Neuromaturation and the Moral Status of Human Fetal Life

Most neocortical synaptogenesis occurs over an extended period of time beginning at about the 28th week.

Michael J. Flower

Fetal personhood: an intrinsic property or a matter of multiple attributions?

The Question; “When does human life begin?" has become the well-known and controversial encapsulation of a central issue in the conflict over abortion-- the moral status of embryonic/fetal life. From one perspective the question as put is thought to frame the issue adequately. In this view personhood is a matter of natural objectivity; we are simply presented with the fact of full humanness or personhood--an intrinsic and scientifically discoverable property emerging during the course of a continuous ontogenetic process. However, there is a problem with this notion of intrinsic personhood, and it is deciding which of several different suggested properties is the one "real" answer to when a particular and personal human life has begun. Is it possession of the unique human genome achieved after fertilization, loss of embryonic ability to twin (i.e. developmental individuality) roughly two weeks later, appearance of fetal motility at six to seven weeks of gestation, emergence of unmistakably human form a few weeks later still, first awareness, or birth? In deciding, one must give reasons for one's choice and thereby necessarily introduce "extra-biological" dimensions as part of the choosing. As a result, the biological indicators come to serve as little more than the material referents for these reasons. The recognition that reasoned choices among contending properties must be made has led many to focus precisely on those reasons, and to claim that the properties whereby we understand and value prenatal personhood are not those discoverable by science but those constituted within a social fabric, and most properly by those who are directly involved with the fetus before and after its birth (Solomon, 1983, p.220).

Harrison (1983), for example, claims that our evaluation of embryonic and fetal human life is a complex exercise of moral agency in the face of a precise moral question: "When shall we predicate full human value to developing fetal life?" Such predication or attribution is clearly a socially constitutive act extrinsic to the fetus. It is not, however, an act unconcerned with the changing nature of the fetus or its intimate and dependent relation to the woman nurturing it. Thus, as we exercise this moral agency we are counselled to take into account "developmental criteria for stipulating the degree of similarity to existing human beings required for counting fetal life as a human life" while attending to "the moral reasons for and against viewing prenatal life as morally continuous or discontinuous with existent humanity" (Harrison, 1983, pp. 208- 209). That is, we are to look for developmental differences which make a moral difference. Given the view expressed by Harrison, how do we engage in the process of predication? If we cannot begin with scientific facts about prental ontogenesis, if the meaning or definition of personhood is simply not something arrived at empirically, then it must be decided upon. The justification for a choice of developmental criterion must originate elsewhere and earlier, within our moral communities. Thus, we look toward the embryo or fetus from the vantage point of existent humanity, having already chosen one or more criteria-- about ourselves--as anchors of a possible moral continuity with the developing fetus. These prior choices of criteria thereby condition the nature of our moral gaze.

While several such criteria have been suggested (and noted above), perhaps the most compelling of prenatal criteria are those related to the central nervous system (CNS). This is so because the CNS materially underpins the development of several capacities we socially construe as of moral importance to us: (1) awareness (especially of pleasure and pain); (2) a discrete and sustainable bodily existence achieved through birth which enables a transition in the manner of nurturance and occasions '"a covenant of caring' that creates personal existence"; (Harrison, 1983, p.223;) (3) a rich meshwork of neocortical circuitry whose post-natal "remodeling" (see below) may in part reflect the neuro-embodiment of an emerging personal existence lived in interaction with others; and finally, those

Engelhart (1983, p.184) associates with persons in the strict sense (i.e. persons of the sort we hopefully are): (4) sense of self, (5) ability to exercise rationality, and (6) capacity to choose freely and responsibly. Thus, our moral sensibilities turn our gaze to a collection of important, neurally-enabled capacities warranting attention. It is at that point scientific methodologies and tools can sometimes be used to tell us when there emerges a nervous system of sufficient material complexity to embody those capacities (already) judged as morally pertinent. Knowing when, we are (perhaps) better prepared to fashion the bridge of moral continuity spoken of by Harrison.

A brief chronicle of human embryonic/fetal neuromaturation:
knowing when integrative transitions occur.

Although the process of human development from newly fertilized ovum to birth is properly considered a continuum of change, it is an uneven continuum. There are periods of developmental transition during which integrative functions appear and increasingly complex embryonic and fetal properties emerge. This general observation is true of neuromaturation as well. Thus, if we adopt the position that the integrative activities of the prenatal CNS are an important consideration for our possible ascription of moral standing, we must ask which integrative functions are of moral significance and what degree of neural development must be evidenced before we are advised to "draw the line" that encompasses particular fetal lives within our moral communities and protects them from harm?

