Ontogenesis of Social Interaction

Igor Val Val Danilov

Research Article ISSN 2639-944X

Journal of Medical - Clinical Research & Reviews

Ontogenesis of Social Interaction: Review of Studies Relevant to the Fetal Social Behavior

Igor Val Danilov*

Academician at Accademia Angelica-Costantiniana, (Rome), CEO at Academic Center for Coherent Intelligence Italy, Tel: +39 3319135422.

***Correspondence:**
Igor Val Danilov, Academic Center for Coherent Intelligence, Italy, Tel: +393319135422, Email: igor_val.danilov@acci.center.

Received: 25 January 2020; **Accepted:** 22 February 2020

Citation: Igor Val. Danilov. Ontogenesis of Social Interaction: Review of Studies Relevant to the Fetal Social Behavior. J Med - Clin Res & Rev. 2020; 4(2): 1-7.

ABSTRACT

Two approaches to understanding roots of social behavior – biological universalism and cultural relativism – have been opposing each other for several decades. Numerous studies in different disciplines have been attempting to understand origins of social behavior, studying also fetal movements. This review explores the origins of social interaction, by studying whether embryos inherit some genetic mechanism of social behavior or their social responses are acquired as a result of social interaction. The articles were included in the review as they studied fetal voice recognition, emotion expression, and twin fetuses co-movement. Analyzing these data, the study found no contradictions that prevent the identification of such fetal actions with the notion of social behavior. The existing data on the genetic determination of brain development were discussed and the hypothesis of an innate mechanism of social behavior was questioned. The study found no evidence of a genetic mechanism for social behavior that could link a particular mental state to a specific situation of social reality. However obviously, fetuses may not exhibit social behavior on their own due to a lack of understanding of social reality, and knowledge of the connection between a particular social situation and corresponding social signs. The disadvantage of their cognitive skills in the period of gestation also cannot help them to behave socially. This article supports the core role of social interaction in shaping of social behavior in fetuses and substantiates the assumption that their social behavior emerges from and is guided by mental collaboration with mother.

Keywords

Interpersonal perception, Socialization, Coherent intelligence, Non-perceptual social interaction, Social behavior, Social interaction, Fetal voice recognition, Emotion expression, Twin fetuses co-movement.

Introduction

In order to understand roots of social behavior, two approaches - biological universalism and cultural relativism - have been opposing each other for several decades. Human social behavior can be briefly determined as the effect of one member(s) on the mental states of others, manifested in their actions. It is also possible to suppose that the notion of human social behavior implies their self awareness and understanding of social reality, the memory of the past relationships and the strategy for creating and maintaining future social contacts. The human reactions - such as voice recognition, emotion expression, and comovement - are social behavior due to the fact that such reactions transpire in specific patterns: the manifestations of them correlate to certain social cases and have particular mutually implied meanings. Specifically, humans perform social behavior presenting their common understanding of social reality, in particular: voice recognition, the focus on co-movements, and expression of emotional cues show subjects' categorization of social reality, understanding of social cues and intention to perceive other human beings. Numerous studies in different disciplines have been attempting to understand origins of social behavior, studying also fetal movements. Castiello (2010) argued: 'the findings force researchers to predate the emergence of social behavior: when the context enables it, as in the case of twin fetuses, other-directed actions are not only possible, but predominant over self-directed actions [1]. Another studies have found evidences of fetal ability to respond to auditory stimuli, 'at gestational week 34, the fetus is able not only to perceive complex acoustic external sounds but also to discriminate between different sounds [2]. The expression of emotions by fetuses has been also discussing: 'a new wave of

investigations has also indicated that emotion-like behaviors and roots of emotions appear during fetal life [2]. The current study observed existing data of such reactions in fetuses, whether they behave socially or not, and found no contradictions that prevent the identification of such fetal actions by the notion of social behavior. However obviously, fetuses may not exhibit social behavior on their own due to a lack of understanding of social reality, and knowledge of the connection between a particular social situation and corresponding social signs. This shortage of correlation with social reality, as well as a disadvantage of their cognitive skills in the period of gestation cannot help them to behave socially: the physical and neurological maturity of fetuses do not satisfy the meanings and needs of social reactions to the extent that fetuses would be able to behave socially on their own independently.

