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Research Article

A Rudimentary Consciousness Appears in the Late Fetal Period

Carlo Bellieni*

Professor, Department of Molecular Medicine and Development, University of Siena, Siena, Italy

***Corresponding Author**: Carlo Bellieni, Professor, Department of Molecular Medicine and Development, University of Siena, Siena, Italy. Email ID: bellieni@unisi.it.

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Abstract

Aim: Aim of this review is to assess the onset of consciousness in the early stages of human life.

Methods: First, we analysed what is meant by the word consciousness, to acknowledge the areas and key-words to be investigated. Then, we retrieved the scientific literature on these areas, focusing on the trials produced in the last ten years.

Results: The fetal and neonatal features that have been mainly associated to consciousness, are active sensorial pathways, and early brain cortex activity, which are the prerequisite for the appearance of memory, a basic marker of consciousness. We examined the clinical trials on these topics published in the last 10 years, and we retrieved 31 studies. Our data show that, since the second half of pregnancy, some short-term memory emerges in the fetus or newborn; the so-called neuroinhibitors in fetal blood, and its long sleep phases, make no difference.

Conclusion: The early appearance of memory is a sign of rudimental consciousness, and it does not depend if the fetus dwells within or outside of their mother's womb, but only on the grade of their brain development.

Keywords: *Consciousness; Fetus; Newborn; Memory*

Introduction

It is only in recent decades that subjective experience - or consciousness - has become a legitimate object of scientific inquiry. This imply a question about the early stages of human life: can a fetus or a preterm baby be conscious? It seems a paradoxical question, because these are the faintest stages of life, seemingly the most inert and amorphous. However, not only has this question remained unresolved for many decades, but it has also fuelled numerous discussions [1-3]. Moreover, if a newborn can be said conscious, why consciousness can be ruled out in a fetus of the same gestational age? We know very much about stimuli perception in the fetus (e.g. pain or smell), but since when can this be assimilated to a rudimental consciousness?

Aim of this Paper

Aim of this review is to investigate if the basic features of consciousness are present in the early development of the human being, even when the fetus, at an appropriate state of development, is still within their mother's womb. To this aim, we performed a search in scientific literature, to assess the main features of consciousness; then we assessed if they are featured in fetal-neonatal period.

Methods

First, we performed a literature search about the definition of consciousness, to retain its main features, that will be used, as key words, to address this review. Then, we retrieved the clinical trials that studied those features in newborns and fetuses, performed in the last 10 years. We used the Embase and SCOPUS databases to retrieve the papers. Inclusion criteria were: papers published from January 2015 to July 2025; being clinical trials that deal at least with one of the topics retrieved in the preliminary search of consciousness features. Exclusion criteria were: review papers, case reports, and opinion papers.

Results

Features of consciousness

The concept of consciousness has many definitions. While the Oxford Advanced Learner's Dictionary of Current English [4] (2020) defines it as "the state of being able to use one's senses and mental powers to understand what is happening," researchers have proposed countless other definitions in recent decades. They consider consciousness as a neurobiological process, as well as self-awareness or free will [5]. But in some cases, consciousness can be present, even if the subject has some disease or immaturity that compromises their awareness, as in the case of babies, people with mental disabilities or brain damage. In recent years, research has further challenged the boundaries of this otherwise vague concept, discussing the self-awareness of fish [6] and birds [7]. Considering these findings and the variety of possible definitions, consciousness is not an all-or-none phenomenon, but rather it exists in varying degrees. Even Edelman., *et al*. [8] who divide consciousness into primary and higher-order consciousness, to describe basic consciousness focuses on the integration of diverse sensory inputs along with memory, allowing for dynamic adaptation to a situation [9]. Memory seems then to be a peculiar feature of consciousness; also according to Kent., *et al*. [10], consciousness is closely linked to memory, particularly the ability to form memory traces. They require the presence of a rudimental sensoriality, capable of retaining reminders of the stimuli. Bekinschtein., *et al*. [11], who worked with patients with disorders of consciousness, introduced an auditory oddball paradigm for investigating memory traces across different time scales, the so-called "local-global" paradigm. The local-global paradigm consists of tone sequences that can either contain only identical tones or end with a different tone (Box 1). The authors concluded that the ability to form a memory trace long enough to incorporate second-order regularity, which goes hand in hand with the ability to formulate a prediction on the appropriate time scale, is a sign of conscious processing [11]. As well as in the case of people with impaired consciousness, Basirat., *et al*. [12] demonstrated that this paradigm also fits infants. Also, most recent papers correlate the dawn of the consciousness with that of personal memory, even though this is not verbally expressed [13-17]. From the above synthesis, the basic feature of consciousness - its minimum common denominator - appears to be memory, and the substrate for its functioning are sensorial pathways, and the appearance of an active brain cortex or other structures that can act for it (Figure 1).

