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A Bioengineering System for Assessing Children's Cognitive Development by Computerized Evaluation of Shared Intentionality

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***Abstract*—The article creates a conceptual framework for translational research on the bond between shared intentionality magnitude in caregiver-child dyads and scores of children's cognitive development trajectory. The current study assessed the shared intentionality magnitude in 30 subjects (neurodivergent (ND) and neurotypical (NT) children) aged 2 to 10 years. Disclosing the relation of shared intentionality magnitude across different stages of children's development with their diagnoses allows for developing an assessing method of cognitive development trajectory in preverbal children. The article proposes directions for future research regarding (i) evidence of shared intentionality; (ii) proof of a shared intentionality assessment method validity, (iii) conditions for quantitative measurement to satisfy dependability in the cognitive development assessment.**

Keywords—Bioengineering system, children development, social cognition, shared intentionality, quantum entanglement

I. Introduction

A recent long-term study [1] found that about 17% of children aged 3–17 years were diagnosed with cognitive developmental disorders, including: 9.04% of children were diagnosed with attention deficit/hyperactivity disorder (ADHD); 7.74% with learning disabilities (LD: dyslexia, dyscalculia, etc.); 1.10% - with intellectual disability (ID); 1.74% - with autism spectrum disorders (ASD). Early detection of developmental delay in children allows early treatment to be more effective [1-4]. Diagnostic methods are based on assessing children's behavioral markers–the observation of markers by a specialist during a visit and the verbal assessment of markers by parents. After Piaget, we know that children in the preverbal period manifest their intelligence in behavior. Since the middle of the twentieth century, behavioral markers have been used to assess the cognitive development of young children.

There are several limitations of the behavioral markers' method for assessing cognitive development: first, although the social communication features of cognitive delay, for example ASD, are present before that time, frequently some of them are not yet fully present [5]. Second, difficulties in early diagnosis reflect the intrinsic problems in the assessment of very young children [6], e.g., there is no specific period for the manifestation of "marker" skills in a child, instead, there is an idea of a "window of opportunity." Third, there is the potential for rapid developmental changes even without intervention [6] —ongoing development yields an extent of uncertainty in developmental diagnosis. Fourth, the manifestation of the child's behavioral markers in the specialist's office is influenced by endogenous and exogenous factors; assessing the impact on the child's behavior requires the high professionalism of the specialist. During a short appointment, it is needed to detect discrepancies between the child's development and the "markers". Fifth, the behavior markers in diagnosing bear limitations that require parents' competence in reporting and the level of experience of the professionals to recognize them from the parent's rapport. High parental competence in reporting symptoms is required, as the specialist cannot confidently diagnose all markers during a short visit.

While ADHD and LD problems account for about 90% of the total number of cognitive delays, their symptoms at 18-30 months are ambiguous. It becomes obvious the need to correct the developmental trajectory of a child with ADHD and LD after three years of age, already when children reach obvious markers. ADHD is a debilitating mental health disorder most frequently diagnosed in school years [7]. ADHD is marked by symptoms of inattention, overactivity, and impulsiveness that have an early onset. They are age-inappropriate, persistent, and pervasive [7;8]. However, these markers are not universal. Longitudinal studies demonstrate that high levels of preschool ADHD symptoms do not always persist into the school years and later life [9-11]. Many studies have focused on such behavior problems among children from 3 years of age. Even though behavior problems at 18 months are relatively common, we can begin to predict which children will have persisting problems after the early childhood phase [11].

Learning disabilities also usually manifest at school [12]. However, behavioral markers are only available for determining LD in children [13]. Skills to be assessed are (i) procedural counting knowledge, (ii) the ability to seriate in preschool, and (iii) the conceptual counting knowledge of young children. In particular, the inability to do such things in preschool (at the age 5 to 6) may be a marker for later arithmetic disabilities [13]. Further research requires finding an accurate and efficient behavior classification since young students with LD also manifest behavior problems and interaction difficulties [14;15].