Biological Universalism VS Cultural Relativism

Human social behavior can be determined by both the individual characteristics of the person, and the situation they are in [3]. The very meaning of social behavior contains in se two questions to the hypothesis of biological universalism. Firstly, it is widely believed that phenotypic correlations between psychological traits show significant and substantial genetic mediation [4], all psychological traits show significant and substantial genetic influence.

But, no trait is 100% heritable, heritability is caused by many genes of small effect (5). Psychological traits influence social behavior, but they do not define it unambiguously and completely, sharing their competence with the impact of environmental and free will. Therefore, the association of genes-traits-behavior does not have a cause-and-effect relationship between genes and behavior directly: even a strong association is not a proof of causation.

Secondly, in reality, the variability of the meanings of social events exceeds the possibility of a limited number of behavior patterns to represent them unambiguously. The expression of social behavior is even more complex than the association of genes-traits-behavior, it connects phenomena from personal and social reality. Social behavior is possible only when a lot of circumstances are involved: (a) mental state of individual, (b) meanings of personal reality to express this certain state, (c) individual's psychological traits, (d) a particular social reality with a set of conventional social meanings that correspond to a particular social behavior. Social behavior is intermediary between a mental state of a particular individual and a set of meanings of a concrete social reality. It has already been convincingly that genes shape brain development. For instance, the genetically modified model of Williams syndrome (WS) supports the hypothesis of the relationship between genes, brain circuits, and atypical socioemotional behavior. 'These findings suggest that brains of individuals with WS develop differently from the outset. Such brain development probably has subtle but widespread repercussions at the cognitive and behavioral levels (4, p.4).' Obviously, the atypical brain development can change the formation of brain circuits that affects on the expression of social behavior: atypical brain structures contribute to the development of atypical mentality and atypical psychological traits. The fact that genes shape brain development does not mean that genes shape patterns of social behavior. The WS case shows that the greater exhibition of positive emotions (or atypical sociability) in subjects is genetically programmed, this only means the atypical brain development but does not mean the innate body language that links a particular emotional state to certain life situations. The study did not find any knowledge about the genetic mechanism of social behavior - no findings or even ideas about the genetic mechanism that could control and maintain the development of certain innate patterns of social behavior, such as emotional expression through body language - that could link a particular mental state of individuals to a certain social reality, affecting the behavior of individuals depending on a specific set of meanings of a concrete social reality. No data was found on the genetic determination of un individual's behavior in a certain social situation, that can construct the above mentioned set of circumstances involving all of them from (a) to (d). For instance, the western culture promote the emotional expression of smile with the cohort of different meanings from friendship and kindness to sarcasm, depending on certain situation. Other cultures also promote various meanings of this facial mimicry that are not even related to the aforementioned range of Western meanings.

Even if there is an innate muscles pattern of "smile", the innately connection of these muscle movements with the meaning of, for example, "kindness" is not obvious. Furthermore, even if one suppose that the meaning of "kindness" is innately associated with the muscular movements "smile", the manifestation of the "smile" in the corresponding certain situation of social reality depends more on actual circumstances and norms of society and less on individuals traits, especially innate ones. Thus, in order to express the simple "smile" in a certain situation, the individual must know the meaning of this muscle movements in a particular society, as well as the meaning of the social situation corresponding to this "smile" with a set of conventional social meanings, and only then decide whether to express this facial mimicry in the actual situation or not.

That is, the article stands that genes shape brain development from the outset, but they do not manage social behavior; genes influence the development of particular composition of psychological traits, but genes cannot impose on an individual how to apply them to a certain social event. The study discusses articles about social behavior of fetuses exploring stimuli for such behavior and what helps them acquire patterns of social behavior.

Method

The articles were included in this review as: they show social behavior of fetuses through twin fetuses comovement, emotions, and voice recognition; and they demonstrate social behavior of subjects in response to stimuli.

