New Findings in Education:

Primary Data Entry in Shaping Intentionality and Cognition

Igor Val Danilov
Academic Center for Coherent Intelligence
ACCI
Rome, Italy
e-mail: igor_val.danilov@acci.center

Sandra Mihailova
Rīga Stradiņš University
RSU
Riga, Latvia
e-mail: sandra.mihailova@rsu.lv

Abstract— **One of the most intriguing questions in cognitive science is the Primary Data Entry (PDE) problem: where does social knowledge come from? After birth, an organism meets with reality, which is transcendental, staying beyond any experience and understanding of this pure reason. Basic approaches to the study of cognition are cognitivism, connectionism, and embodied dynamicism, The weakness of cognitivism and connectionism is the need to introduce an initial set of social phenomena of the specific community to trigger this system: the PDE problem. There is also a same gap in knowledge in embodied dynamicism approach, this interpretation of a dynamic system is not accurate. The current paper presents the Model of Coherent Intelligence (MCI) and its neural foundation. The analysis of recent empirical data proposes new insights on the origin of intentionality: (i) cognition begins from separating sensory stimuli: Long-Term Potentiation can be induced in neurons of particular Modality-Specific gateways (ignoring other stimuli)–selective induction promotes selective sensitivity to the chaos of stimuli. (ii) Neurons can learn spike-timing-dependent plasticity in social interaction: immature neurons learn the timing code to modulate certain synaptic strength, which triggers either Long-Term Potentiation or Long-Term Depression. The hypothesis of the MCI argues that social interaction shapes organisms' intentionality, promoting similar categorization of stimuli in intimately related individuals with shared social routine and interests. This approach provides a wide range of possibilities for developing a human-computer interface.**

Keywords-coherent intelligence; emotional contagion; interactional synchrony; social entrainment; embodied cognition

I. INTRODUCTION

The academic knowledge on the study of mind historically and conceptually has settled three main approaches within cognitive science: cognitivism, connectionism, and embodied dynamicism [1]. Many theories of mind combine all three approaches, where they co-exist in various hybrid forms. The more interesting of them are the Embodied dynamic system [1], the theory of innate intersubjectiivity and innate foundations of neonatal imitation [2], the theory of natural pedagogy [3], and the theory of sensitivities and expectations [4]. All these theories are plausible; the current paper observes different views to engage a gap in knowledge.

According to Thompson [1], cognitivism (the metaphor is the mind as digital computer) and connectionism (the mind as neural network), in different ways, appeal to the same computational principle of cognition. This principle based upon processing a signal within neural networks. This computational principle certainly requires the primary data entry as a necessary initial condition to launch processing. None algorithm and/or a sequence of instructions may perform the computation of any process without corresponding to the specific situation inputs, that should substitute variables and parameters of the formulas. The algorithm remains just a set of mathematical variables without this input. This argument may mean the necessity to input an initial set of social phenomena of the specific community to trigger this system – the Primary Data Entry (PDE) problem [5].

According to embodied cognitivists, the mind is an autonomous system by its self-organizing and self-controlling dynamics, which does not have inputs and outputs in the usual sense, and determines the cognitive domain in which it operates [1][6][7]. This approach is grounded on the dynamical hypothesis [8]. However, this interpretation of a dynamic system is not accurate. Why does the dynamic system need PDE:

Argument A. According this approach embodied features of cognition deeply depend upon characteristics of the physical body. If the agent's beyond-the-brain body plays a significant causal role, then the primary data yet makes sense.

Argument B. In mathematics, a dynamic systems model is a set of evolution equations. It means that entering primary data is required. The dynamic system may not begin its life cycle without introducing initial conditions corresponding to specific situation inputs and parameters.

Argument C. The dynamical system hypothesis [8] have not claimed the lack of initial conditions. Dynamicists track primary data less than dynamic changes inside. However, it does not mean that primary data do not exist and do not necessary.

Given these above arguments, the PDE problem must be considered in the onset of cognition. The embodied dynamic system approach tends to solve the above-noted gap by introducing the notion of dynamically embodied information [1]. Although, to introduce this concept, it is necessary to

 ISBN: 978-1-61208-847-1

explain the categorization of reality through intentionality. According to embodied cognition approach, symbols encode the local topological properties of neuronal maps [1], a dynamic action pattern. The sensorimotor motor network yields pairing of the binary cue stimulus with the particular symbol saved in the structures and processes that embody meanings. 'Representational “vehicles” are temporally extended patterns of activity that can crisscross the brain-body-world boundaries, and the meanings or contents they embody are brought forth or enacted in the context of the system’s structural coupling with its environment [1, p.36].' This idea requires introducing the nature of intentionality. In a multi-stimuli environment, the stimulus-consequence pair is unpredictable due to the many stimuli claiming to be associated with the embodied dynamic information randomly. The bond of stimulus-consequence pair of a social phenomenon in the sensorimotor network requires categorizing reality by the nervous system before applying the innate reflex about this social phenomenon to a specific case. Therefore, dynamically embodied information can be useful if intentionality is already in place. Meanwhile, the embodied dynamic system introduces intentionality without a biological and / or physical basis. The theory of natural pedagogy [3], and the theory of sensitivities and expectations [4], as well as many others may not solve the problem of PDE [9].

