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Journal of Clinical Research and Reports

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Review Article

# Why Intellectual Stimulation is Important before Birth?

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**Received date:** July 02, 2026; **Accepted date:** July 15, 2026; **Published date:** August 07, 2026

**Citation:** Zygmunt L. Ostrowski, (2026), Why Intellectual Stimulation is Important before Birth? *J Clinical Research and Reports,* 24(3); **DOI:**10.31579/2690-1919/642



## Abstract

Advances in developmental neuroscience have significantly expanded our understanding of fetal brain maturation, demonstrating that the fetus is capable of perceiving, processing, and retaining sensory information during pregnancy. Research involving fetal behavior and premature infants indicates that prenatal exposure to auditory, tactile, and emotional stimuli contributes to the development of neural pathways associated with learning and memory. These findings support the view that the intrauterine environment serves as the earliest setting for cognitive development, where maternal interactions and environmental influences begin shaping the child's intellectual potential.

**Keywords:** fetus; intellectual stimulation; emotions; conscience; sounds; touches; iq

## Introduction

In 1989, the international colloquium on intellectual stimulation at the very beginning of life, organized by the European Association for Child Development [1] under the auspices of UNESCO in Paris showed already that it is important to take into consideration the intellectual stimulation which can begin not only from the first weeks of life but also before birth. These considerations may have long-term consequences to a greater extent than other health problems that have already been addressed. The conclusions of this colloquium, even if they were only fragmentary and appeared more often as suggestions, were considerable.

Unfortunately, it is the period about which we know the least even if recent research on brain development in the uterus increased our knowledge about maturation and memorisation. Only studies in later fetal life could be conducted in infants born prematurely, assuming that these babies developed before birth would develop after birth in exactly the same way as babies who remain in the womb for the average duration of pregnancy [2]. According to Brian and Robert Morgan [3], "the greatest and subtlest qualities of the human mind lie in its capacity to think and reason, that is, in its intellect".

Rather than being born as "blank slate", a newborn has already surprisingly extensive experiences on the surrounding world.

Today, we have more knowledge and enough data and observations that babies in utero memorise and that intellectual stimulation before birth has the effect of faster intellectual development of the child. Sounds, touches, emotions and socio-cultural environment are of great importance in intellectual stimulation as early as possible. The importance of conscience, longtime neglected before birth, must be taken into consideration.

### The Brain

Anatomically, the brain develops very early, during embryogenesis, in a strictly programmed way, during which we witness the establishment of connections that will gradually constitute the adult brain.

Human embryonic development or human embryogenesis is the development and formation of the human embryo from fertilisation to the fourth week of development. It is characterised by the processes of cell division and cellular differentiation of the embryo that occurs during the early stages of development, it means the development of the human body entails growth from a one-celled zygote to an adult human being. Then, from the fourth to eighth week, we talk about organogenesis, the development of the organs that continues until birth.

Brain maturation begins in the first month of embryonic development in utero, between the 19 and 28 days. Embryonic cells form nerve tissue and give rise to neurons, which appear around the 4th week.

Neuron migration is essential for the formation of the complex neural circuits that underlie the child's cognitive and behavioral functions. The first synapses begin forming in the fetus's spinal cord and by the sixth week, these early neural connections permit the first fetal movements that researchers can detect through ultrasound imaging. The synapse is a space that separates two neurons; It plays a crucial role in the transmission of nerve information.

After the neuron production is practically completed, the glial cell production continues until the end of pregnancy [4]. The maximum number of neurons remaining in the fetus depends on the neurons or group of neurons that establish enough connections [5].

From the eighth month of pregnancy, the number of neurons and synapses decreases. These neurons atrophy and die is a normal physiological process. In some cases, it is because they have performed vital functions

and are no longer needed, in others it is because they are superfluous and have not been stimulated enough to make connections.

The stabilised phase probably occurs in the last trimester of pregnancy, but in the initial phase of the installation, a stable network already operates under the influence of external stimuli. This period is critical. There are differences in the quantity and quality of stimuli before and after birth. Before birth, the transfer of neuromediators is possible in the placenta.

For Claudia Clopath [6], "Memories are thought to be stored in the connections between neurons called synapses, whose strength can be changed by learning. Every new memory changes the synapse strengths, which in turn alters previously stored memories. This phenomenon is puzzling, because some memories appear to be stored for an entire lifetime. Synaptic plasticity is thought to be the basis of learning and memory".

Thus, the more the brain is stimulated, the more the connections between neurons persist. By stimulating different sensory systems of the fetus, one can reduce the removal of neurons and increase the number of connections [7].

From a functional point of view, development is a learning function. It is known that programming is partly genetically determined (programming defects can result from innate errors or toxic aggression). A team of researchers from the MedUni University in Vienna have shown for the first time that fetal brain development can be measured using functional magnetic resonance imaging (MRI) in the womb.

The brain takes control of bodily functions already in the second trimester. It is possible to measure or record a child's brain activity during external stimulation. It is also possible to observe the movement and expression of the baby's face (smiles and grimaces) using tomography (intersubjectivity in infants), also thanks to the latest medical imaging and micro cinematography technologies (environmental electron microscopy, cellular micro cinematography, computed tomography, MRI, positron emission tomography (PET), 4D ultrasound, foetal scoundrel).

## Sleep and dream

Sleep and the development of the senses depend on age (during pregnancy and after birth). Studies have revealed that in foetuses, 27 weeks of gestation, restless sleep appears, similar to REM sleep. The alternation of the two phases of sleep becomes regular from thirty-six weeks of gestation, even if an indeterminate form of sleep persists.

