

WHEN DID YOU FIRST BEGIN TO FEEL IT? — LOCATING THE BEGINNING OF HUMAN CONSCIOUSNESS

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ABSTRACT

In this paper we attempt to sharpen and to provide an answer to the question of when human beings first become conscious. Since it is relatively uncontroversial that a capacity for raw sensation precedes and underpins all more sophisticated mental capacities, our question is tantamount to asking when human beings first have experiences with sensational content. Two interconnected features of our argument are crucial. First, we argue that experiences with sensational content are supervenient on facts about electrical activity in the cerebral cortex which can be ascertained through EEG readings. Second, we isolate from other notions of a 'functioning brain' that which is required to underpin the view that a cortex is functioning in a way which could give rise to rudimentary conscious experiences. We investigate the development in the human fetus of the anatomical and chemical pathways which underpin (immature) cortical activity and the growth and maturation of the electrical circuitry specifically associated with sensational content in adult experience. We conclude (tentatively) that a fetus becomes conscious at about 30 to 35 weeks after conception; an answer based on a careful analysis of EEG readings at various stages of cortical development. Finally, we survey the possible ethical ramifications of our answer.

Descartes thought that we (humans) are *essentially* thinking beings, by which he is usually taken to have meant that we are essentially *conscious* beings.¹ Whatever the merits of Descartes' claim about our essence, it seems undeniable that what we *most value* about our lives, considered as *our lives*, is our conscious experiences, or at least the pleasant or most personally significant experiences. What we *look forward*

¹ See Descartes, *Meditations* II and VI. For Descartes, anything at all in the stream of consciousness counted as thought. Today, 'thought' is used in a more narrow sense to encompass only cognitive events, states and processes.

to, is *continued* conscious experience of at least a certain minimal pleasantness and/or personal significance. Whatever answer to the question 'When will *I* cease to exist?' might turn out to be correct, I lose what I value in continued existence when I lose the capacity for conscious experiences. If conscious experiences — or, rather, *some* conscious experiences — are the aspect of our lives we value when we *look forward*, considerations of symmetry *dictate* that we first acquire a capacity for what we most value in our lives when we first become conscious.²

Although it is clear that the acquisition and the loss of consciousness mark (respectively) the beginning and end of *something* of importance — perhaps a human being, perhaps a person — we are not going to advocate, nor do we need to rely on, any particular view about what that 'something' is. In short, we shall dodge as irrelevant to our concerns the Cartesian question about essence; so our concern with the onset of consciousness must not be taken as an attempt to give an answer to the question of when we (as humans or as persons) begin to exist. Our *sole* concern in this paper is to answer, as clearly and accurately as current science and philosophy will permit, the following question: when does human consciousness begin? Further, just as we intentionally bypass the question about essence, so too are we going to bypass, until the final section, the issue of whether *our* question — and, derivatively, our answer to that question — has special moral significance, and, if so, the further issue of what that significance might be.

One assumption we shall require is this: (mental) facts about human consciousness are supervenient on (physical) facts about the human central nervous system — more specifically, they are (at least largely) supervenient on facts about the cerebral cortex.³ (For the

² Gareth Jones at least appears to be denying what seems to us to be an obvious point in 'Brain Birth and Personal Identity', *Journal of Medical Ethics* 15: 1989, 173–178 at 176. We have two comments to make about his reluctance to apply symmetry considerations. First, he is attempting principally to answer the question of when we first acquire 'brain life', but fails to settle on a clear criterion of what brain life consists in — this conceals from him the obviousness of our answer when the question is put our way. Second, he is, in our view, too impressed by striking differences between (crudely) the brief event of adult brain death and the lengthy process of acquiring brain life. This leads him to be unduly pessimistic about the possibility of finding a satisfactory working criterion of brain 'birth'. For our argument that his pessimism is unfounded, see below, section 6.

³ Unlike others who have tackled our question, we can see no reason for regarding events in other parts of the brain as *sufficient* for consciousness in normal human adults. (We would not, of course, dispute the fact that some such events are *necessary* for normal adult consciousness.) All the relevant empirical evidence suggests that the destruction of the cortex will suffice for the cessation of consciousness. For this reason, we are unimpressed by attempts to locate the beginning of consciousness surprisingly early by attaching undue importance to spinal reflexes and evidence

present, we must remain content with this vague supervenience claim, but we shall sharpen it considerably when we have introduced the concepts necessary to achieve the required sharpening.) Even in this provisional (vague) form, our supervenience claim is highly plausible. And just as well: we shall presently see that unless some such supervenience claim is true, the question we are attempting would simply be unanswerable.

Given the truth of the (vague) supervenience claim just presented, we can give an (equally vague) answer to our question: we first become conscious when the cortical events *on which* consciousness is (largely) supervenient first begin to occur. We shall speak of the beginning of consciousness as the beginning of 'cortical life'. We are of course well aware that other notions of 'brain life' are alive and well in the literature on fetal development and we are also well aware that these notions might prove to be more important than our notion both for the question about essence and the issue of moral status on which we shall be remaining neutral. Our rationale for remaining neutral on these undeniably important questions is simply this: the failure to separate the question of the onset of consciousness from these other issues has led both philosophical and scientific writers sometimes into unwarranted overcautiousness, and sometimes, in our view, into a hopeless muddle. To elaborate briefly, although few authors address our question directly, several start by asking the question when does 'brain life' begin, usually linking this question with the question of when we become human beings,⁴ or even the question of when we become persons with full moral rights.⁵ Some tie the answer to the question *they* begin with — when does brain life begin? — directly to the question of when the neural structures underlying consciousness have developed to a point capable of sustaining consciousness, but locate this point at a gestational age which we shall argue to be implausibly early.⁶ Others exhibit a tendency to vacillate. Gareth Jones, for example, vacillates between several alternative notions of brain life. When he settles tentatively on a criterion that seems to be at least loosely correlated with the onset of consciousness, he seems to

of electrical activity in the brain stem. See for example, Jones G.: 'The Fetus, my Fellow Traveller', in *Manufacturing Humans*, Leicester: Inter-Varsity Press, 1987, pp. 94–124. At page 116, he speaks of consciousness of pain at 14 weeks, prior to the development of the cerebral cortex, but at page 123 his tentative positive proposal is to place brain birth at approximately 24 to 28 weeks of development.

⁴ See for example, Lockwood M.: 'When Does a Life Begin?' in *Moral Dilemmas in Modern Medicine*, Oxford: Oxford University Press, 1985, pp. 9–31.

⁵ See for example Jones, *op.cit.*, note 3.

⁶ Lockwood, *op.cit.*, note 4. Note that we are not claiming that Lockwood himself is muddled, but that the interpretations of the science on which he bases his tentative answer probably are. See page 25 and footnotes 19 and 24.

lose nerve entirely when he notices how late in fetal development brain birth would need to be located according to that criterion. He then concludes that the notion of brain birth is too fuzzy to be of any use.⁷

1. WHAT IS CONSCIOUSNESS?

Consciousness is experienced (in adults) as a multi dimensional *continuous stream* of events and states of which the subject is (more or less) aware. The feeling of hunger may give way to eagerness when food arrives which in turn may give way, first to a warm satisfying inner glow and then to the acute discomfort of indigestion when one realises that one has eaten too much too quickly. Similarly, pleasant memories of a summer holiday in Paros might be accompanied by the sight of a grey threatening sky outside, the familiar hum of the (temporarily) idle computer, a slight toothache, and, if one chooses to attend to them, numerous itches, tickles and minor throbs and spasms in various parts of the body.