According to Trevarthen and Delafield-Butt [10], primary consciousness develops in embryogenesis and is the first operative in early fetal life. 'Consciousness as "acting with knowledge" requires a nervous system that regulates prospective perception in intentional engagement with the world [10, p. 22]’. In the first trimester, patterns of sensory regulation of movements of the fetus' body and limbs gain affective evaluation and sensitivity for sounds and rhythms of other human presence [10]. It means that the pure nervous system should already possess intentionality as well as initial knowledge about social reality: human sounds and rhythms also yield meanings. Even if fetuses can hear different sounds and feel rhythms from outside of the womb, this does not mean that they alone (independently) can process their meanings.

Searle et al. [11] argued that intentionality is the mental power of minds to represent or symbolize things, properties, and states of affairs. According to Crane [12], mental states or events or processes which have objects in this sense are traditionally called 'intentional,' and 'intentionality' is, for this reason, the general term for this defining characteristic of thought. The meaning of directed action implies the purpose of the action, which first requires the categorization of reality. It's a dichotomy of what happens first. Current knowledge does not solve it.

Tomasello [13], through the study on ontogenesis and phylogenesis, introduced the hypothesis of gradually increasing social bond development in children referred to time slices: (1) emotion sharing from the birth, (2) joint intentionality from the nine-month revolution, (3) collective intentionality at around three years of age, (4) reason and responsibility. Tomasello [13] introduced the beginning of cognition through the newborns' basic motive force of sharing intentionality. However, the mechanism of such emotion coordination is not clear because it is grounded on emotion sharing [13]. Whether or not protoconversations imply understanding emotional states. Many researchers, including the authors, believe that the hypothesis about the universality of emotional expressions is formed by limited experimental methods, since other research designs show the opposite outcome [14]-[18]. There is no evidence of a genetic mechanism that can link meaning in mind with certain social reality to apply an appropriate emotional pattern to a specific situation. Even if one assumes that the hypothesis of universal emotional expressions proves innate emotional patterns together with their meanings; even if newborns may alone recognize the basic facial expressions of caregivers and the specific situation to apply them; but in this case, newborns do not have time for such a "training course", because they demonstrate their achievements already in the first hours of life [19]. If there is no innate mechanism, then, apparently, emotional contagion can occur between individuals without their awareness [9][19][21]; it can happen even without awareness of the emotional stimuli existence [21]. Section II discusses the hyperscanning and near-infrared spectroscopy studies' outcome, showing brain-to-brain synchronization. Section III presents, for the first time, the hypothesis of the neural foundation of shared intentionality. Section IV elaborates all findings, describing their meanings.

II. Problem: How Does Social Interaction Encourage Cognition

Brain-to-brain relationships shape the mind during moment-to-moment interactions [22]. The dichotomy of newborns' succeed in beginning knowing and their communicative disability challenges our knowledge on social interaction modalities [19]. We believe that understanding the problem of the intentionality emergence in an organism at the beginning can explain the problem of PDE and the onset of consciousness. This knowledge can contribute to the study of cognition because obviously if and as soon as this implicit modality occurs it continues the whole rest of life. We believe that the caregivers' intentionality forms the intentionality in newborns. Fetuses and newborns are not able to behave intentionally on their own due to the lack of meaningful (informative) sensory interaction at the beginning [5][19][23]. We predict an implicit modality of social interaction that provides shared intentionality at the beginning. Cooperation in a group enhances intentionality, providing categorization.

According to Valencia and Froese [22], their review of studies based on EEG- and fNIRS hyperscanning methodologies shows evidence of inter-brain synchronization in the fastest frequency bands, supporting the possibility of extended consciousness. Among hyperscanning studies, we have chosen 4 studies conducted without explicit interaction between subjects. These studies compared differences of brain-to-brain synchronization in subjects when participants solved tasks together as confronting to the condition in which: (i) the subjects solved them individually [24][25]; (ii) the same task when interacting with a machine [26]; (iii) the individuals from another team solved the same problem [27]. These studies declared an exclusion of sensory interaction between subjects. However, it should be noted that the subjects of all these studies knew about social encounters during the experiments. Therefore, instead of mental collaboration their results may simply mean an increase of brain activity due to similar emotional arousal in participants stimulated by the social encounter.