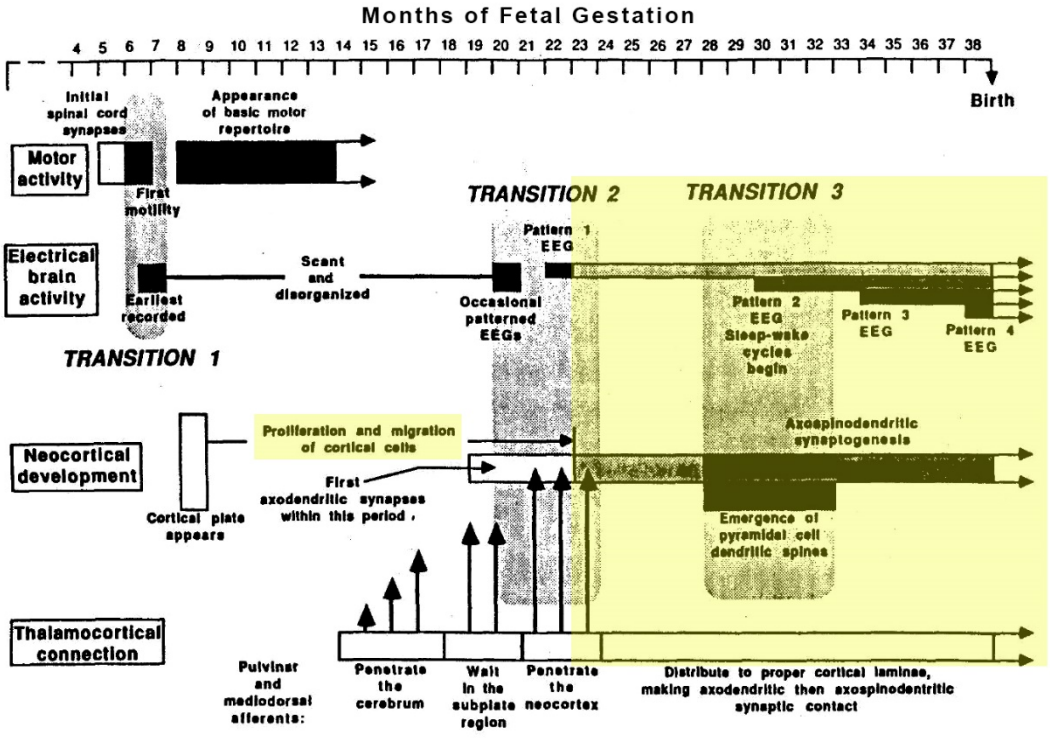

FIGURE 1. Neuromaturational Processes During Fetal Human Life

First, it is important to understand that the development of the nervous system can be followed as a sequence of processes (Flower, 1985), not all of which may be of comparable moral significance. The earliest developmental event is the appearance of unspecialized (or presumptive) neural cells; these are different from other embryonic cells in that only they are destined to produce the CNS as ontogenesis proceeds. There then follow two further changes, developments which begin at different times and proceed at different rates in various parts of the CNS (a circumstance that makes it difficult to speak about neuromaturation of the fetal CNS as a whole). First, presumptive cells begin preparing to function as nerve cells; they differentiate by changing their morphology and biosynthetic activities. This differentiation enables the second major change, a cooperative assembly into supercellular an-ays. Neural cells synapse ("hook up") with one another, producing information-carrying circuits.

As is probably obvious, the last of these developmental processes will eventually come to interest us most, for it is neural circuitry that makes possible the integrative function of the nervous system.

