

The maternal brain

Christian Jarrett examines the evidence behind the widely held belief that pregnancy affects cognitive function

‘I hesitate to admit this, but in the third trimester I’m incredibly stupid.’ These were the reluctant words of feminist *Guardian* columnist Zoe Williams during her pregnancy in 2008. She was referring, of course, to the idea of ‘pregnesia’, ‘preghead’, ‘baby brain’, call it what you will: the widely held belief that pregnant women experience deficits in memory and cognition. An NHS pamphlet published in 2005 on 50 things would-be fathers should know, put it this way: ‘Pregnant women are a bit vague... it’s their hormones’ (tinyurl.com/lnl7ag). Does pregnancy really affect women’s

brains for the worse, or is the idea of pregnesia a sexist myth?

Muddled findings

Research on the topic falls mainly in two categories: those studies that asked pregnant women whether they have any problems, and others that used objective measures. The self-report studies are strikingly consistent. Across the board, approximately two thirds of women report having some kind of memory or attention problems that they attribute to their pregnancy. For example, in a 2003 study

Ros Crawley at the University of Sunderland, and colleagues, used retrospective questionnaires and longitudinal diary sampling and found that 40 pregnant women reported their memory and attention to be significantly impaired relative to the self-reports of 24 non-pregnant women.

By contrast, studies using objective tests of memory and attention during pregnancy have proven to be stubbornly inconsistent. For every study that reports an apparent deficit, there’s another that turns up a negative result. A meta-analysis by Julie Henry of the University of New South Wales in Sydney and Peter Rendell at the Australian Catholic University in Melbourne, published in 2007, helped clear some of the confusion. Of 14 studies conducted over 17 years, they concluded that it is those that placed ‘relatively high demands on effortful processing and, specifically, measures of free recall and the executive component of working memory’ that found a reliable, albeit small, deficit among pregnant women. ‘Many of the previous objective studies had small sample sizes that lacked the power to detect the relatively subtle impairment that was revealed by combining studies in the meta-analysis,’ says Rendell.

‘Some of the inconsistency in objective tests might also be methodological,’ Crawley says. ‘There’s a lot of different tasks used to measure the same cognitive functions and when people talk about the tasks that they use, sometimes one paper uses it to measure one thing and another paper uses it to measure another, so it’s quite complicated.’

Societal expectations

The starkness of the mismatch between the consistent subjective studies and the patchy objective measures led Crawley to wonder whether pregnant women are only reporting problems because that’s what

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What pregnancy does to the brain

At least two human brain-imaging studies have fuelled the pregnancy myth. In 2002 Angela Oatridge and colleagues at Imperial College School of Medicine scanned the brains of a small sample of women (some of whom had pre-eclampsia) before, during and after pregnancy, and reported that brain size shrank during pregnancy and then recovered its size six months after delivery. Many journalists jumped on this, and a similar study published in 1997, as providing final irrefutable evidence for the reality of pregnancy. Other commentators, however, pointed to the woefully small sample size (just nine healthy participants) and the fact that the authors themselves admitted that the 'mechanisms and physiological importance' of their findings were speculative.

Most of the hard facts about the physiological effects of pregnancy on the brain actually come from research on rats, where, in contrast to most human research, the evidence points to significant maternal *advantages* rather than deficits.

One crucial maternal brain region is the medial pre-optic area (mPOA) of the hypothalamus – a structure in the temporal lobe that is involved in memory. Damage to the mPOA has been shown to inhibit maternal behaviours such as nest-building and the grooming of pups. Pregnancy appears to prepare this brain region for the demands of motherhood. For example, research led by Lori Keyser-Marcus at Craig Kinsley's lab at the University of Richmond showed that pregnancy or treatment with pregnancy-related hormones led to increased dendrite density in the mPOA region (dendrites are the branches of neurons that receive incoming signals from other neurons).

The same lab has also looked at dendritic spines – these are thorn-like protrusions on dendrites that improve signalling efficiency.

Kinsley's team found that dendritic spine density was increased in the hippocampus of pregnant rats and rats treated with pregnancy-related hormones, compared with virgin rats.

Yet another study in Kinsley's lab, led by Jennifer Wartella, studied the brains of recently pregnant rats and found signs of reduced activity in the hippocampus and amygdala regions of their brains, compared with virgin rats – a sign, the researchers said, of reduced stress reactivity in the mother rats.

Crucially, all these brain changes have been linked with behavioural improvements. 'Our rats get better at virtually everything they need to, to successfully care for their expensive genetic and metabolic investments,' says Kinsley. 'Foraging, predation, spatial memory all improve; stress and anxiety responsiveness decreases.'

So why is there this mismatch between the pregnancy advantages shown in rats and the deficits shown in some human studies? Kinsley thinks the answer has to do with the kinds of tasks used to test pregnant women. 'Much of the

data from human mothers has been derived from asking females to demonstrate cognitive enhancements to skills, behaviours, occupations that are largely irrelevant to the care and protection of young,' he says. 'Once the questions and approaches become more sophisticated in the human analogs, I believe more data will support the animal work.' Consistent with Kinsley's prediction, a study published late last year by Rebecca Pearson and her colleagues at the University of Bristol found evidence that late human pregnancy is associated with enhanced recognition of threatening facial expressions.

society expects of them. 'Maybe there's this societal view that women, when they're pregnant, will have problems with memory and attention...it might be part of the overall negative view people have of women, as being at the mercy of their hormones,' says Crawley.