The near-infrared spectroscopy study (non-hyperscanning) on asleep newborns shows an increase of the neural response to a familiar (English language) versus unfamiliar language (Tagalog, a Filipino language) spoken by strangers in both conditions [28]. The language stimuli (the identical low-pass filtered sentences) were played through two speakers approximately 1.5 m from the infants' head. According to May et al., [28], this findings show that the newborn's neural processing of language is influenced by early language experience due to neonate brain responds to familiar versus unfamiliar language. To our mind, this outcome may lead to evidence of another inference. This experiment was not a hyperscanning technique. However, subjects were in pairs with their caregivers. Neonates classified these sound stimuli without the ability to perceive them. Sleeping newborns' brains reacted to sound stimuli that their sensing could not provide due to their brains' sensory isolation to meaningless and unfamiliar sounds. Sleepers seem to enter a standby mode, allowing them to balance the monitoring of their surroundings with sensory isolation [29]. Sleepers are sensitive to the semantic content of an auditory stream [29]-[31] and amplify relevant, meaningful stimuli [29][31]. The sleeping brain retains some residual information processing capacity, which, however, does not form enduring memories [32]. Neonates are not able to understand even Mother's speech although her sound is familiar. Given all these, any speech for neonates is meaningless, and asleep newborns may not be sensitive to the sounds even their native tongue (the language spoken by the mother during pregnancy) in experiments when these sounds were pronounced by outsiders. However, they were sensitive to them. Sleeping newborns' brains reacted to sound stimuli that their sensing could not provide due to their brains' sensory isolation to meaningless and unfamiliar sounds. We believe that this outcome may mean the implicit modality of newborns' interaction with caregivers since any other explanation of this outcome is excluded.

Whether or not social interaction contributes to the increase in results of a group mental activity? Whether or not dyads maintain non-perceptual interaction? What are the neurobiological grounds of intentionality?

III. Neural foundation of Coherent Intelligence

A. *Experiments on Problem-Solving in Groups*

Recent research of 24 online experiments presented that unprimed participants show a more significant accuracy level when they complete the thought task simultaneously with confederates who are primed with the correct answer; if they were emotionally stimulated and completed the tasks without communication [9]. Primary groups [33] show empirical evidence of a more significant accuracy in problem-solving in the coherent intelligence state. In specific, we conducted 13 experiments in dyads (116 subjects) with *P*-value < 0,001 (probability-value in null hypothesis significance testing), and 7 experiments in primary group adults (41 subjects) with the *P*-value < 0,002. Experiments with 43 secondary group subjects (unfamiliar adults, M=20) show the effect only with the task of unfamiliar language translation. Non-semantic tasks–with synthetic language and two-color round symbols–did not stimulate the effect in 2 experiments with 207 secondary group subjects (unfamiliar). These results are consistent with research Danilov et al. [34].

B. *The Model of Coherent Intelligence*

According to Danilov and Mihailova [23], a supranormal environmental case–e.g., first hours after birth–stimulates supranormal sensation in dyads. This can push the inherited mechanism of social entrainment of infants to the rhythm of the mother. Both the supranormal sensation and social entrainment may stimulate the common emotional arousal. The latter is increased by the ongoing supranormal sensation and the occurring rhythm of arbitrary movements of the infant. The continuing supranormal sensation and ever-increasing arousal of the infant and the mother along with the rhythm of the infant's unintentional movements stimulate early imitation and emotional contagion. The problem is how the infant capture and reproduce the kinematic of movements.

The MCI proposes that common emotional arousal together with the identical rhythm create coherent mental processes in dyads–Coherent Intelligence (Figure 1). At Sensorimotor Stage (by Piaget, or Stage 3 of the Model of Hierarchical Complexity MHC [35]), organisms do not maintain bilateral communication. According to Danilov and Mihailova [23], individuals are able to interact by distinguishing perceptual signals of identical modality by their significance. This ability can contribute to ostensive cues. After all, this meaningless interaction modifies into communication when individuals imbue perceptual impulses with mutually implied meanings, cascading their signals in response to the history of relations between them [23].

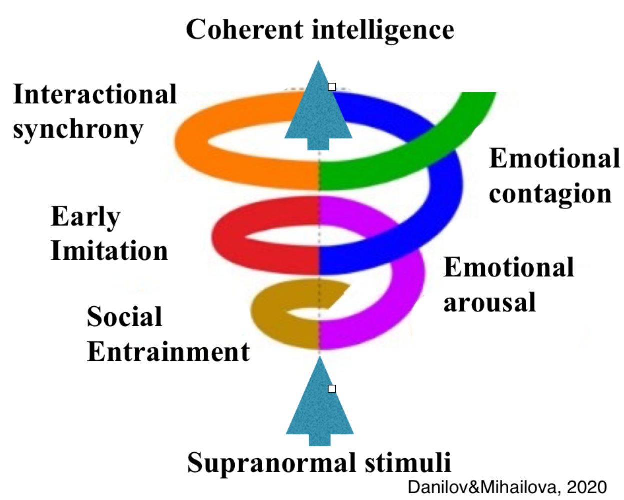

Figure 1. The Model of Coherent Intelligence.