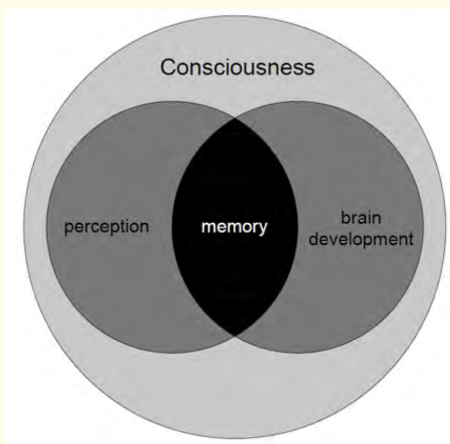

Figure 1: *The features of consciousness.*

Legend: The ability to perceive external stimuli is subordinated to the first appearance of the brain cortex. This is the basis for memory, which is the prerequisite for consciousness. In humans, this starts around the 20-24 weeks since the conception, and becomes more evident in the last trimester of pregnancy.

Trials on consciousness features

We used these first-level results to address our search, and consequently we used as keywords the following: fetus, newborn, preterm, memory, consciousness, taste, voice, touch, smell.

After selecting the papers obtained in a preliminary gross selection of data (n = 139), applying the inclusion and exclusion criteria, we retrieved 31 clinical trials on fetal-neonatal consciousness features. Ten deal with the presence of the anatomic pathways that make the consciousness available [18-27]; fifteen describe the perceptions of the fetus and newborn [28-42]; six deal with memory in fetal and neonatal life [43-48].

Analysis of data

Anatomical and physiological bases

Thalamus and thalamo-cortical fibers

A key element enabling fetal perception is the establishment of thalamocortical pathways in the cortical plate; the structures devoted to stimuli perception and memory develop early in fetal brain. Zheng., *et al*. [18] used multishell high-angular resolution diffusion MRI of 144 preterm-born and full-term infants in both sexes scanned at 32-44 PMW from the Developing Human Connectome Project database to investigate the thalamic development in morphology, microstructure, associated connectivity, and subnucleus division. Using a connectivity-based segmentation strategy, they revealed that functional partitions of thalamic subdivisions were already formed at 32 PMWs.

Some researchers described earlier appearance of thalamo-cortical fibers (TH-C).

Žunić Išasegi., *et al*. report that between 8.5 and 11 post-mestrual weeks (PMW), TH-C fibers from the intermediate zone are initially dispersed throughout the subventricular zone, while sizeable axonal “invasion” occurred between 12.5 and 15 PMW, even before the presence of the cerebral cortex [19]. In fact, in human fetal brain development, TH-C fiber growth begins during the embryonic period [20] and completes by the third trimester of gestation. The thalamus, being a central information relay, plays an important role in regulating diverse brain functions through the interconnectivity of TH-C circuits [21-23]. Sophisticated diffusion models have been utilized to characterize perinatal cortical maturation, such as diffusion compartment imaging in neonates born preterm and multi-shell multi-tissue constrained spherical deconvolution in fetuses [22,23]. Hu., *et al*. [24] showed that at full-term birth or by term-equivalent age (and maybe not before), infants possess key features of the neural circuitry that enables integration of information across diverse sensory and high-order cortical functional modules, giving rise to conscious awareness.