Experiences in adults and all but the youngest children typically have two kinds of content. First an experience can have *representational content*; i.e., it can represent the world to us as being one way or another — as in typical perceptual experiences — or it can be directed towards an object — as with specific fears and desires; fears and desires that a certain object be one way or another. So I can be thinking about the coming weekend, worry about a forthcoming job interview, notice that a book I thought lost is on the shelf, fear the salivating doberman advancing towards me and lust after ... — oops, mind your own business! Second, an experience can have *sensational content*; i.e., it can have content constitutive of what it is like to have that experience. So visual experience presents us with a mosaic of colour sensations whether or not that experience represents the world as being one way or another. Similarly sounds, touched objects, bodily aches and pains and hangovers each have their peculiar 'feel'; experiences of each kind have sensational content regardless of whether they provide us with information or are object directed.⁸

Not only shall we be assuming that every experience has some sen-

⁷ Jones, *op. cit.*, note 3, especially pp. 122–124.

⁸ The distinction we are here introducing is a somewhat crude adaptation and simplification of the distinction between representational and sensational properties of experience presented with great subtlety and refinement in Peacocke C.: *Sense and Content*, Oxford: Clarendon Press, 1983, ch 1. Note in particular that Peacocke refrains from speaking of sensational *content* altogether. For our purposes, the simplifications appear to be harmless. The thesis that every experience has sensational content is our version of a view defended by Peacocke in that chapter.

sational content and may, but need not, have representational content, we shall also be making the commonsense assumption that experiences that only have sensational content precede any experiences which may plausibly be thought to have representational content. Put simply, sensation precedes conceptualised thought and consciously object-directed feelings and emotions.

If it makes sense at all to speak of a fetus as sentient or conscious — and we think that it does — then we are inclined to think that it makes sense to attribute only experiences with sensational content to fetuses. (Note, however, that nothing essential in what we say hangs on this claim being true.) We are now in a position to pose our question in a slightly more refined way thus: when does a fetus first have experiences with sensational content?

One last comment is required to clarify our investigation. In regarding the onset of experiences with sensational content *as* the onset of consciousness, we are using the term 'conscious' in the most liberal possible sense. We are well aware that others would demand more of consciousness 'properly so called': perhaps they would require some degree of concept possession; perhaps they would require the having of experiences with representational content. Although we think that our 'liberal' sense is at least as well-established as any rival, we have no substantive complaint to make against someone who would insist that the term be used more restrictedly. But someone who would press this objection should have no trouble in understanding our project: that person may simply understand us to be asking when a fetus first becomes *sentient*.

2. WHAT DO WE HAVE TO GO BY?

Commonsense psychology recognises two ways in which we may gain knowledge about conscious experiences. The first way — call it the *first-person method* — principally involves being aware of the contents of one's current stream of consciousness. This simple and direct awareness might need to be supplemented with reflection, selective attention, even theory, but all of this seems to be encompassed by the metaphor of 'looking inwards'. Clearly, for all but those who believe in telepathy, this method gives each of us knowledge only of our *own* experiences. Further, in the first instance, it gives us knowledge only of our *own current* experiences. The second way — call it the *third-person method* — requires us to observe and interpret behaviour. Clearly, we regard this method as inferior to the first where both methods can be used — not even the most pigheaded behaviourist would look in a mirror to find out how he or she is feeling. But, again in the absence of telepathy, this is *all* we have to go by if we want knowledge of the

conscious states of others. That it works tolerably well, often enough to be worth the effort, is a precondition of social interaction as we know it. That it fails all too often is a feature of the human condition that we bemoan when we seek intimacy or intrusion and welcome when we seek privacy or deceit.

How far will the foregoing philosophical platitudes help us with our problem? The methods just outlined are those on which commonsense psychology typically relies, but we shall propose shortly that they need supplementation if we are to make progress with our question. Let us clarify immediately why this is so. Consider the first-person method. This approach gives us access to our own past conscious states only through *memory*. Clearly, this alone will get us nowhere. Our earliest memories are fragmentary, of dubious accuracy and of incidents far too late to be plausible candidates for the status of *first* experiences. This should be quite unsurprising if we are right to believe that experiences with sensational content precede even the most rudimentary conceptualised experiences. (Even if we were to give credence to fanciful theories that suggest that we have memories of life in the womb 'I distinctly remember asking mother to put out that cigarette and have a stick of celery instead' — it would be implausible seriously to suggest that we can remember our first experiences. And not even this would be enough. Given the fact that we all too frequently forget even recent experiences, how would we know that the earliest remembered experiences were indeed the first?) Clearly we need the third-person approach of others and, with the help of photographs and home movies, our own third-person techniques, to fill in information about our early post-natal experiences and only the gullible would place any great reliance on the power of these methods to furnish us with an accurate picture.

Can we use some extension of the third-person approach to reach back prior to birth to help us with our question? Clearly, this approach is more promising and — as we shall see presently — it furnishes us with some of the information we shall require to produce a credible answer. Nevertheless, it should be clear that it would be foolish to rely too heavily on evidence of fetal behaviour when attempting an answer. Recall first that the third person approach often lets us down when attempting to interpret the behaviour of other adults. Second, notice how important it is, when interpreting the behaviour of other adults (and children), to know what it is like to be an adult (and to remember what it was like to be a child). We do not, as we have just noticed, remember what it was like to be a fetus. Accordingly, it is an approach fraught with danger to place too much reliance on behavioural evidence alone. Briefly, we need to be able to distinguish behaviour caused by mere spinal reflexes or brainstem

activity from behaviour caused by, or involving, cortical activity. (We suspect that a tendency to locate the onset of consciousness at a gestational age that is, we shall argue, implausibly early is due in part to a failure to notice this danger.)

How, then, are we to proceed? Just as it would be rash to place too much reliance on the extension to the fetus of behavioural evidence of consciousness, so too would it be foolish completely to ignore such evidence. But we need to supplement the available behavioural studies with work of other kinds, for only then will we be able to *interpret* the behavioural evidence in a way that minimises the risk of lapsing into sentimentalist fantasy. To be more specific, our approach involves two integrated tactics. First, we need to investigate the *development* in the fetus of the anatomical and chemical underpinnings of (immature) cortical activity and the growth and maturation of the electrical circuitry specifically associated with sensational content in adult experience. Second, we shall investigate and analyse the evidence supplied by EEG (electroencephalogram) readings at various stages of fetal development to arrive at our positive proposal and to defend it against rival accounts.

3. WHAT IS TO BE DIRECTLY CORRELATED WITH CONSCIOUSNESS?

It has long been recognised that a (relatively) undamaged brain, in particular, a (relatively) undamaged cerebral cortex is a fundamental requirement of normal consciousness in humans. There is now overwhelming evidence that *particular* disorders of consciousness are associated with damage to *specific* regions of the parietal lobes.⁹ In general, there is a gradation of states or levels of awareness from total, attentive consciousness to coma or a state of unarousable unresponsiveness. The gradation of states between these two extremes can be correlated with the extent to which the cerebral cortex has been damaged and/or the level of the damage within the brain.

Damage to large areas of both cerebral hemispheres results either in coma (eyes-closed unconsciousness) or in a persistent vegetative state (eyes-open unconsciousness). The difference between these two states reflects the extent of damage to the brainstem which controls autonomic functions.¹⁰ If the region of the brainstem which controls arousal and the generation of sleep/wake cycles is intact, even though the

⁹ For a good survey of this evidence, see Dimond S.J.: 'Consciousness', in *Neuropsychology*, London: Butterworths, 1980, pp. 417–443, at pp. 418–422.

