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Review article

NEUROPLASTICITY: STRUCTURAL AND FUNCTIONAL CHANGES IN THE BRAIN DURING PREGNANCY AND IN THE POSTPARTUM PERIOD

Abstract:

The term 'mommy brain' is often linked to cognitive decline, however contemporary neuroscientific research shows the opposite: motherhood is a period of intensive neuroplasticity and cognitive reorganization. This paper looks at structural and functional changes in the brain during pregnancy and in the postpartum period, with a focus on the regions involved in social cognition, emotional regulation and motivation for nurturing. The reduction of the grey matter which occurs during pregnancy and postpartum is interpreted as a mark of neuron specialization and functional improvement of the cerebral cortex. Postpartum, there is functional strengthening of the cerebral networks, which is linked to the improvement of social cognition and increased responsiveness to the newborn. The paper suggests redirecting the public and scientific discourse from a narrative of deficit towards evolutionary perspective and valorization of neuroplasticity.

Keywords: *mommy brain, neuroplasticity, pregnancy, postpartum period*

Introduction

The term “mommy brain” (“mommy brain“according to Ellison, 2005 according toMiller, 2016)is a non-medical term which refers to the subjectively experienced changes in the cognitive domain in the period of transition to motherhood. In literature this term can also be found as placenta brain (Christensen et al., 2010) or as baby brain, mom brain, momnesia or pregnancy brain (McCormack et al., 2023), which can suggest that the transition to motherhood is accompanied with a deficit in memory or cognition. In the last few decades this idea gained popularity in pop culture and on social media, with many stories claiming that pregnancy and motherhood are accompanied by cognitive deficit which can last for months or even years (Miller, 2016). Up to 80% of women in transition to motherhood mention forgetfulness as the dominant change (Poser et al., 1986 according to Brett & Baxendale, 2001), however in literature the following variations are also noted: difficulties with reading, distractedness, decreased concentration, absentmindedness, reduced motor coordination, etc. (Parson & Redman, 1991; Brett & Baxendale, 2001). These subjective assessments (measures) are not necessarily confirmed with attempts to identify changes with objective measurement tests. In this respect, the research of Orchard et al. (2022), conducted on 86 women (43 mothers in the postnatal period and 43 women who are not mothers and are not pregnant), did not identify significant differences in the objective cognitive performances between mothers and women who are not mothers. Nevertheless, mothers reported a significantly worse subjective assessment of cognition, which turns to be related to factors such as sleep quality and emotional state. Additionally, the longitudinal research conducted by Christensen et al. (2010) on 2404 women did not identify long-term negative effects from pregnancy and motherhood on cognitive speed, working and long-term memory.

Summarizing the findings, it becomes clear that the perception about “mommy brain” often derives from cultural narratives and societal expectations that reinforce the idea about cognitive decline, while empirical evidence increasingly shows lack of consistent objective changes in cognitive functions.

In an environment where there is strong expectation that motherhood leads to forgetfulness, ordinary everyday mistakes (such as, for example, forgetting a word or misplacement keys), are given excessive importance and are wrongly interpreted as symptoms of cognitive deficit (McCormack et al., 2023). For decades science has been under the impact of the same narrative – which also affects the focus of research and the interpretation of data (McCormack et al., 2023).

This is precisely the reason for the need for a new conceptual approach. An increasing number of scientists use the term matrescence (Raphael, 1975; Athan & Reel, 2015; Orchard et al., 2023), analogous to adolescence, to describe this complex and multidimensional developmental period. Matrescence (period of transition from a woman to motherhood) is seen as a neurocognitive phase

(Orchard et al., 2023), marked with dynamic structural and functional changes, hormone fluctuations, psychological adaptation and social transformations. Instead of viewing the mother as a person with "reduced capacities", contemporary scientific approaches recognize their ability for cognitive reorganization and neuroplastic adaptation.