The research of Michel Jouvet's team showed that there is a genetic programming of REM sleep. This phase of sleep is also characterised by hundreds of eye movements while the rest of the body is sluggish. Jouvet postulates that REM sleep corresponds to the dreams that we remember. The idea emerged of a genetically programmed pattern of motor activation responsible for this state of "seismic" sleep. Such a pattern would underlie, for example, the facial mimics displayed during sleep in early life, whose function would be to "pre-practice" a specific behaviour. Jouvet proposes the speculative theory according to which the function of the dream is "an iterative neurological reprogramming to preserve in the individual the psychological heredity at the basis of his personality". His hypotheses concerning the function of the dream invalidate, according to him, those of Freud; they are, however, like Jungian theories on the function of dreams. He realised that to the different phases of sleep described so far, a new one had to be added, which is characterised by intense cortical activity that resembles those recorded during wakefulness.

According to Curzi-Dascalova [8], "Several data support the hypothesis that restless sleep is essential for the integration of information from the environment and for maintenance, recapitulation, the development of certain innate functions. Observations of fetal behaviour using ultrasound show that both stages of sleep exist in utero, with a clear predominance of time spent in restless sleep." According to Marie-Josephe Challamel [9], the sleep of the fetus is completely independent of that of its mother; there is, however, a circadian influence.

At the 15th week of pregnancy – a period of complete brain formation – we observe better coordination of movements, smiling, and sobbing. When the fetus sleeps, it is possible to see on 3D ultrasound panoply of emotional expressions towards the end of the second trimester: joy, fear, or anger is easy to decipher.

In the 25th week, the foetus begins to recognise certain elements or situations: it has a certain awareness of our presence. In the 27th week, some researchers claim that at this stage of development, the fetus is already dreaming. Beta or REM brain waves, which are fast and of low amplitude, have been detected.

They are associated with the REM sleep phase. "Since infants and fetuses spend much of each day in rapid eye movement sleep, it's not clear if they're dreaming. If we think of dreams as simulations of reality, we might ask what earlier model of the world the child, with his very limited experience, could rely on to generate the dream content. This becomes even more relevant when we ask the question of newborns or fetuses," concludes Tim Bayne [10].

Howard Roffwarg's [11] research has shown that fetal sleep is identical to that of a premature baby at the same gestational age: the first periods of restless sleep appear as early as the sixth month of pregnancy (28 weeks), and restless sleep individualizes earlier than restful sleep. Its amount increases very quickly: it accounts for about 65% of the sleep time in the eighth month of pregnancy. Several studies suggest that the amount of this restless sleep decreases close to the deadline. In the uterus, a peaceful awakening is practically absent. According to Howard Roffwarg, paradoxical sleep (REM) may play a role in brain development and maturation: a very large amount of REM sleep in immature infants at birth "…would allow the establishment and development of neural circuits and the maturation of the brain during fetal life and the first months of life".

Changes in the sleep phase are faster if premature babies are stimulated by an increase in active sleep. It is possible that agitated sleep represents a memorization phase. It is a phase during which the fetus sleeps, but its mental activity is at maximum. Its brain sorts and organises the data it collected when it was awake. In older children, intensive learning prolongs the duration of active sleep, and lack of sleep reduces performance the next day.

## Emotions

Emotions are thoughts which are dependent on certain activities in regions of the brain who manage our attention. It is the limbic system that is the center of emotions and memory. Higher cognitive functions who concern perception, conscious thought, language and long-term reasoning are situated in the neocortex.

In utero, baby's development takes place on a physical level, but also on an emotional level. The baby has a special bond with its mother and lives in total communion with her. According to Alban Lemasson and Martine Hausberger, the fetus can feel its mother's emotions, whether they are positive or negative.

When stressed, the mother's body releases cortisol. Scientists have established that cortisol crosses the placental barrier and can be found in significant amounts in the amniotic fluid. As a result of its presence, the fetus's heart rate is likely to slow down. It is possible that prolonged exposure to maternal stress can have consequences on the baby's development and impact of his future life. Studies by Zietlow [12] and Wu & all. [13] show that fetuses exposed to high levels of maternal stress may exhibit alterations in the development of their auditory system and, consequently, in their language development.

Sensory stimuli and the emotional state of the mother therefore have a crucial impact on the fetus and then on the child's future behaviour and character.

Today, we have data on early emotion imprinting, biological memory, and its effects on child development. Their sensitivity should not be underestimated, as a child's learning and social connections are directly related to their emotional capacity.

It's known that emotions already play a role in utero. This sudden and intense internal reaction runs through the body and mind. It responds to a stimulus and a cause, specific to the baby. According to a study, published by The Conversation, conducted by two researchers from the University of Rennes, there is evidence that the mother's emotions and psychological state play a major role in the baby's evolutionary process.

In utero, the developing fetus learns about the outside world and shapes itself through this bond woven from the moment of conception. The baby is extremely receptive to his mother's behaviour, tastes, sounds and emotions. It smiles when perceives a pleasant taste. It can hear and recognise the sound of his mother's voice; but also, the feelings of a mother who has experienced a stressful life event during pregnancy. Few studies have even found a link between stressful or very exciting life before conception events (PSLEs) [14].

The emotional state of a newborn depends largely on the environment and especially on the living conditions of the mother. The development of happiness is impossible without positive influences. Mental depression is a later phenomenon that occurs at the beginning of the second semester after birth. Depression in mothers before, during, and after pregnancy (immediately or delayed) can have a significant impact on the emotional state of the baby.

## Conscience

A conscience is a cognitive process that elicits emotion and rational associations based on an individual's moral philosophy or value system. But Socrates (470-399 B.C.) and Platon (428-347 B.C.) believed that consciousness, which he calls the soul, is eternal, is not produced by the body, and in fact transmigrates from one body to another.

Neuroscientists from the University of Tübingen in Germany, the Trinity College Dublin in Ireland, the University of Minnesota in the United States, and the Monash University in Australia, conducted a literature review on prenatal and neonatal consciousness. They determined a trend toward an awakening that already occurred during the last month of pregnancy.