¹⁰ Plum F. and Posner J.B.: 'The Pathological Physiology of Signs and Symptoms of Coma', in *Diagnosis of Stupor and Coma*, Philadelphia: F.A. Davis Company, 1980, pp. 1–86, at 27–28; Cranford R.E.: 'The Persistent Vegetative State: The Medical Reality (Getting the Facts Straight)', *Hastings Centre Report*, 18, 1988: 27–32.

cortex is severely damaged, then eye-opening can occur. This, however, should not be taken as evidence for the presence of consciousness. The distinction between arousal mechanisms and the content of consciousness as components of conscious behaviour has been made by Plum and Posner:

'The *content* of consciousness represents the sum of cognitive and affective mental functions. . . . *Arousal* is the other aspect of consciousness and at least behaviourally is closely linked to the appearance of wakefulness. . . . It should be evident that cognition is not possible without at least some degree of arousal.'¹¹

Those who regard mere brainstem activity as indicative of the presence of consciousness seem to think that the activity of arousal mechanisms or their precursors might be all that is required. But this is simply at odds with the evidence just alluded to of loss of consciousness due to cortical damage. If, as this evidence seems overwhelmingly to suggest, widespread and severe cortical damage is enough to deprive a subject of consciousness, then this would indicate that the content of consciousness is at least largely a product of — perhaps even identical with — some kind of activity in the cortex.¹²

In neuropsychology, it is regarded as uncontentious that there is a link, close enough to amount to supervenience, between genuine behavioural evidence of consciousness and electrical activity in the cortex which can be measured by an EEG.¹³ Recordings of the EEG are made by electrodes placed on the scalp of a subject. Scalp electrodes record the overall or summed electrical activity generated by neurons of the underlying cortex. The electrical activity of a single neuron, although a component of the EEG, is not identifiable within an EEG recording. Some muscle movements, such as scalp muscle activity and eye movements, result in changes in electrical activity which are incidentally recorded as part of the EEG. Movements of this kind, however, generate characteristic changes which can be identified as such within an EEG recording so are not likely to mislead us as to what is genuinely cortical activity.¹⁴ If we are to make progress towards an answer to our question, it will be useful first to survey the nature and range of adult EEG recordings.

¹¹ Plum and Posner, *op cit.*, note 10, at p. 3.

¹² Dimond, *op. cit.*, note 9, reaches this conclusion at p. 422.

¹³ Dimond, *op. cit.*, note 9; Plum and Posner, *op. cit.*, note 10; Andreassi J.L.: 'The EEG and Behavior: Sensation, Attention, Perception, Conditioning and Sleep', in *Psychophysiology: Human Behavior and Physiological Response*, New Jersey: Erlbaum, 1989, pp. 56–81.

¹⁴ Spehlmann R.: 'The Source of the EEG', in *EEG Primer*, Amsterdam: Elsevier/North Holland Biomedical Press, 1981, pp. 7–19.

EEG recordings of the adult cerebral cortex are characterised by several distinct features. Perhaps the most important feature is that EEG activity of normal, healthy adults is continuous regardless of behavioural state, that is, it is never interrupted even in the deepest stage of sleep.¹⁵ In addition, EEG activity is correlated with the behavioural state of the individual and distinctive patterns are observed during sleep, wakefulness, attentiveness and anxiety.¹⁶ Since the characteristics of a recorded EEG change with the behavioural state of an individual, it is difficult to define a "normal" EEG; however, we shall provide a brief description of the main behavioural states and the corresponding EEG characteristics.

An EEG recording is composed of various types of activity alone or in combination. The most common type of EEG activity observed for an awake, resting adult is the alpha rhythm which consists of slow waves which are blocked by eye opening, attention and sudden arousal. Beta rhythms, which consist of fast waves, also may be recorded but are less common.¹⁷ Drowsiness (Stage I sleep) is characterised by the reduction or disappearance of alpha waves with the appearance of low amplitude slow waves. As sleep deepens and Stages II, III and IV sleep are observed, high amplitude slow waves become the most prominent feature of the EEG recording occupying as much as 50% of the recording time. In contrast to these stages, which represent progressively deeper levels of dreamless sleep, another stage, rapid eye movement (REM) sleep, is associated with dreaming. REM sleep is paradoxical in that it has characteristics of both very light and very deep sleep.¹⁸ In a similar manner, alert attentiveness, sudden arousal and anxiety can be defined by distinct changes in EEG recordings. Thus, the behavioural state and, perhaps more importantly, the level of awareness of a subject can be determined using EEG recordings.

Another measure of both brainstem and cerebral cortex activity, derived from EEG recordings, is the evoked potential (EP). Sensory EPs include those produced by visual, auditory and somatosensory stimuli. Evoked potentials are of particular significance since they are generated in response to a specific stimulus and the stimulus can be of somatosensory (or tactile) origin. An EP is actually made up of several components that are related to specific regions of the central nervous system and a component described as N₁ signals the arrival,

¹⁵ Spehlmann R.: 'The Normal Sleep EEG of Adults over 20 Years', in *EEG Primer*, Amsterdam: Elsevier/ North Holland Biomedical Press, 1981, pp. 201–211.

¹⁶ Spehlmann, *op. cit.*, note 15; Spehlmann R.: 'The Normal EEG of Wakeful Resting Adults of 20–60 Years', in *EEG Primer*, Amsterdam: Elsevier/North Holland Biomedical Press, 1981, pp. 183–199; Andreassi, *op. cit.*, note 13.

¹⁷ Spehlmann, *op. cit.*, note 16.

¹⁸ Spehlmann, *op. cit.*, note 15.

at the cerebral cortex, of the impulse generated at the periphery.¹⁹ Somatosensory EPs also can be recorded from subjects in all stages of sleep although the characteristics of such EPs change slightly from those recorded in awake subjects.²⁰ The observation that EPs can be recorded, even during the deepest stages of sleep, indicates that sleep is a condition in which the cerebral cortex responds to a stimulus that is probably not consciously perceived.

4. HOW DOES THE BRAIN DEVELOP?

Those who would regard consciousness as occurring relatively early in fetal development — most extremely, in the first trimester — appear to us to be compounding two crucial oversights. First, they have failed to notice a crucial ambiguity in what might be meant by a functioning brain (cortex) — we shall correct this mistake in section 5. Second, they have failed to present either the behavioural facts about early fetal development or the anatomy and chemistry of fetal neural development which underpins the crucial electrical activity in a way which is sufficiently careful and systematic to notice how the first oversight is misleading them. To correct this second oversight, we shall present, in this section, the overlooked anatomical developmental story in considerable detail. (For reasons of space, we shall here suppress the details of neural chemical development in fetuses.)²¹ We shall begin by presenting a brief account of fetal behaviour in early gestation.

4.1 *Fetal movements*

That the fetus begins to move early in development is well-known and is used as an indicator of fetal well-being.²² Fetal movements are detected by the mother from approximately 16 to 18 weeks of gestation. It has been determined by ultrasound, however, that the earliest movements occur at 5.5 weeks gestational age.^{23,24} Systematic studies

¹⁹ Desmedt J.E., Brunko E. and Debecker J.: 'Maturation of the Somatosensory Evoked Potentials in Normal Infants and Children, with Special Reference to the N₁ Component', *Electroencephalography and Clinical Neurophysiology*, 41, 1976: 460–466.

²⁰ Shagass C.: 'Evoked Responses and Impaired Consciousness', in *Evoked Brain Potentials in Psychiatry*, New York: Plenum Press, 1972, pp. 107–127, at 116.

²¹ For the full story, see Susan Tawia: 'When is the Capacity for Sentience Acquired During Human Fetal Development?' *Maternal-Fetal Medicine*, 1, 1992.

²² Sardovsky E. and Yaffe H.: 'Daily Fetal Movement Recording and Fetal Prognosis', *Obstetrics and Gynaecology*, 41, 1973: pp. 845–850.

²³ de Vries J.I.P., Visser G.H.A. and Prechtl H.F.R.: 'The Emergence of Fetal Behaviour. I. Qualitative Aspects', *Early Human Development*, 7, 1982: pp. 301–322.