However, it is useful to look first at earlier events and then proceed in the direction of greater complexity. As the human embryo develops, when is there first "something neural" to observe, characterize, and talk about scientifically? During the third week of human development it is already possible to identify that portion of the embryo which is the presumptive or rudimentary forerunner of the future CNS; at this time, however, there are no functional nerve cells. In the fifth week (Figure 1), maturing neurons can be found in the cervical (neck) region of the embryonic spinal cord (Okado, 1981, pp.212, 215); they are sufficiently specialized that the simplest sort of supercellular circuits (reflex arcs) can be established soon thereafter, serving to support rudimentary fetal motility. At this time, also, there are undoubtedly differentiating neurons in the developing brainstem region (Humphrey, 1978). However, if we look for the neocortex we will not find it even in rudimentary form. It is put in place by processes of cellular proliferation and migration that do not begin until the eighth week and last through the fifth month of development. And even when most of the neocortical cells are in their proper place at five months, the multicellular assemblage does not yet constitute a functioning cellular array, for these neocortical cells have yet to fully differentiate. For instance, if we look for indications of neocortical cellular specialization (evidenced morphologically by the production of long cellular extensions known as axons and dendrites, and by the appearance of multiple synaptic targets or "spines" on the latter) we will find relatively few before 20 weeks. Many weeks later, with the relatively sudden emergence of these specialized cellular morphologies and synaptic points-of-contact, a rapid and quantitatively enhanced formation of complex neocortical circuitry is enabled.

Looking at specific neuromaturational processes The Earliest Events

If at three weeks of development there are no functional nerve cells, how much time passes before neural function (of some sort) appears? We can ask when electrical activity is first detectable and when there first appear functions (such as motility) known to be dependent on neural maturation. In both cases the answer is the same: about the sixth-to-seventh week (Figure 1). As was noted earlier, there is not even the hint of a neocortex at this time; thus, the electrical activity observed (Borkowski and Bernstine, 1955) does not indicate higher brain function. However, such activity may be a manifestation of early embryonic brainstem function.

What of prenatal motility? What degree of neuromaturation is required to support it? Very little, as it turns out. When observed ultrasonigraphically, the late-stage embryo of six weeks can be seen to exhibit occasional and "just discernible movement"; a week later, a "startle" response emerges. Over the next six to seven weeks a relatively complex repertoire of spontaneous motor activities emerges (de Vries et al, 1982); the fetal limbs and head move about, breathing movements occur, and swallowing and sucking are observed. The "control" of this activity might conceivably reside in the relatively simple neural circuitry of the spinal cord, as Robertson (1985) has suggested in his account of the later cyclic motor activity of post-mid-gestation fetuses. However, as the development of younger fetuses proceeds, the various motor activities exhibit temporal patterns of expression which differ one from the other (de Vries et al, 1985), possibly indicative of some measure of modulatory influence "higher" than the spinal cord. It has been suggested (Flower, 1985) that the earliest modulator of such activity is the brainstem (serving, for example, to integrate rudimentary sensory input from such sources as fetal muscle "stretch receptors," small "sensors" embedded in muscle tissue and triggered by muscle contractile activity to send electrical impulses to the CNS). This suggestion of a general integrative function (Transition 1 in Figure 1) is made more reasonable by the recent observations of Visser and colleagues (1985). They found that anencephalic fetuses lacking the brainstem region exhibited considerable but abnormally patterned motility when compared to that of anencephalic fetuses with intact brain stem. They also noted that substantial motility (though again unorganized) was possible even in anencephalics in which only abnormally situated nests of spinal cord neurons were present.

Thus, little neural circuitry was necessary for movement, but an intact brainstem was associated with normal patterns of fetal activity.

Of what significance is this putative brainstem integrative function? Is it, if real, in any way an attractor of our moral concern? At this very early time do we have morally justifiable reasons for establishing a moral bridge expressed through an imputation of some form of fetal personhood? In virtue of what actions on our part would we define the imputation? As the brainstem is not the same thing as the neocortex we can be certain that the patterned changes in fetal motility are not the result of intention; they are not indicative of any sort of conscious awareness and need not draw our moral attention for that reason. However, are there other reasons to attend to a fetus of this stage? At least one philosopher thinks so. Tauer (1985, p.258-259) has argued that "...if integration through the brainstem is a valid hypothesis...it seems reasonable to describe the late first trimester fetus's relationship to tactile stimuli and to its own movements...as fetal 'experience'." While such experience is not conscious as we have noted, Tauer suggests (p.259) that "it is comparable to other nonconscious experience in its significance for psychological life." This is so for Tauer because she counts the foundations of later personal traits (self-consciousness, rationality, and self-determination) as begun when integrative brain pathways are first established, including those of the brainstem. In other words, Tauer advances a "whole brain" conception of personal prenatal becoming. She suggests (citing Mittelman, 1960, p.104-105) that "intrauterine events may be 'physiological antecedents of later happenings...traces that in some way are equivalents of later memory traces...'."If such speculative traces do exist and if they influence (even in part) later neural capacities of moral significance, then one can understand why Tauer would attribute to fetuses older than six weeks a status she calls the psychic sense of person. For Tauer, an integrative foundation is being laid down, one that in some (undoubtedly indirect) way may affect the person-to-be. But what kind of respect does she argue is due a fetus with such a status? Or asked differently (to emphasize the constitutive nature of status- giving), what actions of ours would realize that status in practice?

