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The emotional and hormonal pathways of labour and birth: integrating mind, body and behaviour

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ABSTRACT

Background: Women have described normal labour and birth in terms of their emotions. Major advances in knowledge have occurred within the sciences resulting in an understanding of emotions as prime directors of human behaviour which is orchestrated by neurohormones. **Method:** This paper focusses on key aspects of contemporary knowledge of childbirth physiology, neuroscience and behaviour. It integrates this understanding with women's descriptions of their emotions during labour. **Findings:** Neurohormones associated with labour and birth are designed to trigger a transformation in the body and behaviour and create an environment which supports both the mother and the baby. Hormones and emotions are intertwined and interconnected. Labour hormones are linked to the woman's emotions and behaviour during labour and birth as well as the physical signs of labour. An interactive model is presented which explains labour in terms of both the physical effects and the emotional affects that women have described as part of their labour experience. The hypothesis for this model is that the hormones that initiate and sustain labour also cause the instinctual emotions that women feel, and the behaviour they exhibit, during spontaneous labour and birth. **Conclusions:** Hormonal changes are necessary to support the physical and emotional changes during labour and birth. The neurohormones which operate during pregnancy and during labour and birth also support parenting behaviour. This paper integrates the contemporary scientific understanding of the role of neurohormones and their association, with the woman's behaviour and emotions during labour. It argues for, and provides the foundations of, a new conceptual framework for understanding labour and birth, one which integrates mind, body and behaviour.

KEY WORDS

Emotions, neurohormones, physiology, labour and birth

INTRODUCTION

When women discuss and describe normal labour and birth they often do so in terms of their feelings, their thoughts and their actions, with labour considered to be a continuous process and not one marked by stages or phases (Dixon, Foureur & Skinner, 2012). Research studies exploring the woman's experiences of childbirth have identified that women have a need for information, control and support during birth (Dahlen, Barclay, & Homer, 2010; Gibbins & Thomson, 2001; Halldorsdottir & Karlsdottir, 1996; Lavender, Walkinshaw, & Walton, 1999). There is a range of social, psychological, environmental and cultural factors which may impact on the woman's perceptions and experiences of birth (Hodnett, Gates, Hofmeyr, & Sakala, 2003; Nolan, Smith, & Catling, 2009).

A previous paper has outlined a qualitative research project which explored the woman's perceptions of labour as she moved towards birth (Dixon, Skinner & Foureur 2013). In this study, the 18 women interviewed described labour predominantly in terms of their emotions. Women's emotions appeared to move from excitement at the start of labour, along with feelings of calm and confidence, to a need to focus on themselves and each contraction as the labour became more intense and painful. This led to descriptions of a need for internal focus and disconnection with those around them, a finding consistently uncovered amongst studies exploring childbirth experiences (Burvill, 2002; Duff, 2005; Halldorsdottir & Karlsdottir, 1996; Leap, 2000; Machin & Scamell, 1997). Additionally the women described becoming fearful and overwhelmed or tired and sleepy as the birth became imminent, followed by feelings of happiness, awe and joy once the baby was born. Birth was considered a powerful process and the women described a sense of connectedness to their baby and surprise at the power of their own body's ability to take them through the birth. These emotions were surprisingly consistent and linear and have been found to some extent in other research studies (Table 1).

Table 1:

Emotions during labour identified by Dixon, Skinner and Foureur (2013)	Other research identifying the same emotions
At the start of labour – women reported excitement & anticipation	Burvill (2002). Midwifery diagnosis of labour onset. *British Journal of Midwifery, 10*(10), 600 – 605 Nolan, M., Smith, J., & Catling, J. (2009). Experiences of early labour (1) Contact with healthprofessionals. *The Practising Midwife, 12*(7), 21-24
This was followed by a period of calm & peace - women felt confident to carry on with normal life	Burvill (2002). Midwifery diagnosis of labour onset. *British Journal of Midwifery, 10*(10), 600 – 605
As labour became more intense women described 'The Zone' where they had to really focus on the intensity of the contractions – time passed differently; they felt in a different place in space and time	Halldorsdottir, S., & Karlsdottir, S. (1996). Journeying through labour and delivery: perceptions of women who have given birth. *Midwifery, 12,* 48-61. Machin, D., & Scamell, M. (1997). The experience of labour: using ethnography to explore the irresistible nature of the bio-medical metaphor during labour. *Midwifery, 13,* 78-84. Leap, N. (2000). Pain in labour: towards a midwifery perspective. *MIDIRS Midwifery Digest, 10*(1), 49-53. Burvill, S. (2002). Midwifery diagnosis of labour onset. *British Journal of Midwifery, 10*(10), 600 - 605. Duff, M. (2005). *A study of Labour.* Unpublished PhD dissertation. University of Technology, Sydney.
Some women reported becoming tired and sleepy	Not found in other studies
Women reported becoming fearful, overwhelmed and out of control	Cheyne, H., Dowding, D., & Hundley, V. (2006). Making the diagnosis of labour: midwives' diagnostic judgement and management decisions. *Journal of Advanced Nursing, 53*(6), 625-635. Escott, D., Spiby, H., Slade, P., & Fraser, R. (2004). The range of coping strategies women use to manage pain and anxiety prior to and during first experience of labour. *Midwifery, 20,* 144-156. Halldorsdottir, S., & Karlsdottir, S. (1996). Journeying through labour and delivery: perceptions of women who have given birth. *Midwifery, 12,* 48-61.
After the birth women described feelings of euphoria and joy or shock and disbelief	Halldorsdottir, S., & Karlsdottir, S. (1996). Journeying through labour and delivery: perceptions of women who have given birth. *Midwifery, 12,* 48-61. Carter, S. (2009). Gender and childbearing experiences: revisiting O'Brien's dialectics of reproduction. *NWSA Journal, 21*(2). Retrieved from http://search.rdsinc.com.helicon.vuw.ac.nz Fenwick, J., Hauck, Y., Downie, J., & Butt, J. (2005). The childbirth expectations of a self-selected cohort of Western Australian women. *Midwifery, 21,* 23-35.

The studies shown in Table 1 raise the question of whether the emotions identified by women during labour and birth are a possible indicator of normal labour physiology. What is currently known about emotions and hormones and their links to human parturition? Over the last few decades there have been revolutionary changes in knowledge and understanding of human brain structures and functions. Advances in brain imaging and measurement of neurochemical changes have improved researchers' ability to investigate the role of the neural structures in the brain and their link to behaviour (Brizendine, 2006). This paper will focus on the links between contemporary knowledge of neuroscience and parturition (childbirth) physiology. It will integrate contemporary scientific understandings with the descriptions from women of their emotions during labour and birth. An interactive model will be presented which explains labour in terms of the physical effects and the emotional affects that women have identified during labour and birth (Figure 1). The hypothesis for this model is that the hormones that initiate and sustain labour also cause the instinctual emotions, the behaviour and the feelings women exhibit during spontaneous labour and birth. It suggests that the woman's emotional and physical reactions to labour may be the drivers and signs of progress and that interruption to or intervention of women's instinctual behaviours may delay or slow labour.

UNDERSTANDING EMOTIONS

It has been known for some time that hormones influence the functions of organs within the human body but scientific advances have led to an understanding that neurohormones are also intricately intertwined with emotions (Pert, 1997). Hormones are chemical substances (messengers) secreted into the blood or body fluid that exert a physiological effect on other cells in the body (Blackburn, 2007). They facilitate the maintenance of an optimal internal environment, initiate corrective and adaptive responses to any deviations from normal physiology and direct human behaviour. Neurohormones are hormones which are synthesised and released from neurones; as such they are secreted within the brain to work both on the neurones in the brain and on different sites within the body via the blood stream (Douglas & Ludwig, 2008). These hormones have subsequently been found to influence behaviour because they have an effect on how the body adapts physiologically (Cacioppo & Berntson 2006).

Pert's (1997) discovery of neurohormones, which link human physiology and emotions, led to the construct that hormones are biochemical molecules of emotion; thoughts and emotions are diffused throughout the body and the mind, and can cause physiological changes. The alternative is also true that physiological changes affecting the body's functions can also cause emotions. There is a vital link between the mind and the body

and 'emotions and bodily sensations are intricately intertwined in a bi-directional network' (Pert, 1997, p. 142).

THE BRAIN AND CHANGING NEURAL STRUCTURES

The human brain is a complex and intricate structure with many differing functions and systems. The neocortex is divided into several regions which include the parietal, occipital, frontal and temporal lobes which interact through the thalamus and the thalamus interacts with the limbic system (Amthor, 2011). The limbic system is made up of differing structures (such as the hypothalamus and amygdala) working together to support an overall function which is to regulate autonomic and endocrine function and ensure self-preservation (Swenson, 2006). The neocortex is often conceptualised as the thinking part of the brain and the limbic system as the feeling and reacting part of the brain (Swenson, 2006).