²⁴ It is important to note here that the age of the human fetus can be expressed in

have been made of both spontaneous movements made by fetuses *in utero* and reflex responses elicited by stimulating fetuses *ex utero*.²⁵ The first movements detectable were described as 'just discernible' and occur between 5 and 6.5 weeks of gestation. At this early stage of development, the lips are the only region on the surface of the fetus which elicit a reflex response on stimulation. Stimulation of this kind consistently causes the head to bend or move away from the side of the mouth being stimulated (contralateral head flexion). Fetal maturation is rapid and by 6.5 weeks gestational age the contralateral flexion reflex involves movement of the head, trunk and pelvis away from the stimulus. Early in development, both reflex responses and spontaneous movements are of the whole-body or total-pattern type. Only after this period of total pattern reflexes does the fetus develop local reflexes and this change is mirrored in, and supported by, the observation that more isolated movements of the head and limbs are detectable *in utero* from about 8 weeks of gestation. From this stage onwards, regions of the fetus become sensitive to stimulation or spontaneously active in a predictable and sequential manner. Stimulation of the palm of the hand results in partial finger closure by 9 weeks of gestation; stimulation of the sole of the foot results in flexion of the toes by 9.5 to 10 weeks; and stimulation of the lips elicits reflex swallowing at 10.5 weeks. Isolated respiratory movements and respiratory reflexes are observable at 11 and 12 weeks of gestation, respectively, and by 16.5 weeks, spontaneous chest contractions are detectable.

Spontaneous fetal movements probably occur as a result of some sort of intrinsic activity of the developing nervous system, whereas reflexes are elicited by stimulation of peripheral sensory receptors. The studies just presented, although descriptive and qualitative, provide a large amount of information which gives us clues to the development and maturation of sensory and motor systems. The sensory and motor capacities of a fetus, however, are dependent on the stage of maturation of neural tissue and its capacity to transmit informa-

several different ways. The menstrual age, taken from the day of the last menstrual period, is most commonly used in clinical practice. Since ovulation and fertilisation occur at about the middle of a 28 day menstrual cycle, the fertilisation or gestation age is approximately 14 days or 2 weeks less than the menstrual age. In this discussion, we are concerned with the stages of development of the fetus and, as such, the age at which certain responses or structures appear will be expressed in terms of the gestational age.

²⁵ de Vries J.I.P., Dongen L.G.R. and Goudie E.G.: 'Fetal Movement Patterns in the First Trimester of Pregnancy', *British Journal of Obstetrics and Gynaecology*, 87, 1980: 191-193; Humphrey, T.: 'Function of the Nervous System During Prenatal Life', in *Perinatal Physiology*. U. Stave and A.A. Weech, (eds.), New York: Plenum Medical Book Company, 1978, pp. 651-683.

tion. Therefore, a study of the sensory development of the fetus must involve a study of the nervous system.

These early patterns of fetal behaviour certainly *appear* to be relevant to the question of the emergence of fetal sentience. Since the fetus moves in response to being touched, it might appear to follow that the fetus can feel the stimulus. (We shall soon see, however, that this appearance is quite deceptive.) To begin seriously to investigate the question of when the fetus develops the capacity to feel, we shall first describe how the neural substrate involved in sensory perception develops in the fetus. The maturation of various sensory pathways in fetal development tends to occur in parallel so we shall not consider all sensory pathways. Since our primary concern is with the question of fetal sentience it may be useful to consider in detail the maturation of the somatosensory pathways which are involved in transmission and perception of tactile stimuli. Prior to our discussion of fetal sensory development, we shall present a description of the fully-functioning, mature system to facilitate the identification of a stage in fetal development which approximates that observed in the adult.

Somatosensory receptors located at the periphery are the specialised endings of neurons (first-order neurons) which transmit information from the periphery to second-order neurons within the central nervous system (spinal cord or medulla). The second-order neurons transmit sensory information to third-order neurons located in the thalamus which, in turn, project to the cerebral cortex. The pathway described here results in the conscious perception of a stimulus elicited at the body surface. Aspects of the sensory information arriving at the cerebral cortex are transmitted to the motor cortex where voluntary movements are generated. Motor commands from the cerebral cortex are then conveyed by efferent neurons to motor neurons, via the brainstem or spinal cord, resulting in stimulation of muscles and the production of movements. In addition, reflex actions associated with a stimulus are mediated by a more direct pathway. First-order neurons may transmit information directly to motor neurons or indirectly via interneurons located within the spinal cord.²⁶ It is possible, therefore, to initiate reflexes in isolation from events involved in conscious perception. We shall soon see that this is indeed the most plausible explanation of the early fetal behaviour we have been describing.

4.2 *The anatomy of developing sensory pathways*

The development of anatomical substrates involved in the sensing of

²⁶ Martin J.H.: 'Receptor Physiology and Submodality Coding in the Somatic Sensory System', in *Principles of Neural Science*, E.R. Kandel and J.H. Schwartz (eds.), New York: Elsevier, 1985, pp. 287–300.

somatic stimuli has not been extensively investigated in the fetus, in particular, the human fetus. Some studies have been undertaken, however, which may be useful in defining a period of fetal development which is most likely to be associated with the development of fetal sentience. In section 4.1, we described the development of, and changes in, fetal movements. The neural basis — the anatomical substrate — for the repertoire of fetal movements seen early in gestation was chosen for study because of its simplicity in comparison to other neural systems involving higher centres of the brain. A series of studies were made with the intention of relating human fetal spinal cord development with reflexes elicited from human fetuses. The three components required for the generation of reflexes in response to tactile stimulation of the skin — sensory neurons, interneurons and motor neurons — are found in fetuses of approximately 4 weeks gestational age,²⁷ however, no connections (or synapses) are observed between them. Synapses between motor neurons and interneurons within the spinal cord were first observed at 5 weeks of gestation prior to the formation of synapses between sensory neurons and interneurons which were first observed between 5.5 and 6 weeks gestation.²⁸ Since the gestational age at which the first reflex responses could be elicited was 5.5 weeks,²⁹ initial movements coincide extremely well with the connection of the components of a simple spinal reflex pathway. A second period of synapse formation is observed within the spinal cord of fetuses at about 8 weeks of gestation³⁰ and this period coincides with the onset of local reflex activity observed for fetuses *ex utero*.^{31,32}

To state that fetal reflexes occur as a consequence of a simple spinal reflex may appear to oversimplify the matter, but a description of the connections involved in the responses elicited by stimulation of the

²⁷ Okado N., Kakimi S. and Kojima T.: 'Synaptogenesis in the Cervical Cord of the Human Embryo: Sequence of Synapse Formation in a Spinal Reflex Pathway', *Journal of Comparative Neurology*, 184, 1979: pp. 491–518.

²⁸ Okado N.: 'Onset of Synapse Formation in the Human Spinal Cord', *Journal of Comparative Neurology*, 201, 1981: pp. 211–219.

²⁹ Humphrey, *op. cit.*, note 25.

³⁰ Okado N.: 'Development of the Human Cervical Spinal Cord with Reference to Synapse Formation in the Motor Nucleus', *Journal of Comparative Neurology*, 191, 1980: pp. 495–513.

³¹ Humphrey, *op. cit.*, note 25.