Social Behavior: Co-movements Of Fetuses

Recent studies show the emergence of intra-pair stimulation between twin fetuses (6; 1; 7; 8) and the presence of enhancing of other-directed actions of twins from the 11th week of gestation, as well as twin fetuses execute movements specifically aimed at the

co-twin, starting from the 14th week of gestation and 'the number of contacts between twins rapidly increases during the second semester [1]'.

According to Zoia et al. (2006), movements of fetuses indicate their intentions. The study on singleton fetuses, shows that 'by 22 weeks individual foetus reaching become straighter and more directly aimed towards the target. Importantly, acceleration and deceleration phases seem to be planned according to the size and/or delicacy of the target [9].' This study argues that the size and/or delicacy of the target of the hand-to-mouth and the hand-to-eye movements are planned, suggesting a primitive predictive process.

Castiello et al. (2010) found that 'movement duration and deceleration time were longer for other-directed movements than for movements towards the self or the uterine wall. These differences in kinematic profiles were surprisingly consistent across foetuses and held independently of the gestation period considered, suggesting that already starting from the 14th week of gestation intra-pair contact resulted from the planning and performance of social movements obeying specific kinematic patterns. 'Moreover, 'the kinematic profile of movements directed towards the cotwin displayed an even higher degree of accuracy [1]'.

By 14-weeks twin fetuses progressively increase otherdirected actions: 'Whereas the proportion of self-directed movements decreased between the 14th and the 18th week of gestation and no difference was revealed in the proportion of movements directed towards the uterine wall at the two gestational periods, the incidence of otherdirected movements progressively increased to reach 29% of observed movements at 18 weeks [1].

Another finding by Castiello with colleagues (2010) shows that co-movements of twin fetuses contribute to their physical and neurological maturity in respect of singleton [1]. This study compared singleton movements - without any evidence of coordinated kinematic patterns in the gestational age up to 18 weeks [9] - contrasting them with the performance of twin fetuses which indicate the presence of consistent kinematic patterns already at the 14th week of pregnancy: 'in twins a differential kinematic pattern for movements performed towards the eye region and movements performed towards the mouth were already evident at the 14th week of gestation. At 14 as well as at 18 weeks, movement duration was longer and deceleration time was more prolonged for movements towards the eye compared to movements towards the mouth. This precocious differentiation of movement patterns might be regarded as an expression of early motor development [1]'. Kadic and Kurjak (2017) support this supposition by emphasizing that fetal motor behavior undoubtedly reflects development of diverse cognitive, sensory, and motor systems [2].

Unfortunately the reports of these above studies [1,9] give a little information about the types of twins participated in the research, it is unknown whether they were dichorionicdiamniotic (DD) twin fetuses where each have their own placenta and amniotic sac, or were monochorionicdiamniotic (MD) sharing a placenta but not an amniotic sac, or were monochorionic-monoamniotic (MM) twins who share both a placenta and an amniotic sac. Potentially, MM twins can physically touch each other during gestation period in contrast of DD and MD twins. Interestingly, a study by Sasaki with colleagues (2010) found no significant difference in the total number of all contacts between MD and DD twins at 12-13 weeks of pregnancy, despite the difference in such contacts at an earlier age: 'there was a significant difference in the total number (expressed as median and range) of all contacts between MD (151.5 [43-277]) and DD (4.5 [0-52]) twins at 10-11 weeks of gestation (P b 0.05). However, no significant difference in the total number of all contacts was found between MD and DD twins at 12-13 weeks of gestation. There was a significant difference in the total number of all contacts between 10-11 and 12-13 weeks of gestation in DD twins (4.5 [0-52] versus 132 [19-223], respectively) (P b 0.05). However, no significant difference in the total number of all contacts was noted between 10-11 and 12-13 weeks of gestation in MD twins [8]'.