Taymourtash., *et al*. [25] modeled fetal functional TH-C connectome development using in-utero functional magnetic resonance imaging in fetuses observed from 19^{th} to 40^{th} PMW. They observed a peak increase of TH-C functional connectivity strength between 29^{th} and 31^{st} PMW, right before axons establish synapses in the cortex. The cortico-cortical connectivity increases in a similar time window, and exhibits significant functional laterality in temporal-superior, -medial, and -inferior areas.

The development of connectivity between the thalamus and the maturing cortex is a fundamental process in the second half of human gestation, establishing the neural circuits that are the basis for several important brain functions. It is for this reason that Wilson., *et al*. [23] acquired high-resolution in utero diffusion magnetic resonance imaging (MRI) from 140 fetuses as part of the Developing Human Connectome Project, to examine the emergence of thalamocortical white matter over the second to third trimester. They identified patterns of change in the diffusion metrics that reflect critical neurobiological transitions occurring in the second to third trimester.

Cortex and subplate

Kopic., *et al*. [26] showed that basic neural network components of Highly Ordered Association Frontal Cortex (HOAFC) differentiate during early fetal period (7.5-15 PMW). They also showed that that regional patterning and specification of the prospective HOAFC emerges early in fetal development, contributing to the highly organized cortical architecture of the human brain. This also involved the subplate.

The subplate is a transitory relay for neurons which migrate to form the definitive brain cortex; it has some of the prerogatives of the cortex. The sublate plays a vital role in integrating spontaneous and sensory-driven activity patterns that sculpt the functional neuronal networks of the mature brain. Kostović reports that by 15 PMW it is a distinct and relatively large stratum compared to the cortical plate, containing a reduced density of neurons even in the upper subplate and an increased density of axons, synapses, and extracellular matrix [27].

Fetal senses

Recent studies have analysed the noises [28,29] and tastes [30] that arrive to the fetus from the environment, and the adults' recognition of peculiar odours in amniotic fluid [31]. More studies assessed the actual responses of fetuses to these stimuli, since the middle of pregnancy. These studies report that fetuses show active responses to maternal voice and touch [32-35], as well as to odours transmitted through the amniotic fluid [36-38]. Draganova described the auditory-evoked potential in fetuses of 31-41 PMW [39]. Ronga., *et al*. disclosed that face-like visual stimuli can be transmitted through the maternal abdominal wall to the fetus, and that it can show a preference for this kind of images at the beginning of the third trimester, as soon as thalamocortical projections are established [40]. Bernardes., *et al*. described facial reactions of the fetus to painful stimuli [41]. Other researchers showed fetal responses to their mothers' tactile stimulation performed through the maternal abdomen; they conclude that "Fetuses in the 3rd trimester touched the uterus wall significantly longer than fetuses in the 2nd trimester did, when the mother touched compared to the control condition. This differential response of the older fetuses might be due to the maturation of the central nervous system, and may indicate the emergence of a proprioceptive self-awareness by the 3rd trimester" [42]. Some of these trials included the assessment of the postnatal memory of the prenatal stimulations [35-39].

Fetal and infantile memory as a trace of consciousness

Through fetal magnetoencephalography, Moser., *et al.* [43] demonstrated that fetuses in the final weeks of gestation are capable of learning second-order regularities, as a form of memory (Box 1). This ability develops over the course of the last trimester of gestation, in accordance with processes in physiological brain development and was only reliably present in fetuses older than week 35 of gestation [43]. This ability is considered a sign of conscious processing, and therefore raises the point that consciousness appears before birth. Moser's study shows that it gradually develops further during the last trimester of pregnancy. This development may be related to a general increase in brain connectivity that allows for more comprehensive processing.

Fetuses and newborns respond to stimuli, and these stimuli leave traces as a form of memory. If the stimuli that reach the fetus/newborn are presented again weeks later, the fetus/newborn will behave differently than if these stimuli had not been presented previously [38]. One example is taste: the flavors offered to a fetus/newborn through amniotic fluid or breast milk will even shape the adult's food preferences, remaining imprinted in their memory [39-41].