It would appear that the neural structure within the brain is continually developing and changing throughout life, starting during the intrauterine period (Swaab & Garcia-Falgueras, 2009) and continuing into old age (Brizendine, 2006). This ability to change is termed plasticity and it is thought that the human brain has a high degree of plasticity over short and long term intervals. These changes are directly influenced by the hormones: oestrogen, progesterone, testosterone, oxytocin and prolactin, all of which can have a strong influence on behaviour (Blackburn, 2007; Brizendine, 2006).

During pregnancy there are substantial changes in maternal brain structure and physiology. Nevo, Soustiel and Thaler (2010) found a gradual increase in the cerebral blood flow as pregnancy progresses which they suggest may be due to the impact of oestrogens and progesterone. During the postpartum period Kim, Mayes, Leckman, Feldman, & Swain, 2010 described changes to the brain structure in certain regions of the brain. Using MRI scanning they compared the brain structure and activity of 19 postpartum women (with healthy babies) at two points in time – between two and four weeks postpartum and three and four months postpartum. They found structural changes and increased grey matter within certain regions in the women's prefrontal cortexes, parietal lobes and midbrain areas. These regions are thought to be implicated in maternal motivation and maternal behaviour.

Little is currently known about whether the hormones that instigate and regulate labour and birth have an effect on neonatal and infant neural development. More importantly perhaps is the parallel lack of knowledge as to whether intervention (and interruption) of normal labour hormones could have an effect on the neural development of the infant. There is however substantial evidence that oxytocin and vasopressin (produced within the brain) have a key role in social behaviour (Heinrichs, Dawans, & Domes, 2009).

INFLUENCES ON BEHAVIOUR

Social neuroscience is an emerging field which is attempting to examine and integrate how the nervous, endocrine and immune systems influence social processes and behaviour (Harmon-Jones & Winkielman, 2007). Evolving theories are now outlining the apparently innate need humans have, to behave in ways that are socially acceptable. Social co-operation has ensured improved survival of the species and is reliant on reciprocity, cooperation, communication and collective action (Norris & Cacioppo, 2007).

Humans are fundamentally social beings and it is argued that emotions have evolved as an adaptive process to ensure protection from predators (fear of snakes, etc.) but also to encourage social co-operation and collective action (Norris & Cacioppo, 2007). When an individual perceives a situation that is new, uncontrollable or unpredictable there is an increased stress response. This response can also be caused by social interactions that threaten the social self – for example, when performance can be judged negatively by others (Kudielka, Hellhammer, & Kirschbaum, 2007).

Norris and Cacioppo (2007) and many others suggest that we ensure affiliation with other members of our group through engaging in behaviours that contribute to attachment, and that healthy social relationships are important for emotional and physical wellbeing. Social interactions often lead to social bonds which are defined as behavioural processes in which there is a tendency to prefer and seek contact with others and to seek a partner (Carter, 2007).

The hormones that are thought to affect social behaviour, social bonding and sexual behaviour are: oxytocin, vasopressin, corticotrophin-releasing hormone (CRH) and corticosterone, along with oestrogen and testosterone (Carter, 2007). Oxytocin regulates a variety of intertwined behaviours and whilst much of the research advances have come from animal studies, there is evidence to support similar behavioural effect for humans. The effects of oxytocin are presented in Table 2.

Table 2: Effects of Oxytocin (Pederson & Boccia, 2002)

- Suppresses appetite
- Stimulates sexual arousal, receptivity and grooming behaviours
- Reduces anxiety
- Increases mothering behaviour
- Improves social memory
- Reduces stress and anxiety (Neumann, 2008)
- Increases generosity to others (Zak, Stanton, & Ahmadi, 2007)
- Increases trust in others (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005)

During labour:

- Enhances growth, expulsion (during labour) sociability, curiosity and reduces stress (Uvnäs-Moberg, 2003)
- Binds with oxytocin receptors in the myometrium to initiate rhythmic uterine contractions during labour (Challis, Matthews, Gibb, & Lye, 2000)
- Oxytocin is released in pulses (Leng, Meddle, & Douglas, 2008).
- The pulses increase in frequency, amplitude and duration (Fuchs et al., 1991)
- Works with and enhances levels of beta-endorphin
- Has a strong analgesic hypnotic effect (Gimple & Fahrenholz, 2001)
- Enhanced expulsion during the second stage - also known as the Ferguson reflex (Blanks & Thornton, 2003; Buckley, 2010).

Oxytocin is produced within the hypothalamus and is mediated by other neurohormones. The full effects of this naturally produced hormone are complex and still not fully understood.