According to Tim Bayne et al, "…Some theorists suggest that consciousness requires cognitive abilities that are likely to appear even as early as the gestational age of 24 to 26 weeks, which is when thalamocortical connectivity is first established. Preterm infants and fetuses of equivalent age share some common patterns of cortical activity and both have remarkable learning abilities. Given the difficulties of in utero imaging and the relative ease with which preterm infants can be studied."

The human foetus feels very early on that it is in a perfectly cosy and ideal place. Thanks to his senses, which develop from the twelfth week, it tastes and touches. Moreover, the fetus is able to register the well-being in which it is immersed.

The cognitive neuroscientist, Sid Kouider, in his work on the neural signatures of cognitive processing, relies on psychophysics and brain imaging. Based on his experiences, the consciousness in question is a perceptual consciousness, a primary consciousness. It is not a question of the reflexive consciousness that appears later and allows the subject to conceive of himself as separate from the world around him. Indeed, unborn babies have long been considered beings with limited skills and with mainly automatic, reflex-like behaviours that are not accompanied by a conscious subjective experience. Kuider's study, titled "Discovery of a Neural Marker of Conscious Perception in Newborns" (LSCP), rigorously established that infants have a brain response to external stimuli identical to that of adults.

Recently, the debate on conscience during pregnancy remains open. The few studies on consciousness at this time are not very precise. It is generally accepted that consciousness requires a thalamocortical structure.

According to Stanislas Dehaene, no one knows exactly at what stage it is relevant to talk about consciousness, but experts agree that it can be even before birth. To find out, French researchers in 2017 examined the brain activity of infants born prematurely at the beginning of the third trimester of pregnancy, when the brain is in place. "Around seven and a half months of pregnancy, the foetus knows the difference between the 'be' sound and the 'ga' sound, between male and female voices," says Stanislas Dehaene.

The specialised scientific journal Trends in Cognitive Sciences (December 15, 2023) published a study according to which consciousness could appear in the foetus as early as the third trimester of pregnancy. According to Bayne et al. [15] "Evidence indicates that consciousness began before birth.... at about 24 to 26 weeks of gestation."

Julia Moser, from the University of Minnesota, has also shown that fetuses, as early as the third trimester, seem to be able to learn auditory beeping sequences. "When an auditory tone deviates from a pattern established earlier in the experiment, the fetus shows this 'surprise' response in its magnetic brain activity. Neuronal activity shows a deviation on the ground as if the fetus is saying 'huh'?".

We have evidence that the baby in utero is conscious (reactions to sound, touch, emotions…). According to Lagercrantz and Changeux [16] "...it is unlikely that these reactions are preprogrammed and have an unconscious subcortical origin".

## Sound Stimuli

It is clear that in the womb, babies are familiar with sound stimuli. According to Denis Querleu [17], "There is an intrauterine background noise consisting of physiological noises from vascular noises (aorta) but also placental noises that introduce frequencies between 500 and 1000 Hertz. Physiological intrauterine background noise was noted at 28 decibels. When recorded the intensity of the mother's voice, it emerged 24 decibels above this background noise. For outside voices, the emergence is of the order of 8 to 12 decibels, so less important. The maternal voice is perceived more intensely because it brings the body into vibrations. Voices are detimbred, because the absorption of external sounds is such that low sounds are not absorbed and high-pitched sounds lose about 30 decibels, causing the timbre to change. On the other hand, the intonation persists since it is below 800 Hertz (it is a frequency well transmitted in utero)."

The fetus hears in the womb; it is immersed in a permanent sound environment long before the formation of the auditory system. It perceives the vibrations of sounds from the bones of his skull and the maternal pelvis which act as resonators. From the 7th week of pregnancy, the vibrations of the music or the various sounds perceived give the child his first emotions. Already between the 5th and 8th month of pregnancy the foetus can record perceived sounds and has the opportunity to remember them.

What passes through the placenta are molecules of a relatively low weight. The baby hears sounds, but the mother's voice, as well as external voices, is changed. The fetus perceives its mother's drive state through the rhythmic vocal expressions of its speech (DeCasper& Spence, 1986; Fifer and Moon, 1995; Hepper, 1995; Lecanuet, 1996).

The sound recognition rate is about 30%. High-pitched sounds are less well perceived, since it is filtered by the mother's amniotic fluid and

abdominal wall. Low pitches are transmitted better through the hearing already from weeks 19–20 of pregnancy [18].

Babies are found to remember the sounds they heard and experienced in the womb [19]. In the uterus, the foetus's emotions increase tenfold when it hears music. Sounds and vibrations come like waves caressing the little lips of his/her mouth and his/her hands. This small child is upset by these vivid sensations that give him/her intense feelings and emotions. When the foetus listens to music, it broadcasts and creates in it the effect of relaxation and harmony, an effect that lasts even after birth

Music promotes logical development and memorisation. There are many indications of a kind of prenatal memorisation. This memorisation relates to the recognition of perceived intonations in the placenta (a 4-day-old baby already recognises its mother's voice).

Other techniques used to stimulate the foetus's auditory system include the mother speaking to the foetus and using music with simple rhythm and melody [20]. To test the hypothesis that fetal memory persists into the neonatal period, 41 newborns were repeatedly stimulated by using fontal vibro-acoustic stimulation and were compared with 31 controls. The newborns who were stimulated in utero habituated earlier than those who had not previously experienced the stimulation [21]. These results suggest that the foetuses were able to learn.

Music is therefore an essential pillar of development that allows the baby to awaken and to develop its intellectual capacities. It is known that the foetus has different reactions depending on the type of music. For example, it calms down with Mozart and becomes agitated while listening to rock music.

A study by the Spanish Institute reveals that foetuses are particularly sensitive to classical music (Mozart, Bach, Prokofiev). For example, Mozart's Little Night Music stimulates nine out of ten foetuses. The study is based on the baby's stimulation in utero, via the movements of their lips and tongue.

