medicinska revija
medical review

UDK : 59.953-053.13 ; 612.647:
159.953-053.13
ID BROJ: 193387532

Sovilj M. MD-Medical Data 2012;4(3): 259-266 *MEDICAL DATA / Vol. 4. No 3 /* IX 2012.

Originalni članci/
Original articles

PRENATAL MEMORY AND LEARNING *

PRENATALNA MEMORIJA I UČENJE *

Mirjana Sovilj

The Institute for Experimental Phonetics and Speech Pathology, Belgrade, Serbia
Life Activities Advancement Center, Belgrade, Serbia

Correspondence to:

dr sci Mirjana Sovilj,
Gospodar Jovanova 35,
11 000 Belgrade,Serbia
Tel: +381 11 625-232; fax: 324-168;
Mob. tel. 063/8118-336
E-mail: iefpgmir@gmail.com

*Invited paper /Rad po pozivu

Key words
prenatal child, fetus, memory, classical conditioning, habituation, prenatal, prenatal memory, prenatal learning, prenatal development

Ključne reči
prenatalno dete, fetus, memorija, klasično uslovljavanje, navikavanje, prenatalna memorija, prenatalno učenje, prenatalni razvoj

Abstract

This paper presents a short review of previous researches from the area of prenatal memory and learning. The aim of this paper is to illustrate results of the experimental researches which considerably clarified the question of the existence of memory and learning before birth using various learning patterns of the prenatal child (fetus) such as: classical conditioning, habituation, associative learning and imitation. The researches confirmed the existence of prenatal memory and the ability of prenatal learning.

1. INTRODUCTION

The question of the existence of fetal memory has occupied the attention of researchers for several centuries. In psychology, memory represents the ability of memorizing, storing and recalling information according to need. It is also the basis of normal functioning. The opinion that the baby is born as a „tabula rasa" has been long abandoned.

For a long time, it was believed that the newborn does not have functional memory, but rather a memory which is developed in the months and years after birth. Studies of newborns and prematurely born infants [1,2], changed this point of view. It was recognized that newborns have functional memory. However, we cannot claim that memory (when it starts functioning) is exercised as much as in adults. It is assumed that memory, in its developmental origin in the prenatal period, functions in a basic form, developing both qualitatively and quantitatively alongside with the individual's maturation.

Memory starts developing in the period which is determined by the status of the CNS maturity. If the CNS is developed enough to enable functioning of prenatal memory, it will be developed via different learning patterns such as: habituation [3,4], classical conditioning [5,6], associative learning [7,8], and immitation [9,10].

Large number of experiments aimed at researching prenatal memory and learning were carried out by prenatal auditory stimulation and postnatal follow-up of the newborn's memorized responses to the same auditory stimulus. These experiments indicated the influence of sensory experience in both prenatal and postnatal periods on the development of specific neural, behavioural and perceptual processes.

Let us consider how „programming of the prenatal child" is carried out according to Milakovic, which represents the scheme of the initial stage of creating the child's personality in the prenatal period. Milakovic presented this scheme far back in 1968, at the V International Congress of Biocybernetics in Naples and it was published in his book in 1986 [11]. The fact that after birth, the child is capable of surviving in the outer world means that this ability was acquired in the prenatal period. He asked the following question: How can the mother teach the baby in her womb to adjust to

future life conditions? The starting point was Sontag's theory [12], that the child is a part of the mother's psycho-soma, and that she transfers the states she is in via "blood excitations" thus transmitting her experiences to the child. Milakovic made a step further noting the process of „fetus programming" in the mother's ability to transfer her experience. It is via „blood excitation" that the mother teaches the prenatal child about everyday oscillations and models of frustration and satiation, which will be the content of its life after birth. Communication mother-child in the prenatal period is both mental and verbal, and is of the utmost importance for the child's development, whereas the mother's voice is the „spiritus movens" of the child's personality.

The simplified explanation would be that learning takes place on the metabolic level, because the areas of the CNS in charge of metabolic and vegetative control are fully developed, such as mesodiencephalon, where integration centres of psycho-soma relation are situated.

