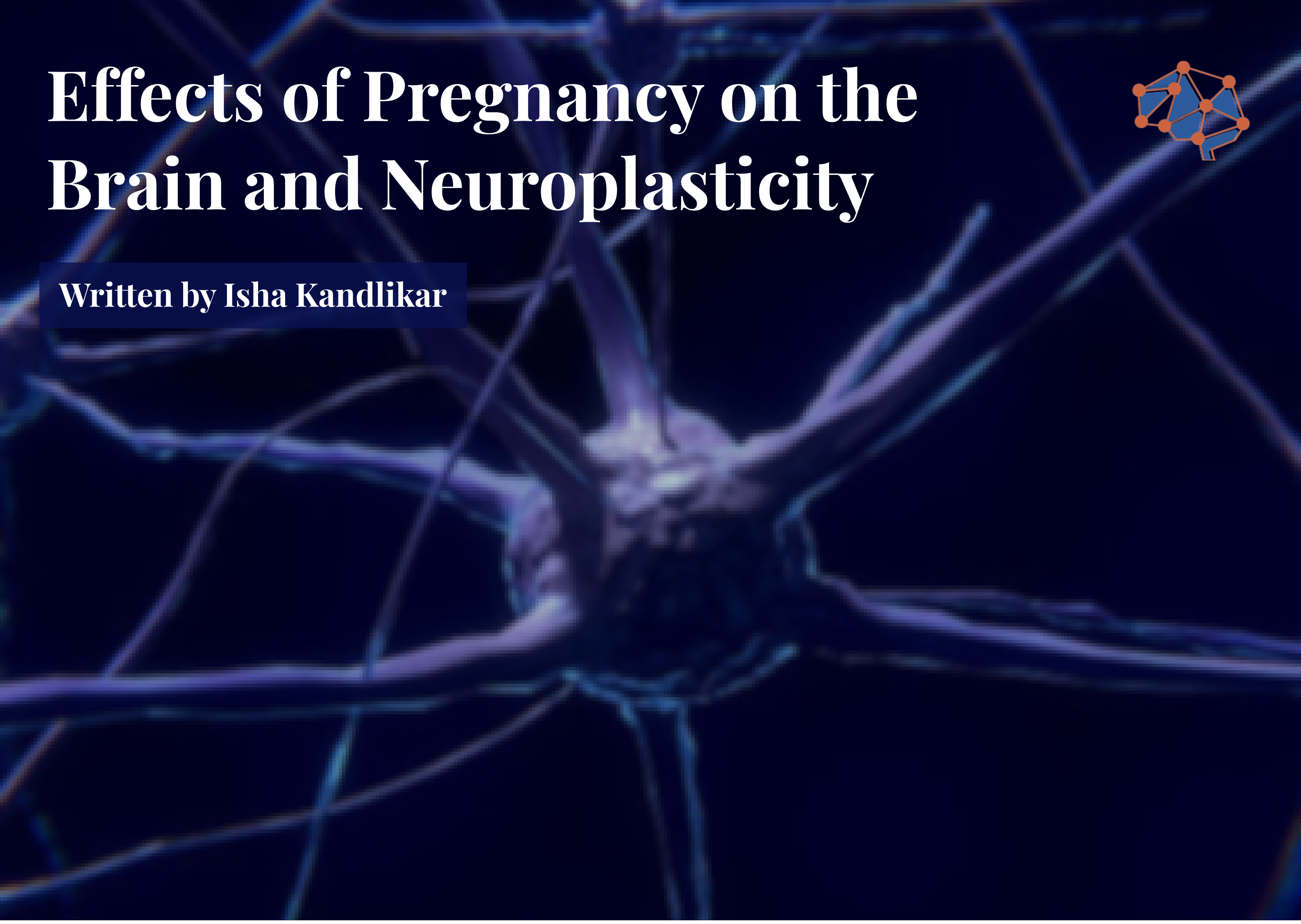
Effects of Pregnancy on the Brain and Neuroplasticity



