RESEARCH SUMMARY

Becoming a mother entails anatomical changes in the ventral striatum of the human brain that facilitate its responsiveness to offspring cues

Hoekzema E, Tamnes CK, Berns P, Barba-Müller E, Pozzobon C, Picado M, Lucco F, Martínez-García M, Desco M, Ballesteros A, Crone EA, Vilarroya O and Carmona S (2020), *Psychoneuroendocrinology* 112, 104507
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Pregnant women experience hormone surges – often unpleasant at the time – that trigger changes to their bodies and brains, helping to protect the growing foetus and to develop the physical and emotional capacity to care for the infant when it is born. This hormonal 'priming' is a necessary trigger for attachment and for the pattern of maternal behaviour that most enables the offspring to survive and thrive.

Similar changes have been documented in several species of non-human mammals. It has been observed that whereas virgin females tend to avoid the odour of pups from the same species, pregnant animals and those who have borne litters are strongly attracted to them. Magnetic resonance imaging (MRI) has linked this attraction to the stimulation of brain circuits associated with reward; one study in rats showed that suckling pups stimulated these circuits more than cocaine. This is believed to be crucial for the development of 'maternal' behaviour, and mother rodents with lesions in these parts of the brain show fewer of these characteristic behaviours.

Imaging has also shown that, in female rodents that were pregnant or had given birth, the presence or odour of pups triggers the release of a hormone called dopamine that is strongly associated with pleasure and reward. It is released into a region of the brain known as the nucleus accumbens, which forms part of the ventral striatum in the forebrain. MRI studies have also shown that the ventral striatum is activated when a human mother is shown a picture of her own child, and that this response is stronger in mothers who show sensitive caregiving behaviour.

A large group of researchers led by Elseline Hoekzema of Leiden University in the Netherlands set out to investigate whether human pregnancy leads to changes in the anatomy and physiology of this brain region, and whether this can be associated with the development of the strong emotional response of a mother to her infant's needs. Hoekzema and her co-workers had previously shown a pregnancy-related reduction in the volume of grey matter in the brain, and a similar change occurring in adolescence. That, too, is a time of profound physical and psychological changes triggered by hormonal surges, and Hoekzema suggests that the 'synaptic pruning' of brain circuits that occurs during both pregnancy and adolescence might increase the efficiency and the specialisation of some types of brain activity. This leads to a prediction that the volume of the ventral striatum would decrease during pregnancy, and that larger reductions would be associated with stronger activation of that region in response to the mother's infant. It is very likely that this reduction is linked to the release of dopamine into the ventral striatum that has been noticed in mother rats, and, therefore, that the volume reduction is not a result of neurodegeneration but, rather, of neural specialisation.

Hoekzema and her co-workers analysed MRI scans of the brains of a cohort of women before and after the birth of their first children and compared them with scans taken at similar times from women who remained childless during the whole study. This enabled them to determine the nature of any pregnancy-related changes in the volume of the ventral striatum. They also used functional MRI to measure ventral striatum activation in the mothers in the study in response to their infants.

The study used the same groups of women that had previously been used to assess grey matter changes in pregnancy. The researchers recruited childless women of childbearing age, some of whom were planning to become pregnant in the near future, and MRI scans of their brains were obtained to form a baseline. Those women who successfully bore a child (or, in at least one case, twins) formed a 'primiparous' (first birth) group, and the others – regardless of whether they had not tried for a baby or been unsuccessful – formed a 'nulliparous' (no births) group. There were 25 women in the first group and 20 in the second. All women participated in a second MRI scan after the babies were born, and a further scan was obtained after a further two years from eleven primiparous women who had not yet experienced a second pregnancy. There were no significant differences between the cohorts in a variety of potentially relevant demographic variables including age at entry to the study, educational or relationship status, or the extent of pre-existing medical conditions.

The ventral striatum is difficult to distinguish from other regions of the forebrain automatically from an MRI scan. Consequently, its position was determined manually using an established approach that has been proved to be reliable, if slow and time-consuming. Each set of images was analysed independently by two different raters who did not know the group the woman was assigned to or the date of the scan. The ventral striatum volume was calculated simply from the number of three-dimensional cubes or voxels assigned to the area of interest. Separate measurements were obtained for the right and left ventral striatum. Volumes obtained from the primiparous women after birth were corrected for the pregnancy-related changes to total brain volume that had also been observed in this cohort, and these volumes compared with those obtained before pregnancy and (where relevant) after a further two years. The activity of the ventral striatum was assessed in these women using functional MRI at the time of the first post-birth scan while the mothers were shown pictures of their own and strangers' infants.

Comparing the measurements for each primiparous woman before and after giving birth showed volume decreases of an average of 7% and 26% in the left and right ventral striatum respectively; this change was only statistically significant in the case of the right striatum. There were no significant volume changes between time points in the nulliparous women, and no volume changes in either group in a different forebrain region known as the dorsal striatum. There were also no significant volume differences between the two groups at baseline (that is, at the time of the first scans), and there were no further volume changes in the primiparous women between scans taken soon after birth and after a further two years. This links the changes to the ventral striatum strongly to the time of pregnancy.

The functional MRI scans showed more activity in the ventral striatum of each mother when she was shown a picture of her own infant than when she was shown a picture of an unknown infant. Furthermore, this difference in activity was greater in the women who had shown a greater reduction in ventral striatum volume during pregnancy.

Taken together, these results show that pregnancy is associated with a significant reduction in the volume of the right ventral striatum, a tendency towards reduction in the volume of the left ventral striatum, and no volume reduction at all in the dorsal striatum. The extent of the reduction can to some extent at least predict the strength of the activation in that region of a woman's brain in response to pictures of her own infant. This neural specialisation seems to cause the female brain to adapt during pregnancy so she becomes exquisitely capable of focusing attention on her infant after the birth. This, in turn, will help provide an environment in which the infant can thrive.

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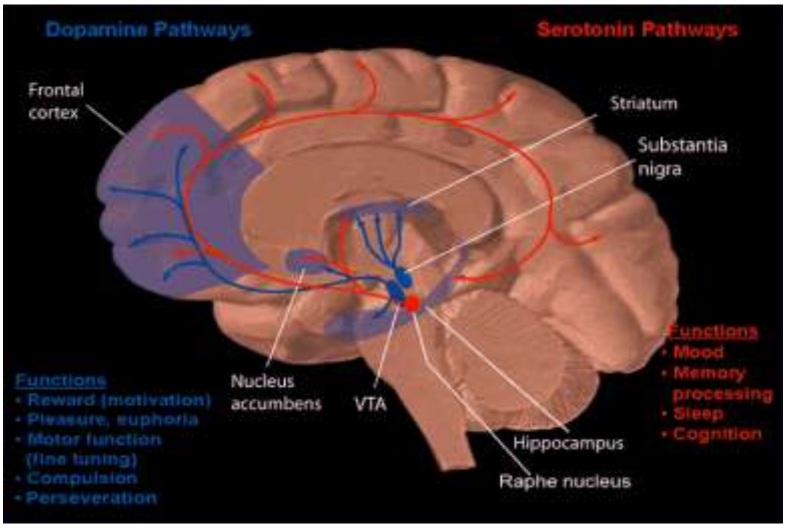

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