Via mechanisms structured in such a way, the prenatal child and the mother communicate via the placenta and information is transferred from the mother's mesodiencephalon to the child's mesodiencephalon in a few seconds, following the principle of the transmitter (mother) and the receiver (child). Programming of the child according to the simplified Milakovic's scheme [11], has the following stages (Figure 1):

1. In the first trimester of pregnancy, hereditary factors have a dominant role and the mother's messages do not penetrate into neurophysiological structure of the fetus. This formulation is no longer acceptable. Namely, it is certain that "communication" mother-child is present already at this period, although heredity is predominant.

2. In the second trimester, the mother's messages penetrate and program the child's structures by their rhythms, emotional reactions, attitudes etc.

3. In the third trimester, the prenatal child refuses the mother's messages and fights against inner and/or outer unpleasant influences, thus fighting for its own homeostasis.

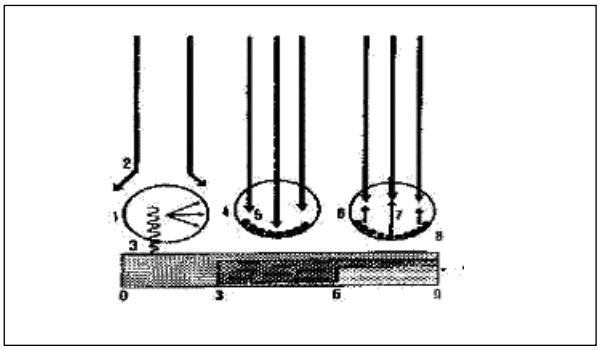

Figure 1. Programming of the child according to the simplified Milakovic's scheme

Figure 2 shows a simplified scheme (A) of the flow of information from the mother into the child's organism. 1, 2, 3 are stimuli which reach the mother's mesodiencephalon (4) from her senses, inner sensors and memory. Via reactions of mesodiencephalon, the mother's state is reflected on the composition of blood which circulates towards the placenta (5). Via the placenta (6), composition of the mother's blood is taken over by the child's blood (7) and then, via umbilical cord it enters its bloodstream and reaches the child's mesodiencephalon (8). Received information from the mother's blood is memorized as a program in the child's mesodiencephalon and other centres, and is completely identical to the mother's. This level of programming lasts from 0 to 6 months. Scheme B shows the period during which the child creates its own program with the aim of preserving homeostasis. Via auto control (10) it reacts to any influence which disturbs its homeostasis. Thus, the child will react to the mother's „messages" of thirst by drinking the amniotic fluid (swallowing movements are mastered), to her increased blood sugar it will react by the increased secretion of insulin, it sucks on its thumb (practicing sucking movements), movements of breathing are also noticed etc. In this period, it practices the functions which are primary in preserving life immediately after birth. Communication mother-child is intensive and it can be physically detected by intensifying or reducing child's movements while verbally addressing the child, stroking the abdomen, listening to music etc. This process of programming is realized within 6 to 9 months.

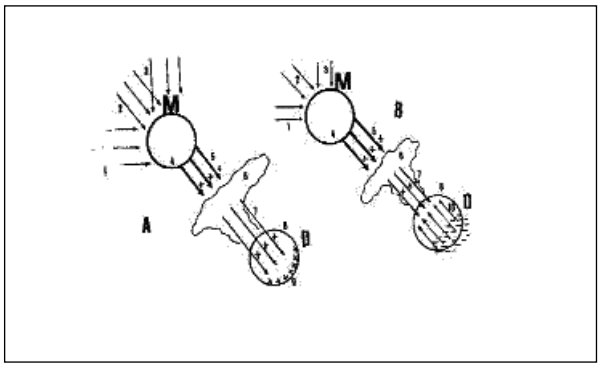

Figure 2. Process of information flow from the mother into child's organism

This simplified presentation of the programming process of the prenatal child shows that it consists of genetically modulated development, as well as the child's ability to adapt. The child carries one part of instinctive knowledge as heritage, whereas it has to learn the other part during the prenatal period in order to develop adaptation mechanisms which will provide „survival" during and after birth.

The mother's sudden stresses cause recognizable chemical changes in the amniotic fluid. When the mother talks to her prenatal child, the communication is usually full of emotions and provides acquisition of basic suprasegment structures of the mother tongue. This form of communication is carried out through the communication below the consciousness threshold, which is known as an emphatic connection (transpersonal) between the mother and the prenatal child. By adequately educating the mother, this communication can be developed into a complete, conscious communication with the child in the prenatal period.

