ENCYCLOPEDIA on Early Childhood Development

Animal models of maternal behaviour: insights into our understanding the endocrinology, neurobiology, genetics and development of mothering

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Introduction

New mothers experience a multitude of physiological changes that under optimal conditions may function to prime them to respond ‘maternally’ to their infants. These perinatal changes include enormous fluctuations in the levels of circulating hormones and changes in brain systems known to regulate mothering in a number of species. In addition, there are changes in other brain regions that indirectly affect mothering-related behaviours such as how rewarding mothers find infants and their cues to be, their attitudes towards infants and parenting, their ability to be

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flexible and playful, to show good memory, as well as their levels of anxiety and depression. Included among maternal behaviours in humans are feeding or nursing, providing safety and warmth, and expression of 'sensitive' and contingent interactions with their infants and, often, positive feelings of nurturance. Under conditions of extreme stress, ill health, immaturity, and adverse early and present experiences, these maternal behaviours and the priming effects of physiology, are often altered or diminished.

Optimal caregiving has been shown to affect brain, behaviour and socio-emotional development of the offspring.[1,2] Children rapidly acquire new motor, verbal, socio-emotional and cognitive skills that are accompanied by changes in their parental needs.[3] As infants transition into toddlerhood, parents are expected to adjust their parental behaviours and strategies to not only comfort, but also to stimulate, direct and discipline their child. Positive and responsive parenting, that includes warmth and positive affect,[4] have been shown to enhance many aspects of child development and to help protect children from certain environmental adversities and undesirable outcomes; in contrast, lack of parental warmth and responsivity, along with hostile-reactive, rejecting parenting in the absence of a social 'buffer' (supportive relative, friend, or professional) are associated with behavioural problems, poorer cognitive outcomes, increased risk for child psychopathology, depression/anxiety and other chronic illnesses.

Subject

Understanding the experiential, physiological, and neural regulation of normative maternal behaviour greatly informs treatment and intervention programs designed to optimize maternal responsivity in those experiencing parenting challenges. For example, factors such as post-partum depression, difficult child temperament, poverty, or marital conflict, may lead to alterations in maternal responsivity, in turn increasing the likelihood of problems in child development.

Problems

To understand what contributes to mothering, one can examine mothering behaviour at four basic levels of analysis related to causality and motivation: (1) proximal (hormonal/neural/genetic); (2) developmental (mother's own early experiences); (3) functional (survival of offspring); (4) and evolutionary. All contribute to our understanding, but none are complete individually when trying to understand a complex reproductive behaviour.

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Research Context

Animal models of maternal behaviour have provided insights into our understanding of the endocrinology, neurobiology, genetics and development of mothering.[5,6] By also providing models of parental-like behaviours among non-mothers (females that have not given birth), animal studies also illustrate how parental behaviour, albeit in the absence of lactation, may develop through simple extended exposure to young and in the absence of effects of hormones.[7] Recently, studies have begun to translate what we have learned from non-human models of mothering behaviour and examine whether similar principles govern the psychobiology of human mothering.[8] Early studies suggest that they do. This body of work uses diverse methodology, including hormonal measures[9,10] genotyping[11,12] questionnaires,[13,14,15] and behavioural quantification of parenting[10,16,17], all of which have demonstrated excellent validity and reliability. With advances in human neuroimaging techniques such as fMRI and fNIRS, we have begun to ask some of the same questions of structural and functional neuroanatomy that we have been asking in animals.[18] As well, we have made considerable progress in our understanding of human mothering by combining insights gained by various fields including using novel statistical methods which make it easier to model the complex interactions among multiple sources of influences on mothering.

Key Research Questions

1. What are the hormonal, neural, genetic, and experiential bases of mothering behaviour in the animal model? What do we know about similar mechanisms in humans?
2. What are the social determinants of mothering behaviour in humans?
3. How does early life experience impact mothering behaviour?
4. What are the trans-generational effects of maternal behaviour in both animals and humans?
5. How does mothering behaviour mediate child outcomes in non-normative situations, such as in high-risk environments?

Recent Research Results

Around the time of birth in most mammals, changes to the hormonal milieu including fluctuating levels of estrogen,[19,20] progesterone[19,20], prolactin[21] and oxytocin[22] trigger a cascade of neurological adaptations that result in typical maternal behaviour.[23] Numan, and colleagues,[24-29] have

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demonstrated that the neurobiology of mothering in rodents relies heavily on projections from the medial preoptic area of the hypothalamus and bed nucleus of the stria terminalis, as well as fibres from surrounding sensory, limbic and cortical systems. Both hormones and sensory input act on these brain systems. Furthermore, studies have consistently shown that the neurotransmitter dopamine acts on various psychobiological systems to affect the expression of species typical maternal behaviour in both mothers who have given birth, and non-mothers who demonstrate materal behaviours through repeated exposure to young.[30-34] New mothers with minimal experience develop an attraction to, and recognition of, their own infants, their odours, cries and visual characteristics;[35] and hence, infants and their cues become rewarding to the mother.[36] Mothers also undergo a change in their emotional states, being more anxious and more often attentive to infants, and to threats to the infant;[37,38] they show greater attentional flexibility and working memory. These psychological changes enhance maternal behaviour towards the infant. The quality of mothering is also affected by her environment, her stress,[39,40] and her recent and early experiences.[38,41] These environmental influences affect and interact with maternal genes.[42,43] For instance, a mother's own experiences being mothered interact with her genes resulting in epigenetic (environmental influences that turn genes on and off) modification of her expressed mothering behaviour.[11,12,17,44-46] Enhancing the quality of mothering behaviour can help improve child outcome later in life. This is particularly true for children in adverse circumstances. Responsive parenting has been shown to help buffer children who are at risk of poor developmental outcomes because of genetic vulnerability,[47] low birth weight,[48] low socio-economic status, or cumulative environmental risk.[49-51]

Research Gaps

Notable gaps in research on mothering behaviour include:

1. How does parental behaviour and the brain change across the lifespan of a child? What changes do we see from parenthood to grandparenthood?
2. Similar neurobiological systems that mediate other motivated behaviours (e.g., eating, sexual behaviour) are active in a new mother. Is there a state of maternal satiety similar to other motivated behaviours? Are there similar addictive properties?
3. From rodent models, the approach/avoidance theory of maternal behaviour suggests that neuroendocrine changes associated with parturition trigger a reduction in the aversive response of mothers towards pups while simultaneously provoking approach behaviours. Thus, the same neural substrates that lead a mother to respond maternally may be involved

in aversive responses to infants. Can this theory inform our understanding of parenting in high-risk samples?

Implications for Parents, Services and Policy

Making conceptual associations between animal and human maternal behaviours is the principal challenge for scientists. Consequent testing of these associations is simpler yet equally valuable. What elements of an animal's maternal behaviour is unique to the animal, and what elements are part of a basic rule that can be transferable or applied to humans are important to determine. The integration of animal and human literature will lead to a better comprehension of maternal response and behaviour and will afford us more scientific understanding of its distinct and common expression in all species that engage in it.

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