³² That the change in synaptic organisation is temporally related to changes in fetal behaviour suggests that it may form the structural basis for this change. Similar temporal coincidence of increased synapses and changes in fetal behaviour have been reported in monkeys. See Bodian D., Melby E.C. and Taylor N.: 'Development of Fine Structure of Spinal Cord in Monkey Fetuses. II. Prereflex Period to Period of Long Intersegmental Reflexes', *Journal of Comparative Neurology*, 133, 1968: pp. 113–166.

skin near the lips may clarify the situation. At 5.5 weeks of gestation, such stimulation elicits contralateral flexion of the head and, at this stage, the growing tips of branches of the trigeminal nerve are found below the surface of the skin around the mouth area. Nerve fibres of the spinal tract of the trigeminal nerve descend to the first cervical level of the spinal cord where synapses are made with motor neurons, via interneurons, which innervate neck muscles involved in the contralateral head flexion. At about 6.5 weeks of gestation when contralateral flexion, after stimulation of the skin near the lips, involves movement of the head, trunk and pelvis, the number of fibres coursing in the spinal tract of the trigeminal nerve is greater and some now enter lower segments of the spinal cord (second and third cervical segments). These fibres can then synapse with interneurons within the spinal cord, thus influencing the activity of motor neurons at different levels and as a consequence more muscle groups can be activated to contract during the reflex³³ giving rise to total body or whole pattern reflexes.

The development of local reflexes in response to a stimulus is suggestive of an increasing complexity of the fetal nervous system. Humphrey described neuronal pathways which may account for the local responses observed in fetuses from 8 weeks gestational age onwards and proposed that the brainstem reticular formation was likely to be involved in such reflex activity.³⁴ With regard to motor activity, the brainstem is the second level in the hierarchy above the spinal cord but below motor and premotor areas of the cerebral cortex. Neurons of the brainstem reticular formation process sensory information ascending from the spinal cord and integrate motor commands descending from higher brain centres in the adult.³⁵ Brainstem neurons participate in specialised motor activity including postural adjustments, that is, setting muscle tone and coordinating eye, head and neck position and are also involved in the modification of spinal reflex pathways.³⁶ Electrical activity of the brainstem has been observed from 10 weeks of gestation onwards.³⁷ This suggests that this brain

³³ Humphrey T.: 'Some Correlations Between the Appearance of Human Fetal Reflexes and the Development of the Nervous System', in *Growth and Maturation of the Brain. Progress in Brain Research, Vol. 4.*, D.P. Purpura and J.P. Schade (eds.), Amsterdam: Elsevier, 1964, pp. 93–135.

³⁴ Humphrey, *op. cit.*, note 25.

³⁵ Ghez C.: 'Introduction to the Motor Systems', in *Principles of Neural Science*, E.R. Kandel and J.H. Schwartz (eds.), New York: Elsevier, 1985, pp. 429–442.

³⁶ Peterson B.W.: 'Participation of Pontomedullary Reticular Neurons in Specific Motor Activity', in *The Reticular Formation Revisited*, J.H. Hobson and M.A.B. Brazier (eds.), New York: Raven Press, 1980, pp. 171–192.

³⁷ Bergstrom R.M.: 'Electrical Parameters of the Brain During Ontogeny', in

structure plays a role in early human fetal movements. At the stage of fetal development when local reflexes can first be elicited, very little development of brain structures above the brainstem has occurred,³⁸ thus, there can be no involvement of the thalamus or the cerebral cortex in the perception of cutaneous sensation and the generation of motor activity. From about 11 weeks of gestation onwards, the fetus exhibits isolated respiratory movements as well as manifesting respiratory movements in response to appropriate stimulation.³⁹ As for motor activity, the involvement of the brainstem reticular formation is sufficient to account for the generation of fetal respiratory movements. Within the brainstem reticular formation is a region, the respiratory centre, from which periodic respiratory movements are generated.⁴⁰

It is, therefore, possible to account for a variety of spontaneous and reflex activities of the fetus as a consequence of spinal cord and brainstem activity in the absence of higher brain centre development. But when do higher brain centres develop in the sequence of fetal development and, perhaps more importantly, when do they begin to function and play an active role in perception? Detailed anatomical investigations have been made of the formation and maturation of the cerebral cortex in human fetuses because of the critical role of this brain structure in the development of consciousness, and we shall now survey these studies.

The structure of the adult cortex is highly complex and specialised and a great deal of change must occur during fetal development before an adult-like cortical structure is recognisable. As with most areas of the central nervous system, young neurons migrate from the region of the brain in which they were generated to the region of the brain where they will reside and become functionally organised.⁴¹ The early development of the cerebral cortex is characterised by the arrival of primitive cortical fibres at the cerebral vesicles at about 5 weeks of gestation. These fibres then form a layer, the primordial plexiform layer, which is well established by the 7th week of gesta-

Brain and Early Behaviour. Development in the Fetus and Infant, R.J. Robinson, ed., London: Academic Press, 1969, pp. 15–41.

³⁸ Marin-Padilla M.: 'Early Ontogenesis of the Human Cerebral Cortex', in *Development and Maturation of Cerebral Cortex. Cerebral Cortex. Vol. 7*, A. Peters and E.G. Jones (eds.), New York: Plenum Press, 1988, pp. 1–34.

³⁹ Humphrey, *op. cit.*, note 25.

⁴⁰ Hugelin A.: 'Does the Respiratory Rhythm Originate from a Reticular Oscillator in the Waking State?' in *The Reticular Formation Revisited*, J.H. Hobson and M.A.B. Brazier (eds.), New York: Raven Press, 1980, pp. 261–274.

⁴¹ Sidman R.L. and Rakic P.: 'Neuronal Migration, with Special Reference to Developing Human Brain. A Review', *Brain Research*, 62, 1973: pp. 1–35.

tion.⁴² In the same study, the fibres arriving at the primordial plexiform layer at this stage were traced backwards and it was suggested that their origin may be the midbrain, possibly the reticular formation. The site of origin of these fibres is speculative, however, and requires further study. At this very early (first) stage of development some synapses — very specialised connections — are observed within the primordial plexiform layer.⁴³ It has been suggested that synapses identified within the primordial plexiform layer are indicative of connectivity between this layer in the cerebral cortex and the midbrain.⁴⁴ The role of these synaptic connections is not known nor is the possible influence of the midbrain on the cerebral cortex during early gestation. Based on anatomical studies, it has been proposed that neurons of the reticular formation could transmit the same primitive information to all neurons of the cerebral cortex regardless of whether they will become specialised as sensory, motor, visual or acoustic neurons. A common, basal tone or level of input may be required for the functional maturity of all cerebral cortex neurons.⁴⁵ It must be remembered, however, that the cerebral cortex is an extremely rudimentary structure at this stage of development.

The adult cerebral cortex is a multi-layered structure with each layer having a distinct function. Of particular interest to this discussion is layer IV which receives direct inputs from neurons originating in the thalamus and which is very well-developed in the primary sensory cortex.⁴⁶ A second band of neurons migrate to, and develop within, the primordial plexiform layer to form the cortical plate at 8 weeks of gestation, and, as a consequence, the plexiform layer is divided and forms two layers, the superficial and deep plexiform layers. The superficial plexiform layer becomes the precursor of layer I of the cerebral cortex; the deep plexiform layer becomes the precursor of layer VII and the cortical plate will give rise to layers II to VI.⁴⁷

⁴² Marin-Padilla M.: 'Structural Organization of the Human Cerebral Cortex Prior to the Appearance of the Cortical Plate', *Anatomy and Embryology*, 168, 1983: pp. 21–40.

⁴³ Larroche J.C.: 'The Marginal Layer in the Neocortex of a 7 week-old Human Embryo', *Anatomy and Embryology*, 162, 1981: 301–312.

⁴⁴ Marin-Padilla M. and Marin-Padilla M.T.: 'Origin, Prenatal Development and Structural Organization of Layer I of the Human Cerebral (Motor) Cortex', *Anatomy and Embryology*, 164, 1982: pp. 161–206.

⁴⁵ Marin-Padilla and Marin-Padilla, *op. cit.*, note 44.

⁴⁶ Kelly J.P.: 'Anatomical Basis of Sensory Perception and Motor Coordination', pp. 222–243 and Kelly D.D.: 'Central Representation of Pain and Analgesia', in *Principles of Neural Science*, E.R. Kandel and J.H. Schwartz (eds.), New York: Elsevier, 1985, pp. 332–343.