Researchers established the effect of the mother's emotional speech, which is transferred through the placenta, and leads to the increase of the fetal heart activity. It was also established that there are changes in pulse, breathing and vascular rhythms in mothers with negative attitude towards pregnancy. This influences the change of rhythms in the fetus, causing disharmonious, repetitive, arrhythmic discontinuity in its acoustic-vibratory surrounding.

2. REALITY OF FETAL MEMORY

Increasing number of experiments, observations and clinical data confirmed that the fetus' memory system is sufficiently mature not only to learn while in the womb, but also to remember prenatal experiences as well as experiences during birth. Before they learn to speak, children can express their feelings in non-verbal ways through: drawing, pantomime, or making authentic sound effects, thus imitating the sound of instruments used at birth, such as aspiration devices [13]. The same author summarized his comprehensive work on newborns' memories of birth, considering them very reliable based on the comparison to mothers' memory and hospital records. These memories show clear awareness of violence, danger and loss of faith, the same as adults in similar situations.

It is believed that fetal learning and memory begin in the 24th week, when neural connections are established in the cortex [14]. However, standpoints differ with regard to the scope in which memory and learning abilities exist outside the cortex. Following the series of researches on mammals, it was established that higher nuclei in the auditory pathways in the region of the lower colliculus and the auditory thalamus can have the capacity of memorizing [15]. So far, postnatal behaviour experiments on the human fetus, have not succeeded in registering the existence of memory for prenatal sounds before the 26th gestation week [16,17].

The proofs on learning and memory in the months after birth increased in number with the introduction of a direct ultrasound observation of fetal behaviour [18]. The literature is comprehensive and the examples are numerous, so we shall mention but a few. It was observed that twins develop the same movements and habits in the 20th gestation week, which are then continued in the years after birth. During the ultrasound, the brother and the sister who were positioned cheek to cheek in utero, on both sides of the parting membrane, used to touch as if they were cuddling. Their favorite game in early childhood was to stand behind opposite sides of a curtain and start laughing as soon as they touched each other. A number of different behaviours were recorded during an ultrasound examination such as „avoiding" instruments during medical inerventions in utero, grasping the needle during an intervention etc. When the prenatal child is stimulated by a light source, it blocks the light by its hand (the palm is turned towards the light source) which indicates that it is „aware" of the position of the light source. At the meeting on the prevention of verbal disorders, a pediatrician told me about a fascinating example he heard from his colleague, who was a gynecologist: a woman in the 28th GW came into his office in tears because the father of the child had left her and she wanted to „abort the baby" because she could not support the child and her parents had already refused to help her. He tried to encourage the young mother and told her about different possibilities and her legal rights, also pointing out that she would not abort, but actually kill the baby. He also did the ultrasound and was shocked to see the prenatal child holding the ubmbilical cord, wrapping it around its neck!?

Table 1. Advantages of prenatally stimulated children

Language	Memory	Social intelligence	Reasoning
38%	47%	51%	82%

Studies of learning abilities in the prenatal period are based on the comparison of the group of prenatal children who were exposed to the rich prenatal stimulation and the group which was not included in the stimulation. Postnatal development of both groups was examined by standard development tests, which indicated significant contribution of sensory stimulation in the sphere of motor performances, visual skills, emotional reaction and verbal communication. Even more impressive is the fact that when these prenatal effects are consolidated with postnatal reactions, the group which was prenatally stimulated has the advantage. Table 1 shows the results of the success analysis of the stimulated group in the areas of language development, memory, social intelligence and reasoning, obtained by Stanford-Binåt IQ tests for the age of 3. Test results of children at the age of 3 indicate significant advantage in development of prenatally stimulated children and clearly point to the advantages of the experimental compared to the control group.

3. RESEARCHING FETAL MEMORY BY MEANS OF DIFFERENT LEARNING PATTERNS

In order to research memory in the newborn, learning patterns were applied and similar patterns were applied in fetuses, using the following paradigms: classical conditioning, habituation, associative learning and imitation.

Classical conditioning

There have only been several researches with classical conditioning of the fetus. They were based on the combination of vibrations and loud noise [19,20]. Researchers emphasized that after 15-20 such combinations, most of the fetuses in the last two months of gestation responded only to vibrations, and concluded that „prenatal education" is possible. In the similar research [17,21], mothers' relaxation was combined with music, whereas fetuses were also examined individually after birth. After 24 matches of stimuli, when the fetus was exposed to music in the last week of pregnancy, it would start moving. After birth, the same music was played to the newborn (previously stimulated fetus), who stopped crying, opened its eyes and made several clonic movements.