What we do know is that oxytocin enhances maternal behaviour and is supported by prolactin. Prolactin works on many different cell types; it does not have a single endocrine function but a range of distinct, and what appear to be unrelated, functions. Grattan and Kokay (2008) suggest that the many and widespread functions of prolactin can be considered as a single function – that of inducing or regulating a variety of neuroendocrine adaptations to pregnancy and lactation (Grattan & Kokay, 2008). Prolactin is the only hormone that remains elevated throughout pregnancy and lactation (Grattan, Steyn, Kokay, Anderson, & Bunn, 2008). It is thought that these elevated prolactin levels in conjunction with oxytocin contribute to maternal behaviour (Grattan & Kokay, 2008; Grattan et al., 2008).

Thus it appears that neurohormones have both a physiological function (acting on the body) and a behavioural function (acting on the brain and behaviour); these dual functions enhance maternal behaviours that will ensure optimal survival for the baby following birth. All mammals have

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an innate need to ensure survival of their offspring and to do this there is a need for a change in behaviour (Winberg, 2005). The hormones which support pregnancy and trigger labour and birth are also designed to trigger a transformation in the behaviour of the mother and baby and create an optimal environment which supports them (Schmid & Downe, 2010).

THE PHYSIOLOGY OF PARTURITION (CHILDBIRTH)

Recent advances in knowledge about human physiology suggest that pregnancy, labour and birth are a continuous physiological process (Baddock, 2010; Challis, Matthews, Gibb, & Lye, 2000; Douglas & Ludwig, 2008). Parturition relies on complex and highly co-ordinated behaviours involving a myriad of endocrine, neuro-endocrine and immunological responses with complex interrelated signalling between the maternal and fetal systems (Challis et al., 2000; Douglas & Ludwig, 2008). The initiation of labour remains poorly understood although it is thought that there may not be a single pathway to the onset of labour in humans but several pathways suggestive of a failsafe system (Power & Schulkin, 2005). Before these pathways can occur however, there is a need for different maternal cells to change their behaviour. With the cells of the uterine myometrium undergoing the most dramatic changes from early pregnancy, through labour and into the postpartum period (Shynlova, Tsui, Jaffer, & Lye, 2009).

Myometrium regulation during pregnancy and parturition is a necessary part of birth which is achieved as a continuum of four distinct physiological phases (Challis et al., 2000; Norwitz, Robinson, & Challis, 1999; Smith, 2007; Terzidou, 2009). These phases involve uterine quiescence, activation, stimulation and involution. During uterine quiescence the contractility of the myometrium is suppressed, to enable the baby and uterus to grow. It occurs for the majority of pregnancy and is mediated by corticotrophin releasing hormone, progesterone, and a variety of uterotonic inhibitors working together to promote uterine relaxation. The activation phase prepares the myometrium to respond to stimulation. This involves an increase in myometrial receptors (oxytocin and prostaglandin) and gap junctions and occurs over several days or weeks. During the labour stimulation phase the myometrium contracts in response to uterotonic stimulators such as oxytocin, prostaglandins and cytokines. The final phase is myometrial involution which involves tissue remodelling, apoptosis and cell growth.

The changes between these phases evolve and are dependent on an integrated response between hormones and neurohormones. Pregnancy and childbirth are a physiologically continuous process, with a gradual transition between the end of pregnancy and the start of labour moving through to the birth and into the postpartum period (Baddock, 2010).

THE NEUROHORMONES IMPLICATED IN LABOUR AND BIRTH

The full physiology of labour and birth is not yet fully understood but evidence to date suggests that the hormone prostaglandin and the neurohormones oxytocin and CRH are necessary for labour initiation and progression (Challis, Matthews, Gibb, & Lye, 2000). Activation of the stress response (increasing levels of CRH) stimulates the secretion of hypothalamic beta- endorphin resulting in an increased stress-induced analgesic response (Charmandari, Tsigos, & Chrousos, 2005). These neurohormones are mediated by other hormones such as oestrogen and progesterone, and influence the production of prostaglandin which has a direct effect on the myometrium to stimulate contractions. These hormones also have an important role in the woman's emotional, physical and social responses to labour, birth and motherhood.

THE ROLE OF CORTICOTROPHIN RELEASING HORMONE

CRH has a fundamental role in events that require a flight or fight response and therefore has an important role in survival and adaptation (Charmandari et al., 2005; Grammatopoulos, 2008). There is a complex set of interactions between the hypothalamus, the pituitary and the adrenal glands (HPA axis). CRH is released from the hypothalamus and travels to the anterior pituitary to orchestrate an integrated stress response (Brunton, Russell, & Douglas, 2008: Grammatopoulos, 2008). It stimulates the release of beta-endorphin and adrenocorticotropin hormone (ACTH). ACTH regulates glucocorticoids and cortisol production with the HPA axis working alongside the sympathetic-adrenal-medullary (SAM) axis to regulate the autonomic nervous system (Charmandari et al., 2005). During pregnancy the role of maternal secreted CRH is unclear but it is hypothesised that it integrates the homeostatic mechanisms that enable the mother and baby to adapt to an increasingly stressful environment (Grammatopoulos, 2008; Brunton, Russell, & Douglas, 2008; Ochedalski, Zylinska, Laudanski, & Lachowicz, 2001).