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Introduction to Pregnancy-Induced Neuroplasticity

The brain constantly reshapes itself and adapts throughout pregnancy, utilizing a process called neuroplasticity. In this process, the brain undergoes structural changes and reorganization in response to injury, environmental changes, learning, and a variety of other experiences. Pregnancy not only transforms the body but also influences the brain's emotions, maternal instincts, cognition, and overall regulation (Pawluski, Lambert, & Kinsley, 2016). Neuroplasticity, as well as these neurological adaptations, creates long-term shifts in the brain structure and function, which allows the brain to adapt to parenthood and changes in mental state and behavior. Several key neuroplastic changes occur during and after pregnancy, which have implications for maternal cognition and emotional health, highlighting the importance of such changes in maternal and child development.

Hormonal Influences on Maternal Brain Remodeling

During pregnancy, there is a dramatic spike in hormones—primarily estrogen, oxytocin, and progesterone– all of which play a crucial role in shaping the mother's brain for the long-term experiences following pregnancy. According to the NIH, progesterone, which regulates the menstrual cycle and maintains pregnancy, also reaches peak levels before delivery and has a neuroprotective role that includes reducing stress responses and modulating the limbic system, which regulates emotions (Cable, 2023). However, after the mother gives birth, progesterone levels rapidly decrease, which leads to the mother's vulnerability towards disorders like postpartum depression. Oxytocin, a hormone that plays a role in social interactions and emotional regulation, steadily increases during pregnancy, then rises dramatically during labor and breastfeeding to encourage uterine contraction and lactation. Oxytocin further remodels the brain through enhancing neural plasticity in the medial preoptic area (MPOA), amygdala, and nucleus accumbens, which are key regions for maternal motivation and emotional bonding (Thul, 2020). This ultimately changes the mother's brain by rewiring and strengthening mother-infant attachment, increasing her sensitivity to infant cues. Not only does oxytocin affect the mother during pregnancy, but it also maintains a lasting effect through breastfeeding, as it promotes emotional resilience and reduces stress by decreasing activity in the hypothalamic-pituitary-adrenal (HPA) axis, which regulates cortisol production (Blankers, 2024). The intricate interplay between oxytocin, progesterone, and estrogen leaves long-term impacts on emotional regulation, cognition, and maternal instincts during and after pregnancy.

Structural Brain Changes: Gray and White Matter

Neuroimaging studies have led researchers to believe that pregnancy induces changes in the regions of the brain that regulate social cognition and emotional regulation (Younis, 2025). One of the most notable findings is gray matter volume reduction in areas such as the prefrontal cortex, medial temporal lobe, and limbic system, primarily in the amygdala and hippocampus. Furthermore, a reduction in gray matter likely reflects a neural pruning process, which shapes maternal instincts and caregiving behaviors. Since these regions are crucial for social cognition and emotional processing, the mother's ability to look after her child and tend to their needs is improved as maternal sensitivity is increased (Snyder, 2017).

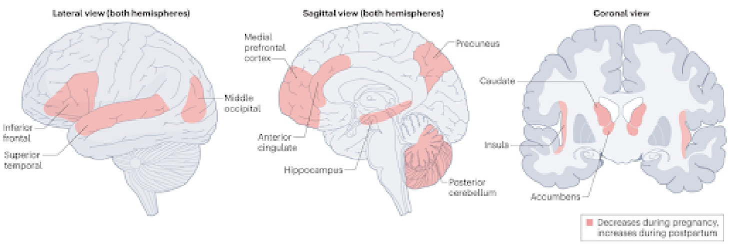

Figure 1. This image illustrates brain regions that decrease in volume during pregnancy and increase postpartum, highlighting areas involved in emotional regulation, cognition, and maternal behavior (Medical Xpress, 2023)

Pregnancy also induces white matter expansion, which speeds up neural transmission and improves connectivity via myelin, a lipid coating of a neuron's axon. White matter tracts facilitate communication between brain regions – this increase in white matter density occurs specifically in pathways that involve cognitive control and emotional regulation. White matter volume is increased in the prefrontal cortex, enhancing cognitive control and decision making (Blankers, 2024). Additionally, there is an observed increase in the cingulum bundle, a white matter tract that connects the prefrontal cortex and limbic system (including the amygdala and hippocampus), playing a role in emotional processing, stress regulation, and maternal motivation (Blankers, 2024). These changes can contribute to lower cortisol levels, which helps the mother remain calm under stress. Increased connectivity in reward pathways may also boost dopamine signaling, enhancing maternal motivation and infant bonding.