The above-noted limitations challenge the efficiency and validity of the behavior markers' approach, especially for children from the preverbal period. In addition, the demand for remote detecting cognitive delay even in 18-30 month children raises the need for a new computerized method. For instance, a recent study [16] showed a new non-verbal computerized approach to assessing the focal size of attention and operative memory. They proposed to detect LD by testing a rapid apperception of a few items called "subitizing". Moreover, this

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study proposed a training course for expanding operative memory. According to Danilov and Mihailova [16], multiple exercises to grasp a set of items in "subitizing" develop the quality of apperception of an array, operative memory, and numeracy in a child. Indeed, according to the received view in cognitive science, an internalisation of rational actions shapes cognitive schemes, which are elements of cognition. This finding means that although a verbal-perceptual approach (based on behavioral markers) provides an assessment of cognitive development in young children in the preverbal period, a non-verbal approach may contribute to its validity when taken together.

The current article accounts for the bond between shared intentionality in caregiver-child dyads and children's cognitive development trajectory. Vygotsky [17] stated that interactions with others enable the internalization of cognitive processes first achieved in the social context. Developmental delays possess a common feature–children's lack of interaction ability [2;4;17-19]. It is common for children with developmental delays to have difficulty with social and emotional skills. Social interaction is linked with cognition in the preverbal period. A growing body of research supports the idea of protoconversation in mother-infant dyads, when children still lack communication skills, [e.g., 20-24], providing evidence of this interaction [25-27]. Tomasello [24] argues that, at the onset of life, protoconversation occurs due to the newborns' primary motive force of sharing intentionality (ShI); it appears through emotional sharing.

What is an underlying mechanism and developmental trajectory of this "emotional sharing"? The growing body of research shows that emotional contagion can occur among individuals without awareness of the emotional stimuli [28]. Increasing inter-brain research in neuroscience shows growing evidence of brain-to-brain synchronization [29;30] However, pure ShI–occurring during meaningful interaction without sensory cues–is understudied in neuroscience. While the 74 research studies [29;30] explored coordinated neuronal activity during meaningful collaboration, their experiments did not exclude all sensory interactions between subjects. From them, the only study by Fishburn et al. [31] tried to account for ShI, observing interpersonal neural synchronization in functional near-infrared spectroscopy (fNIRS). Fishburn et al. [31] reported coordination of cerebral hemodynamic activation in subjects pairs when completing a puzzle together in contrast to a condition in which subjects completed identical but individual puzzles. Another neuroscience study by Painter et al. [32] apparently registered pure ShI in the inter-brain experiment. They excluded any sensory interaction between collaborators by placing subjects in isolated locations. This research study registered an increase in coordinated neuronal activities in the subjects during coordinated mental activity without sensory cues [32].

A growing body of literature shows increasing psychophysiological research on shared intentionality. Atmaca et al. [33] argued that shared representations in complementary tasks are the key to understanding the emergence of ShI. Their experiments with 86 subjects showed a joint spatial numerical association of the response codes effect. Evidence showed that numerical (symbolic) stimuli that are mapped onto a spatially arranged internal representation (a mental number line) could activate a co-represented action in the same way as spatial stimuli [33]. Empirical data of experiments with 115 subjects showed that ShI leads to implicit coordination [34]. Reddish et al. [35] reported that synchrony combined with ShI leads to greater cooperation than synchrony without ShI or ShI combined with asynchronous movement or vocalizing. The experiments with 69 pairs of subjects showed that ShI is the key to perceiving the task as mutualistic (a help is a viable option in this game) as opposed to an individual [36]. Val Danilov et al. [37] reported a significant increase (11%, the relative value of ShI R= 0,11) in 51 adult subjects' performance under a condition with clues for 53 confederates. Other experiments with young children showed a significant increase (above chance) in NT subjects' performance. NT children achieved an average of R=1,05 and ND children – R= 0,33 [38]. Val Danilov and Mihailova [39] explored 58 mother-child groups (68 children, M=9 years). The experiments showed a significant increase (48-123%, R=0,48-1,23) in subjects' performance under a condition with clues for mothers [39]. Tang et al. [40] argued that ShI is a pivotal element in human cooperation while playing a virtual collective game. Experiments with 11 groups (of 3 subjects each) showed robust joint commitment. Results demonstrate a successful expansion of human social perception [40]. Another part of the longitudinal research [38] showed a significant increase (above chance) in ND children's performance [41]. ND children achieved an average of the relative value of ShI R=0,62 and NT children – R= 0,09 [41].