Discussion

The findings of above studies propose:

- Enhancing of intra-pair stimulation of twins from the 11th week of gestation [1,6-8];
- The movements of the fetus seem intentional [9], and the intra-pair movements of the twins are even higher degree of accuracy [1];
- By 14-weeks twin fetuses progressively increase otherdirected actions [1];
- Co-movements of twin fetuses contribute to their physical and neurological maturity [1,2];
- Different types of twin demonstrate the same intra-pair activity.

Even if interaction is limited by a barrier, it still appears, and at the age of gestation of 12- to 13-weeks MD twins indicate the similar number of contacts as DD fetuses [8].

Taken together, these 5 finding from observed studies seem to raise the following questions:

(i) The intra-pair activity of twin fetuses indicates their social behavior from 11- to 12-weeks of gestation: they increase co-movements without apparent stimuli, and show an interest in co-twins, aiming to them precisely and accurately, as well as this intra-pair stimulation gives the twin fetuses the increase in their development. It is already widely believed that twin fetuses are stimulants for each other. What do they expect from a twin fetus;

(ii) There are concerns that physical and neurological maturity of the fetuses at this stage of their development can satisfy sense and needs of social relationships to such extent that fetuses can manifest an intention to others on their own without any help. There are several arguments to support these doubts. Sensory perception: it is still unknown whether 12-weeks-old twin fetuses can perceive each other perceptually. The amniotic sac is a thin but tough transparent pair of membranes: the inner, amnion, encloses

the amniotic cavity, containing the amniotic fluid and the fetus; and the outer membrane, the chorion, contains the amnion and is part of the placenta. Even the absence of such a barrier between the twin fetuses does not simplify their interaction, at this stage of development, the fetus can only show somatosensory sense, responding to stimuli: 'nerve fibres grow into the fetal spinal cord from 8 weeks. These fibres, however, are specialised for the control of movement and some aspects of touching or prodding the body or positioning a limb. However, when sensory nerves have reached the skin, mechanical stimulation of the body can produce reflex movements [10, p.5]. The fetus must not only feel sensory stimuli, but also perceive them as impressions. Lagercrantz (2014) argued: 'assuming that consciousness is mainly processed in the cerebral cortex, the thalamocortical connections must be established. This does not occur until around gestational weeks 23rd to 25th [14]. Before that time, the neurons from all the sensory organs end in the subplate, waiting for entrance to the cortex, except the neurons from the olfactory organ in the nose, which bypass the thalamus. Thus, for anatomical reasons it seems less likely that fetuses or extremely preterm infants can be conscious. However, after about 24 weeks sensory impressions can be processed at a cortical level, which is also suggested by the finding of spontaneous resting activity in primary visual areas and the somatosensory and auditory cortices of the newborn brain [11, p.303]. Other senses also don't still appear. Vision: the fetal eyelids can finally open and the eyes are fully formed when the fetus reaches the 26th week as well as 'from around the 20th to 27th weeks the fetus responds with arousal and body movements to vibroacoustic and loud sounds delivered to the maternal abdomen [12]'. Hearing: 'the cochlea becomes structurally developed from about the 18th gestational week, although the auditory does not function until after the 26th week when brainstem-evoked responses can then be recorded [41]. The fetus may react to sound by tachycardia from the 20th week. Cortical activation to sound was detected in the fetus from the 33rd week [11]'. But the approach of physiological reflection can not explain the phenomenon of intra-pair movements from above-mentioned 5 findings: specifically aimed at the co-twin already from the 14th week of pregnancy, as well as their growth and dominance over other movements later. Moreover, if the fetuses can exhibit their co-movements, then this happens without any possibility of awareness of the fetus: 'the growth of sensory nerve fibres into the spinal cord is required for the fetus to display reflex movements in response to external stimuli. In mammals these reflexes are mediated by the spinal cord and brainstem. The fetal spinal cord and brainstem develop well before the cerebral cortex. This means that these reflex movements occur without any possibility of fetal awareness [10, p.5], due to the fact that cerebral cortex plays a key role in perception, awareness, thought, memory, and consciousness, but Kadic and Kurjak (2018) emphasize that only by 20 weeks, the cortex has acquired its full complement of neurons. Cortical area differentiation begins approximately between 24 and 34 weeks [2]. Even if one supposes any sensory perception of twins by each other, then fetuses also need to distinguish other fetus from the mother's body, which is not a simple problem. And as it happens, this makes it seem that their bodies as well as the mother's body should be perceived as different items for fetus at the 12-weeks of pregnancy. Taking in account the above conclusions, may it mean that someone else helps fetuses to perceive each other and exhibit their comovements.