Changes in the Default Mode Network and Empathy Processing

In addition to the reduction of gray matter and white matter expansion, pregnancy also alters the functional connectivity within the Default Mode Network (DMN), the inter-regional connections that control empathy, self-reflection, and social processing involving the medial prefrontal cortex, posterior cingulate cortex, and inferior parietal lobule. Research suggests that the reduction of gray matter, particularly in areas associated with theory of mind and social cognition, contributes to changes in DMN connectivity. These changes in the DMN activity highlight a shift in the maternal brain regarding responsiveness towards infant-related stimuli, which continues to reinforce the infant-mother bond (Paternina-Die, Martínez-García, Martín de Blas et al., 2024).

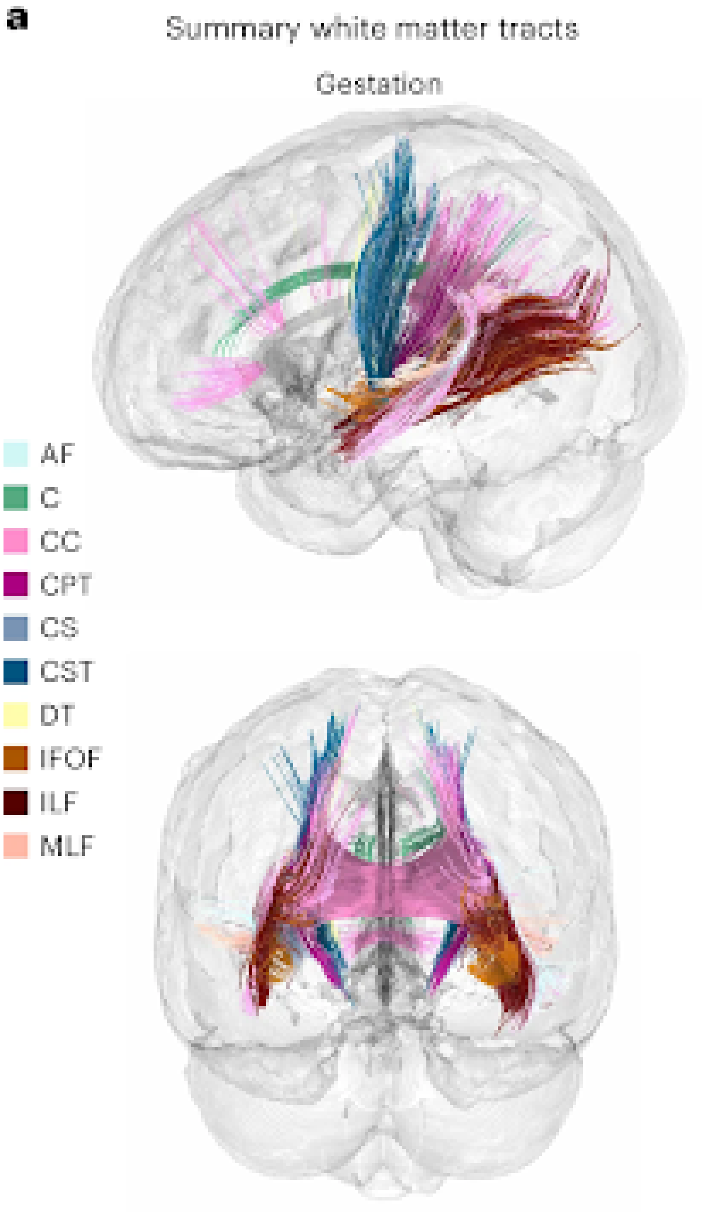

Figure 2. This image shows the distribution of white matter tracts during gestation, emphasizing the enhanced neural connectivity that supports cognitive control, emotional regulation, and maternal behaviors (Pritschet et. al., 2024).