Exposure to learning was the final pattern for researching fetal learning and memory. This paradigm has the potential to be a good instrument in examining the ability of fetal memory, which can provide good control of the stimulus presentation.

Habituation

Habituation was one of the most successful patterns used to examine memory in the fetus and the newborn. It can be determined as a decrease of the responses to the repeated stimuli [22]. Although most of the researches of habituation in the newborns used visual stimuli, auditory stimuli were used to examine habituation in fetuses. The earliest response appeared in the 22nd and 23rd GW, possibly earlier in females than in males [23]. It is interesting that the initialization of auditory habituation coincides with the initialization of fetal auditory abilities [24]. Habituation might occur earlier than the mentioned abilities, but it is impossible to record habituation to an auditory stimulus earlier than in the 22nd GW, since the fetus cannot respond to auditory stimuli before this time. In our researches [25] of the reaction to sound in the prenatal period, in the 24 GW, we noted that after the first sound stimulus, the fetus reacts by increasing the blood flow for 30%, when measured in aa cerebri media and/or in aa cerebri anterior of the fetus. The repeated stimuli had the same level of the change of flow, whereas the peak lasted twice shorter (4 seconds: 2 seconds). Also, the values returned to the basal level faster. After 5-6 repeated stimuli (with five-minute intervals between the stimuli), these reactions disappeared, indicating that habituation to the repeated auditory stimulus occurs in this period of the prenatal development.

Stimulation by other sensory modalities such as the senses of smell and taste, which functionally appear in the earliest gestation period [26,27], can indicate habituation even at the earliest period of gestation.

Associative learning

Researches [7] and [8] indicated that fetuses who were stimulated by music „kicked" more frequently during the periods without music than during the periods when the music was played. Within the researches of even more complex memories, an experiment was carried out on the sample of 16 pregnant women [28]. During the last 6 weeks of pregnancy, mothers read their fetuses a story „The cat in the hat" twice a day. After birth, babies listened to the tape with this story and their reactions while breastfeeding were monitored. It was noted that the speed of sucking increased each time the babies heard the mentioned story.

Imitation

In the independent researches [9] and [10] it was established that in response to the mother's positive emotional reaction when listening to music, the prenatal child „breathes" slowly, or makes slow movements. When the mother enjoys dancing in a discotheque, it increases the number of its movements, or it completely calms down.

I witnessed an ultrasound examination at the 8th month of pregnancy, during which we made excited comments about the baby, when it suddenly waved its hand and shaped its mouth into a „smile". The mother was included in the prenatal school group which I ran at our Institute.

Exposure to learning

Our research [29], aimed at observing the possibilities of prenatal learning, was carried out on two pregnant women in the 6th month of pregnancy. During that period, one of them attended an intensive French language course (PW1), whereas the other (P2) had the task of listening to the News theme on Channel 3 twice a week, until the end of pregnancy. Upon birth, reactions of the newborns (a boy and a girl) were monitored. The newborn of the P1 mother would stop crying and slow down or stop moving whenever it heard French language. From the fourth month onwards, this baby reacted to the French language stimulus by smiling and attempting to sit, happily waving its hands. The newborn of the P2 mother woke up to the sound of the News theme and directed its auditory attention towards the sound source, each time attentively listening to the whole of it. This reaction was present until the end of the first month

Exercising memory and Prenatal hearing screening

Memory is the basis of normal functioning, so it is not surprising that such an important psychological function is practiced in some form before birth. Fetal memory can serve the functions which are practiced.

Breathing of the prenatal child is one of such examples. These movements commence in the 10th and 11th GW [30], similar to those after birth, in order to enable breathing [31]. Eye movements offer the similar example. Coordinated eye movements appear in the womb in the absence of all, or the most limited visual stimuli [32]. The movements of sucking and swallowing are practiced (thumb sucking and swallowing the amniotic fluid), as well as tactile movements of touching its own body, or the uterus wall, or playing with the umbilical cord etc.

Since the CNS structure is partly under the control of the activities inside the system [33,36], certain functions and behaviour of the prenatal child crucial for the development after birth, are practiced prenatally in order to ensure their functioning when it is necessary.