Since the fetus associates sounds and emotions and memories of them, it is important to stimulate them by all means. Babies exposed to a rich variety of sounds and language stimuli before birth can show, according to Mariani [22] and Movalled [23], signs of accelerated development in these areas.

Music also promotes children's concentration. Listening to a melody develops the infant's listening skills, which is essential in learning a language. Music stimulates children's creativity and awakens and promotes good intellectual development. An infant who lives with music learns to live with other children and develops a broader ability to communicate with those around him/her.

An Italian study called "in Canto" [24] that lasted 6 years (from the sixth month of pregnancy to 6 years) was conducted on children whose mothers had taken music or singing classes. This study found that children have a memory for the melodies perceived in the womb. These same children chirped earlier and demonstrated an earlier ability to articulate the first words. They were able to sing just before they were 3 years old, whereas in other children, this ability was only observed around the age of 6 years.

Hearing is one of the sharpest senses when a baby is born. The development of the ear begins as early as the third week of gestation and continues until the 24th week, when the fetus can begin to hear sounds in a significant way. The bones of the inner ear, eardrum, and associated structures form and become functional, allowing the fetus to pick up sound vibrations.

From birth, the baby turns its head to the source of sound but does not distinguish between different sound sources. Children begin to communicate through radiant smiles.

Recent research shows that babies begin to perceive and process sounds long before they are born. This phenomenon, often referred to as "language in utero," reveals that foetuses are exposed to a variety of auditory stimuli that play a crucial role in their cognitive and linguistic development. Among all the noises and vibrations, the maternal voice, is one of the clearest sounds perceived by the foetus. Research has shown that newborns recognise and prefer their mother's voice over other people's. Moreover, according to Busnel & Heron [25], they also show a preference for the language spoken by their mother during pregnancy. This early recognition indicates that auditory learning begins in utero.

From the eighth day after birth to the third week of life, they try to grab with their hands. The first characteristics of language appear at between 2 and 3 months of age. This location of the sound source will develop at around the third month, which will allow the baby to distinguish between sounds and voices. In a newborn, the response to sound stimuli depends on the specific time within the sleep cycle and on the stability and duration of sleep. The maturation of the auditory system will be effective at around the sixth month, and the baby will then be sensitive to intonations and music. With modification in anatomical conditions, the onset of intelligible speech can also occur at the age of about 6 months. The mother tongue affects the production of vocal sounds after 10 months of age.

According to a study "The Mozart Effect" by the University of California (1993) [26], in students exposed for 10 minutes to classical music, their IQ increased by 8 points. It is known that a child in a multilingual environment will be able to learn another language more easily. Indeed, the brain is "open" to the sounds of several languages, so it will quickly master them in practice. This is related to the stimulation of neurons that establish links between them.

New research, published by Eino Partanen & all, in the PLOS ONE journal, shows that exposure to music before birth can indeed influence a child's long-term memory. "Our results show that extensive prenatal exposure to a melody induces neural representations that last for several months."

Music radically develops emotional sensitivity. For children, music with more catchy rhythms and lyrics promotes memory and language learning. Music is a language.

## Touch

Touch is the psychic organiser of the human being, the sense in which the sense of the unity of the self develops. Touch is the first sense that develops in the foetus, long before hearing. Some touch receptors appear as early as the 4th week of pregnancy. Around the 7th week, touch receptors are present on the foetus's mouth: the foetus moves when something touches its lips. Later, around 11 weeks, touch receptors are present on his face, the palms of his hands, and the soles of his feet. In the womb, the foetus is exposed to several tactile sensations. It moves in all directions and likes to snuggle and rub his nose against the wall of the amniotic sac. It also sucks his thumb and plays with his umbilical cord or with his feet.

Unfortunately, birth specialists have underestimated the extent of fatal sensory and cognitive capacities, even though they were known to Descartes (1596–1650) who stated: "Touch is the most certain of all the senses and the ultimate foundation of all-natural certainty."

Long before, Aristotle (384-322 BC) had already put forward the idea that taste was a kind of touch since the sensations perceived by taste depend, as for touch, on a direct contact of our body with the things whose properties we want to perceive.

At the beginning of the twentieth century, researchers at the German School of Psychology introduced the word "haptics" to mean the mechanical sliding of the fingers on the surface of objects that is the source of a significant part of conscious sensations.

More recently, Vincent Hayward (1955–2023), Nobel Prize winner for studies on the understanding of the sense of touch and "haptic" systems

aimed at reproducing tactile sensations, as well as David Julius and Ardem Patapoutian, 2021 Nobel Prize in Medicine for their discoveries on touch receptors, have advanced research on touch.

According to Lejeune and Gentaz [27], "Touch, the first of the senses to develop in utero, plays an essential role in the cognitive perceptual development of the child". For Concetta Pagano [28], "It is in fact a part of a complex sensory modality, somaesthesia, which is differentiated from the other four so-called specific sensory modalities: olfaction, taste, vision and hearing. Finally, sensation is the message that the skin sends to the brain and that the brain integrates, in connection with all the concomitant events, producing a perception."

Since touch is a very powerful non-verbal mode of communication, it allows us to convey our empathy sometimes better than by speaking.

Developed by Dutch scientist Frans Veldman [29], haptonomy is a technique that focuses primarily on touch and offers future parents the opportunity to get in touch with their baby in utero through touch. Touching and caressing by parents are very important for developing attachment and a sense of security in the baby. The physical presence of his parents stimulates his immune and hormonal system. Following Bremer & Spence [30], this has a positive effect on their growth and attachment hormone levels, while also decreasing their stress hormone levels.

Tiffany Field [31], said "…that the new Touch Research Institute at the University of Miami School of Medicine, is the first of its kind in the world for touch and skin. So, although the skin is the largest sensory organ in the body, it has been the most neglected research topic." According to Field, "…touch is especially important for fetal growth and development."