The plasticity of the woman's brain through life has recently become a prominent field for scientific research. This led to the understanding the transition to motherhood is marked with some of the most significant changes in the brain plasticity in adult women (Pawluski et al., 2022). Even though it might be unexpected, the plasticity which occurs in the mommy brain often involves reduction of brain volume, which leads to neuron specialization, but also serves for optimization of social cognition in the postpartum period (Hoekzema et al., 2017; Pawluski et al., 2022).

Precisely in this context, this paper focuses on showcasing the structural and functional changes in the brain during pregnancy and in the postpartum period. The goal is to show that the functioning of a mother's brain is not deteriorating but is reorganized and finetuned to respond to the new demands of motherhood. From this perspective, "mommy brain" is an indicator of maturity, adaptability and functional precision which do not reflect cognitive decline, but the evolutionary ability of the brain to adapt to the new and responsible role of motherhood.

Neuroplasticity: Brain's hidden power in the period of transition to motherhood

The change in the cognitive capacity which Rachel experiences after the birth of her daughter Emma in the TV show Friends, shown through scenes of distractedness, forgetfulness and humorous cognitive moments, is a reflection on a deeply rooted cultural narrative about "mommy brain". But what really happens in the brain of a mother? To understand this, it is necessary to address the term neuroplasticity – the brain's capacity to change, adapt and reassign its resources in response to new experiences, including parenthood.

What is neuroplasticity?

Before understanding the term neuroplasticity, it is necessary to start with a broader understanding of the term plasticity. Plasticity, in its broadest sense, refers to the ability of any structure to change by external stimulus, however strong enough not to mould permanently or immediately (Hawkins, 2014). It signifies balance between flexibility and stability – the ability to adapt without losing the basic function and structure.

The human brain, with its highly complex nerve tissue, is one of the most plastic structures in the human body. This internal ability for adaptation makes it possible to change during its lifetime – not only in childhood, but in maturity and old age. This is precisely the essence of neuroplasticity.

Neuroplasticity or brain plasticityis defined as the ability of the nervous system to change its activity, structure or connections in response to intrinsic or extrinsic stimuli (Puderbaugh & Emmady, 2025). It includes various processes, the most important of which are the following:

Synaptic plasticity – changes in the strength of the connections between neurons through mechanisms such as long-term potentiation (LTP or sprouting) and long-term depression (LTD or pruning);

Structural plasticity – changes in the morphology of neurons, such as growth of dendrites, number of synapses, changes in the cortex thickness and volume of grey matter;

Functional reorganization – the ability of some brain areas to take on functions from damaged regions, such as after stroke.

Background

In early scientific stages it was believed that the human brain is "fixed" after childhood or in other words, that synaptic connections form only during the so-called "critical periods" of development, and then they remain stable. This gave rise to the idea that the adult brain is not capable of significant regeneration after injury or illness.

However, this view changed over time. The first theory about brain plasticity was proposed as early as 1890 by William James, who in his book Principles of Psychology pointed out the brain's ability for reorganization (Puderbaugh & Emmady, 2025). Later, the term 'neuroplasticity' was officially introduced by Polish neuroscientist Jerzy Konorski in 1948, and was then made popular by Donald Hebb in 1949 through the principle of „cells that fire together wire together" – an idea that the joint activity of neurons strengthens their connection (Puderbaugh & Emmady, 2025).

Research from the second half of 20th century until today has shown that many parts of the brain adapt even in maturity. Contemporary neuroscientific studies confirm that neuroplasticity is a continuous process that occurs in both healthy people and in those with neurological damage. An example of this is the recuperation after stroke, where other areas of the brain can take on functions of the damaged area through reorganization. Also, in motherhood, significant functional and structural changes occur in areas linked to emotional regulation, social cognition and motivation, which enables more efficient care and attachment with the child (Oberman & Pascual-Leone, 2013).