On a much broader scale, pregnancy affects multiple brain structures, including the hippocampus (memory and learning), prefrontal cortex (decision-making and emotional regulation), and amygdala (emotion processing and threat detection). As a whole, these changes enhance maternal responsiveness, improve memory for infant cues, and reduce the fear response to infant stimuli. Improved memory for infant cues allows mothers to better recognize responses such as their baby's facial expression and cries, while reducing fear response to infant stimuli helps the mother stay calm in overwhelming situations. Overall, during pregnancy, the size of the brain is reduced temporarily but returns to its original size 1-2 years postpartum (Kohl, 2019).

Cognitive Shifts and Evolutionary Adaptations

Pregnancy induces cognitive shifts as a result of the changes in neuroplasticity and is commonly referred to as the "mom brain" (Phoenix Health, 2025). This phenomenon is characterized by cognitive fog, forgetfulness, and altered attention during pregnancy and early motherhood. As the size of the brain decreases during pregnancy, it goes through a neural pruning process, which allows it to shift its focus onto infant-related stimuli. For example, mothers may experience a heightened sensitivity to infant cues such as crying, facial expressions, and touch. During pregnancy, many women struggle with focus, verbal fluency, and memory, which is due to the hormonal fluctuations but also to the physical structural changes. The changes and volume reduction of the hippocampus may explain the reduced cognitive flexibility as well as the short term forgetfulness. While these changes may seem negative, they are necessary for evolution and evolutionary mechanisms of the mother during pregnancy and its lasting effects (Phoenix Health, 2025). Neural pruning allows the brain to be more specialized and more efficient by streamlining information deemed necessary to motherhood (Kim, 2010). By restructuring the "mom brain", these changes are optimizing maternal behavior through increases in maternal instincts, emotional regulation, and awareness of infant cues with empathy and vigilance.

While pregnancy is universally known to impact neuroplasticity, affect the hormonal balance, and change the physical structure of the brain, the extent and persistence of such changes vary. Some alterations to the brain and body, such as changes in gray matter volume or hormonal shifts, can persist for months or even years postpartum, influencing long-term maternal behavior and emotional regulation. Mothers experience different changes in neuroplasticity based on genetics, mental health, trauma, and previous life events. Genetic factors contribute to individual differences in terms of hormonal regulation, maternal behavior, brain plasticity, and more. The main variants in genes are related to the oxytocin receptor function (OXTR), dopamine signaling (DRD2), and serotonin regulation (5-HTTLPR), all of which contribute to maternal sensitivity, stress management, and emotional bonding with the infant (Duarte-Guterman, Leuner, & Galea, 2019). Women with genetic predispositions for higher oxytocin receptor sensitivity can experience stronger, more natural maternal instincts and emotional bonding. Mothers with genetic vulnerabilities to dopaminergic dysfunction are more likely to struggle with postpartum mood disorders or attachment difficulties.

Mental Health and Its Influence on Postpartum Brain Adaptation

Furthermore, the mother's mental health and past experiences before pregnancy can significantly impact how her brain adapts to pregnancy and life after. Women with a history of anxiety, depression, or trauma are more likely to exhibit altered neural plasticity in response to pregnancy-related hormonal shifts. This is highlighted in conditions such as pre-existing stress-related dysregulation in the HPA axis, which is correlated to higher susceptibility to postpartum depression (Kim 2010).