During labour increasing levels of CRH stimulate an increase in myometrial prostaglandin receptors, prostaglandin release, oxytocin release, fetal cortisol and beta-endorphin release (Blackburn, 2007; Petraglia, Florio, & Vale, 2005). The maternal plasma CRH levels of seven women during labour who gave birth vaginally were compared with those of 10 women who had elective caesarean sections (Petraglia et al., 1990). The results indicated that for the women who had a caesarean section the maternal plasma levels did not differ significantly from those found prior to the birth. However, for those women who had a vaginal birth the maternal plasma CRH increased progressively during labour reaching a peak at 8 and 9 cm of cervical dilatation and at the

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birth, followed by a significant reduction in the two hours postpartum. The effects of CRH are described in Table 3.

Table 3: The role of CRH

CRH controls and regulates reactions to fear and stress:

- There is a complex set of physical influences and feedback interactions between the hypothalamus, the pituitary and adrenal glands.
- The hypothalamus releases CRH which travels in the blood to the anterior pituitary to orchestrate an integrated stress response (Brunton, Russell, & Douglas, 2008; Grammatopoulos, 2008).
- CRH stimulates the release of beta-endorphin and adrenocorticotropic hormone (ACTH)
- ACTH stimulates the secretion of glucocorticoids and causes the release of cortisol from the adrenal glands (Greenstein & Greenstein, 2000; Kudielka, Hellhammer, & Kirschbaum, 2007).
- The HPA works alongside the sympathetic-adrenal-medullary (SAM) axis which regulates the release of adrenaline and noradrenaline.

During pregnancy CRH:

- Supports the physiological adaptation to pregnancy (Grammatopoulos, 2008)
- Increases the numbers of prostaglandin receptors in the myometrium

During labour CRH stimulates the release of (Petraglia, Florio, & Vale, 2005):

- Prostaglandin
- Oxytocin
- Beta-endorphin

THE STRESS RESPONSE

Increasing levels of CRH stimulate the stress response. Stress is defined as a threat or perceived threat to the body's dynamic state of equilibrium or homeostasis (Charmandari et al., 2005). The stress response is a complex cascade of physiological and behavioural adaptive responses which support homeostasis. It involves responses such as enhanced analgesia, elevations in core temperature, adaptive redirection of energy and increases in cardiovascular and respiratory rates. Enhanced analgesia occurs through other central nervous system components such as the opioid peptide producing neurones resulting in the production of beta-endorphin and its derivatives.

During the 1980s and early 1990s several studies found that beta-endorphin was released during labour (Mauri et al., 1990; Pancheri et al., 1985; Sasaki et al., 1987). It was hypothesised that the increased stress of labour supported and co-ordinated the body's response to stress. Maternal plasma concentrations of CRH and beta-endorphin were seen to have a correlated rise during labour which was thought to be a response to pain perception (Mauri et al., 1990; McLean, Thompson, Zhang, Brinsmead, & Smith, 1994; Pancheri et al., 1985). The levels of beta-endorphin and CRH during labour were found to reach values similar to those found in athletes during maximal exercise (Laatikainen, 1991).

More recently and due to improved testing techniques, the relationship between authentic beta-endorphin and labour stress has not been established (Harbach et al., 2008). Harbach and colleagues (2008) have found that there is a stress response which results in rising levels of some endorphin derivatives but only minimal increases of what is called the 'authentic beta-endorphin'. They have yet to clarify the specific function of the endorphin derivatives (B-endorphin IRM and B-LPH) although beta-endorphin is still considered to play a role in supporting an enhanced analgesic response during labour. A fuller understanding of this response is yet to be reached. One of the problems of testing for neurohormones relates to sensitivity in that the very nature of the test itself can alter or disrupt the neurohormones being measured.