Why does touching have this effect? Apparently, touch stimulates brain chemicals that are crucial for growth. Saul Schanberg and his associates [32] at Duke University demonstrated this with pups (newborn rats). Stress releases painkillers called endorphins from the human nervous system. Endorphins inhibit the production of ornithine decarboxylase (ODC), the brain hormone that stimulates growth.

## Skin

The skin and the brain, these two organs have the particularity of sharing the same embryological origin. On the 21st day of embryonic development, its outer cell layer gives rise to the nervous system and epidermis, which explains the similarities between skin cells and neurons.

The embryo is covered with a layer of flat cells (epidermis) and six months later, the nerve pathways that connect the skin to the spinal cord are established.

There is an interaction between the brain and the skin.

Martine Colignon [33] described in her book "The skin, metaphor for an encounter between art and clinic" that the skin as being "metaphorically a second brain" or an "extension" of the brain.

The skin's neural system, which represents the outermost boundary of the nervous system, serves as the primary sensor of environmental stimuli. It contains various afferent nerve fibres that transmit different types of sensory information to the brain. This information is detected by a specific class of receptors, called "s" receptors, which are distributed throughout the skin and specialise not only in perceiving physical stimuli, but also in converting these stimuli into electrical signals. These signals travel through the afferent nerve fibres of sensory neurons to the central nervous system, where they are processed and interpreted by a transduction mechanism.

A neural network captures tactile sensory information and causes oxytocin to be released into the blood, as a neurohormone, and into brain regions as a neuromodulator. If the sensation is pleasant, the secretion of oxytocin and serotonin increases. Under the effect of stimuli, the skin sends messages to the brain, which in turn responds with the local release of neuromediators, including beta endorphins, which has analgaesic effects.

According to Valentina Lucia La Rosa et al. [34], "The neurophysiological basis of affective touch involves a set of nerve fibres called C-tactile afferents (CTs). The activation of afferent CT plays a critical role in the brain's processing of tactile stimuli, particularly in the insular cortex, which is involved in assigning emotional value to sensory experiences. When CT fibres are stimulated by a gentle, slow touch, oxytocin is released both peripherally, in response to skin stimulation, and centrally, in the brain.

According to Dominique Cupa [35], "... The skin is the source, the place and the model of pleasure." As the first interface with the outside world, it remembers what is reassuring or what is suffering. It keeps the information of all contacts. Our epidermis seems to have its own language, responsible for relaying all the unspoken things in our lives.

The discoveries of these astonishing connections between skin and brain are very recent. The skin receives, the skin transmits, the skin vibrates and the skin lives. Skin reflects our emotions. The psychoanalyst Didier Anzieu [36], who wrote "Le Moi-Peau" in 1974, is convinced of that touching and letting oneself be touched is a source of psychic and bodily vitalisation [37]. In utero, the developing foetus learns about the outside world and shapes itself through this bond woven from the moment of conception.

The skin, the main organ of touch, is the most sensitive to touch. The face, fingertips and palms of the hands, the erogenous zone is very richly innervated (2,500 receptors per square centimetre in the fingertips). Receptors send sensory information to the central nervous system through the spinal cord or cranial nerves. Also, according to Jenkins and Lumpkin [38], "Tactile sensation is transmitted by mechanosensory neuron integrated into the skin and transmitting signals from the periphery to the central nervous system. During embryogenesis, axons elongate from these neurons to meet the developing skin."

Depending on the thickness of the fibrous tissue and the degree of myelination, the afferent fibres of the skin have different conduction velocities. Among the different types of fibres, Aβ fibres have a thick myelin sheath allowing rapid transmission of the signal from the skin to the central nervous system; C-fibres, which are unmyelinated and thin, conduct signals more slowly and are more sensitive to slow stimuli such as a gentle caress.

According to a recent study by Umea University in Sweden, neurons in the skin, especially those in the fingers, in addition to transmitting information about what they touch, interpret this information.

So, is the skin capable of "thinking"?

Recently, neuroscientists have confirmed what poets already knew: "Haptic memory and tactile sensations remain in our memory long after the encounter [39]."

According to Didier Anzieu [40], "Personality is first built by an awareness of the skin... hence the importance of touch". The skin is nevertheless the memory of our sensations and emotions. Indeed, according to the British Journal of Dermatology [41], some skin cells contain the memory of particular conditions.

Can or are these emotions transmitted to the baby in utero? Do they indeed have on this baby? Do they have an effect on his conscience?

If so, which part of the skin will be most sensitive to the touch? Does the skin of the pregnant woman's belly, which is very frequently affected, have any particular effects on the baby? By custom and for various reasons, the father would touch the pregnant woman's belly in the belief

that this would be felt by the baby. The pregnant woman is convinced that these touches soothe and calm her baby...

From a psychological point of view, this touch comforts and reassures the mother and father. However, it does not seem that this touch has a direct effect on the baby, but it certainly does have an effect on the pregnant woman who transmits her emotions to the baby.

The place of touch plays a fundamental role. The more sensitive the place is to touch, i.e. the more receptors there are that transmit information to the pregnant woman's brain, the more her emotions can be felt by the baby. However, it is necessary to take into consideration the singular sensitivity of each woman.

So which areas of the body will the skin be more sensitive to touch?

Indeed, this system differs from other sensory systems because its sensory receptors are distributed throughout the body and not in localized places such as those of vision or hearing.

The number of receptors varies from one region of the body to another. Since the forehead of the face, fingers and dorsal aspect of the hand contain a very large number of the receptors, direct contact of the fingers with these regions seems to have a greater effect on the emotions felt.

However, if it is a father's touch, accompanied by his thoughts, the effect on the emotions felt is stronger.

## Intelligence

During intrauterine life, the brain of the future baby develops several skills that will be useful in his future intellectual life.