The phenomenon of habituation is another example of fetal/neonatal memory, namely short-term memory. Habituation is characterized by the progressive decrement of response to a stimulus, and is a form of short-term memory. It is present in newborns [44-46] as well as in fetuses [44-48].

Authors (#ref)	Enrolled subjects	Methods	Conclusions
Zheng., *et al*. [18]	144 preterm-born and full-term infants. 32-44 PCW	Multishell high-angular resolution diffusion MRI	Functional partitions of thalamic subdivisions were formed at 32 PCW or earlier
Krsnik., *et al*. [20]	Post-mortem fetal brain from 7 to 34 PCW Number: not available	Histological sections from post-mortem fetal brains Images were compared with post mortem diffusion tensor imaging (DTI)-based fiber tractography	Between 14 and 18 PCW, the TH-C interdigitate with callosal fibers, running shortly in the sagittal stratum and spreading through the deep SP ("waiting" phase). From 19 to 22 PCW, TH-C axons accumulate in the superficial SP below the somatosensory cortical area.
Calixto., *et al*. [21]	44 fetuses between the 23 and 36 PCW	Motion-corrected diffusion tensor imaging (DTI)	Results showed significant PCW-related changes in amniotic fluid and mean diffusivity in all regions of interest except in the thalamus' fractional anysotropy and corpus callosum's mean diffusivity.
Eaton-Rosen., *et al*. [22]	89 infants born at fewer than 34 PCW completed gestation, each imaged at up to four timepoints between 27 and 42 PCW	Structural T2-weighted MRI	The radiality index has a consistent progression across time, with the rate of change depending on the cortical lobe. The occipital lobe changes most rapidly, and the frontal and temporal least: this is commensurate with known developmental anatomy.
Wilson., *et al*. [23]	140 fetuses 21-37 PCW	Diffusion magnetic resonance imaging	Emergence of TH-C white matter over the second to third trimester.
Hu., *et al*. [24]	282 full-term neonates (age 41.2 PCW ± 12 days) and preterm neonates scanned at term-equivalent age (n = 73, 40.9 PCW ± 14.5 days), or before term-equivalent age (n = 73, 34.6 PCW ± 13.4 days)	Functional MRI	At full-term birth or by term-equivalent age, infants possess key features of the neural circuitry that enables integration of information across diverse sensory and high-order functional modules, giving rise to conscious awareness. Conversely, this brain infrastructure is not present before infants reach term-equivalent age.
Taymourtash., *et al*. [25]	72 fetuses 19-40 PCW	Functional magnetic resonance imaging	Observed a peak increase of thalamo-cortical functional connectivity strength between 29 and 31 PCW, right before axons establish synapses in the cortex.
Kopić., *et al*. [26]	15 PCW. Number: not available	NanoString GeoMx™ Digital Spatial Profiler (DSP) technology to examine gene expression differences in the transient cortical compartments of the dorsal and ventral regions of the developing frontal lobe	Higher-order association prefrontal cortex emerges early in fetal development, contributing to the highly organized cortical architecture of the human brain.