Having in mind that Tomatis [37] claimed that "90% of energy which the brain needs is stimulated via hearing. The brain was developed from the organ of hearing and owing to the EAR, over millions of years, it became more refined and complicated in its structure", we can anticipate the significance of auditory perception, as well as memory and learning capacity in the development of a human being.

There are many proofs that the fetus learns speech characteristics from its mother prenatally and that it prefers the mother's voice to other female voices after birth [38,39]. This becomes possible due to the development of hearing in the 16th gestation week. The mother's voice reaches the uterus with minimal distortion, sound waves passing directly through the body. Acoustic spectroscopy, used to accurately describe sound, similar to the accuracy of a fingerprint, documents prenatal learning of the mother's language. In utero recording of the auditory surrounding of the fetus indicates that the prosodic nature of speech can be heard clearly inside the womb [40,41].

In our previous researches [25,29,42-46] we examined reactions of the prenatal child to a story read by the mother during the third trimester of the prenatal period. The experiment, based on the analysis of CTG recording, aimed to establish differences in the reactions of a prenatal child when: the mother read a story, when the same story was read by unknown female and male voices, and when an English translation of the story was read by the mother and by an unknown male voice. At the same time, rustle of water and murmur of people were used as stimuli [44].

The results of this experiment indicated that the prenatal child reacts identically (there are no significant changes of the heart frequency) when it is stimulated by rustle of water, murmur of people and reading a story in English, regardless of whether it is read by the mother or a stranger. Significant increase of the heart rhythm frequency appeared when the mother read the story in the mother tongue. When the story was read in the mother tongue by unknown male or female voices, differences appeared in the reaction to these two readers, but the heart frequency was significantly lower in both cases compared to the period when the same story was read by the mother [45,46].

The experiment was repeated after birth, at the beginning of the second month (after birth, the story was not read until the commencement of the experiment), and the newborn's reactions were monitored by quantitative EEG (maps) record. Again, it was unmistakably established that during the stimulation by rustle of water, murmur of people and reading the same story in English, the same cerebral regions are activated, very similar to the state of silence (without stimulation), whereas completely different regions are prompted when the story, by which the child was prenatally stimulated, was read by the mother. Also, there is a difference in the activation of the regions in reaction to unknown male and unknown female readers [44].

In the experiment which was conducted at the beginning of the second month after birth, the mother also read an unfamiliar text and the child heard the text for the first time. The result was fascinating. The unfamiliar text activated new cerebral regions in the newborn in relation to the regions which were activated when the familiar story was read. At the same time, our researches opposed some researches which state that prenatally memorized contents are maintained up to 21 days after birth [47-50]. Our results indicate that prenatal memory is capable of retaining information for more than 3 months after birth.

The experiment in the prenatal period indicates that the prenatal child has an ability to differentiate between familiar and unfamiliar voices, as well as between male and female voices - at the same time, it differentiates between the mother tongue and a foreign language, and between the familiar and the unfamiliar text.

Having in mind that the prenatal child has perception and memory, it is obvious that this knowledge is transferred into the postnatal period. Namely, the newborn prenatally perceives and forms an engram of certain acoustic characteristics (markers) of the story and can recognize them after birth. Therefore, the newborn can again recognize rhythmic and melodic structures it often listened to before birth and has an "imprint" about them in its consciousness, which is not the case with the text it hears for the first time.

Obviously, the newborn manages to decode certain acoustic segments (markers) which are based on the acoustic structure of sounds, syllables, words, sound clusters, sentence melody, speech rhythm and tempo acquired in the prenatal period, which it memorized through the prenatal stimulative story, and which it recognizes again in the repeated experiment in the third month after birth. It is able to recognize the text and not just the voice.

Having in mind the results of such researches, we developed Prenatal hearing screening (PHS) by authors Sovilj-Ljubic, which represents an early detection of the degree of hearing development in the prenatal child, aimed at preventing verbal communication disorders, and adequate behaviour and learning in the postnatal period. This method examines the cerebral circulatory changes in aa. cerebri media caused by the defined sound stimulus. Registered changes of the Pulsatility index (Pi) indicate the changes of the blood flow in the observed blood vessel [51]. PHS is applied from 28th gestation week. PHS values up to 14.6 are considered a normal reaction, whereas increased values indicate the presence of prenatal and risk factors for hearing development, and for the development of verbal communication, behaviour and learning in the period after birth. There are two directions of PHS reactibility – increased values in relation to the basic speed of flow and decreased values which might indicate the existence of the basis for the development of basic personality typology, extrovert and introvert according to type, already in the prenatal period. These researches are ongoing at our Institute.