Intelligence is characterised through logic and the ability to use language to express one's thoughts and to understand others. There are six other forms of intelligence. Spatial intelligence: from the 12th week of pregnancy, the foetus moves in reaction to stimuli, it is aware of the amniotic environment in which it moves with agility. Musical intelligence: the fetus has different reactions depending on the type of music. Body intelligence: the fetus controls its body and movements. Interpersonal intelligence: the foetus can understand its own personal emotions; he may smile when he perceives a pleasant taste. Intrapersonal intelligence: the foetus develops an ability to bond with the twin. Logical intelligence: the fetus responds with the same number of kicks if we give its mother few small taps on her belly.

Is the child's intelligence transmitted only through the mother because the genes for intelligence come from the X chromosome? According to an American scientific study [42] this possibility is due to the fact that women have two X chromosomes who are more likely (than men's X chromosome) to influence their children's cognitive abilities. Jessica Delgado [43] added that "… in the embryo, certain genes that play an important role in brain development are only active if they are found on a chromosome from the mother". Also, Lehrke [44] said that the genes influencing cognitive abilities (memorisation, language, attention, reasoning faculties, etc.) were all located on the X sex chromosome.

Professor Nicolas Pilon described that a similar phenomenon exists in genes that have a paternal X chromosome. Also, other scientists reveals that the father influences many aspects of cognitive development. Some scientists agree that the mother's genes, like the father's, play an essential role in the development of a child's brain, but it's really the interaction between the genes and the environment that makes all the difference.

Professor Michael R. Johnson and al. [45] of Imperial College London showed that "…genetics plays a role in intelligence, but we didn't know which ones were involved in our cognitive performance or to what extent they interacted with each other. Probably it is possible to develop others through stimulation and exercises." Michael R. Johnson [46] added that "… maternal genetic fingerprinting does influence a child's brain development, but not more so than a father. For this reason, intelligence is not defined solely by the X chromosome. The research has shown that our cognitive abilities depend on two important networks of genes, M1 and M3, which together contain nearly 1,200 genes". Genetics plays a role in intelligence, but until now we didn't know which genes were involved, concluded Professor Johnson.

According to Howard Gardner [47], intellectual improvement requires the development of skills that already exist at the very beginning of life. Therefore, from the first months of pregnancy, intellectual stimulation should be included in the "care programs" for the pregnant mother. We do not yet have scientific evidence for the effects of intellectual stimulation of the child in the period before birth, but we have enough observations that stimulation before birth causes faster intellectual development of the child.

## Taste and Smell

Taste and smell are archaic cognitive ways. The baby's taste buds start forming during the first two months of pregnancy. According to Witt and Reutter [48], "In human foetuses, taste buds develop anatomically at 8 weeks' gestation". Those taste buds are already connecting to the brain through tiny nerve cells.

Eight weeks later, taste pores are in place. At that time the baby has started swallowing amniotic fluid.

Amniotic fluid is the first place where foetuses start to sense their environment.

The sensory modalities of taste and olfaction are functional very early, practically from the fourth month of intrauterine life. This has been proven, for example, by injecting pregnant woman intravenous glucose solutions. When glucose arrives in the amniotic fluid, the foetus begins faster to suckle and swallow amniotic fluid, since it is sweeter.

The very first flavour is the salty amniotic fluid. Three weeks later the taste buds will recognise taste sensations like sweet, salty, bitter, sour, and umami. At around 32 to 36 weeks, the baby reacts to the flavours with discernible facial movements.

The psychologists of the Durham's Fetal Neonatal Research Laboratory have shown the first direct evidence that babies react differently to various smells and tastes by looking at their facial expressions. Ustun, Reissland and Blissett [49] study demonstrates that it is possible to visualise the short-term development of facial expressive reactivity to flavours during late pregnancy.

Breastfeeding promotes the discovery of these different flavours and develops taste, as well as the subsequent diversification of the diet (4 basic flavours: salty, sweet, sour, and bitter).

Smell is a much richer feeling and does not develop as a hedonic model. The sense of smell start developing around weeks 9 to 11 of pregnancy.

From the 24th week of pregnancy, a baby perceives odours thanks to the amniotic fluid, which carries odour molecules from the food, Mother eats. Smell is always an emotional pattern: cultural and from personal experience. According to Maty Soule [50], a person perceives 500 up to 10,000 smells. At birth, his nose is already an ultra-sensitive sensor, capable of recognising and being soothed by familiar smells.

## Sight

Vision is the last sense to develop in the foetus. During week 4 of pregnancy, cells from the developing brain tissue begin to form two optic nerves, one on each side of the head. These thick bundles of millions of individual nerve fibres will pass information from the eyes to the brain and vice versa. The eye structure has become even more complex.

The retina (the layer of cells at the back of the eye that perceive and process light) has begun to form but it still lacks pigments that will be sensitive to light, to its shades of intensity and colour. The cones and rods

are still widely dispersed on the retina, which explains the baby's very low visual acuity at birth.

By week 16, the baby's eyesight development has advanced to the point where it can start to pick up on light. The eyes can make slight movements from side to side in response to it, even though the eyelids still aren't open. The eyelids remain fused until the 24th week of pregnancy.

At 26 weeks, the fetus has eyelids partially open, by 28 weeks the eyes are wide open and at 31 weeks the pupils can constrict, dilate, and detect light. The baby can distinguish shadows and shade in the light. It reacts as if a strong light is directed at its mother's belly. Its heart beats faster when a light source is inserted during an amnioscopy. This reaction means that its visual system is sensitive to light. Purpura found that "… the cells of the primary visual area of the cortex had their chief burst of maturation in the relatively brief period between 28 and 32 postmenstrual weeks. At this time the dendrites grew and 'spines' appeared on them, which is believed to signify full maturation."

Following to Tim Donovan & all. [51], "In 2D ultrasound, the lens of the fetal eye can be distinguished as white circles within the hypoechoic eyeball, and eye movements can be visualised from about 15 weeks' gestation. It has been shown that for 31 weeks gestational age the foetal sensory system is capable of directed vision if enough light is available."