A hypothesis of neurobiological processes supposed a neuronal coherence agent for shared intentionality occurring during meaningful social interaction even without sensory cues [42]. According to this hypothesis, entangled protein molecules from neurons engage these neurons of different organisms in cooperative reactions to shared stimuli. Any biological system is dynamic–it can self-educate from feedback. In this way, the neurons of a mature organism train the connected neonate's neurons regarding the fitting reactions to the excitatory inputs of the specific structural organization. This cooperation enables the neonate's neurons to develop a Long-Term Potentiation that links particular stimuli with specific embodied sensorimotor neural networks [42]. That is, indwelling in the coordinated state, neonates' neurons fix (remember) these states' features in the particular environmental condition, which is shared with the mature neurons' state. Therefore, the neonate chooses the same stimulus as the caregiver, learning the stimulus-context bond; ShI provides training of newborns' nervous systems. The entangled proteins of neurons do not transmit signals from the mature organism neurons to the neonate neurons. The mature organism neurons train the neonate neurons how to react in the particular context, indwelling in the same condition under the same stimuli [42]. This training ensures shared intentionality in dyads. A recent study [27] proposed a theoretical framework for research on a digital method for estimating cognitive development in children by assessing their ShI magnitude.

II. MATERIALS AND METHODS

The study aims to accomplish a causal investigation during 8 years of children's developmental period to observe an interaction modalities evolution. The association of diagnoses of different aged children with the shared intentionality magnitude allows for predicting the cognitive development trajectories in children. Disclosing the relation of ShI magnitude across different stages of children's development with their diagnoses allows for developing an assessing method of cognitive development trajectory in preverbal children. ShI in dyads accomplishes the infants' success in keeping track of statistical information available in the environment. This is a statistical mechanism that needs statistical analysis only available in big data. Therefore, the current study collects data from 30 neurodivergent (ND) and neurotypical (NT) children aged 2 to 10 years to observe the ShI magnitude in different ages. The outcome creates a conceptual framework for translational research on the bond between entangled protein molecules of neurons, shared intentionality magnitude in caregiver-child dyads, and scores of children's cognitive development trajectory.

A. Subjects

The 11 dyads with ND and NT children from 24 months to 10 years participated in the current experiment. For the data robustness and inferences validity, the article joins empirical data of the dyads with ND children and those with NT children from other research with the same design [38;41] by combining the current experiment data with the extracted data from the reviewed research studies (Tables 1 and 2). Totally, results of 30 dyads with ND and NT children aged 18 months to 10 years are observed. The original data set contains information about 30 participants, including tests score files stored, age, sex, education, and diagnosis.

B. Development of the Model

The method of assessing shared intentionality in human pairs is based on modeling the mother-newborn biological system that encourages shared intentionality with the components: unfamiliar stimuli (unintelligible test items), social entrainment, and increasing interpersonal dynamics in pairs [27]. The system software stimulated interpersonal dynamics by creating a rhythmically changing electromagnetic field of wavelengths of 700 and 400 nm alternately with 80 bpm. The article calls it hereafter the Computerized Assessment ShI magnitude in Bioengineering Systems (CASIBS) method. According to Val Danilov and Mihailova [42], a single harmonic oscillator during the continuing social dynamics of intimately-related organisms can induce the entanglement state of the neurons of certain M-S gateways in different nervous systems, thereby stimulating Long Term Potentiation in all of them simultaneously. The engaged Modality-Specific (M-S) gateways of different organisms render these particular gateways relatively more sensitive to a certain stimulus, while the other M-S gateways of the same sensory modality remain depressed.

