RESEARCH SUMMARY

Pregnancy leads to long-lasting changes in human brain structure
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Even in countries with falling birth rates, most women will become pregnant at some time during their lives. Pregnancy causes dramatic changes to some aspects of a woman's physiology, starting with a surge of steroid sex hormones that is unprecedented at any other time in her life. We know that changes in steroid concentration can affect the number and nature of neurons (nerve cells), and we also know that other processes that cause changes in these hormones, such as puberty, also change the structure and nature of brain tissues. It is therefore perhaps surprising that we so far know very little about how pregnancy itself affects the brain.

There have, however, been a few observations of changes to brain structures in pregnancy, starting as early as 1909 with the report of enlarged pituitary glands in the bodies of women who were pregnant when they died. Later, the relative sizes of several brain regions were found to differ between late pregnancy and early motherhood. Similar results have been observed in non-human animals.

A group of researchers led by Elseline Hoekzema of Universitat Autònoma de Barcelona, Barcelona, Spain has now carried out the first extensive comparison of the structure and volume of grey matter in the brain between women who were pregnant for the first time (known technically as primiparous) and women who had never been pregnant (similarly, nulliparous). Grey matter is one of the major components of brain tissue; it is found throughout the main regions of the brain and contains many neurons.

This study used a technique called magnetic resonance imaging (MRI) to scan the participants' brains and obtain high-resolution anatomical images of 'slices' through each one. Women who were childless but wished to become mothers were recruited into the study and a first MRI scan ('pre' scan) was performed on each participant before a pregnancy was achieved. Each woman who became pregnant was also scanned after her baby was born (in the 'post' session). These paired scans were compared with paired MRI scans of the brains of a control group of childless women, taken at similar times. Some women underwent follow-up scans two years after their pregnancies, and all results were compared with those from similar experiments with a group of first-time fathers to investigate whether any of the changes observed might be to do with the psychological preparation for parenthood.

Comparison of the pre- and post-pregnancy scans from each of the women who became pregnant, and of the post-pregnancy scans with those of the control group, showed that pregnancy was associated with a significant reduction in the volume of grey matter in certain areas of the brain. There were no significant differences between the scans from the women who were planning to become pregnant and those of the nulliparous control women, and none between women who had conceived normally and those who had used IVF techniques. Volume reductions were concentrated in parts of the frontal lobe in the front part of the brain, and the temporal cortex nearer the base of the brain. Interestingly, these parts of the brain are known to be activated when an individual is working on tasks connected to the theory of mind: the distinction between one's own mental state and those of others. No similar changes, and

in fact no significant changes at all, were observed in the brains of men who became first-time fathers between the two scans.

Noticing that the differences between the brains of the women who had been pregnant and the others were both significant and consistent, the researchers tested their consistency further by developing a statistical pattern-matching algorithm to deduce automatically which subjects had been pregnant, based on their pair of brain scans alone. This proved very successful; every woman was classified correctly as either having been pregnant between the two scans or not.

Two parameters that relate to the volume of cortical tissue, and that can be extracted from MRI scans, are the thickness of the cortex and its surface area. Hoekzema and her colleagues extracted these parameters from the scans for comparison, and showed that the changes in surface area were more closely related to pregnancy than those in thickness: over 80% of women could be correctly classified as pregnant or not from surface area alone, but fewer than 70% were correctly classified from thickness alone. Standard tests of memory and cognitive function revealed no pregnancy-associated changes in the individual subjects.

Next, the researchers investigated whether there was a link between the strength of these pregnancy-associated changes in the brain and the developing relationship between a mother and her baby. Firstly, the degree of attachment between each mother and infant was assessed using a well-known questionnaire called the Maternal Postnatal Attachment Scale. The mothers with the largest changes in grey matter volume were most closely attached to their babies and never or very rarely had hostile thoughts towards them.

They also tested the response of the mothers' brains to their infants using a technique called functional molecular resonance imaging (fMRI), in which regions of the brain are observed to 'light up' in scans when they are activated. Functional MRI images were obtained of the mothers' brains as they viewed pictures either of their own or of unrelated infants. There was a significant overlap between regions of the brain that were more active when a woman looked at her own baby rather than another baby, and those regions that lost grey matter volume during pregnancy.

Eleven of the mothers in the study who had not had a second pregnancy within two years took part in a follow-up scan to investigate whether these changes in brain volume endured for at least this time. Scans taken from these women at least two years after giving birth showed that most of the pregnancy-related brain changes, apart from a loss of tissue in part of the hippocampus, remained.

Taken together, these results suggest that the physiological condition of pregnancy, rather than the psychological condition of preparing to become a parent, induces a profound and long-lasting change in the structure of the grey matter in parts of the brain. The observations that the largest changes were observed in brain regions that responded to pictures of the women's own babies, and that individuals displaying larger changes were more securely attached to their infants, suggested to Hoekzema and her co-workers that they may have evolved to aid the transition to motherhood.

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