Copyright (c) IARIA, 2021. ISBN: 978-1-61208-847-1

C. *Neural Foundation of this MCI*

Leaving aside semantic constraints, it seems consistent to say that intentionality manifests itself in intention. Specific brain regions may be engaged in shared sensory/cognitive processes irrespective of the feedback's valence and in encoding the subjective relevance of the feedback [36][37].

Outside areas involved in this processing, additional brain areas are specifically engaged according to the particular communicative modality [38]. According to Tettamanti et al. [39], Intention Processing Network (IPN) involves the medial prefrontal cortex, precuneus, bilateral posterior superior temporal sulcus, and temporoparietal junctions. Depending on different social interaction modalities, the IPN is complemented by activation of additional brain areas, reflecting different Modality-Specific (M-S) input gateways to the IPN [39]. The M-S gateways mediate the structural and semantic decoding of stimuli and provide M-S information [39]. Sensory inputs of a specific modality can activate the precise association of certain sensorimotor networks with specific brain emotion circuits [40].

We believe that this emotion-motion coherence can involve the particular cognitive process of a high order. When two or more organisms are in common emotional arousal and simultaneously in the interactional synchrony, then these two different experiences may meet each other in high-order cognitive processing. Emotional arousal can trigger evolutionarily old brain circuits, which interact with high-order cognitive and linguistic processing [40]. It seems uncontroversial to say that infants' pure nervous system may experience emotions, but only primitive ones related to survival, such as those associated with hunger and pain. However, newborns cannot express emotions themselves appropriately to a specific social case on their own, even though they possess inherited neuronal patterns of primitive emotional impressions. They also cannot understand the expression of others' emotions (as is discussed above). They are only able of experiencing primitive emotions. Research on insects–organisms in stage 3 of MHC [35] like human newborns–assumes that they also experience emotions [41]. Researchers argued that agitated honeybees exhibit pessimistic cognitive biases: 'Whether animals experience human-like emotions is controversial and of immense societal concern. The next reason is that animals cannot provide subjective reports of how they feel, emotional state can only be inferred using physiological, cognitive, and behavioral measures. In humans, negative feelings are reliably correlated with pessimistic cognitive biases, defined as the increased expectation of bad outcomes. Recently, mammals and birds with poor welfare have also been found to display pessimistic-like decision making, but cognitive biases have not thus far been explored in invertebrates [41].'

In parallel, interactional synchrony stimulates a sensorimotor network engaging neural networks responsible for communicative intention processing (including high-order cognitive and linguistic processing)[38]. Neural networks of emotional excitation and the sensorimotor networks are separately connected to many different M-S gateways. Meanwhile their coherence intersects in certain M-S gateways of each organism depending on (i) pattern of neural circuit engaged through emotional excitation and (ii) pattern of the sensorimotor network [38].

We propose a rough hypothesis of how Long-Term Potentiation (LTP) can be induced only in particular M-S gateways, retaining information about the certain received stimulus. Different areas of the brain exhibit different forms of LTP, their types depend on a number of factors, such as age and the neuron's anatomic location. However, the common processes are the same for all. The simple nature of Hebbian learning, based only on the coincidence of pre- and post-synaptic activity, LTP is persistent, lasting from several minutes to many months, and it is this persistence that separates LTP from other forms of synaptic plasticity [42]. Spike-timing-dependent plasticity (STDP)–that involves the pairing of pre- and postsynaptic action potentials (APs)–causes a variation of LTP or Long-Term Depression (LTD) [43]. The timing between pre- and postsynaptic APs modulates synaptic strength, triggering LTP or LTD [43]. The sign and magnitude of the change in synaptic strength depend on the relative timing between spikes of two connected neurons (the pre- and postsynaptic neuron) [43]. The structural organization of excitatory inputs supporting STDP remains unknown [43]. Even though the ensemble of emotion-motion integrated networks weakly stimulates the intersected neurons in their junction with M-S gateways. If all M-S gateways also simultaneously receive weak stimulation from the receptors (due to the chaos of stimuli received by the pure nervous system), then this multi-signal contributes to LTP in the neurons of particular M-S gateway at the junction of this emotion-motion ensemble due to the effect of the synaptic cooperativity, because of the following. LTP can be induced either by strong tetanic stimulation of a single pathway to a synapse, or cooperatively via the weaker stimulation of many. Neurons from the gateways in the connections of these networks receive cooperative stimulation. Induction of cooperativity can ensure LTP.

According to Tazerart et al. [43], the synaptic cooperativity of only two neighboring synaptic inputs onto spines in the basal dendrites of L5 pyramidal neurons extends the pre–post timing window that can trigger potentiation. The engaged M-S gateways retain a certain stimulus, while other M-S gateways (also of the same sensory modality) remain depressed without keeping information of other stimuli. Therefore, specific M-S gateways are sensitive, and all these organisms respond to specific sensory modalities. Figure 2 shows a schematic picture of this process. The induced emotion and sensorimotor networks (they are red in the picture) together activate certain M-S gateway even with weak stimulation of sensory input. The different colors of M-S gateways refer to different sensory modalities. At this point, the analysis encounters the ground of the PDE problem of how immature neurons learn the timing code to modulate certain synaptic strength, which triggers either LTP or LTD. Because the structural organization of excitatory inputs supporting STDP remains unknown [43].