Kostovic., *et al*. [27]	35 fetuses from 8.5 PCW	Sublaminar distribution of different microstructural elements and the associated maturational gradients throughout development, using immunocytochemical and histological techniques on postmortem brain material	Subplate compartment of the lateral neocortex shows changes in laminar organization throughout fetal development: the monolayer in the early fetal period (presubplate) undergoes dramatic bilaminar transformation between 13 and 15 PCW, followed by subtle sublamination in three 'floors' (deep, intermediate, superficial) of midgestation (15-21 PCW). During the stationary phase (22-28 PCW), subplate persists as a trilaminar compartment, gradually losing its sublaminar organization towards the end of gestation and remains as a single layer of subplate remnant in the newborn brain.
Gélat., *et al*. [28]	Pregnant sheep gestational age, 103-130 days. N=6	A calibrated hydrophone was attached to the occiput of the fetal head within the amniotic sac. Two calibrated microphones were positioned in the operating theatre, close to the head and to the body of each ewe	Measurement of acoustic transmission through the maternal abdominal and uterine walls indicates that frequency contents above 10 kHz are transmitted into the amniotic sac and that some frequencies are attenuated by as little as 3 dB.
Gélat., *et al*. [29]	4 pregnant patients from 24 PCW	MRI scans	The sound transmitted in utero is attenuated by as little as 6 dB below 1 kHz, confirming results from animal studies that the maternal abdomen and pelvis do not shelter the fetus from external noise.
Halasa., *et al*. [30]	amniotic fluid (n = 13) 16-25 PCW, and cord blood samples (n = 15)	Concentrations of four Non-nutritive sweeteners (acesulfame-potassium [ace-K], saccharin, steviol glucuronide, and sucralose) were measured using liquid chromatography-mass spectrometry.	Results provide evidence of human transplacental transmission of non-nutritive sweeteners.
Gellrich., *et al*. [31]	11 women 16-25 PCW undergoing diagnostic amniocentesis after eating garlic oil or vanilla powder in high-fat yogurt	Volunteers (8 males, aged 26.5 ± 5.0 yr) were asked to judge amniotic fluid samples with potential garlic or vanilla odors	According to the results of this study, the vanilla odor probably passes into the amniotic fluid.
Marx 2015 [32]	23 fetuses (21st to 33rd PCW)	3D real-time (4D) sonography.	Fetuses in the 3rd trimester showed increased regulatory (yawning), resting (arms crossed) and self-touch (hands touching the body) responses to the stimuli when compared to fetuses in the 2nd trimester.
Rolland Souza., *et al*. [33]	28 foetuses 24 - 31 PGW	Fetal cardiotocography	Baseline fetal heart rate, accelerations, decelerations, and variability did not change with maternal touch of the abdomen, but fetal movements increased

Nagy., *et al*. [34]	Foetuses (N = 12), 25-33 PCW	4D scanning	Foetuses in the third trimester discriminate between interactive and non-interactive external stimuli and respond to contingent interactions.
Valiani., *et al*. [35]	36 foetuses PCW 27 stimulated with massage and music. Control group with no stimulation	Assessment of habituation	Fetal stimulation techniques can bring about positive effects on the neonate's behaviors including the area of habituation.
Faas., *et al.* [36]	7-14 day-old newborns	Assessed in terms of behavioral responsiveness to alcohol's chemosensory attributes or to a novel odor (lemon).	A positive and significant correlation was found between overall maternal absolute alcohol consumption per month and frequency of appetitive facial expressions elicited by alcohol odor.
Ustun., *et al*. [37]	Two groups of 35 and 36 fetuses of 32-36 PCW, either exposed or not during pregnancy to carrot flavor through their mothers' diet	Assessment of facial movements when exposed to carrot flavour after birth	The complexity of facial gestalts increased from 32 to 36 PCW in the kale condition, but not in the carrot condition
Ustun., *et al*. [38]	35 neonates (32 fetuses PCW to 1 month after birth)	Asking mothers to consume a single calorie-controlled encapsulated dose of powdered kale (n = 14) or a carrot (n = 18) before 4D ultrasound scans at 32 and 36 PCW. Following the 36-PCW scan, mothers consumed the capsules daily for three consecutive weeks Neonatal facial reactions to specific odors	Showed a decreased frequency of cry-face, and an increased frequency of laughter-face gestalts in response to the odor stimulus experienced prenatally
Draganova 2018 [39]	Fifty-five pregnant women between 31 and 40 PCW	Fetal magnetoencephalography	Still before birth the fetal brain processes the sound slopes at the onset in different integration time-windows, depending on the time for the intensity increase or stimulus power density at the onset, which is a prerequisite for language acquisition.
Ronga., *et al*. [40]	Sixty fetuses were recruited at 26, 31, and 37 PCW	Face-like configurations (FCs-three dots composing a downward-pointing triangle), as compared to the inverted configurations (ICs). Fetal lens movements in response to FCs and ICs was monitored with 2D-ultrasound.	Significantly more lens movements were observed in response to continuous as compared to flashing light stimuli. Furthermore, lens movements linearly increased within the third trimester and, regardless of the time-point, significantly more lens movements were observed in response to FCs versus ICs. Moreover, a significant correlation in the first time-point, wherein the greater the FCs versus ICs differential response the larger the thalamic nuclei dimension.