Types of neuroplasticity

Neuroplasticity in humans can be divided into two main types:

Structural plasticity, which refers to physical changes in the brain structure, such as increase or decrease of the grey matter volume, growth of dendrites and changes in the cortex thickness. These changes can be assessed with the help of Magnetic Resonance Imaging (MRI), which enables imaging of the shape, volume and thickness of various brain structures and

Functional plasticity, which refers to changes in the way the brain organizes its functions, such as when one damaged area loses its function, another, healthy area can take over that function. Functional plasticity is measured with the use of several techniques, such as functional Magnetic Resonance Imaging (fMRI), which registers changes in brain activity through blood flow, Positron Emission Tomography (PET), which monitors metabolic processes in the brain, and electroencephalography (EEG), which measures the brain's electric response to certain external stimuli.

Structural changes in the mother's brain

Below we look at specific structural changes which occur in mothers during pregnancy and after giving birth.

Several authors (Duthie & Reynolds, 2013; Elster et al., 1991; Fischer, 1931; Gonzalez et al., 1988) state that one of the earliest structural researches into mothers' brains is focused on the pituitary gland, which undergoes significant changes during pregnancy. As the pregnancy progresses, lactotrophic cells increase the production of prolactin, a key hormone for initiating and maintaining lactation. These early findings, originally obtained through autopsies (Kont, 1898 according toPawluski et al., 2022), have been confirmed almost a century later with in vivo methods such as Magnetic Resonance Imaging, which showed that hyperprolactinemia results in cell hypertrophy and enlargement of the pituitary gland (Martínez-García et al., 2022).

Further, the research by Oatridge et al. (2002), with the use of Magnetic Resonance Imaging, revealed that the size of the brain reduces, with the most prominent reduction in late pregnancy (third trimester), after which there is gradual return of the brain volume to the prenatal level around six months after giving birth. The volume of brain chambers increases during pregnancy and reduces after giving birth (Oatridge et al., 2002).

Pregnancy

More recently, structural Magnetic Resonance Imaging (sMRI) has enabled researchers to investigate more specific changes in brain morphology, such as cortical thickness, surface area, total brain volume, and other related measures. In this respect, Hoekzema et al. (2017) studied the surface and the thickness of the cerebral cortex with the use of advanced Magnetic Resonance Imaging software (FreeSurfer). They concluded that changes in the grey matter volume are reflected in reduction in the surface and the thickness of the cerebral cortex, and these reductions are long-lasting and remain for at least two years after birth (Hoekzema et al., 2017), even up to six years postpartum (Martínez-García et al., 2021, according to Pawluski et al., 2022). They also state that the reduction of the surface is greater than the reduction of the cerebral cortex thickness. This suggests that pregnancy impacts not only the entire volume, but also the morphological features of grey matter. Even though the abovementioned research also includes analysis of the white matter volume, no significant differences were identified between women who were pregnant and those in the control group. Numerous studies about the structural changes in maternal brain (Hoekzema et al., 2017; Hoekzema et al., 2020; Martínez-García et al., 2022; Pawluski et al., 2022) agree there are differences in the grey matter volume during pregnancy and in the postpartum period, particularly in regions such as the medial frontal cortex, the precuneus, the anterior cingulate cortex, inferior frontal gyri, superior temporal sulci, the hippocampus and the ventral striatum.

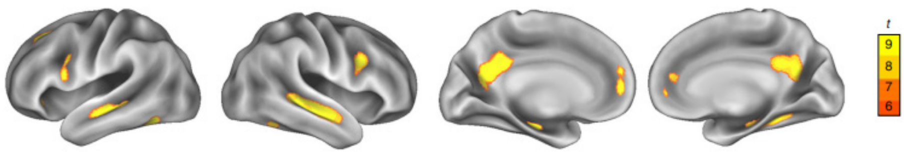


Figure 1. Reduction of grey matter volume in mothers after pregnancy compared to the control group[1]

The importance of these structural changes becomes clearer when we look at their functional role in social cognition, particularly in the context of the mother's sensitivity and care for the baby. Further analyses show that some of these structures, particularly the medial frontal cortex, the precuneus, the anterior cingulate cortex, the inferior frontal gyri and the superior temporal sulci have the greatest quantitative overlapping with the network that supports the "theory of mind" – cognitive ability key in the context of emotional sensitivity and social interaction with the newborn (Hoekzema et al., 2017; Schaafsma et al., 2015, according toPawluski et al., 2022). This will be further discussed in the next chapter.