The study of the PDE problem leads to the analysis of the axiomatic foundations of Psychology, Sociology, and Neuroscience–the basic notions that form these sciences–from the perspectives of the actual scientific paradigm.

 ISBN: 978-1-61208-847-1

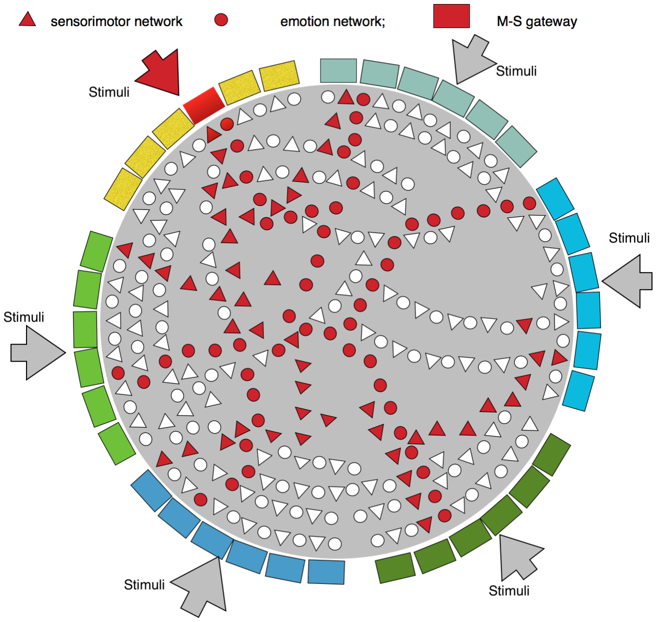

Figure 2. The Scheme of M-S Gateway Activation.

The question of "how can the blank mind begin to learn from social interaction" is reduced to "how immature neurons learn the timing code to modulate certain synaptic strength, that triggers either LTP or LTD". The sign and magnitude of the change in synaptic strength depend on the relative timing between spikes of two connected neurons (the pre- and postsynaptic neuron). How can neurons of an immature organism (even a newborn) learn the structural organization of excitatory inputs that support STDP? The further arguments show why we believe that the entanglement state of neurons can contribute to simultaneous LTP in neurons.

The daily routine develops neural patterns of primitive emotions and sensorimotor neural patterns in infants. Their everyday coherence with the social world forms various integrated neural patterns of different emotions from the existing ensemble of emotion scripts in their community. We believe that caregivers contribute to the formation of emotion scripts and, consequently, shaping of specific neural patterns in infants. Obviously, adults experienced intentionality before their coherent mental process began with newborns. Life experience taught them particular emotion scripts and defined their precise motion kinematics, that formed more elaborated sensorimotor patterns. In routine cooperation with newborns, a caregiver enters in interactional synchrony with a newborn, under the influence of supranormal stimuli, being in social entrainment. Therefore, the similar M-S gateways are excited in the dyad. Meanwhile, the adult's current intentionality has already triggered a particular network that includes current emotion patterns and sensorimotor patterns. Part of it corresponds to a primitive complex emotion-sensorimotor network in the newborn with similar M-S gateways. This newborn's primitive network is less developed, although it is similar to the part of the adult's integrated complex network. It can be assumed that the neurons in the connections of different excited emotion patterns and sensorimotor patterns go into the entangled state because they receive LTP, being induced cooperatively via many stimulations. In such a manner, the adult and infant neurons behave as a single unit. Therefore, specific M-S gateways are sensitive in dyads, and these organisms equally respond to specific sensory modalities. The induction of t-LTP and t-LTD in single spines follows a bidirectional Hebbian STDP learning rule [43]. Hebbian theory claims that an increase in synaptic efficacy arises from the learning process. The PDE problem in a chaos of stimuli requires a teaching mechanism from the beginning. The entanglement state of neurons is a possible option of how infants' neurons learn spike-timing-dependent plasticity. In the entanglement state, the behavior of the neurons of a mature organism determines and trains the neurons of a newborn.

Emotion sharing indicates implicit modality of social interaction. The entanglement state of neurons in the certain M-S gateways is a possible option of how infants' neurons learn STDP. This involvement of similar networks and the sensibility of the certain M-S gateways lasts as long as is necessary to teach the immature nervous system. The entanglement state of these neurons ensures their immediate response to the specific stimulus, regardless of the spatial division of organisms. Therefore, specific M-S gateways are sensitive, and these organisms equally respond to specific sensory modalities.

