The neuroscience of motherhood

Pregnancy and lactation can have significant long-lasting effects on the neurobiological processes in female mammals. These effects sometimes include changes in the brain's neurochemical sensitivity, its substrates, and hormonal regulation, as well as possible shifts in behaviour such as maternal instinct and perceived anxiety. **Dr Robert Bridges**, working at Tufts University in North Grafton, MA, has conducted extensive research in the field of neuroscience, particularly in relation to reproductive biology. His latest work focuses on how the reproductive experience of pregnancy and lactation affects brain connectivity and activity later in life.

Motherhood can be a both challenging and fulfilling experience for women and female mammals, which often leads to huge emotional and life-related changes. Yet pregnancy and lactation have been found to affect more than just a mother's life circumstances, leading to a number of remarkable changes in brain chemistry and connectivity, as well as hormone secretion patterns and behaviours. The study of neuroscience in relation to reproductive experience is truly fascinating, as it aims to better understand the changes in the brain that take place in a woman after pregnancy and lactation. Dr Bridges has dedicated most of his career to investigating these dynamics and his findings have helped to shed light on some of the biological effects of reproductive experiences on the brain of female mammals.

NEUROPLASTICITY: HOW THE BRAIN ADAPTS THROUGH LIFE

The brain is an ever-changing organ, wired to constantly re-organise itself throughout life, forming new neural connections in reaction to life experiences and maturation. Neuroplasticity is the quality of the brain that allows neurones in the brain to adjust their activity and structure in response to changes in the body or the surrounding environment.

While many of these connections are formed during childhood and adolescence, the brain keeps changing and adapting throughout adulthood, particularly in response to significant environmental changes and life events. These changes can be prominent or minor and can occur during or after a number of more or less life-altering events, including strokes or major physical injury, as well as traumas or dramatic changes in lifestyle. Whether we are acquiring new skills or recovering from serious bodily harm, the brain is in constant evolution; and the experience of pregnancy is no different.

BEHAVIOURAL CHANGES IN MOTHERHOOD

Dr Robert Bridges conducted extensive research into the biological dynamics associated with reproductive experiences such as pregnancy and lactation. Dr Bridges found that motherhood results in a long-term increase in maternal behaviours, which is typically a direct result of the experience

Dr Bridges' work substantially contributes to the scientific understanding of the biological regulation of motherhood

of pregnancy and giving birth. He carried out experiments on female rats and found that reproductive experience had a number of effects on their brains, starting from the establishment of what appeared to be a long-term maternal memory and instinct. Mothers displayed greater activation in areas of the brain related to emotional behaviours and memory (amygdala).

He also found that the maternal experiences of pregnancy and lactation can alter the regulation of hormone secretion from the pituitary gland, a part of the brain that secretes hormones directly into the bloodstream. Female mammals generally tend to experience shifts in anxiety during mid and later life, often modulated by changes in secretion of oestrogen, a hormone that promotes the development of female characteristics in the body.

Dr Bridges found that reproductive experience altered anxiety-like behaviour in rats, to different extents according to age, the state of the animal's ovaries and individual differences in hormonal imbalances. While he observed a general reduction in anxiety after pregnancy, he suggested that this reduction could be task-specific and might not apply to tasks that do not involve exploration, such as startle responses or social interactions. Dr Bridges found that a number of less dramatic changes also occurred in virgin adult rats that were exposed to pups and displayed maternal care towards them. These changes included an increase in cell proliferation and development of new neurones. These same changes were present in a far greater extent in biological mothers. These changes in the brain could potentially account for positive or negative changes in behaviour and physiology at later stages in life.

Dr Bridges' work has helped to shed light on some of the biological effects of reproductive experiences on the brain of female mammals

MOTHERHOOD AND THE BRAIN

Research conducted by Dr Bridges suggests that reproductive experience often has a transformative and significant effect on the brain and biological states of female mammals, affecting a number of hormonal, immunological and neural processes. In both women and rats, a prior reproductive experience can result in enhancements in dopaminergic activity, or secretion of dopamine, a neurotransmitter that results in feelings of reward, well-being, and energy.

Following the experience of an earlier motherhood, this increase in dopaminergic activity appears to contribute to reductions in the secretion of prolactin (PRL), a pituitary protein known for enabling the production of milk in mammals. The responses of the brain to prolactin also appeared to be enhanced in mothers that were well beyond the end of nursing. Dr Bridges' studies on rats found that in experienced mothers, genetic expression for the prolactin receptors was greater in particular brain regions. They also suggested that neural responses to prolactin treatment increased with maternal experience, due to changes in hormonal regulation.