Bernardes., *et al*. [41]	1 fetus 30 PCW	Recorded facial expressions of the foetus before and after the anaesthetic puncture by the use of 4D ultrasound	The procedure was safe and feasible
Marx., *et al*. [42]	28 fetuses (20th to 33rd PCW of gestation; N=15 in the 2nd and N=13 in the 3rd trimester)	3D real-time (4D) sonography	Fetuses in the 3rd trimester touched the uterus wall significantly longer than fetuses in the 2nd trimester did, when the mother touched compared to the control condition.
Moser., *et al*. [43]	56 healthy fetuses between PCW 25 and 40, during an auditory oddball paradigm containing first- and second-order regularities.	Fetal magnetoencephalography	Fetuses in the last weeks of gestation are capable of consciously processing stimuli that reach them from outside the womb
Dumond., *et al*. [44]	61 preterm neonates, born between 32 and 34 PCW.	At 35 weeks of corrected gestational age, we measured orienting responses (forearm, hand, and fingers movements) during vibrotactile stimulation of their hand and forearm; during a habituation and dishabituation paradigm, the dishabituation being either a location change or a pause in the stimulation sequence.	Preterm newborns displayed a manual orienting response to vibrotactile stimuli which significantly decreased when the stimulus was repeated
Poli., *et al*. [45]	106 8-month-old infants	To test habituation, infants were shown 16 sequences of cue-target trials. In each sequence, the cue consisted of a simple shape appearing in the middle of the screen.	Habituation time was related to individual differences in processing speed, while dishabituation was related to curiosity, but only for infants who did not habituate.
Hartkopf., *et al*. [46]	N=30 fetuses (age: 28-39 PCW) and N=28 infants (age: 0-3months)	An auditory habituation paradigm including two different sequences of syllables was presented to each subject. Magnetic brain signals were recorded.	Fetuses and infants showed acoustic evoked responses to syllables. Unlike fetuses, infants showed a discriminative neural response to syllables. Habituation was not observed in either fetuses or infants.
Reissland., *et al*. [47]	35 fetuses, mean PCW: 32 w.	A control group with no stimulation and an experimental group exposed to experimental sound, light and cross-modal stimulation. For both groups ultrasound scans were performed and fetal eye-blink was assessed. using 4D ultrasound:	Sound stimulation but not light stimulation significantly affected blink-rate with fetuses habituating to the stimuli
Muessinger., *et al*. [48]	41 fetuses (PCW 30-39) and 22 newborns or babies (age 6-89 days).	Fetal magnetoencephalography (fMEG). An auditory habituation paradigm consisting were presented	The current study used fMEG to directly show fetal habituation and provides evidence of fetal learning in the last trimester of pregnancy.

Table 1: *Features of the clinical trials retrieved in this review.*

Legend: PCW: Post-Conceptional Weeks; SP: Subplate; TH-C; Thalamo-Cortical.

Discussion

A key element enabling fetal perception is the establishment of thalamocortical pathways in the cortical plate. Previous research shows that during the mid-fetal period (15 - 23 weeks after conception), thalamocortical axons enter the intermediate zone and gradually accumulate in the subplate before moving to their cortical target regions [49]. The thalamocortical pathways continue to grow into the late fetal period (early preterm phase, 24 - 28 weeks), enabling cortical responses to sensory input [50]. This anatomical development in the fetal period indicates that the neural networks necessary for consciousness are established before birth [51]. Data we have reported confirm these observations. The identification of sensations does not require a mature development of the cerebral cortex; in fact, it will complete its maturation only after adolescence. Indeed, intrauterine life includes structures which, at least partially, replace the developing cortex, that the fetus begins to form around 20 weeks of gestation. These structures are the subplate, useful for most sensations, and the thalamus for pain [52]. The connections that it will develop later with the cortex, will serve to develop the spatial features of the sensation and the idea of "self" [53]. But sensations are perceived even before this step; we can realistically say that the first sensations are perceived by mid-pregnancy [54]. This is what data reported in our search affirm. Some authors questioned this point, on two main bases: first, the potential absence of wake periods in the fetus, and second, the presence in fetal blood of neuroinhibitors which might promote a continuous sedation [55,56]. Nonetheless, it is easy to demonstrate that different fetal behavioural states are still present in the last trimester of pregnancy, among which wake is present [57,58]; moreover, neuroinhibitors are present in fetal blood at a level insufficient to provoke actual sedation [59,60]: in their latest review of fetal awareness [61], the RCOG cite no more these two points as a demonstration of the deep sedation of the fetus, unlike they did in their previous paper on this topic [56]. Thus, it seems evident that a fetus or a newborn of similar gestational age can perceive stimuli since the middle of pregnancy. We have reported evidence that these stimulations can elicit specific responses when they are repeated in a few seconds or days; in the former case, this is a matter of habituation; in the latter, it is long-term memory. Habituation is a tool used in gynaecology to assess fetal well-being [62,63] as well as in neonatology [64-66].