(iii) The cooperation of twin fetuses improves their neurological maturity, this can probably mean that both sides of interaction imbue this collaboration with meanings. Otherwise, what other explanation can satisfy this relationship as this interaction develops neurological maturity of twins. That is, what is the content of this interaction, that it stimulates the growth of the nervous system of fetuses compared to the development of a singleton, which also moves, but alone without a pair.

Social Behavior: Fetal Emotions

Recent studies show that fetuses exhibit facial mimicry that may be associated to the expression of distress and positive states: 'Different facial movements can be observed during pregnancy: mouthing, yawning, sucking, tongue protrusion, eye blinking, eye movements, smiling, cry movements and scowling. Most fetal movements can be easily recognized with conventional 2D ultrasound. However, some facial movements, such as smiling, cry movements and scowling, are more readily discernible with 4D ultrasound [13, p.1]. Over the second to third trimester, it is possible in the fetuses studied to see a development from few facial action units observed in isolation at 24 weeks gestation to an impressive number of the 19 possible facial actions units observed at 34 to 35 weeks gestation [14]. There are numerous studies which show different facial movements associated with the expression of emotions. These findings have not confirmed the presence of emotional state of fetuses but evidence of facial muscle configurations similar to emotional expression of children and adults through facial mimicry may be considered. The only one study was found that demonstrates the manifestation of facial expression of fetuses in the response to external stimuli, which can be considered as evidence of the exhibition of emotions in fetuses. Gingras and colleagues (2005) have been reported to show 'crying' of fetuses after external stimuli, recording movements of the fetus at 33 weeks gestation before and during vibroacoustic stimulation. Fetal eye movements and gross body movements were observed in real time using ultrasonography and recorded on video.

'In a study assessing the effects of exposure to tobacco and cocaine during pregnancy on fetal response and habituation to vibroacoustic stimulation, what appears to be the fetal homologue of crying was observed. These behaviours were seen on ultrasound, and have been captured on video recordings and include: an initial exhalation movement associated with mouth opening and tongue depression, followed by a series of three augmented breaths, the last breath ending in an inspiratory pause followed by an expiration and settling [15, p.F415]. The study observed this social behavior during vibroacoustic stimulation of ten other fetuses: in three cases with fetuses 28–31.9 weeks of pregnancy, in four cases with fetuses 32–35.9 weeks, and in six cases with fetuses 36 weeks.

Discussion

Previous studies have shown that social relevance is crucial for

mimicry to occur [16]. This body movements mainly relate to the expression of emotions, but also are attributed to other social phenomena such as infer perceptual-cognitive processes [17], and/or preparations for behavioral actions [18], and/or social threats and motives [19], and/or a neurophysiological state that underlies simply feeling good or bad, drowsy or energized [20], as well as the symbiosis of all above performances together. Objections to the Ekman's thesis of 'universal signals' are multiplied in a number of studies [21-25], increasing the conviction of those who support the dominance of environment in the formation of such mental expressions. Significantly, that within cultural groups facial expressions demonstrate stability of their meanings, which also supports the argument about the effect of social interaction on shaping of social behavior, taking into account the weakening of the 'universal signal' hypothesis. However, there is no idea on how to explain expressions of fetuses attributed as smiling, cry movements and scowling, other than the innate mechanism or not to confuse them with the social qualities of fetuses. The finding of Gingras and colleagues (2005) convincingly supports the viewpoint about social causality of fetal gestures and mimicry. It demonstrates the connection between their mental state and the meaning of stimuli, which is manifested itself in body language with common conventional symbols. Growing number of testimonies of emotional cues of fetuses – along with doubts about the relevance of the mental maturity of fetuses for social expression, as well as the idea of innate emotional patterns – requires research on the ontogenesis of social interaction.