Crucial for the attribution of psychic personhood is the realized potential of such fetuses to become persons in the strict sense. The status of psychic personhood is morally relevant only if fetal "experience" is continuous with and determines the development of personal psychological characteristics of a person like you and me--that is, only if a full pregnancy is anticipated and completed. Thus, Tauer's argument for psychic personhood (as she recognizes) is not one on the basis of which we would proscribe abortion during the first trimester. Instead--and certainly of importance--Tauer's argument for attributing psychic personhood to a human life during its seventh week of prenatal development is relevant to the question of--and is constitutued by--the care and nurturance necessary to protect the normal integrative embodiment of a CNS crucial for continued creation of a personal existence. That is, even if the speculative claims of (later-effective) "memory trace-like" experience as early as six to seven weeks of gestation can be sustained, the notion of psychic personhood instructs us only as to our proper relationship to a fetus that will develop to birth: we ought to avoid injurious intervention (e.g. experimentation or traumatic therapeutic measures) and to care for the fetus's normal development through proper maternal nutrition, avoidance of undue stress, harmful chemicals and the like, thus protecting a future person. Of course, such a concern for protective behavior would come into play before six to seven weeks of gestation because earlier processes of CNS (and other organ-system) development are subject to developmental mishap as evidenced by such abnormalities as anencephaly and spina bifida. While Tauer would surely be concerned about such outcomes and the avoidance of conditions producing them, her arguments concerning psychic personhood--as we have seen--are directed to those processes of CNS emergence involving the formation of integrative pathways which might exert some type of "memory" effect. Such concern surely entails not only responsible maternal care but also an enabling societal concern, one that ensures the availability of proper prenatal services to all women seeking to care well for the fetal lives their bodies sustain. Thus we find, perhaps surprisingly, that the early events of human neuromaturation--as stated thus far--may have much to do

with how we view and support full-term pregnancies while having nothing to do with the morality of early abortions.

Emergence of the neocortex: As noted earlier, neocortical development requires many months.

The cells of the neocortex are produced by a zone of proliferative cells located some distance from the site of neocortex formation, thus prospective neocortical cells must actively migrate to their final position--a process that begins at about 52-54 days of embryonic development (Molliver et al, 1973, p.406; Marin-Padilla, 1983, p.34). Continuing for more than three months, this process of cell proliferation and migration produces a succession of neocortical cell layers within which neurons of different function specialize and begin forming synapses, the interconnections that produce a supercellular form of organization: neocortical circuitry. The first of these synapses are formed sometime between 19 and 22 weeks of development (Molliver et al, 1973, p.404), although **most neocortical synaptogenesis occurs over an extended period of time beginning at about the 28th week** (Purpura, 1975, p.45-46, examining the visual neocortex), a time after which the key neuronal classes of the neocortex exhibit on their dendritic extensions the tiny projections or spines which are the necessary "targets" for establishing neocortical circuitry which is morphophysiologically equivalent to that of a full-term neonate.

Of greater importance for our purposes here, perhaps, is Purpura's observation that such dendritic spine development "does not represent a continuous process traceable to early fetal phases of dendritic differentiation." Thus, for example, while neocortical cells of 24 to 27 week fetuses have already begun formation of dendritic extensions, they possess no dendritic spines (Purpura, 1975, p.46). Rather, they begin to appear "suddenly" at around the, 28th week. This rapid appearance of dendritic spines is an example of what was earlier termed an "uneven continuity," a developmental transition (Transition 3 in Figure 1) occurring over a relatively short time period (in this case, the seventh month of pregnancy). This observation should not be taken to mean that prior to 28 weeks the visual region of the neocortex is inactive. In fact, preterm infants exhibit electrical activity in the visual neocortex (visual evoked responses or VERs) as early as 24-25 weeks of gestation (i.e. aft.er the time of appropriate thalamocortical connection to be noted below). In the particular situation studied by Purpura and his colleagues, the transition in synaptic capability (and thus supercellular circuit-forming capacity) was associated with a qualitative change in this functional VER activity to that characteristic of a full- term neonatal VER (i.e. attainment of morphophysiological equivalence as an outcome of neuromaturational events of the seventh gestational month).

Abridged