Vision begins to develop from birth when the sharpness is only 1/10. Net perception is about 30–50 cm distance. About 8–10 days after birth, the baby fixates its eyes on nearby objects. At around one month, the baby follows large, close objects at an angle of 90° and on a horizontal plane. In the second month, objects are tracked at an angle of 180°, always on a horizontal plane. The child sees colours. Human faces attract his/her attention and he/she smiles at them. At 3–4 months, the vision is bright to 80 cm; the gaze is both vertical and horizontal. Binocular vision begins at around 4–6 months. After 6 months, the development of the eye is complete. From 9 to 24 months there is precise coordination of vision, ending with depth perception. Peripheral vision develops between 12 and 18 months and visual acuity is 10/10 at 24 months [52].

### The Influence of the Sociocultural Environment

It is difficult to assess the role of the environment and genetics with precision, concerning the intellectual development of children.

The influence of the socio-cultural environment is of great importance. The environment has a significant impact on children's emotional responses and intelligence. Intelligence is not acquired from birth; it is necessary to work on it and cultivate it. By developing the child's cognitive abilities, it significantly increases his/her IQ.

In view of the current accelerated technological development in our societies, we should better prepare future generations so that they can fully experience this evolution, and therefore intellectual stimulation should begin early, even before birth.

This action should also be a fundamental problem of states and international organisations in the field of health and well-being of MAN, as well as in education.

Observations in China showed the differences in the conception of the term of birth and the means of early children's stimulation.

For the Chinese, the baby is born at the time of conception (for us on the day of birth), so the age of the child is also counted from conception. Since the baby already exists during pregnancy, with time fast almost all its functions, it is considerate as a child.

Due to the one-child policy, the two parents and the four grandparents are present during pregnancy. This means that they can influence the baby's intellectual stimulation through discussions with the pregnant mother and even through the touch of her skin. Grandparents' words can act directly on the baby if they are low pitched, but they can especially affect the pregnant woman, triggering emotions that can act on the baby.

Observed since the last 30–40 years, the Chinese "boom" is associated not only with the political and economic opening of the country. The Chinese, who for a long time were hibernating and remained as if asleep, when they "woke up", they developed very fast, using their innate intellectual abilities thanks to the influence of several thousand years of civilisation and their intellectual abilities that were more developed than ours, at that time. An example is their spoken (4 intonations) and written (over 50,000 ideograms) language, which affects the brain's abilities. Remembering these thousands of signs is also decisive in the development of their brain. China has the highest average IQ in the world for 2025. This comes from a large IQ test taken by more than 1.3 million people around the world in 2024. China scored 107.19, which is the top score among all countries.

In Africa, the environment can affect the development of the brain, especially after birth when stimulation is the most important. The baby is constantly carried on the mother's back, so it is stimulated by movements, sounds, words and a varied field of vision. Unfortunately, from the age of 3 years, the intellectual "development curve" decreases in relation to "Western" children who are more stimulated by schools and the richness of the environment, compared to African children. In addition, despite the rapid growth in the level of education of African populations, following to Hyejun Chi & all [54], only 4% of African children had parents who jointly engaged in high stimulation.

## Discussion

During many months spent in the mother's womb, the foetus perceives sensations and emotions from its mother that it can remember them after birth.

In utero, baby's development takes place on a physical level, but also on an emotional and intellectual level. Since few decades, research on brain development in the uterus increased our knowledge about maturation and memorisation.

Since early brain development is highly sensitive to nutritional status, malnutrition in the foetus exerts its effects during early organisational processes such as neurogenesis, cell migration, and differentiation. Micronutrient deficiencies are intricately linked to unfavourable outcomes in child development, manifested through compromised neurocognitive functioning processes.

The consequences of malnutrition on the pregnant woman and the fetus depend on the degree of malnutrition (moderate to severe). Malnutrition of the mother certainly plays a role, but the fetus is protected, because it is the mother who, even if malnourished, "pays the price". On the other hand, if the pregnant woman is severely malnourished, she cannot be stimulated and she cannot stimulate her baby, even after birth.

There are many indications of a kind of prenatal memorisation. This memorisation relates to the recognition of perceived intonations in the placenta.

We know that the baby hears in the womb from the 7th week of pregnancy and reacts to vibrations and sounds very early. The vibrations of the music or the various sounds perceived give the baby his first real emotions. The newborns recognise and prefer their mother's voice over that of other persons, because the mother's voice is emitted not only through the abdominal wall but also through emotions in her voice. However, the family members' voices, especially the husbands' voices, have a greater impact because, not only of the low-pitch voice, but also of his thoughts which are received by the mother and probably by the baby. These precise, intensive and concentrated thoughts can be transmitted to the baby.

According to Karen Lawson from the University of Minnesota, thoughts are mental cognitions. While thoughts are shaped by life experiences, genetics, and education, they are generally under conscious control. Thoughts and emotions have a profound effect on one another. Thoughts can trigger emotions and also serve as an appraisal of that emotion.

Music promotes logical development and memorisation. After birth, music helps in socialisation. Barberos' studies [55], using electroencephalography (EEG) show that newborns respond differently to familiar sounds they have heard in the womb, suggesting a process of memorisation and recognition of sound patterns. This will mean that parent-baby communication begins in utero.

On the other hand, babies exposed to tonal languages like Chinese will show increased sensitivity to tonal variations compared to babies exposed to non-tonal languages. This early sensitivity to the specific characteristics of the mother tongue could, according to Busnel & Héron, lay the foundations for later language acquisition.

Also, the sensory modalities of taste and olfaction are functional very early, practically from the third-fourth month of intrauterine life. The fetus perceives primary flavours; its mother's scent is contained in the amniotic fluid and memorise them.