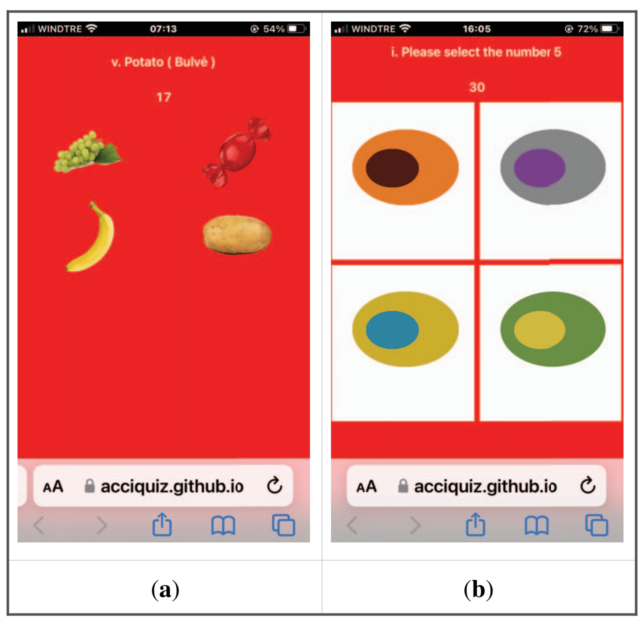
Specifically, the bioengineering system re-created interpersonal dynamics in the dyads by stimulating their interactional synchrony and emotional contagion [38;41]. The detection system of shared intentionality (based on forced-choice design) can be presented as a classification task. We have investigated a binary classification task: correct-incorrect categorization of unfamiliar symbols. The probability of the correct symbol's categorization was 0,25, and the incorrect was 0,75 (the items' example is in Fig. 1). While the mother and child saw the quiz-test on their smartphone, only the child independently responded to items by pushing the options on the screen [38;41]. The software processed the quiz-test and collected the child's inputs. The novelty of the current study is the analysis of own data with data obtained in other studies: totally from 30 dyads with neurodivergent (ND) children and those with neurotypical (NT) children aged 18 months to 10 years.

C. Stimuli–Unintelligible Test Items

The subjects were asked to solve unintelligible tasks, indwelling with their caregivers who knew the correct answers (Figure 1). The items for young children up to 3 years were different fruits and vegetables. The experimenter asked young children to classify them in an unfamiliar language. The children older 3 years classified the artificial numeric color system. In this system, the particular bicolor circle was assigned to a specific number from 1 to 6. The interaction length was about 5 minutes, 10 items 30 seconds each. Caregivers only mentally solved these tasks; they were informed that children should respond to items independently. The experiment's software registered children's scores.

III. RESULTS

The article observes shared intentionality magnitude in 30 children. These data are collected by joining empirical data from the current experiment (11 dyads) with data from other research studies (19 dyads) with the same design [38;41] Tables 1 and 2 present the joined data. The research study by Val Danilov et al. [38] verified four young children's ability to create the link between sounds of spoken numbers (unfamiliar to them) and the appropriate set of objects without any clues. The research study [41] applied the assessment method from the recent study with adults by Val Danilov and Mihailova [39]. The 15 subjects were asked to categorize the unintelligible tasks [41]. These three research studies applied the similar CASIBS method. The ND children 3- to 10-year-olds achieved the mean score of Mnd = 3,6 with Sample Standard Deviation SD = 1,26.



1. The items' examples: (a) for young children up to 3 years; (b) for children from 3 years. Subjects were asked to choose one option from the four on the screen.

The NT children of the same ages achieved the minor mean score of Mnt = 2,8 with Sample Standard Deviation SD =1,14 (Table 2). The ND and NT children aged 18- to 33-months showed the opposite results, respectively Mnd=2 and Mnt=4,6 scores (Table 1).

The study used the probability theory math tools. The relative value of shared intentionality is denoted by R (Equation 1). The R-value compares the current input data with the value calculated from the Bernoulli equation for independent events (Equation 2). Specifically, observed scores are denoted by X(o), and expected scores are denoted by X(e), i.e., the number of events with the highest probability of occurring calculated by the Bernoulli equation (2).

$$R = \frac{1}{n}\sum_{n=0}^{n}\frac{(X(o) - X(e))}{X(e)},$$

(1)

The Bernoulli equation (2) shows a probability of a number of events (correct responses on items) made in independent trials, where: C – number of combinations n by k; p – the probability in each task; n – independent trials (items), the probability of each is p (0<p<1); k - events, how many items the child answers correctly; q = 1 – p.

$$P\,(k)=C^k p^k q^{n-k},$$

(2)