⁴⁷ Marin-Padilla M.: 'Dual Origin of the Mammalian Neocortex and Evolution of the Cortical Plate', *Anatomy and Embryology*, 152, 1978: pp. 109–126.

From this stage, the 8th week of gestation, the cerebral cortex undergoes a long period of differentiation and maturation. Early on, the cortical plate grows rapidly but remains undifferentiated. As the cortical plate grows, however, a large number of neurons that will become the input (afferent) and the output (efferent) fibres of the cerebral cortex are forming below the deep plexiform layer or layer VII.⁴⁸ This is an important observation — development of both areas progresses through gestation, but only after some time do they interconnect as the final link between the receptor located on the body surface and the cerebral cortex. The migration of a new group of neurons to the cortical plate triggers the first wave of differentiation of neurons within the cortical plate. It has been proposed that these neurons are nonspecific thalamocortical fibres and that they induce the differentiation of neurons in layers V and VI of the cortical plate.⁴⁹ The first signs of differentiation are observed at 15 to 16 weeks of gestation.⁵⁰ There is, however, no evidence of any synaptic connections between the incoming neurons and those differentiating within the cortical plate.⁵¹ The first signs of differentiation of this layer are observed between 18 and 20 weeks of gestation and occur in response to the arrival of specific thalamocortical fibres.⁵² Prior to 18 weeks of gestation, synapses are never found within the cortical plate. They have been found at 23 weeks,⁵³ however, so their appearance correlates with the progressive differentiation of the cortical plate. The sequential differentiation of the cortical plate continues throughout gestation with layer II differentiating as late as 38 to 40 weeks of gestation.⁵⁴

The basic neuronal substrate for sensory perception in the fetus has developed by mid-gestation (18 to 23 weeks), but the mere presence of the neural material is not necessarily indicative of a functional circuitry. Neuronal maturation consists of many steps which must occur before a fully functional circuitry is established: axonal growth and elongation, the elaboration of dendritic processes (extensions of the cell body which increase the cell contact area), neuronal differentiation, synapse formation and neurotransmitter production. When determining the stage at which the fetal sensory system may be able to function, all these factors must be considered. In this section, we

⁴⁸ Bergstrom, *op. cit.*, note 37.

⁴⁹ Larroche, *op. cit.*, note 43.

⁵⁰ Larroche, *op. cit.*, note 43.

⁵¹ Molliver M.E., Kostovic I. and Van der Loos H.: 'The Development of Synapses in Cerebral Cortex of the Human Fetus', *Brain Research*, 50, 1973: pp. 403–407.

⁵² Larroche, *op. cit.*, note 43.

⁵³ Molliver, Kostovic and Van der Loos, *op. cit.*, note 51.

⁵⁴ Larroche, *op. cit.*, note 43.

have described axonal outgrowth and elongation, synapse formation and neuronal differentiation in some detail. After the initial growth of neurons, more complex connections must be made and, concomitantly, the production of neurotransmitters must occur for transmission of information from the periphery to the cerebral cortex.

It ought by now to be evident that it is highly implausible to suppose that a fetus could have experiences with sensational content before 18 weeks gestation, even though considerable 'activity' has been going on. Cortical 'life' does not begin while the cortex is getting organised, nor does it begin even then until everything is 'settled', 'feels at home' and has 'limbered up', as it were. (A football match has not begun while a team is being gathered together, no matter how frantic the activity involved.)

5. WHAT EXACTLY IS A FUNCTIONING BRAIN?

We are now in a position to produce our central argument against those who would locate the first experiences with sensational content at an implausibly early gestational stage. Everybody who has attempted to answer our question agrees on this: conscious experiences first begin when that part of the brain that is essential to consciousness — in our view, the cortex — first begins to function. But there are two senses in which any given part of the brain might be said to function.

- (i) Brain (cortical) functioning might be said to occur when there is identifiable activity — just *any* old activity⁵⁵ — in what recognisably is (or will become) the brain (cortex).

To view a point identified by this criterion as the beginning of brain (cortical) life-cortical 'birth' if you like — is, in our view, the principal mistake that has misled others into regarding sensational experiences as present as early as the first trimester. To adopt this view is rather like regarding a building as functioning as soon as the builders have commenced construction. This brings us to the second notion of function.

- (ii) The brain (cortex) might be said to function when there is identifiable activity of the kind that normal adult brains (cortices) have evolved to indulge in, or at least activity identifiable as a crude, undifferentiated ancestor of mature activity of this kind.⁵⁶

⁵⁵ Any developmental activity counts here, not just electrical activity — for example, migration, cell division, differentiation and maturation.

⁵⁶ A fully rigorous development of this distinction would require more than the analogies we rely on here. For our purposes, however, the analogies we have used should make the distinction we intend clear enough. We are indebted to Barry Taylor for this point.

Clearly no brain (cortex) can function in this sense until (a) it has attained a critical minimal level of structural organisation, (b) the functional components are not only 'in place' but are mature enough to perform — they need to have reached 'puberty' — and (c) there is clear evidence that they are 'up and running'; i.e., EEG readings of the right kind have been recorded. It is much more plausible to adopt this notion of function as that which marks brain (cortical) 'birth', and this will be our approach.

Not only do many authors opt, initially, for (i) rather than (ii) as the crucial notion of function to operate with; they compound the error by sliding to (ii), thus giving the impression that experiences with sensational content are occurring *because* the brain (cortex) is 'functioning' in sense (i).⁵⁷ This is like arguing that an office is functioning *as* an office as soon as the builders have begun to lay the foundations of the building which (on our view) will come eventually to house that office.

6. THE 'EVOLUTION' OF CONSCIOUSNESS

Now that we have established the principle, it is time to get down to the hard bargaining. Given that electrical activity in the cortex is what is directly correlated with consciousness — is that upon which facts about consciousness supervene — and this is best analysed through EEG recordings, it is time to move to a consideration of the best available evidence in order to provide a plausible answer to our question. But, here we strike two difficulties that have misled several authors into doubting whether the notion of brain (cortical) birth is even intelligible, let alone useful.

Briefly, the *first difficulty* is this: cortical death in adults and even relatively young children is a relatively brief event — after electrical activity has ceased for five minutes, the cortex has suffered damage so great as to result in irreversible loss of cortical function.⁵⁸ Cortical birth, however, seems to be different: it is so gradual that it might seem more accurate to speak of functional 'evolution' rather than birth — hence the title of this section.⁵⁹

The *second difficulty* is that two bizarre facts — soon to be announced — about early cortical functioning throw the whole question of cortical birth out of focus for several authors. Whilst there is some truth in

⁵⁷ Although he shows sensitivity to this distinction elsewhere, Gareth Jones is surely making this conflation when he claims that a fetus can experience pain at 14 weeks. See Jones, *op. cit.*, note 3 at p. 106. See also Flower M.J.: 'Neuromaturation of the Fetus', *The Journal of Medicine and Philosophy*, 10, 1985: pp. 237–251.

⁵⁸ Cranford, *op. cit.*, note 10.

⁵⁹ This point has been stressed by Gareth Jones, *op. cit.*, note 2 at p. 177.

the first difficulty and no reason to doubt the facts that give rise to the second difficulty, we believe, somewhat ironically, that the bizarre facts, when properly analysed, provide the clue needed to overcome the first difficulty.

The *first bizarre fact* is this: EEG data make it clear that the stream of consciousness begins not suddenly, nor as a trickle, but as a series of *isolated discontinuous puddles*. Spontaneous electrical activity has been consistently recorded from the brainstem of human fetuses as early as 10 weeks gestational age⁶⁰ and there is one report of the detection of brainstem activity in a fetus of 6 weeks gestational age.⁶¹ (There is, of course, no reason to believe that electrical activity of this kind is indicative of a capacity for consciousness.) Data on the development of the human brain prior to the 24th week of gestation is extremely limited, therefore, any discussion of such development must necessarily be based primarily upon data obtained from 24 weeks onwards. Assessment of the electrical activity of the developing brain (preterm) has been largely confined to the recording of EEG activity and the stimulation of EPs from premature newborns.