It was also established that the fetus learns about smells and tastes form its mother [52]. In accordance with that, memory in utero can be of great significance in establishing the breastfeeding function. If the mother consumes spicy food, it influences both the amniotic fluid and her milk [53-55]. The fetus can learn about the taste and smell of the amniotic fluid by swallowing it, which begins in the 12th GW. When the newborn is offered the breast for the first time, it recognizes colostrum (the first milk after birth, generated by mammary glands) as a familiar taste, which was contained in the amnioitic fluid and this may motivate the newborn to suck. Prenatal introduction to the taste of milk could contribute to successful breastfeeding. Researches indicate that the fetus can learn about tastes through experience [56] thus acquiring the liking for these tastes [57]. Moreover, mothers who experienced the biggest changes in nutrition between, before and after the birth, also had the greatest difficulties in establishing the breastfeeding function.

Researches indicate an important connection between the mother's anxiety during pregnancy and the child's development after birth [58]. The mother's high prenatal anxiety is connected with the child's reduced mental and motor development at eight months of age, reduced mental development at the age of two and behavioural disorders and emotional problems at the age of six. It is stated that the mother's anxiety influences the functioning of the mother's hypothalamus-hypophysis-adrenal axis, which, in return, influences fetal cerebral development, resulting in the reduced psychological and behavioural performances of the child.

Comprehensive literature and researches in the area of prenatal psychology indicate that aggressive behaviour, violence and other forms of antisocial behaviour originate from the prenatal period, i.e. that prenatal traumas and traumas at birth represent the basis for the development of these behavioural forms.

4. INSTEAD OF A CONCLUSION

Life in the womb is extremely active and interactive. The womb is our first classroom, where we learn and develop at the speed we will never achieve again in our lives.

Observing results of researches in the world and in our country, it is beyond despute that the prenatal child has consciousness and memory and is capable of learning. It does not have the complexity level of the adult, or even the child – it is structured up to the level which provides continuous progressive development in the prenatal and postnatal periods. This knowledge obliges all societies in the world to change their attitudes towards conception, pregnancy and birth. In many countries, the terms „embryo" and „fetus" are replaced by the term „prenatal". We use the term „prenatal child". The change of attitudes implies adequate education and upbringing based on modern knowledge about conception, pregnancy and birth, from preschool to academic level, with a particular focus on the promotion of education of health workers, psychologists, pedagogues, special education teachers and other educators and the change of technology of being born and giving birth (awareness of the synergy of two events), including the care of the pregnant woman and the prenatal child in the function of optimal utilization of the prenatal potential for the development of healthy offspring.

Acknowledgement – This work was financed by the Ministry of Education and Science of the Republic of Serbia - Project OI-178027.

Apstrakt.

U radu je dat kratak pregled dosadašnjih istraživanja iz oblasti prenatalne memorije i učenja. Cilj rada je da ilustruje rezultate onih eksperimentalnih istraživanja koja su u velikoj meri rasvetlila pitanje postojanja memorije i učenja pre rođenja. Za ova istraživanja korišćeni su različiti obrasci učenja prenatalnog deteta (fetusa), kao što su: klasično uslovljavanje, navikavanje, asocijativno učenje i imitacija. Istraživanja su potvrdila postojanje prenatalne memorije i sposobnost prenatalnog učenja.

REFERENCES

1. Thomas EB, Ingersoll EW. Learning in premature infants. Devel Psychol 1993;29:692-700.

2. Gekoski MJ, Fagen JW, Pearlman MA. Early learning and memory in the preterm infant. Infant Behav Devel 1984;7:267-76.

3. Slater A, Morison V, Rose D. Habituation in the newborn. Infant Behav Devel 1984;7:183-200.

4. Slater A, Morison V, Town C, Rose D. Movement perception and identity constancy in the new-born baby. Br Devel Psychol 1985;3:211-220.

5. Blass EM, Ganchrow Jr., Steiner JE. Classical conditioning in newborn humans 2-48 hours of age. Early Human Devel 1992;8:76-82.

