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Introduction: Towards a Fetal Psychology

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INTRODUCTION

Developmental psychology has moved on from the description by William James (1890/1981) of the newborn's awareness of the world as 'a *blooming buzzing confusion*' to considerations of how internal and external factors combine to influence the developing child from birth. But what about development before birth? Attempts to address this question have given rise to the relatively new field of fetal psychology that, for example, concerns itself with issues about the ways in which maternal psychological states may have an impact on the development of the fetus, and thereby on development after birth. Examining human development starting with life in the womb brings new perspectives as well as challenges to understanding of psychological development, some of which will be considered in this Special Issue on fetal psychology.

This Special Issue considers the current status of the field by means of critical examinations of recent theoretical and methodological perspectives concerning fetal development as it pertains to the emerging mental life of the human fetus. For both perspectives, there are target articles, each followed by a commentary that strives to highlight issues raised, while adding new points to the debate.

In his target article, Ellison highlights the impact of the introduction of the 'fetal programming hypothesis', first in epidemiology and subsequently across a broad range of disciplines concerned with developmental biology. As he points out, it has generated fresh interest in phenotypic plasticity, the mechanisms that govern it, and its place in evolutionary biology. A number of epidemiological studies link small size at birth, assumed to be a consequence of constrained prenatal energy availability, with adverse effects on the risk of various forms of chronic disease later in life. The cluster of chronic ill health associated with the metabolic syndrome and alterations of glucose metabolism are particularly implicated. Recent evidence suggests that epigenetic modification of gene expression affecting the hypothalamic-pituitary-adrenal (HPA) axis may have a part in these effects (e.g. Gicquel, El-Osta, & Le Bouc, 2008; Meaney, Szyf, & Seckl, 2007).

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The epigenetic change of HPA axis activity and responsiveness has been demonstrated in a number of animal studies. For example, Szyf, Weaver, and Meaney (2007) suggested, based on research with rats, that the epigenome of the developing fetus is sensitive to psychological stress and is associated with changes in adult behaviour and stress reactions (see also Szyf, McGowan, & Meaney, 2008).

The potential for similar effects to contribute to psychological and psychiatric outcomes has been explored in a number of contexts, including famine exposure in the third trimester of pregnancy and their associations with reduced birth weight (Stein, Zybert, van de Bor, & Lumey, 2004). While fetal programming effects have now been widely demonstrated in human populations as well as across species, the adaptive significance of these effects is still a matter of debate.

Gluckman and Hanson in their commentary argue that developmental plasticity operates over the whole range of environmental experiences, which bestows an evolutionary advantage for the organism when challenged in terms of maintaining or enhancing fitness. Studies of the long-term consequences of different developmental environments for human health and disease have shown that there is a graded effect across the whole range of the prenatal environment. Thus, in contrast to fetal programming, which is consensually interpreted as a reflection of the maladaptive consequences of developmental plasticity, the universality of developmental plasticity suggests that it has not only negative but also positive consequences, something acknowledged by Ellison. Maladaptive consequences of developmental plasticity arise from discordance between the triggering and later environments. However, a poor fetal environment is not always accurately reflected in birth size. For example, growth restriction, according to Gluckman and Hanson, is not always a pre-requisite for increased disease risk, as shown by studies which such risk is dependent on maternal nutrient intake but not birth-weight.

Not only can one observe an influence of the environment on the fetus, but studies have also shown that the fetus influences its own environment, specifically that provided by the mother. DiPietro, in her target article, comments directly on the psychological and psycho-physiological consequences of pregnancy. Pregnant women construct mental representations of the fetus, and feelings of affiliation or 'maternal-fetal attachment' generally increase over the course of gestation. The construction of maternal representations is helped by the advent of techniques allowing for the visualizing of the fetus. Hence, mothers not only feel their fetus moving but can also see it in 3-D, which has been shown to reduce anxiety and increase feelings of attachment to the fetus by mothers. Fetuses respond to maternal psychological states. For example, maternal indicators of perceived anxiety and stress are associated with higher levels of motor activity and greater variability in fetal heart rate.

While there is a fairly substantial literature on the development and moderation of psychological features of the maternal–fetal relationship, including the role of ultrasound imaging, relatively little is known about the manner in which maternal psychological functioning influences the fetus. Van den Bergh, in her commentary, agrees with Di Pietro that although significant progress has been made in the study of fetal psychology, more basic empirical work needs to be done before we can understand the complex interactions between the fetus and the social context in which the fetus develops and grows. She argues that 'society' has an important role regarding the experience of pregnancy, and that at times the high expectations raised by scientific findings are not in step with how pregnancy is managed in a social context. Consequently, mothers are left exposed

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to heightened worries and concerns during pregnancy. According to van den Bergh, we still lack the knowledge of specific effects of stress and which types of stress might influence fetal development, both positively in the sense of maternal emotional investment in the fetus and negatively such as fetal growth restriction.

Fetal learning, according to James, is not just of academic interest but is relevant to the controversial issue of whether fetal neurodevelopment can be positively influenced and enhanced. He explains and discusses different types of learning, including habituation, classical conditioning, and exposure learning. Habituation times get faster with neurological maturation and are correlated with corticotrophin-releasing hormone (CRH) concentration in the placenta. However, CRH is also related to stress since it is secreted by the paraventricular nucleus of the hypothalamus in response to stress (Imaki *et al.*, 2001). Hence, findings on CRH are relevant to research on the effects of stress on fetal biological, physiological and psychological development. The few studies that have used classical conditioning responses in the human fetus have produced unreliable results. The same is true for studies using exposure learning, which are flawed because of methodological limitations such as not using a novel stimulus, which the fetus could never have heard before, or a change of the fetal response-rate with repeated exposure. Hence, according to James, learning in the fetus is an area which is still lacking in convincing results.