Totally, the ND children 3-to 10-year-olds achieved the mean score of Rnd = 0,69 with Sample Standard Deviation SD=0,58. The NT children of the same ages achieved the minor mean score of Rnt=0,25 with Sample Standard Deviation SD =0,48 (Table 2). The ND and NT children aged 18-to 33-months showed the opposite results, respectively Rnd=–0.66 and Rnt=0.93 scores (Table 1). The ND and NT children's difference of R values denoted Δ si shows that in children 3-to 10-year-olds Δ si=Rnt–Rnd= –0.44. The same comparison method for 18-to 33-month-olds yields a value Δsi=Rnt–Rnd=1.59 of the difference. Neurotypical (NT) young children aged up to 33 months showed relatively high scores in assessing ShI compared to their ND peer at 33 months. The differences between ND and NT children's scores and the association of these data with children's diagnoses allow supposing contrast abilities of ShI in the ND and NT children.

I. TABLE CHILDREN SCORES

Child Age	18-month-olds to 33-month-olds		
	Diagnosis, study	***Rnd-effect in ND child***	***Rnt-effect in NT child***
1) 18 m	NT , [38]		1
2) 28 m	NT , [38]		1,5
3) 31 m	NT , [38]		0.66
4) 33 m	ND , [38]	0.33	
5) 33 m	NT, the current study		1
6) 31 m	ND, the current study	-1	
7) 24 m	NT, the current study		0.5
		MRnd= -0,66	MRnt= 0,93

II. TABLE CHILDREN SCORES

Child Age	3-year-olds to 10-year-olds		
	Diagnosis, study	***Rnd-effect in ND child***	***Rnt-effect in NT child***
1) 4 y	NT , [41]		0.5
2) 3 y	ND , [41]	1	
3) 3 y	ND , [41]	0.2	
4) 5 y	ND , [41]	1.5	
5) 5 y	ND , [41]	0	
6) 6 y	NT , [41]		0.2
7) 5 y	NT , [41]		-0.2
8) 5 y	NT , [41]		0.5
9) 5 y	NT , [41]		0.5
10) 5 y	ND , [41]	0.5	
11) 4 y	NT , [41]		0
12) 4 y	ND , [41]	0.5	
13) 3 y	NT , [41]		0.5
14) 5 y	NT , [41]		-0.6
15) 3 y	NT , [41]		-0.6
16) 6 y	NT, the current study		0.2
17) 4 y	NT, the current study		0.6
18) 9 y	ND, the current study	1.4	
19) 5 y	NT, the current study		0.6
20) 8 y	ND, the current study	1	
21) 10 y	ND, the current study	1	
22) 8 y	ND, the current study	-0.2	
23) 8 y	NT, the current study		1
		MRnd= 0,69	MRnt= 0,25

IV. Discussion

The research outcome presents evidence of shared intentionality in human pairs. ND and NT children correctly solved unintelligible tasks in more items than predicted by probability, being with their caregivers who knew the correct answers. The improved performance means that the bioengineering system (computer-dyad) can successfully encourage shared intentionality in human pairs by modeling the mother-newborn biological system. The outcome shows the contrasting abilities of ShI in the ND and NT children.

The outcome also shows high dispersion in the ND and NT children's performance. It is because shared intentionality appears in human pairs only in some interpersonal dynamics and not always to the same extent. ShI depends on the psychophysiological conditions of both sides of the protoconversation (e.g., of the mother and the child). On the day of the test, four factors' domains contribute to facilitating or depressing ShI during an assessment.

A. *Four Shared Intentionality Factors' Domains*

1) Facilitating ShI endogenous factors. This domain consists of the following psychophysiological factors: social entrainment, an average level of hormones (e.g., cortisol, oxytocin, and dopamine) in NT children, and an increase in oxytocin concentrations in a woman during the menstrual cycle. According to Danilov et al. [38], the notion of social entrainment relies upon and highlights the following crucial features: (i) it can occur both explicitly and implicitly. (ii) Unified cyclical routine stimuli enable social entrainment. (iii) It appears in intimately related individuals, stimulating coherent psychophysiological rhythms. A rapidly changing environment cannot just as quickly affect the decline in social engagement. Therefore, social entrainment is the endogenous factor.