Knowledge about consciousness is being developed by studying the interaction of neurons, whose dimensions are similar to objects studied from the perspective of quantum mechanics scale. Knowledge about their behavior may complement the set of social interaction modalities. The generation of entanglement between increasingly macroscopic and disparate systems is an ongoing effort in quantum science [44]. Recent studies have shown that the behavior of objects 15 micrometers in size is consistent with the quantum world's laws, such as the phenomenon of quantum entanglement [45]-[47]. An entangled state was generated even between a millimeter-sized dielectric membrane and an ensemble of 109 atoms [44]. In comparison, a neuron's nucleus has a diameter of 3 to 18 micrometers, and a neuron has a size of 4 to 100 micrometers. The quantum entanglement state of particles is not something rare in Nature. Quantum systems can become entangled through various types of interactions, for the moment we know: (a) light's polarization. One of the most commonly used methods is spontaneous parametric down-conversion to generate a pair of photons entangled in polarization; (b) decay cascade of the bi-exciton. Fiber coupler to confine and mix photons, photons emitted from decay cascade of the bi-exciton in a quantum dot; (c) Hong-Ou-Mandel effect; (d) in the earliest tests of Bell's theorem, the entangled particles were generated using atomic cascades. An exciting question is how to create a quantum entanglement state of living cells. According to Marletto et al. [46], experiments show entanglement between living sulfur bacteria with quantized light. Whether or not neurons of different organisms become entangled through similar stimulation of their emotion networks?

Entanglement is an essential property of multipartite quantum systems, characterized by the inseparability of quantum states of objects regardless of their spatial separation [44]. Recent study tested quantum entanglement over unprecedented distances, beaming entangled pairs of photons to three ground stations across China—each separated by more than 1200 kilometers. 'Yin et al. used the Micius satellite, which was launched last year and is equipped with a specialized quantum optical payload. They successfully demonstrated the satellite-based entanglement distribution to receiver stations separated by more than 1200 km [45]'.

We believe that these findings may contribute to an advanced curriculum, specifically in facilitating the teaching of young children.

IV. CONCLUSIONS

The analysis of recent empirical data yields a hypothesis of beginning cognition–the Model of Coherent Intelligence and its neural foundation of how the pure nervous system distinguishes sensory stimuli. This hypothesis postulates two new ideas of the PDE basis: (1) cognition begins from a separation of sensory stimuli: LTP can only be induced in neurons of particular M-S gateways (not all)–selective induction promotes selective sensitivity to the chaos of stimuli. (2) Neurons can learn STDP in social interaction by repeating the timing code of other organisms' mature neurons to modulate certain synaptic strength, which triggers either LTP or LTD. We believe that the MCI shapes intentionality in intimately related individuals. Coherent Intelligence is the integration of M-S gateways of particular brain areas, which contributes to different organisms' sensibility to similar sensory inputs. The 24 online experiments show empirical evidence of the MCI. We believe that this approach may contribute to study the mind and, in specific, to understanding the appearance of intentionality and the Primary Data Entry problem. We believe that these findings may contribute to an advanced curriculum, specifically in teaching 2- to 3-year-old children. Further research should also examine whether the MCI can provide a contactless interaction of the computer with neuronal circuits, in which the computer would become a part of extended mind. This approach provides a wide range of possibilities for developing a human-computer interface.

AUTHORS CONTRIBUTION

Igor Val Danilov formulated the hypothesis and wrote the first draft of the manuscript. Igor Val Danilov and Sandra Mihailova improved the text over several iterations.

ACKNOWLEDGMENT

The authors express their gratitude to Iegor Reznikoff, Emeritus Professor Université de Paris Ouest Nanterre, France, for commenting this paper.