We know as well that the baby reacts emotionally to the touch of the mother's body. Touching and tapping the womb together with the kicking game of the foetus are among the techniques from week 27 of gestation. It is the best time for performing these techniques, in order to observe their beneficial effects on neonate behaviour and mother-neonate bonding [56]. Caressing the skin of the pregnant woman provokes emotions that affect the baby's emotional state. "Haptonomy" leads the father and mother to establish with the foetus a tender and complicit relationship. This is why the father's participation during pregnancy is highly appreciative. "Thus, haptonomic perinatal accompaniment is important in the life of a mother, a father and a child.", said Veldman.

A great importance is the emotional state of the mother herself. Fewer negative emotions she received, more positive impact on the baby's future lives may be observed. Researchers suggest that in utero communication helps train specific neural networks that facilitate language learning after birth. According to Busnel & Héron, speaking, singing, or reading aloud during pregnancy can not only strengthen the bond between Mother and fetus, but also support the baby's cognitive and linguistic development.

Observation of special events that occur around the pregnant woman may explain her emotional status, which may have repercussion on her baby. Emotions can be triggered by something external (from seeing someone who suffers or watching an event or a movie) or something internal (an upsetting memory). In a book about Franz Schubert, the author mentioned an episode when the mother was pregnant with Franz Schubert. She was very absorbed in the musical events that were happening around her. Since she was under these emotions, she had the impression that her baby was reacting with accelerated and repeated movements. Could the emotions felt by the baby have had repercussions on his developing brain, in the musical sense?

There are certainly similar events in many pregnant women, but they are often unknown or ignored.

Since any additional stimulation can be a chance for babies' further development, there are several ways of stimulation, observed both in the environment of the average population of European civilisation but, especially in the environment of a population still living in a traditional way, without education. Personal observations allowed to develop several stimulation schemes.

We can stimulate the baby before birth directly through sounds, songs, and music. It is known that the foetus has different reactions depending on the type of music. For example, it calms down with Mozart and becomes agitated while listening to rock music. Following Mariani & al. [57] and Movalled & al. [58] research, babies exposed to a rich variety of sounds and language stimuli before birth may show signs of accelerated development in these areas, since in utero communication helps train specific neural networks that facilitate language learning after birth.

Aside sound stimulation (especially by the voices of men), and haptonomy (touching mother's skin), also other activities may have an impact on babies in utero.

Indirectly, working on the mother's memory through certain intellectual activities may have as well an impact on babies' intellectual stimulation. Reading books, but more complicated than usual, leading to the strengthening of her attention. Painting or embroidery, according to the mother's abilities and possibilities, but more complicated or difficult, that require additional mental efforts.

The type of stimulation should be individualised. Often repetition of different stimulation is advised. Beyond intellectual stimulation, the effectiveness of stimulating babies' senses in utero remains the best way to give him/her the feeling of well-being and serenity. By developing the child's cognitive abilities, it significantly increases his/her IQ.

Of course, further studies would be desirable to confirm the impact of intellectual stimulation in utero.

But the reason for conducting studies must be carefully chosen.

The Marquès Institute, which specialises in gynaecology and obstetrics in Barcelona, has carried out a clinical study on the stimulation of the baby by music in the mother's womb. The objective of the study was to find out the effects of music on the brain of the unborn baby, using the vaginal route.

Three groups of pregnant women from the 16th week of pregnancy were formed to test the sound and music: abdominal with a sound level of 98 decibels, vaginal with a vibrator that emitted noises of 68 decibels and with a Babyhood with a sound level of 58 decibels. These pregnant women were monitored over several weeks of pregnancy through a 4D ultrasound during audio test phases and during sound rest phases.

The results showed that the babies responded significantly to the music transmitted vaginally with the Babypod. Each of the fetuses babbled, stuck out its tongue, opened its mouth to make a sound.

The conclusions were as follows: sounds passing through the abdominal route is distorted (the baby hears about 30 decibels), on the other hand, there is almost no loss of decibels or distortion of the sound or music passing directly through the vaginal route.

However, the danger of using the vaginal route and the loudspeaker must be raised. Indeed, the sounds will be louder and not distorted but aren't they more dangerous for the baby's brain because of the proximity of the speaker which emits the sounds transformed anyway by the Babypod. Sounds that are too loud can destroy sensory cells. And these cannot be rebuilt. The child can be born with cells that have already been damaged since the auditory system goes through a critical period of development from 27 weeks of gestation through six months of age. Music that is too loud or left on too long could damage the baby's developing inner ear. In addition, the mother and her baby are deprived of direct contact with the father or other persons around her.

## Conclusion

It would be advised to follow longitudinal observations on many pregnant women to get more detailed and significant data about the impact of intellectual stimulation before and after birth. Would it not be interesting to look at the pregnant women descriptions and to conduct a prospective studyo n several pregnant women to find out the effect of intellectual stimulation in utero on the effects in adulthood? It would also be interesting to involve in the study the influence of the father and all special events that occur around the pregnancy.

It would take decades of observations and recordings. Today, thanks to the use of computers and the recently developed and trendy impact of the artificial intelligence (AI), could lead to fascinating results: to know the impact in utero stimulation on future geniuses. The use of AI is not yet known, but the effects can be interesting.

In addition, the link between quantum physics and the enigma of the mind would soon become a major topic. In his book "The Quantum Origin of Consciousness - An Inquiry Into the Nature of Mind" [59], Emmanuel Ransford opens an interesting path towards a global understanding of existence, from collective consciousness to, perhaps one day, an artificial consciousness.

What will be the resonance with Socrates' and Platon's vision that the consciousness they call the soul is eternal, it is not produced by the body... Or to the Catholic Church, that the soul is the principle of man's life and thought…

## Recommendation

Intellectual stimulation at the earliest stages of life should be one of the most important concerns of health professionals in maternity and neonatology. It should be included in maternal care programs. It should also be a fundamental occupation for WHO, UNESCO and UNICEF.

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**DOI:10.31579/2690-1919/642**