Kawai, commenting on James, highlights a further problem. He does so by pointing out the differences between studies with non-human fetuses and those with human fetuses in that associative learning has been demonstrated in the rat fetus, while only non-associative learning (i.e. habituation and exposure learning) has been evident in the latter. Additionally, in classical conditioning studies with rats, fetuses were stimulated directly via an incision in the maternal abdomen. Human fetuses experience the acoustic stimulus while remaining untouched within the uterus in the relevant studies. Human fetuses are not touched during stimulation, and moreover, the periods of pregnancy vary widely from 3 weeks in the rat to 40 weeks in the human. Given these differences (i.e. types of learning, method of stimulation, the gestation age at onset of learning, and memory period) among human and non-human animal studies, Kawai advocates caution when extrapolating results obtained from animal fetuses to humans as it is not clear whether the same mechanism occurs in the two species.

Turning to methodological issues, Kisilevski and Hains argue that although lack of direct access to the fetus limits research paradigms and response measures for fetal studies, neural regulation of the fetal heart rate shows a number of parallels with adult regulation. For example, discrimination, habituation, and learning of auditory stimuli provide evidence of a relation between fetal heart rate and cognition. Heart rate measures, however, come with their own problems. One problem is that precise measurements have not yet been achieved, because the calculation of gestation in naturally occurring pregnancies is not precise. Hence, timing of maturational changes can vary from one to two weeks over reports. Another problem concerns our understanding of how the link between heart rate and cognitive development is achieved. Given the complex interaction of the sympathetic and the parasympathetic nervous systems and the homeostatic mechanism for maintaining blood pressure (viz. the baroreflex), heart rate measures, in terms of increases, decreases, or heart rate variability changes, cannot be accounted for by a simple one-to-one correspondence with cognitive factors, such as attention or memory. In spite of these methodological problems associated with heart rate measures and cognitive development in the fetus, Sandman, in his commentary, supports Kislevski and Hains findings with additional studies.

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All three authors are in agreement that the study of the human fetal heart rate offers a unique opportunity to examine central nervous system activity.

The second technique, discussed by Sheridan and colleagues, concerns fetal magnetoencephalography (fMEG), which is the only non-invasive method for investigating evoked brain responses and spontaneous brain activity generated by the fetus *in utero*. Successful applications of fMEG have been wide ranging, covering recordings of fetal auditory as well as visual evoked fields in basic stimulus–response studies. Moreover, 'markers' indicating cognitive development, such as habituation and mismatch responses, have been studied by means of fMEG. In summary, not only is fMEG a promising tool for the prenatal assessment of cognitive development, but future fMEG studies might even enable the identification of developmental delays prenatally. Additionally, fMEG could have an important role in the implementation and evaluation of fetal intervention programs with at-risk populations. Huotilainen, in her commentary, agrees that MEG can be effectively used to record fetal and neonatal cognitive abilities by recording completely non-invasively the magnetic fields produced by task-specific regions, such as visual, auditory, or somatosensory areas (e.g. Wheless *et al.*, 2002) in the brain. Furthermore, in agreement with Sheridan *et al.*, Huotilainen argues that studies of fetal and neonatal brain activity with MEG, and possibly studies of fetal and neonatal cardiac reactivity to stimulation with fetal magnetocardiography (e.g. Strasburger, Cheulkar, & Wakai, 2008), may provide important indices of potentially problematic developmental patterns in areas such as language acquisition and emotion perception.

Hata and colleagues examine limitations of studies of fetal behaviour using two-dimensional (2-D) ultrasonographic technology and how the advances to 4-D allow for the assessment of fetal behavioral assessment in real time 3-D during pregnancy. A limitation of 4-D sonography is that after around 20 weeks gestation only a narrowly defined region of the fetal body can be visualized through a 20° angle. The main strength of 4-D technology is that it allows for more detailed analysis of behaviours and according to Hata *et al*. body and limb movements can be visualized one week earlier in 4-D compared with 2-D ultrasound. This might be of interest for detecting pathology, for example, where it is important to signal problems earlier rather than later. Safety issues have been raised with the advancement of imaging techniques and limiting exposure time according to the ALARA (As Low As Reasonably Achievable) principle is recommended although no adverse effects have so far been reported.

Emory discusses the role of fetal behaviour in the broader context of human development. He calls the approach used by Hata and others 'the womb with a view' approach, which permits a detailed account of facial and body movements and so potentially the possibility of identifying emotions prenatally. However, he warns that the types of studies made possible with advanced technology also provide a challenge that they could easily become an end in and of themselves. Emory warns that some scientists are so impressed by new technology that they fail to see the larger picture, which opens up misuses or misinterpretations of findings based on these new techniques.

This Special Issue summarizes up-to-date theoretical and methodological contributions to the psychology of fetal development. Although fetal development has fascinated researchers for at least the last 100 years (e.g. Kisilevski & Low, 1998), since the advent of ultrasound, such as documented in the work of Donald, MacVicar, and Brown (1958), the visualization of the fetus has spurred a great number of researchers to examine movements in greater detail. Having

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improved movement analyses in the last few years, the next step concerns the question of the relationship of fetal movements not only to fetal physical or physiological well-being but also to the psychology of the fetus. Given that advances in science are based on both theoretical ideas and methodological possibilities to test these ideas, this Special Issue addresses topical questions and issues from both perspectives and gives a timely overview of this evolving field in psychology.

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