REFERENCES

1. E. Thompson, Mind in Life : biology, phenomenology, and the sciences of mind. The Belknap press of Harvard University press. Cambridge, Massachusetts London, England. 1st Harvard University Press paperback edition. 2010.
2. J. Delafield-Butt and C. Trevarthen, Theories of the development of human communication. 2012. [Online]. Available from: https://strathprints.strath.ac.uk/39831/1/Delafield_Butt_Trevarthen_2012_Theories_of_the_development_of_human_communication_final_edit_060312.pdf [retrieved: March, 2021].
3. G. Csibra and G. Gergely, "Natural Pedagogy," Trends Cogn. Sci., vol. 13, pp. 148–153, 2009.
4. S. R. Waxman and E. M. Leddon, "Early Word-Learning and Conceptual Development". The Wiley-Blackwell Handbook of Childhood Cognitive Development. 2010. [Online] Available from: https://www.academia.edu/12821552/Early_Word-Learning_and_Conceptual_Development [retrieved: March, 2021].
5. I. Val. Danilov, "Imitation or Early Imitation: Towards the Problem of Primary Data Entry." The Journal of Higher Education Theory and Practice (JHETP). In press.
6. F. J. Varela, Principles of Biological Autonomy. ISBN-10:0135009502, ISBN-13:978-0135009505. 1979.
7. F. J. Varela and P. Bourgine, "Towards a practice of autonomous systems. In Towards a Practice of Autonomous Systems." The first European conference on Artificial Life, ed. F. J. Varela and P. Bourgine, pp. xi–xviii. Cambridge: MIT Press. 1992.
8. T. Van Gelder, "The dynamical hypothesis in cognitive science." Behavioral and Brain Sciences, vol. 21 (5), pp. 615-628. 1998. DOI: 10.1017/s0140525x98001733.
9. I. Val. Danilov and S. Mihailova, "Knowledge Sharing through Social Interaction: Towards the Problem of Primary Data Entry." The 11th Eurasian Conference on Language & Social Sciences which is held in Gjakova University, Kosovo. p.226. 2021. [Online] Available from http://eclss.org/publicationsfordoi/ abst11act8boo8k2021a.pdf. [retrieved: March, 2021].
10. J. Delafield-Butt and C. Trevarthen, Development of human consciousness. 2016. [Online]. Available from: https://strathprints.strath.ac.uk/id/eprint/57845. [retrieved: March, 2021].
11. J. R. Searle, W. S. Slusser, and M. Slusser, Intentionality: An Essay in the Philosophy of Mind. Cambridge University Press. 1983.
12. T. Crane, "Intentionalism." The Oxford Handbook to the Philosophy of Mind. Oxford: Oxford University Press. pp. 474–493. 2009.
13. M. Tomasello, Becoming human: A theory of ontogeny. Belknap Press of Harvard University Press. 2019. https://doi.org/10.4159/9780674988651.
14. R. E. Jack, "Culture and facial expressions of emotion". Visual Cognition vol. 21, pp. 1248–1286, 2013, https://doi.org/10.1080/13506285.2013.8353.
15. C. Crivelli and M. Gendron, In e Science of Facial Expression (eds José-Miguel Fernández-Dols & James A. Russell) Oxford University Press, 2017.
16. L. F. Barrett, R. Adolphs, S. Marsella, A. Martinez, and S. Pollak, "Emotional Expressions Reconsidered: Challenges to Inferring Emotion in Human Facial Movements." Psychological Science in the Public Interest, vol. 20, pp. 1–68. 2019. https:// doi.org/10.1177/1529100619832930.
17. K. Hoemann et al., "Context facilitates performance on a classic cross-cultural emotion perception task". Emotion. (Washington, DC). vol. 19, pp. 1292–1313. 2019.
18. M. Gendron, K. Hoemann, A. N. Crittenden, S. M. Mangola, G. A. Ruark, and L. F. Barret, "Emotion Perception in Hadza Hunter-Gatherers". Scientific reports, vol. 10, pp. 3867 , 2020. https://doi.org/10.1038/s41598-020-60257-2.