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THE ROLE OF OXYTOCIN DURING PARTURITION

Oxytocin is produced in the hypothalamus and transmitted along secretory neurones to be stored in the posterior pituitary; it is released from the hypothalamus following neural stimulation (Leng, Meddle, & Douglas, 2008). Oxytocin has an affinity to oxytocin receptors which are expressed in the uterus during labour, the myoepithelium of the breasts during lactation (milk let down), and also on neurones within the central nervous system (Leng et al., 2008). The oxytocin neurones become less sensitive to stressful stimuli in late pregnancy, and it is theorised that this hypo-responsiveness may allow the pituitary to build stores of oxytocin in readiness for labour and breastfeeding (Leng et al, 2008). Oxytocin is the prime initiator of rhythmic uterine contractions during labour (Blackburn, 2007; Buckley, 2005; Challis et al., 2000) and is released from the maternal pituitary in pulses resulting in synchronous uterine contractions (Fuchs et al., 1991). The oxytocin neurones fire in bursts during labour and birth and breastfeeding, but at all other times oxytocin is discharged in a sustained release (Leng et al., 2008). These pulses increase in frequency, amplitude and duration during labour and are necessary for the maintenance of spontaneous labour (Fuchs et al., 1991). As the baby's head descends and the cervix and associated soft tissues begin to stretch, receptors within these tissues create a feedback loop to increase oxytocin production - resulting in strong expulsive contractions also known as the Ferguson reflex (Blanks & Thornton, 2003; Buckley, 2010). Oxytocin increases levels of beta-endorphin and also appears to have a strong analgesic effect itself (Gimple & Fahrenholz, 2001).

DISCUSSION

These, then, are the molecular structures that are flooding the woman's body during labour and birth. They will have a direct action on the cells and tissues but simultaneously will influence the woman's emotions and behaviour during labour and following the birth. What do these advances in scientific understanding mean when considered in the context of the emotions women have described during labour and birth? We now know that hormones and especially neurohormones influence and enhance the ability of the woman's body to adapt to the necessary physiological changes. These emotions and feelings are probably representations of some of the necessary drives and biological bodily functions that occur during parturition.

The onset of labour is characterised by specific physical signs such as period-type pains, a bloody mucous 'show', ruptured membranes,

contractions, backache, and stomach upsets (diarrhoea, nausea, vomiting). With these physical manifestations of labour some women have reported positive feelings of excitement and anticipation. It is uncertain whether these positive emotions cause or are caused by a neurohormone such as dopamine providing a positive feedback to the limbic system. This may enhance the production of oxytocin (Uvnäs-Moberg, 2003) which works with the hormone prostaglandin to stimulate continued rhythmic uterine contractions. The neurones of the hypothalamus release oxytocin in pulses which build in frequency. The woman's cognitive abilities are unimpaired and she continues with her normal daily activities. Some women have described feeling calm and peaceful at this time and able to interact normally with the world (Dixon, Skinner, & Foureur, 2013). Oxytocin is known to reduce anxiety and this effect may be enhanced by the earlier release of a neurohormone such as dopamine (Uvnäs-Moberg, 2003).

'THE ZONE'

The hormones oxytocin and prostaglandin work together to ensure increasing frequency, length and strength of myometrial contractions (Challis et al., 2000; Fuchs et al., 1991). Physically therefore women experience contractions which gradually increase in strength and intensity. These contractions become more painful as the baby descends, the cervix dilates and the myometrium retracts. With increasing pain an increased stress response occurs and CRH levels rise. Simultaneously, the hormone beta-endorphin or a derivative is produced, and these hormones work together to mediate stress (Mauri et al., 1990; McLean et al., 1994; Pancheri et al., 1985). With rising levels of beta-endorphin (or its derivative) and oxytocin there will be an increased hypnotic and analgesic effect. As each of these hormones increases it is possible that there is a reduced functioning of the neocortex, and the neural pathways between the limbic system and the body act as dominant fluent highways of information. This may be the point at which some women describe feeling that their world is 'shrinking' and that they are 'on a different planet', or in 'the Zone'. It would also account for the different temporal experience of time and the inability to focus on events or people around them. The cognitive part of the brain is still able to function but at this point the limbic system is dominating so the body can proceed with the full physiological adaptation that is required for birth. If the cognitive part of the brain is engaged at this point it is possible that the limbic system will lose dominance and labour will stall or slow. This is somtimes seen when women move from their home environment to hospital – with the change in environment resulting in a need to evaluate for threats and therefore a need for re-engagement with the neocortex.

The way a woman feels and behaves during labour may provide an understanding and an indication of the hormones that are exerting an effect on the woman's body during labour.

BECOMING SLEEPY, FEARFUL OR OVERWHELMED

As the levels of oxytocin, CRH and endorphin (or derivative) rise, women experience strong and sustained contractions. The stress response and oxytocin neurohormones work in balance exerting strong analgesic properties and a powerful anti-stress response (Gimple & Fahrenholz, 2001). These hormones can also cause reduced gastric functioning which may in turn cause vomiting during labour. There may also be a sedative effect making the woman feel very tired and sleepy at this point.