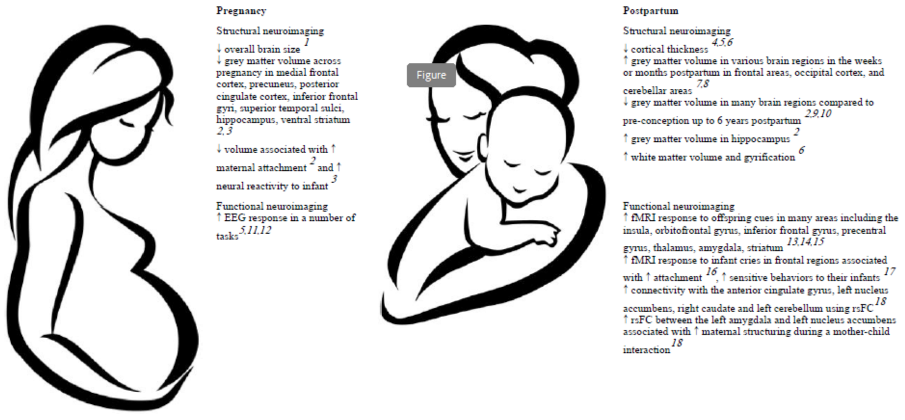
At the same time, Hoekzema et al. (2020) concluded that the transition to motherhood is linked to structural changes in the ventral striatum, so that in women who have been pregnant, between measurements in the research, it was noticed that there is a more pronounced reduction of volume in the right side rather than the left side of this structure, compared to non-pregnant women. These findings also suggest that structural changes in the ventral striatum which occur during transition to motherhood are not only structural in nature,

[1]Source: Hoekzemaet al. (2017). The colored areas indicate statistically significant reductions in grey matter, with yellow representing the highest *t*-values. The changed regions overlap with the basic regime network and the networks in the Theory of Mind.

but are functionally significant, as they contribute to stronger reactivity of the mother's reward system in response to stimuli related to her child.

Postpartum period

Even though the abovementioned findings point out to consistent reduction of grey matter during pregnancy, which also remains in the postpartum period, longitudinal research conducted after the birth suggests that this period is also a dynamic phase of brain plasticity. Several such studies (Kim et al., 2010a; Lisofsky et al., 2019; Luders et al., 2020 according to Pawluski et al., 2022) document an increase in the grey matter volume in a wide scope of cortical and subcortical regions in the first weeks and months after the birth. Some of these changes were noticed in regions that were previously affected during pregnancy, although we should have in mind that these studies did not involve a control group Pawluski et al. (2022) (see Figure 2).



1. Oatridge et al., 2002
2. Hoekzema et al 2017
3. Hoekzema et al., 2020
4. Carmona et al., 2019
5. Luo et al 2020
6. Zhang et al., 2020
7. Kim et al., 2010a
8. Luders et al., 2020
9. Martinez-Garcia et al., 2021
10. Lisofsky et al., 2016
11. Rutherford et al., 2019
12. Fiterman and Raz, 2019
13. Bjertrup et al., 2019
14. Paul et al., 2019
15. Rocchetti et al., 2014
16. Laurent and Ablow, 2012
17. Musser et al., 2012
18. Dufford et al., 2019

Figure 2. Summary of key changes in a maternal brain of humans with structural and functional neuroimaging. EEG = electroencephalography; fMRI = functional Magnetic Resonance Imaging; rsFC = resting state Functional Connectivity[2]

[2]Taken from (Pawluskietal., 2022).

Functional changes in the mother's brain

It can be assumed that the neuroplasticity observed during pregnancy and in the postpartum period does not refer only to structural changes in the brain, but also includes functional adaptations (see Figure 2). Based on the locations of structural changes related to pregnancy (Hoekzema et al., 2017), research suggests there is increased sensitivity in pregnant women to social and emotional information – which is considered to be a reflection of the adaptations in social cognition (Anderson & Rutherford, 2012).

