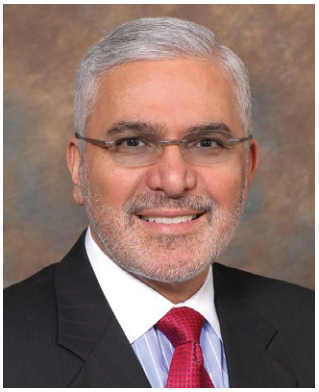
Brain structural and cognitive changes during pregnancy



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Pregnancy is unquestionably a major milestone in a woman's life. During gestation, her body shape noticeably changes, but the invisible structural and cognitive changes in her brain are more striking. Some of those neurobiological changes are short-term, while others are long-lasting, well beyond delivery, and even into old age.

Physiological changes during pregnancy are extraordinary. The dramatic increases in estrogen, progesterone, and glucocorticoids help maintain pregnancy, ensure safe delivery of the baby, and trigger maternal behavior. However, other important changes also occur in the mother's cardiac output, blood volume, renal function, respiratory output, and immune adaptations to accommodate the growth of the fetus. Gene expression also occurs to accomplish those changes, and there are lifelong repercussions from those drastic physiological changes.

During pregnancy, the brain is exposed to escalating levels of hormones released from the placenta, which the woman had never experienced. Those hormones regulate neuroplasticity, neuroinflammation, behavior, and cognition.

Structural brain changes[1-6]

Brain volume declines during pregnancy, reaching a nadir at the time of parturition. However, recovery occurs within 5 months after delivery. During the postpartum period, gray matter volume increases in the first 3 to 4 weeks, especially in areas involved in maternal behavior, including the amygdala, prefrontal cortex, and hypothalamus. Hippocampal gray matter decreases at 2 months postpartum compared to preconception levels, and reductions can still be observed up to 2 years following delivery. Gray matter reductions occur in multiple brain regions involved in social cognition, including the superior temporal gyrus, medial and inferior frontal cortex, fusiform areas, and hippocampus. Those changes correlate with positive maternal attachment. It is noteworthy that neural activity is highest in areas with reduced gray volume, so a decline in brain volume is associated with enhanced maternal attachment. Interestingly, those changes occur in fathers, too.

Childbearing improves stroke outcomes in middle age, but body weight will increase. The risk of Alzheimer's disease increases with a higher number of gestations, but longevity is higher if the pregnancy occurs at an older age. Reproduction is also associated with

The neurobiological sequelae of pregnancy extend to the rest of a woman's life

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shorter telomeres, which can elevate the risk of cancer, inflammation, diabetes, and dementia.

Cognitive changes[7-10]

The term "pregnancy brain" refers to cognitive changes during pregnancy and postpartum; these include decreased memory and concentration, absent-mindedness, heightened reactivity to threatening stimuli, and a decrease in motivation and executive functions. After delivery a mother has increased empathy (sometimes referred to as Theory of Mind) and greater activation in brain structures involved in empathy, including the paracingulate cortex, the posterior cingulate, and the insula. Also, the mirror neuron system becomes more activated in response to a woman's own children compared to unfamiliar children. This incudes the ventral premotor cortex, the inferior frontal gyrus, and the posterior parietal cortex.

Certain forms of memory are impaired during pregnancy and early postpartum, including verbal free recall and working memory, as well as executive functions. Those are believed to correlate with glucocorticoids and estrogen levels.

The following cognitive functions increase between the first and second trimester: verbal memory, attention, executive functions processing speed, verbal, and visuospatial abilities. Interestingly, mothers of a male fetus outperformed mothers of a female fetus on working memory and spatial ability.

Other changes[11-16]

• Cells from the fetus can traffic to the mother's body and create microchimeric cells, which have short-term benefits (healing some of the other's organs as stem cells do) but long-term downsides include future brain disorders such as Parkinson's disease or Alzheimer's disease, as well as autoimmune diseases and various types of cancer. The reverse also occurs with cells transferring from the mother to the fetus, persisting into infancy and childhood.

• Postpartum psychosis is associated with reductions in the volumes of the anterior cingulate, left parahippocampal gyrus, and superior temporal gyrus.

• A woman's white matter increases during pregnancy compared to preconception. This is attributed to the high levels of prolactin, which proliferates oligodendrocytes, the glial cells that continuously manufacture myelin.

• The pituitary gland increases by 200% to 300% during pregnancy and returns to pre-pregnancy levels approximately 8 months following delivery. Prolactin also mediates the production of brain cells in the hippocampus (ie, neurogenesis).

• Sexual activity, even without pregnancy, increases neurogenesis. Plasma levels of prolactin increase significantly following an orgasm in both men and women, which indicates that sexual activity has beneficial brain effects.

• With pregnancy, the immune system shifts from proinflammatory to anti-inflammatory signaling. This protects the fetus from being attacked and rejected as foreign tissue. However, at the end of pregnancy, there is a "burst" of proinflammatory signaling, which serves as a major trigger to induce uterine contractions and initiate labor (to expel the foreign tissue).

• Brain levels of the anti-inflammatory cytokine interleukin-6 increase in the postpartum period, which represents a significant modification in the neuroimmune environment, and the maternal brain assumes an inflammatory-resistant state, which has cognitive and neuroplasticity implications. However, this neuroimmune

dysregulation is implicated in postpartum depression and anxiety.

• Older females who were never pregnant or only had 1 pregnancy had better overall cognitive functioning than females who became pregnant at an young age.

• In animal studies, reproduction alleviates the negative effects of aging on several hippocampal functions, especially neurogenesis. Dendritic spine density in the CA1 region of the hippocampus is higher in pregnancy and early postpartum period compared to nulliparous females (based on animal studies).

Pregnancy is indispensable for the perpetuation of the species. Its hormonal, physiologic, neurobiological, and cognitive correlates are extensive. The cognitive changes in the postpartum period are designed by evolution to prepare a woman to care for her newborn and to ensure its survival. But the biological sequelae of pregnancy extend to the rest of a woman's life and may predispose her to immune and brain disorders as she ages.

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The cognitive changes are designed to prepare a woman to care for her newborn and to ensure its survival