The development and maturation of cortical EEG activity has been extensively studied in premature and term newborns and can be divided into periods with distinguishing patterns of activity. Between 22 and 25 weeks of gestation the most distinctive feature of EEG activity is its discontinuous nature (Pattern 1). At this stage of development the EEG is made up of bursts of activity of up to 20 seconds interspersed with periods of no activity for up to 8 minutes.⁶² At 24 weeks, periods of activity occupy an average of only 2% of the EEG recording time and the EEG consists of a variety of slow waves. EEG activity is still discontinuous from 26 to 29 weeks; however, the periods of inactivity tend to be shorter than those occurring between 22 and 25 weeks gestation.⁶³

Two EEG patterns can be distinguished from 30 to 33 weeks of gestation. Pattern 1, characterised by discontinuous activity, is still present but a second pattern (Pattern 2) develops which consists of continuous slow waves. The two patterns are weakly correlated with

⁶⁰ Bergstrom R.M. and Bergstrom L.: 'Prenatal Development of Stretch Reflex Functions and Brainstem Activity in the Human', *Annales Chirurgiae et Gynaecologiae Fenniae*, 52, 1963: Suppl. 1-21.

⁶¹ Borkowski W.J. and Bernstine R.L.: 'Electroencephalography of the Fetus', *Neurology*, 5, 1955: pp. 362-365.

⁶² Hughes J.R., Fino J. and Gagnon L.: 'Periods of Activity and Quiescence in the Premature EEG', *Neuropediatrics*, 14, 1983: pp. 66-72.

⁶³ Spehlmann R.: 'The Normal EEG from Premature Age to the Age of 19 Years', *EEG Primer*, Amsterdam: Elsevier/North Holland-Biomedical Press, 1981; Torres F. and Anderson C.: 'The Normal EEG of the Human Newborn', *Journal of Clinical Neurophysiology*, 2, 1985: 89-102.

the development of sleep/wake cycles in the premature newborn with Pattern 1 associated with quiet sleep and Pattern 2 being associated with wakefulness and active (REM) sleep. From 34 weeks of gestation until term, the two EEG patterns already present are modified and a third pattern (Pattern 3) becomes apparent. Discontinuous activity of Pattern 1 is still present but the periods of inactivity are shorter and, within the periods of 'inactivity', some low amplitude slow waves may be discernible. By 34 weeks of gestation, periods of activity occupy an average of 80% of the EEG recording time.⁶⁴ Pattern 2 consists of continuous regular slow waves of low frequency. The new pattern, Pattern 3, consists of low amplitude irregular slow waves. As before, Pattern 1 is associated with quiet sleep, whereas both Patterns 2 and 3 are associated with wakefulness and active sleep. Sleep/wake cycles which start to become organised at about 34 weeks are now clearly discernible by 37 weeks of gestation. A fourth EEG pattern (Pattern 4) appears at term and slight modifications of the other preterm patterns are also made. Pattern 4 consists of continuous high amplitude slow waves and is associated with quiet sleep.⁶⁵

For our purposes, the most distinctive features of the developing EEG are the discontinuity of activity and the appearance of sleep/wake cycles. Discontinuity of the EEG persists until about 4 weeks post-term; however, maturation of the EEG is characterised by a progressive decrease in discontinuity with increasing gestational age.⁶⁶ Similarly sleep/wake cycles show a progressive maturation with increasing gestational age. Sleep/wake cycles which appear at about 30 weeks of gestation become more organised at about 34 weeks and are well-established by 37 weeks.

The maturational stage of the developing brain can also be measured by determining the response of the cerebral cortex to an evoked potential. Somatosensory EPs have been recorded from premature newborns with gestational ages ranging from 25 weeks to term.⁶⁷ In very early premature newborns of less than 29 weeks of gestation, somatosensory EPs are characterised by a large, slow negative wave. Before the appearance of distinct primary components, the signifi-

⁶⁴ Hughes, Fino and Gagnon, *op. cit.*, note 62.

⁶⁵ Spehlmann, *op. cit.*, note 63; Torres and Anderson, *op. cit.*, note 63.

⁶⁶ Hughes, Fino and Gagnon, *op. cit.*, note 62; Nolte R. and Haas G.: 'A Polygraphic Study of Bioelectric Brain Maturation in Preterm Infants', *Developmental Medicine and Child Neurology*, 20, 1978: pp. 167–182.

⁶⁷ Hrbek A., Karlberg P. and Olsson T.: 'Development of Visual and Somatosensory Evoked Responses in Pre-term Newborn Infants', *Electroencephalography and Clinical Neurophysiology*, 34, 1973: 225–232; Klimach V.J. and Cooke R.W.I.: 'Maturation of the Neonatal Somatosensory Evoked Response in Preterm Infants', *Developmental Medicine and Child Neurology*, 30, 1988: pp. 208–214.

cance of the response to somatosensory stimulation is difficult to determine. It has been suggested that the large, slow negative wave represents the poorly-defined response of undeveloped and undifferentiated cells within the cortex.⁶⁸ In addition, at this early stage the response to the stimulus does not appear to be limited to the corresponding projection area and other stimuli — for example, visual stimuli — elicit EPs with strikingly similar characteristics to somato sensory EPs. At 25 weeks of gestation, a response to somatosensory stimulation within the cerebral cortex can be detected, although it may be diffuse and largely undefined. The significance of the response to stimulation at this early stage is, therefore, questionable.

After 29 weeks of gestation, the primary negative component, N_1 , is detectable within the response to somatosensory stimulation.⁶⁹ Primary components of somatosensory EPs are detected weeks earlier than the primary components of visual EPs.⁷⁰ These data suggest that maturation of the somatosensory cortex occurs prior to maturation of the visual cortex and adds weight to the proposal that the development, in the fetus, of the capacity to feel begins before that of other sensory capacities, and matures earlier than them.⁷¹ In conjunction with the appearance of primary components within the EP, the latency of the response to a stimulus decreases with increasing gestational age. The efficiency with which a signal is transmitted to the cerebral cortex is thus increased.⁷²

The *second bizarre fact* is this: EEG activity in normal, full-term children can be discontinuous — for several seconds, and, in extreme cases, for hours — for some weeks after birth, without being associated with the total, irreversible loss of cortical function through physical decay associated with cortical death⁷³ in older children and adults.⁷⁴

The second bizarre fact appears conclusively to rule out one candidate for cortical birth that is suggested by the first fact but which might have been a plausible candidate in any case. We might have proposed as the beginning of consciousness, properly so-called, the

⁶⁸ Hrbek, Karlberg and Olsson, *op. cit.*, note 67.

⁶⁹ Hrbek, Karlberg and Olsson, *op. cit.*, note 67; Klimach and Cooke, *op. cit.*, note 67.

⁷⁰ Hrbek, Karlberg and Olsson, *op. cit.*, note 67.

⁷¹ Gottlieb G.: 'Conceptions of Prenatal Development: Behavioral Embryology', *Psychological Review*, 83, 1976: pp. 215–234.

⁷² Hrbek, Karlberg and Olsson, *op. cit.*, note 67; Klimach and Cooke, *op. cit.*, note 67.

⁷³ Cortical death is not what is usually understood by brain death but there is considerable controversy as to whether it should suffice for brain death.