19. I. Val. Danilov, "Social Interaction in Knowledge Acquisition: Advanced Curriculum. Critical Review of Studies Relevant to Social Behavior of Infants". The Twelfth International Conference on Advanced Cognitive Technologies and Applications COGNITIVE2020. 2020.
20. J. Decety and P. L. Jackson, "The functional architecture of human empathy". Behavioral and Cognitive Neuroscience Reviews, vol. 3, pp. 71-100. 2004.
21. M. Tamietto et al., "Unseen facial and bodily expressions trigger fast emotional reactions". PNAS, vol. 106: pp. 17661-17666, 2009.
22. A. L. Valencia and T. Froese, "What binds us? Inter-brain neural synchronization and its implications for theories of human consciousness". Neuroscience of Consciousness, vol. 6(1), 2020. doi: 10.1093/nc/niaa010.
23. I. Val. Danilov and S. Mihailova, "Emotions in e-Learning: The Review Promotes Advanced Curriculum by Studying Social Interaction". The International Conference on Lifelong Education and Leadership for All (ICLEL). pp.8-17. ERIC Number: ED606507. 2020. [Online] Available from: https://faf348ef-5904-4b29-9cf9-98b675786628.filesusr.com/ugd/d546b1_2d77ecc9e07f4b0fb2cccce23af201f7.pdf. [retrieved: March, 2021].
24. C. Szymanski et al., "Teams on the same wavelength perform better: Inter-brain phase synchronization constitutes a neural substrate for social facilitation". Neuroimage, vol. 15, pp. 425–436, 2017.
25. F. A. Fishburn et al., "Putting our heads together: interpersonal neural synchronization as a biological mechanism for shared intentionality". Soc Cogn Affect Neurosci, vol. 13, pp. 841–849, 2018.
26. Y. Hu et al., "Inter-brain synchrony and cooperation context in interactive decision making". Biol Psychol, vol. 133, pp. 54–62, 2018.
27. L. Astolfi et al., "Neuroelectrical hyperscanning measures simultaneous brain activity in humans". Brain Topogr, vol. 23, pp. 243–256, 2010.
28. L. May, K. Byers-Heinlein, J. Gervain, and J. F. Werker, "Language and the newborn brain: does prenatal language experience shape the neonate neural response to speech?" Front. Psychology, vol. 2, pp. 222, 2011, doi: 10.3389/fpsyg.2011.00222.
29. T. Andrillon and S. Kouider, "The vigilant sleeper: neural mechanisms of sensory (de)coupling during sleep." Current Opinion in Physiology, vol. 15, pp. 47–59, 2020.
30. A. Ibanez, V. Lopez, and C. Cornejo, "ERPs and contextual semantic discrimination: degrees of congruence in wakefulness and sleep." Brain Lang, vol. 98, pp. 264-275, 2006.
31. G. Legendre, T. Andrillon, M. Koroma, and S. Kouider, "Sleepers track informative speech in a multitalker environment." Nat Hum Behav, vol. 3, pp. 274-283, 2019.
32. R. Cox, I. Korjoukov, M. de Boer, and L. M. Talamini, "Sound Asleep: Processing and Retention of Slow Oscillation Phase-Targeted Stimuli." PLoS ONE, vol. 9(7), pp. e101567. 2014, https://doi.org/10.1371/journal.pone.0101567.
33. C. H. Cooley, Social organization: A study of the larger mind , (pp. 23-31). New York, NY: Charles Scribner's Sons, xvii, pp. 426, 1909.
34. I. Val. Danilov, S. Mihailova, and V. Perepjolkina, "Unconscious social interaction, coherent intelligence in learning." The 12th annual conference. ICERI 2019. doi: 10.21125/iceri.2019.0606.
35. M. L. Commons, "The fundamental issues with behavioral development." Behavioral Development Bulletin, vol. 21(1), pp. 1-12, 2016, http://dx.doi.org/10.1037/bdb0000022.
36. S. Oldham, C. Murawski, A. Fornito, G. Youssef, M. Yucel, and V. Lorenzetti, "The anticipation and outcome phases of reward and loss processing: A neuroimaging meta-analysis of the monetary incentive delay task." Human Brain Mapping, vol. 39, pp. 3398-3418, 2018.
37. D. Martinsa et al., "Mapping social reward and punishment processing in the human brain: A voxel-based meta-analysis of neuroimaging findings using the Social Incentive Delay task." 2021, bioRxiv preprint doi: https://doi.org/10.1101/2020.05.28.121475.
38. I. Enrici, M. Adenzato, S. Cappa, B. G. Bara, and M. Tettamanti, "Intention Processing in Communication: A Common Brain Network for Language and Gestures." Journal of Cognitive Neuroscience, volume 23, issue 9, pp. 2415-2431, 2011, https://doi.org/10.1162/jocn.2010.21594.
39. M. Tettamanti, M. M. Vaghi, B. G. Bara, S. F. Cappa, I. Enrici, and M. Adenzato, "Effective connectivity gateways to the Theory of Mind network in processing communicative intention." NeuroImage, vol. 155, pp. 169-176, 2017, doi: 10.1016/ j.neuroimage.2017.04.050.
40. L. Nummenmaa et al., "Emotional speech synchronizes brains across listeners and engages large-scale dynamic brain networks." NeuroImage, vol. 102, pp. 498-509, 2014.
41. M. Bateson et al., "Agitated honeybees exhibit pessimistic cognitive biases." Curr Biol., vol. 21;21(12), pp. 1070-1073, 2011, doi:10.1016/ j.cub.2011.05.017.
42. W. C. Abraham, "How long will long-term potentiation last?". Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences. vol. 358 (1432), pp. 735–744, 2003, doi:10.1098/rstb.2002.1222.
43. S. Tazerart et al., "A spike-timing-dependent plasticity rule for dendritic spines." Nat Commun vol. 11, pp. 4276, 2020, https://doi.org/10.1038/ s41467-020-17861-7.
44. R. A. Thomas et al., "Entanglement between distant macroscopic mechanical and spin systems." Nat. Phys., 2020, https://doi.org/10.1038/ s41567-020-1031-5.
45. J. Yin et al., "Satellite-based entanglement distribution over 1200 kilometers" [Online] Science: vol. 356, issue 6343, pp. 1140-1144, doi:10.1126/science.aan3211, 2017. [retrieved: March, 2021].
46. C. Marletto, D. M. Coles, T. Farrow, and V. Vedral, "Entanglement between living bacteria and quantized light witnessed by Rabi splitting." Journal of Physics Communications, vol. 2(10). [Online] Available from: http://iopscience.iop.org/article/10.1088/2399-6528/aae224/ meta. [retrieved: March, 2021].
47. M. Sillanpää and S. Hong, "Spooky quantum entanglement goes big in new experiments." [Online] Science News 25 April 2018. Available from: https:// www.sciencenews.org/article/spooky-quantum-entanglement-goes-big-new-experiments. [retrieved: March, 2021].