Alternatively, the level of pain may be increasing faster than the anti-stress response can mediate, causing a temporary imbalance – this would result in high levels of the neurohormone CRH resulting in feelings of fear and overwhelming pain. Thus women will feel fearful, panicky or overwhelmed – these feelings frequently occur prior to pushing, they may also be due to, or the cause of, a surge in oxytocin levels leading to the Ferguson reflex and expulsive contractions.

PUSHING

The urge to push may be due to the stretching of the birth canal resulting in increased oxytocin production (Blanks & Thornton, 2003; Buckley, 2010). Nulliparous women have described becoming more focused at this point with a need to concentrate on 'how' and 'whether' they should push (Dixon, Skinner & Foureur, 2013). This is suggestive of a re-engagement of the neocortex and may be a mechanism that supports the woman's safety in that the neocortex becomes more dominant so that danger or threats can be more fully assessed.

AFTER THE BIRTH

Immediately following the birth some women have described feeling shocked and a little disconnected from reality, whilst others have described feeling wide awake, alert and euphoric (this response may be due to the high levels of oxytocin and beta-endorphin). The differences between these reactions require research into whether both are indicative of a normal adaptive response. These feelings continue into the third stage of labour where a high level of oxytocin is necessary to ensure the successful completion of the birth of the placenta and involution of the myometrium.

A MODEL FOR WOMEN

A model of this description is provided as a means of representing how the woman's hormones may work to facilitate labour and birth whilst also simultaneously having an effect on how the woman feels and behaves during labour. It is suggested that these hormones and feelings work in an integrated way to support and facilitate labour and birth (Figure 1). This model seeks to integrate the women's feelings with the associated hormonal actions alongside the physical process. It has been built from what is currently known about women's feelings and integrated with the contemporary knowledge of the hormones of labour and birth.

The way a woman feels and behaves during labour may provide an understanding and an indication of the hormones that are exerting an effect on the woman's body during labour. A woman's feelings and behaviour are instinctive and may be due to the dominance of the limbic system as it enables and supports the woman's physiologically driven requirement to give birth. The feelings women have described may be an indication of normal undisturbed neuro-physiology. Each neurohormone that is released will have an impact on both the woman's body and the way she feels; the alternative may also be true that the woman's feelings may inhibit or support the release of the neurohormone. This way of understanding and theorising labour is new and may be oversimplified. It is useful and important however, because as midwives working in partnership with women it is fundamental that we inform them about the nature of labour - not so much in clinical terms, but in terms meaningful to them. To do so we must increase our understanding about the interconnecting roles of feelings, hormones and behaviour.