6. Crowell DH, Blurion LB, Kobayashi LR, McFarland JL, Young RK. Studies in early infant learning: classical conditioning of the neonatal heart rate. Devel Psychol 1976;12:373-97.

7. DeCasper AJ, Fifer WP. Of human bondage: Newborns prefer their mother`s voices. Science 1980;208:1174-6.

8. Fifer TM, Moon C. Psychobiology of newborn auditory preferences. Seminars in Perinatology 1989;13:430-3.

9. Field TM, Woodson R, Greenberg R, Cohen D. Discrimination and imitation of facial expressions by neonates. Science 1982;218:179-81.

10. Anisfield M. Neonatal initiation. Devel Rev 1991;11:60-97.

11. Milakovic I. When Mother and Her Child Were Alone. Svijetlost: Sarajevo, ZUNS: Belgrade; 1986.

12. Sontag LW. Significance of fetal environmental differences. Am J Obstetrics and Gynecology 1941;42:996-1003.

13. Chamberlain BD. The Mind of Your Newborn Baby. Berkeley CA: North Atlantic Books; 1988/1998.

14. Morowitz HJ, Trefil JS. The Facts of Life. Oxford UK: Oxford University Press; 1992.

15. LeDoux JE. Emotion, memory and the brain. Scientific American 1994;270:6 (June).

16. Hepper PG. An examination of fetal learning before and after birth. Irish J Psychology 1991;12:95-107.

17. Feihoo J. Le foetus Pierre et le loup...ou une approche Originale de lžaudition prenatale humanine. In Herbinet E, Busnel M-C (Ed.), L`Aube des Sens, Cahiers du Nouveau-ne. Stock: Paris; 1981, pp. 129-209.

18. Chamberlain BD. Prenatal intelligence. In Thomas Blum (Ed.), Prenatal Perception, Los Angeles, 1988, pp. 20-21.

19. Ray WS. A preliminary report on a study of the foetal conditioning. Child Devel 1932;3:175-7.

20. Spelt DK. The conditioning of the foetus in utero. J Exp Psychol 1984;38:338-46.

21. Feihoo J. Ut conscientia noscatue. Cahier de Soprologie 1975;13:14-20.

22. Thompson RF, Spencer WA. Habituation, a model for the study of neuronal substrates of behavior. Psych Rev 1966;73:16-43.

23. Leader LR, Baille P, Martin B, Vermeulen E. The assessment and significance of habituation in normal and high risk pregnancies. J Perinatology 1991;11:25-9.

24. Hepper PG, Shahdullah S. Noise and the fetus, a critical review of the literature. Sudbury Norfolk: HSE Books; 1994.

25. Sovilj M, Ljubic A, Milenković V, Djokovic S. Possibilities of prenatal researches of reaction to sound in fetus with congenital infections. Collection of Abridged Works, X Jubilee Symposium – Section for Perinatal Medicine. S.L.D.: Belgrade; 1992, pp. 17-18.

26. Hepper P G. The beginnings of the mind - evidence from the behaviour of the fetus. J Reprod Infant Psychol 1994;12:143-144.

27. Hepper PG. Fetal psychology, an embryonic science. In: Nijuhuis JG (Ed.). Fetal Behaviour, Developmental and Perinatal Aspects. Oxford UK: Oxford University Press, 1992.

28. DeCasper AJ. Studying learning in the womb. Science 1984;225:384.

29. Sovilj M. Sound, hearing and consciousness, downward processes in the perception representation mechanisms, Naples; 1998, pp. 487-493.

30. Vries JIP, Visser GHA, Prechtl HFR. The emergence of fetal behavior. Quantitative aspects. Early Human Devel 1985;12:99-120.

31. Kozuma S, Nemoto A, Okai T, Mizuno M. Maturational sequence of fetal breathing movements. Biol Neonate 1991;60:36-40.

32. Horimoto N, Hepper PG, Shahdullah S, Koyanagi T. Fetal eye movements. Ultrasound in Obstet Gynecol 1993;3:362-9.

33. Purves D, Riddle DR, White LE, Gutierrez-Ospina G. Neural activity and the development of the somatic sensory system. Curr Opin Biol 1994;4:120-3.