This body of evidence shows that human beings already exhibit the beginnings of consciousness in the fetal and neonatal period. It will certainly be rudimentary consciousness, but it already contains the requisites for being so. Memory can develop in response to stimuli because the neural pathways that allow its emergence are present. And the presence of memory, we have seen, is the first sign of consciousness.

Previous papers excluded the presence of fetal consciousness [67], but recently the same authors accepted it, at least partially, writing that "the foetus can only be regarded as conscious at a rudimentary level" with "islands of consciousness" [68]. Nonetheless, evidence show that consciousness cannot be ruled out in the fetal period [57-60,69,70]. This is due to wake period in fetal third trimester [58] and to the inefficacy of blood neuroinhibitors, at the concentration present in fetal blood [57].

Obviously, the consciousness assessed in the fetal-neonatal period is not the same as that present in older children. In the latter, it is more explicit and should not be sought solely through indirect signs. However, these first rudiments of consciousness, detectable through subtle signs, are significant and seem indisputable. In older infants, consciousness signs will be increasingly evident. Studies measured infants' gaze toward target faces, and found an attentional blink in 5-month-old infants [71,72]. Perception of a second face is blocked approximately 1s after perception of the first face, suggesting a much longer attentional blink than in adults. This slow processing in infants is consistent with reported EEG signature findings of a late P300-like slow wave occurring in 5-month-old infants. Dopierala and Emberson [73] suggest that attentional blinking is a signal of conscious perception and, therefore, that these findings are evidence that newborns perceive consciously. The awareness of the "self" and personal experiences will be a further conquest: it will happen only after the first 12 months of life [74-76]. This is beyond the aims of this review.

A limitation of this study is that we needed to focus on the basic, almost rudimental bases of what can be acknowledged as "consciousness". Of course, we are aware that the debate is still ongoing on this definition [77] and the researchers' conclusions are far to be univocal [78]. However, we needed a starting point, and what we described in the first paragraph seems a good hypothesis. The fact that a dawn of memory is present across several experiments on fetal habituation or on their memory of prenatal sensations after birth, encourages us to propose this as a challenging research field.

Conclusion

This paper shows that a form of consciousness appears in the second half of pregnancy, with special evidence after 35 weeks of gestation [43]. The basic features for its presence (stimulus reception, brain development, and memory) start some activity since the second trimester of pregnancy, and they will mature in the following weeks. Other researchers recently admitted the possibility of a fetal consciousness [68]. This is an important step in the acknowledgement of consciousness development: the presence of the baby within or outside of their mothers' uterus does not determine it, but the grade of their neurological development does.

What this means in terms of personal experience of the developing individual, is not known. This kind of consciousness is present, though rudimental, and of course it is not describable in words. However, it will become more personal and evident as time passes; the importance of precocious experiences is crucial in this process. The advances in psychology [77-79] have shown how early experiences profoundly impact a child's future life, even if these experiences occur at a time when the child is unable to express themself or appears unresponsive to their environment. Thus, early experiences and stimuli can leave a significant mark on the early conscience.

Conflict of Interest Statement

None to declare.

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