⁷⁴ Hughes, Fino and Gagnon, *op. cit.*, note 62, Green J.B. and Lauber A.: 'Return of EEG Activity After Electrocerebral Silence: Two Case Reports', *Journal of Neurosurgery and Psychiatry*, 35, 1972: pp. 103–107.

beginning of what will turn out, *ex post facto*, to be an unbroken stream of consciousness. But, if lengthy discontinuities can occur without constituting cortical death, long after the first EEG readings which record cortical activity associated with waking states, it is quite implausible to suppose that those early readings are not indicative of experiences with sensational content.

Ruling out the beginning of non-discontinuous EEG activity leaves us with two possible answers to our question which seem to have some clear rationale. First, we could locate cortical birth at the occurrence of the first 'puddle' of cortical electrical activity which occurs around 20 weeks of gestation. This would certainly appear at least to be a lower bound to the possible location of cortical life; it seems to be the most conservative location we could plausibly advocate. Clearly, it is also the beginning of cortical functioning, even though the 'functioning' is extremely rudimentary and occurs only briefly and intermittently. That the functioning is intermittent is not in itself a drawback — we have already seen that full continuity of EEG activity is too strong a requirement to impose. A more significant drawback is the extremely rudimentary nature of the electrical activity at this stage. The EEG readings suggest that the cortical states a fetus enjoys at this stage are precursors of *sleep states*. There is no evidence we know of to suggest that a fetus at this level of maturity could be jolted 'awake', nor that it could enjoy anything remotely like a rudimentary 'dream'. Accordingly, we can see no reason to suppose that these states have sensational content; in short, we do not think it plausible to claim that a fetus at this gestational age is yet conscious.

The second possible answer is to locate the beginning of consciousness at the time when the first waking-state EEG readings appear, or, better, the first EEG readings appear that indicate states that could plausibly be regarded as ancestors of adult waking states. This varies from fetus to fetus but occurs somewhere between 30-35 weeks of gestation. This is also the time when cortical functioning in the fetus begins to resemble mature cortical functioning in other important respects. First, at about this time, the periods of continuous EEG activity are considerably longer than the periods of inactivity. Second, this is also the period in which something recognisable as the precursors of sleep/wake cycles develop. These landmarks in cortical development are undeniably significant. But we do not rest our case for locating the beginnings of consciousness at this point on either of these features. Rather, what we regard as significant is the emergence of *waking states*. Surely, it is states of this kind that we *really value*. It is states of this kind that we want to continue when we wish to survive. If this is not the only notion of consciousness that can be isolated, it is certainly the most important to us, and, at least in the current state

of scientific knowledge, it is here that we are inclined to locate the beginnings of consciousness, *properly so called*. (Those who would insist on a less liberal notion of consciousness would almost certainly be forced to locate its onset even later.)

Two comments on the answer we have just provided are called for at this point. First, even if we are correct in equating the beginnings of consciousness with the beginnings of waking states which we suppose to have *sensational content*, but probably not any other kind of content, it is important to emphasise that we cannot be *certain* that our approach is even broadly correct — although we think that it is. Still less can we be *certain* that it is refined enough; we know it probably isn't — too little is known at present about fetal development to draw anything but a tentative conclusion — and all we claim for our proposal is that it seems vastly more plausible than any other we know of. Secondly, we are well aware that someone might wish to locate the beginning of consciousness at the time of arrival of the first dream states. We have nothing absolutely decisive to say about this proposal. But all the EEG data suggest that no dreamstate ancestors can be identified earlier than 30 weeks and we are not even sure that the first such states could plausibly be said to have sensational content. Whatever the truth of the matter, it would seem to make no very substantial difference to our proposal.

7. THE MORAL SIGNIFICANCE OF CORTICAL BIRTH

Although limitations of space preclude our providing here a careful and detailed exploration of the moral significance of our proposal, we shall conclude by indicating, in brief outline, what we take to be the principal issues that our proposal might help to illuminate. First, although there is probably no such thing as a completely uncontentious claim about which things have intrinsic value or disvalue, the view that pain and suffering are intrinsically bad probably comes as close as any to universal acceptance in both unreconstructed commonsense morality and in systematic normative ethics. Clearly, being sentient is a minimal prerequisite for possessing the capacity to experience pain and suffering. Were we to claim no moral significance for our proposal beyond the minimal importance that (almost) uncontentiously accompanies the presence of sentience, that proposal would clearly have morally important practical consequences. For example, our answer clearly bears on the question whether analgesia or anaesthesia is advisable when performing operations on premature infants or when performing operations *in utero*. Whilst we do not think that the correct answer to this question depends only on the question of when a human being first becomes sentient, we do think that our ques-

tion has more than a merely tangential relevance to this uncontentionally important issue.

The question of when human beings first become conscious is of much greater importance to adherents — and to opponents — of a position that Bonnie Steinbock calls the ‘interest view’ of moral status.⁷⁵ Put briefly, the interest view is the doctrine that the boundary between those beings who are morally considerable and those who are not coincides with the boundary between those beings who have interests and those who lack interests. To be morally considerable is to have interests that can be advanced or harmed. Further, it is both a necessary and sufficient condition for having interests, in the sense that is relevant to the question of moral status, that one be conscious in the minimal sense of that term that we have been employing. As expounded by Steinbock, the interest view is neutral in two important respects. First, it is equally at home in consequentialist and rights-based normative frameworks. It seems to be just as appropriate when used by Peter Singer as the foundation for a preference utilitarian approach to moral status⁷⁶ as it is when used by Joel Feinberg to answer the question of what kinds of beings can have rights.⁷⁷ Secondly, it is silent on the question of whether or not all morally considerable beings are of equal value. Accordingly, whilst we can confidently expect different members of the large family of normative positions that accept the interest view to give somewhat different answers to the question of what precisely is the moral significance of the onset of consciousness in humans, we can equally confidently expect each member of that family to view that event as being of very great moral significance.

It is no part of our project to defend the interest view of moral status; neither is it part of our project to pretend that the view can easily be provided with a satisfactory formulation that draws the boundaries of moral considerability exactly where its proponents would wish. It is nonetheless evident that the view has considerable intuitive plausibility and is endorsed, in one form or another, by a great many moral theorists. Accordingly, any developments that help to clarify the practical consequences of the interest view will be of considerable importance to proponents and opponents of that view alike.

How exactly does our proposal help to clarify the interest view? Anybody who adopts that view will want to apply it to the question

⁷⁵ See Steinbock B.: *Life Before Birth: The Moral and Legal Status of Embryos and Fetuses*, New York, Oxford: Oxford University Press, 1992, ch. 1.

⁷⁶ See Singer P.: *Practical Ethics*, Cambridge: Cambridge University Press, 1993.

⁷⁷ See, for example, Feinberg J.: ‘The Rights of Animals and Unborn Generations’ in Blackstone, W.T., *Philosophy and Environmental Crisis*, University of Georgia Press, 1974.

of the moral status of fetuses. In the absence of a tolerably clear and carefully argued answer to the question we have been addressing, it is simply impossible to apply the interest view to the question of the moral status of fetuses. We have attempted to produce both a proposal that is sufficiently explicit, and an argument for that proposal that is sufficiently rigorous, to provide both proponents and opponents of the interest view with a plausible working hypothesis about the onset of consciousness in humans. Even if our hypothesis should turn out to be entirely correct, it would not, of course, serve alone to generate answers to the difficult moral questions concerning the appropriate treatment of fetuses at different stages of development. But it does clear away a major obstacle to the provision of credible answers to those questions.⁷⁸

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⁷⁸ We should like to acknowledge that our research was supported by an Australian National Health and Medical Research Council grant to Prof. P. Singer, Dr. H. Kuhse and Ms. E. Gaze, Centre for Human Bioethics, Monash University. We should like to thank Lloyd Humberstone, Sandra Rees, Peter Singer, Barry Taylor, Michael Tooley and Giles Yates for helpful comments on earlier drafts.