34. Blakemore C, Cooper GF. Development of the brain depends on the visual environment. Nature 1970;228:477-8.

35. Weisel TN, Hubel DH. Effects of visual deprivation on morphology and physiology of cells in the cat`s lateral geniculate body. J Neurophysiol 1963;26:978-93.

36. Miller KD. Models of activity-dependent neural development. Progr Brain Res 1994;102: 303-18.

37. Tomatis AA. Ontogenesis of the faculty of listening. In Verni TR (Ed.). Pre-and Perinatal Psychology. Human Sciences Press; 1987.

38. Hepper PG, Scott D, Shahdullah S. Newborn and fetal response to maternal voice. J Reproduct Infant Psychol 1993;11:147-53.

39. DeCasper AJ, Spence MJ. Prenatal maternal speech influences newborns perception of speech sound. Infant Behav Devel 1986;9:133-50.

40. Querleu D, Renard X, Versyp F, Paris-Delrue L, Crepin G. Fetal hearing. Eur J Obstet Gynecol Reprod Biol 1988;29:191-212.

41. Hepper PG, Shahdullah S. Development of fetal hearing. Arch Dis Childhood 1994;71:F81-F87.

42. Sovilj M, Djokovic S. Development of crying-cry of a newborn from birth to the end of the first month. Defectology in Theory and Practice. Belgrade; 1994, pp. 194-200.

43.Dobrijević Lj, Ljubić A, Sovilj M, Ribaric-Jankes K, Miković Ž, Cerović N.

Changes in Doppler blood flow velocity in middle cerebral artery in response to airborne sound in low- and high-risk human fetuses. Int J Pediatric Otorhinolaryngology 2009;73(10):1381-1384.

44. Dobrijevic Lj, Sovilj M, Ljubic A, Stokic M. The examination of fetal cerebral circulation during defined sound stimulation. XXth Congress of Neurology, Abstract Book - www2.kenes.com/wcn/Pages/Home.aspx, Marrakesh, Marocco, 12-17 Nov 2011, p. 1196.

45. Radičević Z, Vujović M, Jeličić Lj, Sovilj M. Comparative findings of voice and speech: language processing at an early ontogenetic age in quantitative EEG mapping. Exp Brain Res 2008;184:529-532.

46. Radičević Z, Sovilj M, Jeličić L¼, Vujović M. The analysis of strength of coherence of infant electric brain activity in function of speech and language processing examination. Appl Psychophysiology and Biofeedback 2006;31(4):348-348.

47. Richards DS, Frentzen B, Gerhardt KJ, McCann ME, Abrams RM. Sound levels in the human uterus. Obstetrics & Gynecology 1982;80:186-190.

48. Shahdullah S, Hepper PG. Frequency discrimination by the foetus. Early Human Devel 1994;36:13-26.

49. Prechtl HFR. In Nijhuis JG (Ed.). Fetal Behaviour. Development and Perinatal Aspects. Oxford UK: Oxford University Press; 1992.

50. Haynes H, White BL, Held R. Visual accommodation in human infants. Science 1965;148: 528-530.

51. Jelicic Lj. Exploring Reaction of Fetus on External Sound Stimulus. MS Thesis. Center for Multidisciplinary Studies, University of Belgrade; 2006, in Serbian.

52. Porter RH. Mutual mother-infant recognition in humans. In: Hepper PG (Ed.) Kin recognition. Cambridge UK: Cambridge University Press, 1991.

53. Menella JA, Beauchamp GK. Maternal diet alters the sensory qualities of human milk and the nurslingžs behavior. Pediatrics 1991;88:737-744.

54. Menella JA, Beauchamp GK. The transfer of alcohol to human milk, effect on flavor and the infant`s behavior. New Engl J Med 1991;325:981-85.

55. Hepper PG. Foetal soap addiction. Lancet 1988;1:1147-1148.

56. Schaal B, Orgeur P. Olfaction in utero, can the rodent model be generalized? J Exp Psychol Med 1992;44B:245-78.

57. Hepper PG. Human fetal olfactory learning. Int J Prenatal Perinatal Psychol Med 1995;7:153-9.

58. O'Connor TG, Heron J, Golding J, Glover V. Maternal antenatal anxiety and behavioural/ emotional problems in children: A test of a programming hypothesis. Journal of Child Psychology and Psychiatry 2003;44(7):1025-1036.

■ Invited paper was received and accepted on 30.07.2012.