According to Kim (2016), during pregnancy and the early postpartum period, there are normative psychological changes that support women's adaptation to motherhood. He mentions the following:

In late pregnancy, women show increased vigilance to threats (for example, fearful and angry faces), which is considered an adaptive mechanism for protection of the baby (Pearson, Lightman, & Evans, 2009);

Increased sensitivity to cues from the fetus and the infant (Pearson, Lightman, & Evans, 2011);

Increased feelings of emotional attachment to the fetus (Levine, Zagoory-Sharon, Feldman, & Weller, 2007).

Even after birth, the increased sensitivity of mothers remains, which is manifested through stronger reactivity to signals such as crying, the smell or the smile of the baby (Kim, 2016).

Intrinsic brain networks

Recent neuroscientific research focuses greater attention on distributed processing in the brain, contrary to the previously dominant approach which focused on the centralized processing within isolated brain structures.

Additionally, contemporary research shows that one brain structure can be part of several functional networks, depending on the task or the context. Contemporary models suggest that complex mental processes are implemented through distributed systems of functionally connected brain regions (Yeo et al., 2011).

One of the most influential studies in this respect is that of Yeo et al. (2011), who, by using data from functional resting state Magnetic Resonance Imaging in 1,000 healthy adults, mapped several intrinsic brain networks, including:

Default Mode Network (DMN)
Dorsal Attention Network(DAN)
Ventral Attention Network(VAN)
Somatomotor Network
Visual Network
Limbic Network
Frontoparietal Control Network(FPCN)

Table 1. Intrinsic brain networks: basic functions and anatomic structures (according to Yeo et al., 2011)

Network	Function	Key structures
Default mode network	Internal thoughts, self-reflection, mentalization, social cognition	Medial prefrontal cortex, anterior cingulate cortex, precuneus, hippocampus, angular gyrus, hippocampal formation and lateral temporal cortex
Dorsal attention network	Sustained attention to external tasks	Superior temporal lobe, frontal eye field
Ventral attention network	Detection of important stimuli, redirection of attention	Insula, ventral frontal cortex
Somatomotor network	Sensory and motor control	Precentral and postcentral gyrus
Visual network	Processing of visual information	Occipital cortex
Limbic network	Emotions, motivation, memory	Amygdala, hippocampus, orbitofrontal cortex
Frontoparietal control network	Attention control, planning, working memory	Dorsolateral prefrontal cortex, intraparietal sulci

It is useful to mention that these networks are not isolated, they cooperate or inhibit each other, such as when the dorsal network is active (we focus on some task), the default mode network is suppressed.

Pregnancy

In addition to psychological adaptations, research reveals related neuron processes. Thus, together with increased alertness to threats, pregnant women show increased neuron reactivity to threatening signals. In a study that followed women during the whole pregnancy, researchers investigated the activity of the frontal part of the brain, more specifically the prefrontal cortex while women looked at frightened faces, which is considered a threatening signal. The results of this research by Roos et al. (2011) showed that the brain reacts strongest in the second trimester, which suggests there is increased sensitivity to potential threats (according to Kim, 2016). Similar results were obtained in a different study (Raz, 2014), where pregnant women in the third trimester showed increased brain activity when watching angry faces (according to Kim, 2016). These findings suggest that the brain of a pregnant woman adapts functionally, i.e., becomes more sensitive to emotionally significant information.

This is also confirmed by the findings of Hoekzema et al. (2017), which show that pregnancy is related to a noticeable decrease in grey matter volume, particularly in brain parts involved in thinking of higher order, what is called associative areas of the cerebral cortex. These reductions are not randomly scattered, but are grouped in regions that are well known for their role in social and emotional processing. Interestingly, the model of these changes in the brain resembles a lot to the network of theory of mind – a collection of regions used to understand thoughts and feelings of others (mentalizing). This overlapping was confirmed by the study of Hoekzema et al. (2017), by comparing the data from the meta-analysis of Schurz et al. (2014), which maps the basic brain regions involved in tasks related to theory of mind. Further comparisons with the abovementioned intrinsic brain networks of Yeo et al. (2011), also show that the strongest overlapping occurred in the three networks that are most engaged during the tasks of socialization and mentalizing. Although these changes in the brain seem to be focused on the functions of theory of mind, they probably support a broader scope of cognitive and emotional processes that are necessary for adaptation to motherhood.