The persistence of neuroplasticity postpartum is largely affected by the mother's pre-existing mental health conditions, such as anxiety, depression, or trauma. Research indicates that women with a history of major depressive disorder or anxiety show altered connectivity in maternal brain regions, specifically the prefrontal cortex and amygdala, which both impact emotional responses to infants and motivation for caregiving (Meireles, 2021). Such disruptions can potentially lead to a shortened duration of adaptive neuroplasticity, making it more difficult for these mothers to sustain long-term changes and to support maternal responsiveness and bonding. This not only changes the way the maternal brain adapts, but also the duration of its impact (Meireles, 2021). Conversely, mothers with minimal mental health concerns show stronger connectivity between the amygdala and PFC, allowing for better emotional regulation and lasting positive adaptations. Mothers with past experiences of positive emotional regulation are able to sustain the neuroplasticity changes in the amygdala, reinforcing maternal instincts for longer (Meireles, 2021).

Because pregnancy is a period of significant neuroplastic adaptation, it can induce long-term neurological vulnerabilities. A representative example of this is preeclampsia, a hypertensive disorder that affects approximately 5–8% of pregnancies (Karrar, 2024). Preeclampsia is associated with hypertension, endothelial (relating to blood vessels) dysfunction, and systemic inflammation, which not only pose immediate perinatal risks but can also increase the mother's long-term susceptibility to neurodegenerative diseases such as Alzheimer's disease, vascular dementia, and stroke. This increased vulnerability is hypothesized to stem from persistent endothelial dysfunction and systemic inflammation, which make up cerebrovascular integrity and neuronal function even decades after pregnancy (Logue, 2016). Heightened levels of pro-inflammatory cytokines, such as IL-6, TNF-α, and oxidative stress markers observed in preeclamptic pregnancies can persist postpartum, leading to accelerated neurovascular aging and white matter damage (Friis et al., 2024).

Beyond preeclampsia, there are many neurological vulnerabilities created from the postpartum period itself. Hormonal imbalance and the sudden drop in estrogen and progesterone in the postpartum period can exacerbate neuroinflammatory pathways, increasing the risk of neuropsychiatric disorders and cognitive deficits. Examples of potential neuropsychiatric disorders include postpartum depression, anxiety disorders, and even postpartum psychosis, while examples of cognitive deficits are memory impairments, brain fog, and decreased processing speed (González-Mesa et al., 2020). Additionally, the reduction of the hippocampus postpartum can impair synaptic plasticity specifically in women with pregnancy complications, leading to longer-term cognitive impairment and dysfunction. Some preventative measures to reduce neurodegenerative effects include routine neurological screenings, blood pressure management, and exercise (González-Mesa et al., 2020).

As more than 80% of biological women become mothers by the age of 40 in the USA (Pew Research Center, n.d.), understanding of the effects of pregnancy on neuroplasticity is crucial. Pregnancy induces reshaping of the brain and hormonal changes well past childbirth. These cognitive changes are not always deficits, but adaptations that enhance maternal instincts, emotional regulation, and caregiving behaviors, strengthening the mother-infant bond. Consequently, further neuroscience research is essential in order to improve maternal healthcare, mental health support for mothers, and long-term brain intervention therapies.

Conclusion and Future Directions

Driven by hormonal change and structural remodeling that enhance cognition, maternal behaviors, and emotional regulation, pregnancy overall triggers many neuroplastic changes in the maternal brain. These adaptations and shifts are essential in optimizing the mother's caregiving abilities and responsiveness to the infant. However, many genetic factors, pregnancy complications, and individual mental health struggles influence and affect the persistence of these brain changes. Understanding pregnancy-induced neuroplasticity and continuing research is vital for advancing maternal health care, supporting mental well-being, and addressing long-term neurological risks.

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Isha Kandlikar is a rising junior at the UIUC majoring in Molecular and Cellular Biology with minors in Business and Public Health. She is an undergraduate researcher in the Rudolph Lab, where she studies genetic mouse models to explore treatments for psychiatric disorders. Outside the lab, Isha is a marketing and healthcare consultant, a member of the Illini Medical Screening Society, and involved in Alpha Epsilon Delta, a pre-health fraternity on campus. Passionate about neuroscience, she is excited to write for Brain Matters and dive deeper into specific topics within the field.