(iv) That is, the next question: whether the physical and neurological maturity of fetuses satisfy to senses and needs of emotional expressions to such an extent that they can understand social phenomena and express emotional cues independently on their own.

Social Behavior: Voice Recognition

It is widely believed that fetuses discriminate segmented speech sounds and voices over the last trimester of pregnancy [26]. There are several interesting findings:

- Mother's voice and heart beat sounds elicit auditory plasticity in the human brain before full gestation [2];
- Fetuses respond differentially to their own mother's voice vs. a female stranger's reading the same story [26];
- Fetuses, 36 weeks of gestational age, evidenced no ability to discriminate between their mother's and a stranger's voice played to them via a loudspeaker on the abdomen [27];
- Fetuses did discriminate between their mother's taperecorded voice and her speaking directly [26-29];
- At 36–40 week GA, fetuses discriminated a change in the gender of a speaker reading a sentence (male to female, female to male) [30].

Discussion

Sounds of objective reality are assigned with meanings, which individuals harvest and categorize throughout life. There are thousands of different social meanings that human ear can nominally hear in the limits from 0.02 kHz to 20 kHz. Categorization of social reality and cognitive development also depend on perception of world of sounds, e.g. the common situation for deaf children around the world is serious delays in cognitive development [31]. Sounds in the environment of a pregnant woman penetrate the tissues and fluids surrounding the fetal head and stimulate the inner ear, the sounds available to the fetus are dominated by low-frequency energy, whereas energy above 0.5 kHz is attenuated by 40 to 50 dB. The fetus easily detects vowels, whereas sounds which are higher in frequency than vowels, are largely unavailable [32]. The acceptable for fetuses diapason of 0,02-0,5 kHz is still big source of sounds, containing many different meanings. Several findings from the studies on fetal voice recognition complement this knowledge and require take more attention to ontogenesis of social interaction.

(v) The findings 2+3+4 taking together raise the question of what circumstances or conditions help fetuses discriminate the direct voice of their mother from her own recorded voice and from other voices.

(vi) The finding 5 supports the above question developing it with a bewilderment about who helps fetuses categorize external social reality, i.e. the mind distinguishes the human voice from other sounds of objective reality because of its meaning, different human voices are filled with certain meanings, and they are all social signals. Even if fetuses can hear different sounds from outside of the womb, this doesn't mean that they alone can understand their meaning. Even if fetuses can distinguish human voices from other sounds, this doesn't mean that they can understand the difference between the social meanings of male and female voices;

(vii) What additional properties do mothers' voices have or accompany their voices, that the mother's voice causes auditory plasticity in the fetal brain, as shown by the finding 1, i.e. from the full spectrum of sounds - outside (all the sounds of an objective reality outside of the mother's body) and internal to the mother's body (sounds of digestion, respiration, body movement etc.) that fetuses can perceive - only the specific voice contributes to the brain development.

Conclusion

The study found no contradictions that prevent the identification of fetal actions – voice recognition, emotion expression, and twin fetuses co-movement – with the notion of social behavior. The existing data on the genetic determination of brain development were discussed and the hypothesis of an innate mechanism of social behavior was questioned. The study found no evidence of a genetic mechanism for social behavior that could link a particular mental state to a specific situation of social reality. However obviously, fetuses may not exhibit social behavior on their own due to a lack of understanding of social reality, and knowledge of the connection between a particular social situation and corresponding social signs. The disadvantage of their cognitive skills in the period of gestation also cannot help them to behave socially. If fetuses are able to socially behave, their social skills cannot be based on self-learning; if they can promote a range of behaviors,

the innate endowment must be something more complex than a couple of reflexes. When the above mentioned 7 questions (i-vii) are answered based on the existing laws of physics, then it can be argued that social behavior is acquired either through social interaction or an innate mechanism.