Postpartum period

In the postpartum period, several fMRI studies investigated mothers' reactions to visual or auditive signals from their infants. In the early postpartum period, the mother's brain undergoes a functional reorganization with the aim to support the nurture, the emotional regulation and the social connection with the infant. Various research show that new moms constantly demonstrate increased neuron activity in response to cues from their newborns, such as crying, facial expressions and smells, compared to reactions to unknown babies.

These responses include several functional brain networks, including the system for reward and motivation in mothers (including the ventral tegmental area, nucleus accumbens, the striatum and the medial prefrontal cortex), which increases the emotional relevance of the newborn (the infant gets a central emotional significance for the mother) and encourages the motherly caring behaviour. In this respect, the structural changes in the ventral striatum (Hoekzema et al., 2020) most probably reflect the adaptation of the mother's system for rewarding certain reactions. Even though the ventral striatum is a subcortical structure, its functional interactions with the cortical regions connected to the default mode network (DMN) and the limbic network (Yeo et al., 2011) point to a wide network reorganization which supports the mother's motivation and reactivity.

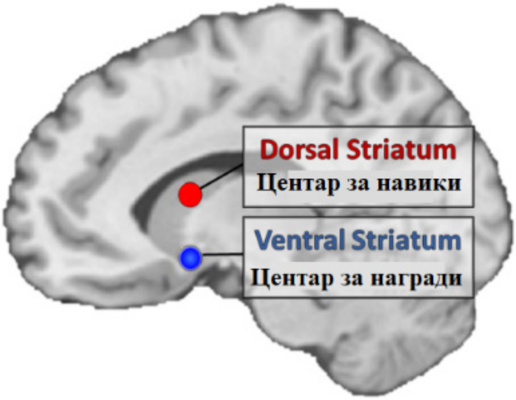


Figure 3. Ventral Striatum and the Dorsal Striatum[3]

Additionally, increased activity was noticed in regions related to social cognition and empathy, such as the insula, the fusiform gyrus and the superior temporal gyrus. These structures are key for recognition of the newborn's emotions and intentions, which corresponds with the concept of the theory of mind.

Furthermore, there are reports about the activation of regions included in emotional regulation, such as the frontal cingulate cortex and the lateral prefrontal cortex, which suggests stronger capacity for dealing with stress and sustaining sensitive reactions to the child's needs.

Although different authors have different names for these networks, some call them classical functional networks (Kim, 2016), while others conceptualize them as networks active at resting state (Pawluski et al., 2022), there is a consensus that motherhood includes an integrated neuron system which fine-tunes the mum's sensitivity and reactions to the infant. This neuron plasticity is not only adaptive, but also has a prognostic value for the quality of the connection between mother and child.

Further confirmation of the possibility that these changes present adaptive reorganization which facilitates the role of a mother comes from the findings which link brain structure with aspects for child nurturing. Namely, the research by Hoekzema et al. (2017) with multivariant regressive analyses based on the three dimensions of the Maternal Postnatal Attachment Scale, showed that the changes in the grey matter volume envisage better attachment between mother and child and lack of hostility toward the infant in the postpartum period.

[3]Figure taken from https://brainconnections.ca/gambling-when-it-isnt-funt/

Practical implications for redefining 'mommy brain'

The widely spread stereotype of 'mommy brain' suggests cognitive decline and is usually linked to forgetfulness, brain fog or reduced executive function. Yet, the empirical evidence presented in this article contest this belief by uncovering a fundamentally different reality: pregnancy and the postpartum period are not marked by cognitive decline, but neuroplasticity. The structural and functional changes in mothers' brains are not signs of loss, but of targeted remodeling of the neuron networks involved in social cognition, emotional regulation and reward – all of these are necessary for nurturing.