These findings could help gain a better understanding of postpartum disorders affecting maternal care, as well as other prolactin-associated pathologies. For instance, the reduced secretion of prolactin after early motherhood might potentially be a reason why early pregnancies can have protective effects against breast cancer later in life, while an enhanced neural sensitivity to prolactin might result in a lower chance of postpartum depression. These possibilities are interesting topics for further investigation.

UNDERSTANDING REPRODUCTIVE BIOLOGY

Pregnancy and lactation can be truly transformative experiences for female mammals, in terms of life circumstances, as well as biological states and brain activity. A mother's brain changes and adapts, as a result of her experience of pregnancy and in order to face the new challenges that come with motherhood.

Dr Bridges' work substantially contributes to the scientific understanding of reproductive biology and neuroscience. In the future, this could help to shed light on the biological dynamics behind a number of post-partum or hormone-related disorders in women, consequently assisting in the development of more effective treatments.

Q&A

When and how did you first start being interested in the neuroscience of reproductive experiences?
My interests in neuroscience and behaviour emerged during my undergraduate education at Earlham College. As a biology major, I became very interested in exploring the biological basis of behaviour. My specific interests in maternal behaviour and reproductive biology developed as a graduate student in the laboratory of Dr M. X. Zarrow in the BioBehavioral Sciences Program at the University of Connecticut. My behavioural and neuroscience skills were further honed during my postdoctoral trainings at the Institute of Animal Behavior at Rutgers University and at the UCLA Brain Research Institute and as a young faculty member at Harvard Medical School.

What have you found to be the most prominent changes in terms of female mammals' brain activity after pregnancy and lactation?
The most striking long-term changes in the adult female following pregnancy and lactation occur at both behavioural and neurochemical levels. Behaviourally, previously parous mothers (who have already had offspring) display enhanced maternal care towards young, a so-called "maternal memory", as well as reductions in anxiety. The neurochemical shifts include reductions in pituitary prolactin hormone release, an increase in neural sensitivity to prolactin stimulated gene expression, and increases in neural dopamine release and actions. Prior parity also results in reductions in neural opiate sensitivity as measured by the reduced ability of opioids to interfere with maternal care in females with greater reproductive experience.

What do you feel have been your most important findings so far, and why?
Our most significant research findings are that the normal states of pregnancy, birth, and lactation exert long-term effects on the adult female's behavioural, neuroendocrine, and neurochemical states. These findings emphasise the fact that the female's brain can profoundly change in association with motherhood and that these changes appear long-lasting. In addition to identifying these specific changes in the female's behavioural and neurochemical states, our prior research demonstrated that prolactin and placental lactogens act in specific brain sites to stimulate maternal care. Together, these research findings advance our understanding of the biological basis and consequences of motherhood.

How could your fascinating field of research best inform medical practice in future?
Our research raises the question of how shifts in neurochemical sensitivities may impact the treatment of women with drugs that affect the dopaminergic and opioidergic systems. Drug dosing may need to be tailored more to the woman's reproductive history. The research also impacts our understanding of addiction tendencies, since female rats become more tolerant of opiates with increased reproductive experience. Likewise, that maternal experience alters subsequent behaviour and neural connectivity could affect treatment approaches for anxiety and depression. Finally, understanding how reproductive history affects endocrine activity will help enhance our understanding of endocrine–mediated diseases, including breast cancer.

What are your next steps in terms of research and investigation?
Future research will focus on which specific molecules and brain regions are modified by the female's reproductive history. Presently, we are investigating whether the behavioural changes produced by prior maternal experience are mediated by changes in the brain oestrogen receptor system. Moreover, in collaboration with the Center for Comparative Neuroimaging at the University of Massachusetts Medical School, we plan to examine how motherhood modifies neural connectivity in brain regions associated with maternal care and reward. Finally, we will examine how the neural prolactin receptor system may be involved in the expression of maternal memory.

Detail

RESEARCH OBJECTIVES

Dr Bridges' research focuses on neuroscience and reproductive biology. His recent research project explores the possible long-term increase in neural sensitivity to oestrogens induced by pregnancy and lactation and how reproductive experience affects brain connectivity and activity.

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BIO

Dr Bridges received his BA from Earlham College and PhD from the University of Connecticut. He was a postdoctoral fellow at Rutgers Institute of Animal Behavior and UCLA's Brain Research Institute before joining the faculty at Harvard Medical School in 1978. He moved to Tufts University in 1990 where he is currently full professor.

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