The notion of consciousness in its simplest form – without entering into broad philosophical discussion on its essence – refers to the sensation or awareness of inner and outer existence. Even this very simple definition of the concept already emphasizes the crucial factor of social interaction in the manifestation of consciousness, which must already consist of phenomena of reality in order to exist, since consciousness is impossible without knowledge of a minimum set of phenomena. Consciousness emerges gradually as the fetus and baby develop, it is a progressive, stepwise, structural, and functional evolution of its multiple intricate components [33]. The current review supports the probability of this statement. Acquisition of knowledge is based on the discovery of new causal connections within the prior knowledge, as well as on the disclosure of links between elements of the prior knowledge and the new information domain [34]. The mind (or the mind in its under-stage of the development) begins to create connections with new subsequent phenomena on the basis of initial phenomena, comparing new knowledge with them and pushing cognitive development. Therefor, questions about when and how fetuses acquire initial meanings of social reality become more intriguing, since fetuses – due to their immaturity – are not able to conquest new social phenomena through the 5 perceptual senses.

Hence, the assumption of the existence of an ancient non-perceptual social interaction – that was developed before the appearance of the 5 perceptive organs of perception – may help to understand this problem as well as complement the ontogenesis of social interaction corresponding to the paradigm of the theory of evolution. This non-perceptual social interaction is evident in all social creatures with a nervous system, from social insects to mammals, it permeates all social relationships, encourages meaningful communication and accompanies it throughout life [35]. This non-perceptual interaction occurs in the very beginning of the cognitive development of fetuses, at the first steps of the emergence of consciousness.

This article supports the core role of social interaction in shaping of social behavior in fetuses and substantiates the assumption that their social behavior emerges from and is guided by mental collaboration with mother. The latest study by Danilov et al. (2019) on language acquisition in adults supported this conclusion showing the increase of group performance provided by such unconscious mental collaboration [35]. The article has not confirmed the presence of non-perceptual social interaction but evidence indicates that the possibility has not been ruled out. The article substantiates the new concept of non-perceptual social interaction, one of the explanations of which is the theory of Coherent Intelligence that was introduced by Igor Val. Danilov in 2018 [36].

Acknowledgments

I thank Dr. David Vernon for his help commenting this review.

References

1. Castiello U, Becchio C, Zoia S, et al. Wired to be social: the ontogeny of human interaction. PLoS ONE. 2010; 5: e13199.
2. Kadic AS, Kurjak A. Cognitive Functions of the Fetus. Ultraschall in Med. 2017; 38: 181-189.
3. Snyder M, Ickes W, Lindzey G, et al. Personality and social behavior. Handbook of social psychology. 1985; 883-948.
4. Pezawas L, Santos A, Meyer-Lindenberg A. Genetics and Emotion. The Oxford Handbook of Cognitive Neuroscience. 2013; 2.
5. Plomin R, DeFries JC, Knopik VS, et al. Top 10 replicated findings from Behavioral genetics. Perspect Psychol Sci. 2016; 11: 3-23.
6. Arabin B, Bos R, Rijlaarsdam R, et al. The onset of inter-human contacts longitudinal ultrasound observations in early twin pregnancies. Ultrasound Obstet Gynecol. 1996; 8: 166-173.
7. Piontelli A, Bocconi L, Kustermann A, et al. Patterns of evoked behavior in twin pregnancies during the first 22 weeks of gestation. Early Human Development. 1997; 50: 39-45.
8. Sasaki M, Yanagihara T, Naitoh N, et al. Fourdimensional sonographic assessment of inter-twin contact late in the first trimester. 2010; 108: 104-107.
9. Zoia S, Blason L, D'Ottavio G, et al. Evidence of early development of action planning in the human foetus a kinematic study. Springer-Verlag. 2006.
10. https://www.rcog.org.uk/globalassets/documents/guidelines/rcogfetalawarenesswpr0610.pdf.
11. Lagercrantz H. The emergence of consciousness Science and ethics. Seminars in Fetal & Neonatal Medicine. 2014; 19: 300-305.
12. Joseph R. Fetal Brain Behavior and Cognitive Development. Developmental Review. 2000; 20: 81-98.
13. Merz E, Pashaj S. Fetal Facial Expressions Demonstration of the Smiling, the Sad and the Scowling Fetus with 4D-Ultrasound. Ultraschall in Med. 2015; 36.
14. Reissland N, Francis B, Mason J, et al. Do Facial Expressions Develop before Birth? PLoS ONE. 2011; 6: e24081.
15. Gingras JL, Mitchell EA, Grattan KE. Fetal homologue of infant crying. Arch Dis Child Fetal Neonatal Ed. 2005; 90: F415-F418.
16. Hess U, Fischer A. Emotional mimicry as social regulation. Pers Soc Psychol Rev. 2013; 17: 142-157.
17. Lee DH, Susskind JM, Anderson AK. Social transmission of the sensory benefits of eye widening in fear expressions. Psychological Science. 2013; 24: 957-965.
18. Frijda NH, Tcherkassof A, Russell JA, et al. Facial expressions as modes of action readiness. The psychology of facial expression. Cambridge University Press. 1997; 78-102.
19. Fridlund AJ. Human facial expression: An evolutionary view. Academic Press. 1994.
20. Russell JA, Russell JA, Fernández-Dols JM. Reading emotion from and into faces Resurrecting a dimensional-contextual