'I'm drawing parallels with the work that's been done with premenstrual cognitive effects and menopausal effects [showing a mismatch between objective

and subjective measures of cognitive performance],' she explains. There's certainly evidence for pregnancy-related prejudice elsewhere in the research literature. Sara Corse at the University of Pennsylvania, for example, had MBA students interact with what they thought was a manager but was really a research assistant. Students told that the 'manager' was pregnant subsequently gave her more negative ratings than students not fed this

tale. Apparently the students were disappointed when the pregnant manager turned out to be authoritative rather than passive and giving.

Crawley tested societal expectations about cognitive deficits and pregnancy in a paper published in 2008, with her colleagues Sophie Grant and Kim Hinshaw. Crawley's team first showed that 13 pregnant women performed just as well as non-pregnant controls on a driving simulator task (described by the researchers as 'a complex, cognitively demanding environment that more closely resembles an everyday activity than the laboratory tasks so far reported in the literature'), thus throwing yet more doubt on the objective reality of pregnancy-related deficits. Most importantly, though, they also quizzed dozens of pregnant and non-pregnant women and their partners about whether pregnant women typically experience cognitive deficits in pregnancy. Consistent with the idea that pregnancy-related

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cognitive deficits have become a deep-rooted cultural myth, all the participants, not just those with experience of pregnancy, reported that pregnancy is typically associated with mild cognitive decline.

'When women are pregnant, it's very obvious, their femaleness is very obvious, so maybe that triggers people to notice in themselves and in other pregnant women when they make cognitive slips – the kind that we all make – and they attribute those slips to their pregnancy,' Crawley said.

Yet another possibility is that pregnancy is associated with cognitive deficits, not because of the effect of being pregnant *per se*, but simply because pregnancy is a major life event involving huge emotional and practical upheaval. Consistent with this, various studies have linked the cognitive deficits of pregnancy with sleep deprivation, fatigue and depression. 'Maybe you'd find something similar if you looked at another major life event like bereavement where those factors might be contributing,' says Crawley. 'But because it's fairly plausible that pregnancy as a physiological event might have an effect on cognition – because of the hormonal changes – I suspect that's why people have looked for that more intently, in terms of pregnancy itself.'

A fresh clue?

In 2008 Peter Rendell and Julie Henry pursued a new angle, publishing one of the first-ever tests of prospective memory in pregnancy. Prospective memory is our ability to remember to perform future actions at the right time, such as making appointments or taking the dinner out of the oven. 'When you ask people to reflect on memory problems or what concerns them most about memory, it is prospective memory that is often mentioned as being important to daily life,' Rendell says.

Rendell and Hendry tested 20 pregnant women on two kinds of prospective memory test: one was a Monopoly-style board game that required them to remember to perform hypothetical tasks over a week, such as phoning the plumber or picking up the dry cleaning. The other was a real-life task that took place over a week and

required the women to check in with a PDA-style electronic device at the same four time points every day.

Compared with non-pregnant controls, the mothers-to-be performed normally on the board game, but not on the real-life task. 'This wasn't subtle at all,' says Rendell. 'This was a very strong effect, so maybe pregnant women have trouble marshalling resources over longer periods of time, or maybe they are more distracted by daily life, and challenging tasks in that context exposes problems.'



Mothers-to-be performed normally on the board game, but not on the real-life task

The strength of this finding led Rendell to wonder whether past studies have underestimated the impact of pregnancy on cognition. 'We only found an effect over several days, so maybe past studies didn't tap into the key problem with the tasks that they used,' he says.

But consistent findings remain elusive. The very latest investigation on the pregnesia controversy was published last month in the *British Journal of Psychiatry*. In a press release last year, the study authors claimed to have confirmed that there is, after all, no evidence that pregnancy has an adverse effect on women's brains (prompting the *Daily Telegraph* headline 'Pregnant women's brains are not mush'). The study by Helen Christensen and colleagues at the Australian National University in Canberra was unusual for the fact that it followed a large sample of women over time. By casting a wide net, the researchers were able to test 76 women before and during their pregnancy. 'Our research suggests that although women – and their partners – think there may be a link between brain capacity and

pregnancy and motherhood, there are certainly no permanent ones that we can find,' Christensen said.

Does it matter?

We've seen that whilst many women report experiencing cognitive difficulties during pregnancy, objective evidence for a link between pregnancy and cognitive decline has been inconsistent. This begs the question: does the memory deficit, if it exists, matter? Is there sufficient cause for women to worry about it? On the other hand, if there is no deficit, should we be doing more to combat what amounts to a pervasive sexist myth?

Crawley says that even if there is a real deficit, it's nothing to worry about. 'In a previous study of mine, before I gave women the standard questionnaire comparing their cognition now to before they were pregnant, I asked them to tell me about the kinds of changes they'd noticed about themselves since they'd become pregnant. Out of 198 women, only three spontaneously mentioned cognitive changes, so I don't think they're very salient.'

Although no longer active in the field, Crawley's previous findings have left her feeling that more could be done to counteract the idea that pregnancy is definitely associated with cognitive decline. 'It's absolutely time we exploded this myth,' she says. A book published in 2005 by journalist Katherine Ellinson called *The Mommy Brain. How Motherhood Makes Us Smarter* certainly started to turn the tide, but that was in relation to the effects of being a mother, rather than pregnancy itself.

But then again, there's that new robust finding on prospective memory, so maybe we shouldn't be too hasty in dismissing the pregnesia myth. For pregnant women who'd rather err on the safe side, Rendell has the following advice. 'Specific strategies', he says, 'include creating external physical cues or imagining vivid cues that can function as alerts, for example: leave a prominent reminder note next to the lock on your office door to help you remember to take home something from work, and set a timer to remove food from the oven on time. Another specific strategy is to not delay carrying out an intended task once it has been brought to mind. Research has shown that even brief delays involving several seconds can substantially reduce the chances of the intended action being successfully carried out.'

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