In order to step away from this notion based on deficit or decline, there is a growing consensus among researchers that 'mommy brain' should be re-conceptualized as a phase of transformation, not of deterioration. This reconceptualization gives meaning to mommy brain as a dynamic and responsible system shaped by hormonal, emotional and social changes in the preparation for parenthood.

In support of this change, many authors (Athan & Reel, 2015; Sacks & Birndorf, 2019; Orchard et al., 2023) support bringing back to life the term matrescence (period of transition to motherhood), originally created by Raphael (1975), to better capture the complex, multidimensional transition to motherhood. Orchard et al. (2023) describe this period as neurocognitive phase which includes structural and functional changes in the brain, together with emotional and social adjustments. This period is a sensitive neurodevelopmental window, during which the brain is getting ready to acquire skills and knowledge dependent on experience necessary for nurturing.

Recognizing motherhood as a phase of neuroplasticity not only improves scientific understanding, but also has important practical implications. Public messages should reflect the strength and the adaptability of mothers' brains, opposing cultural narratives that stigmatize or pathologize women's experiences. Clinical practices should adopt a strength-based framework that confirms maternal cognitive and emotional transitions and supports more efficiently the needs for mental health. In addition, medical education and public health programmes should integrate models of motherhood informed by neuroscience, which underscore adaptation and plasticity and not cognitive decline.

Future research should further investigate long-term cognitive and neuron trajectories linked to motherhood through longitudinal and environmentally valid designs. These studies should take into account individual differences such as the number of live births, stress and sociocultural factors, offering a more nuanced understanding of mothers' brains plasticity.

Lastly, redefining 'mommy brain' as a transformative developmental phase based on neuroplasticity and a period of transition to motherhood has the potential to reshape the public discourse, reduce stigma and give greater support and recognition to mothers – by respecting the complexity and the value of their experience.

Conclusion

The findings summarized in this paper contest the widespread cultural understanding of 'mommy brain' as a state of cognitive decline. Instead, neuroscientific evidence reveals that pregnancy and the postpartum period are marked with deep, dynamic and adaptive changes in mothers' brains. They include both structural transformations, such as reduction of grey matter volume in the regions involved in social cognitive thinking (e.g., the medial prefrontal cortex, temporal and parietal areas) and functional reorganizations, such as increased activity in the neuron networks connected to emotional reactions, motivation and reward for nurturing.

Instead of reflecting damage or cognitive decline, these changes support functional reorganization of the brain, optimizing mothers' abilities to perceive, interpret and respond to the needs of their infants. This plasticity corresponds with the broader definitions of neuroplasticity – it underscores the lifelong capacity of the brain for changes in response to intrinsic and extrinsic demands. It seems that mothers' brains reconfigure to give priority to the functions connected to care, from recognition of cues from infants to regulation of stress, reduction of hostility and encouragement of attachment.

Nevertheless, despite recent achievements, this field still faces several important limitations. The majority of existing studies are based on small samples, short-term monitoring or lack of adequate control groups (for example, women who did not give birth). There is a particularly urgent need for longitudinal studies that monitor changes from before conception to late postpartum age to map the entire trajectory and reversibility (or persistence) of the mothers' brains adaptations. Additionally, contemporary findings in neuroscience can significantly contribute to stigma reduction, promotion of empathy and development of more effective support systems for new moms. Finally, there is a strong need for inclusion of scientific findings in public awareness and medical education. The dominant narrative about 'mommy brain' as brain fog downplays the legitimacy of women's experiences and neglects reality of adaptation and neuroplasticity.

Terms such as 'neuroplastic motherhood' or 'neurocognitive phase' reflect more precisely the scientific reality and enable a more dignified discourse about motherhood. Motherhood is not dull, but profoundly transformative. Rather than being 'damaged', the maternal brain is reorganized and remarkably attuned to the transitions that are unfolding or yet to come.

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