perspective. The psychology of facial expression. Cambridge University Press. 1997; 295-320.
21. Russell JA. Is there universal recognition of emotion from facial expression? A review of the cross-cultural studies. Psychological Bulletin. 1994; 115: 102-141.
22. Jack RE, Blais C, Scheepers C, et al. Cultural confusions show that facial expressions are not universal. Current Biology. 2009; 19: 1543-1548.
23. Jack RE, Garrod OGB, Yu H, et al. Facial expressions of emotion are not culturally universal. Proceedings of the National Academy of Sciences of the United States of America. 2012; 109: 7241-7244.
24. Gendron M, Roberson D, van der Vyver JM, et al. Perceptions of emotion from facial expressions are not culturally universal Evidence from a remote culture. Emotion. 2014; 14: 251-262.
25. Crivelli C, Russell JA, Jarillo S, et al. The fear gasping face as a threat display in a Melanesian society. PNAS. 2016; 113: 12403-12407.
26. Kisilevsky BC. Fetal Auditory Processing: Implications for Language Development? Fetal Development. Research on Brain and Behavior, Environmental Influences, and Emerging Technologies. 2016; 133-152.
27. Hepper PG, Scott D, Shahidullah S. Newborn and fetal response to maternal voice. Journal of Reproductive and Infant Psychology. 1993; 11: 147-153.
28. Lee GYC, Kisilevsky BS. Fetuses respond to father's voice but prefer mother's voice after birth. Developmental Psychobiology. 2014; 56: 1-11.
29. Krueger CA, Cave EC, Garvan C. Fetal response to live and recorded maternal speech. Biological Research for Nursing. 2015; 17: 112-120.
30. Lecanuet JP, Granier-Deferre C, Jacquet AY, et al. Prenatal discrimination of a male and a female voice uttering the same sentence. Early Development and Parenting. 1993; 2: 217-228.
31. Peterson CC, Siegal M. Deafness, conversation, and theory of mind. Journal of Child Psychology and Psychiatry. 1995; 36: 459-474.
32. Gerhardt KJ, Abrams RM. Fetal Exposures to Sound and Vibroacoustic Stimulation. Journal of Perinatology. 2001; 20: S21-S30.
33. Padilla, Lagercrantz. Making of the Mind. Acta Paediatr. 2020; 10.
34. Danilov IVal, Mihailova S, Perepjolkina V. Unconscious social interaction, coherent intelligence in learning. The 12th annual conference. ICERI. 2019.
35. Danilov IVal. Social interaction in learning from the standpoint of physics review of studies relevant to non-perceptual interaction. International Journal of Communication and Media Studies. 2020; 10: 29-36.
36. Danilov IVal. Unconscious Social Interaction: Coherent Intelligence. Second edition complemented. 2019.