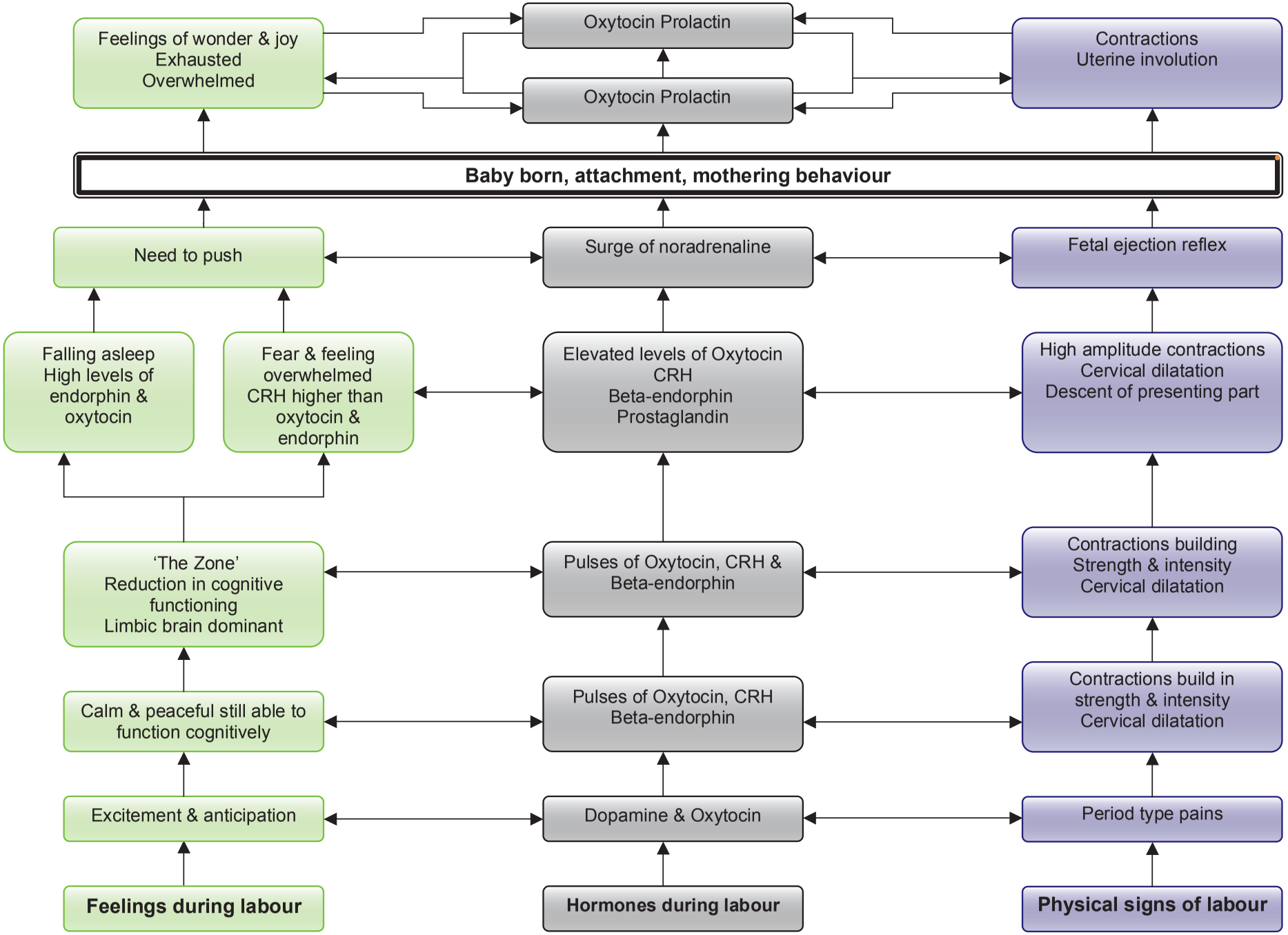

Figure 1: Integration of feelings, hormones and physical signs of labour and birth

The feelings and behaviour women exhibit during labour may be strong indicators of normal labour physiology and that labour and birth are proceeding normally.

IMPLICATIONS FOR PRACTICE

Walsh (2003, 2007, 2010) and Schmid and Downe (2010) argue for a change in our way of conceptualising labour with a move away from a linear understanding of stages and phases to one of cycles and rhythms. Midwives have long observed women's behaviour and considered that the behaviour provides indicators that labour is moving towards birth (Burvill, 2002; Duff, 2005). We now know that behaviour can be seen as an adaptive response and the manifestation of the drives and instincts of biological processes (Damasio, 1994). As such behaviour is driven by feelings and feelings are derived from, and initiate, neurohormones which act on both the brain and the body to ensure the maintenance of an optimal internal environment and corrective adaptive responses.

Integrating contemporary scientific knowledge with women's descriptions of their feelings during labour improves our ability to theorise, and to comprehend the complexity of the physiological, emotional and physical changes that occur during labour and birth. This mind/body/behaviour concept supports health professionals and women to a better understanding of labour physiology. Midwives need to explore ways of maximising and enabling the instinctive drives that support the woman's physiology. This may include reviewing the birthing environment to ensure the woman can go into 'The Zone'. There are simple but key environment enablers such as keeping the lights low, staying quiet during contractions and not making eye contact. Ensuring women maximise the limbic brain connection is about supporting them to 'disconnect' with others during labour whilst also maintaining the usual physical and emotional midwifery care. This may be a difficult concept for partners and family/whānau present during labour. As an example: it involves explaining the intrusive nature of cell phones, videos, games, cameras, bright lights and background conversation. When we explain how the labouring woman's emotions and behaviour women can be signposts to the progress of labour and how important it is to ensure the woman is able to labour 'undisturbed', we can provide women, their partners, families/whānau with ways of understanding what is happening. This can both reassure and support the woman's confidence in her own physiology.

CONCLUSION

The functioning of the human brain is complex although with advances in technology scientists are uncovering new insights to help us understand. Pregnancy and the process of labour and birth are designed to bring about behavioural changes which culminate at the birth in maternal attachment and mothering behaviour. The hormones that are necessary for social and maternal bonds are also those responsible for the initiation and continuation of labour (Challis et al., 2000; Taylor et al., 2000; Uvnäs-Moberg, 2003). As such the process of pregnancy, labour and birth is not just a physical process but also a transitional process in which the woman is prepared (biologically and emotionally) to become a mother and exhibit maternal behaviours. The feelings and behaviour women exhibit during labour may be strong indicators of normal labour physiology and that labour and birth are proceeding normally.

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