A high concentration of oxytocin hormone is associated with pro-social behavior. In humans, the level of oxytocin molecules correlates with the expressions of reciprocity in interaction, social recognition, and social bonding [43;44]. In addition, it is associated with establishing affective links and affiliative behaviors [44;45]. Empirical data showed a significant increase in oxytocin concentrations in a woman during the menstrual cycle from the early follicular phase to ovulation [46]; the average length of the follicular phase is 16 days. This period is favorable for ShI in mother-child dyads.

2) Facilitating ShI exogenous factors. Six exogenous factors enable ShI: exciting stimuli of a supranormal situation for ongoing interpersonal dynamics enabling emotional arousal and interactional synchrony; unintelligible intellectual stimuli; pleasant social stimuli (pleasant tactile or mental contact, social recognition, and social bonding); and motivation. The first two are stimuli for pushing interpersonal dynamics: overlapping emotional arousal and interactional synchrony. According to Danilov and Mihailova [39], these interpersonal dynamics appear in the dyad if they share a purpose of the event being in the environment with supranormal stimuli (e.g., new environment, new tasks, Etc.). Reviewed studies reported that each dyad completed the online quiz-tests on their smartphone via video-conference indwelling at home. The smartphone interface produced rhythmically changing red/violet light of the smartphone, facilitating emotional arousal and enabling interactional synchrony.

The third factor is unfamiliar stimuli. Unintelligible intellectual quiz-test items conditioned the child's intention toward SgI. The problem should encourage the child to ask for help from the caregiver since the quiz-test asked children to solve unintelligible tasks. The child could not solve tasks independently without assistance.

A cortisol concentration. An exciting stimuli performance increases physiological or mental arousal, but only up to a point [47] with a medium (not low and not high) cortisol secretion [48].

Pleasant social stimuli increase oxytocin secretion. For instance, Carter et al. [49] tested changes in salivary oxytocin, reporting an increase from 1,75 pg/ml before to 2,1 pg/ml after the body massage.

The last one is the child's motivation. These quiz-test items are unintelligible tasks without any feedback. Evidence reveals that task difficulty affects performance, e.g., [50;51;52], and limiting the feedback reduces the incidence of trial-and-error problem-solving strategies, e.g., [53;54]. Scores in low-stakes tests (purposes of no consequence to the test-taker) correlate with motivation [55]. Too complex problems reduce motivation during problem-solving. The research design is forced to maintain children's motivation. The motivated stimulation in pauses between the items keeps the child engaged in testing throughout the entire quiz-test.

3) Depressing ShI endogenous factors. Low oxytocin concentration is a factor for depressing social interaction. The most common cause of lower-than-normal oxytocin levels in children, for instance, are ASD, depressive symptoms, and panhypopituitarism [56]. Empirical data showed a significant decrease oxytocin concentrations in woman during the menstrual cycle from ovulation to the mid-luteal phase [46]; this unfavorable for ShI period lasts 6-8 days in a month.

4) Depressing ShI exogenous factors. Too exciting stimuli depress mental processes provoking a higher cortisol concentration. According to Yerkes and Dodson [47], performance decreases when arousal levels become too high. A too high and deficient cortisol secretion impairs cognition, e.g., verbal working memory encoding, decreasing performance [48;57]. De Veld et al. [57] observed an inverted U-shape association between low and very high cortisol secretions and poor performance [57].

The disadvantage of a child's situation during a testing day may depress her scores in performance–sleep and food shortage, fatigue, and depressed mood–may affect scores test performance. In general, the child's psycho-physiological state is conditioned to a large extent by the parents' socio-cultural situation. Studies that have used a neurocognitive framework to investigate disparities have documented that children and adolescents from socioeconomically disadvantaged backgrounds tend to perform worse than their more advantaged peers on several domains, most notably in language, memory, self-regulation and socio-emotional processing, e.g., [58-61]. Both parental educational attainment and family income accounted for differences in the surface area or size of the "nooks and crannies" of the cerebral cortex [60]. A child's experience varies tremendously based on her family's circumstances [60;62]. Notably, these socioeconomic disparities in brain structure that studies reported were independent of genetics [60]. It means that this "neurondivergence" develops gradually due to socio-economical reality. The current socio-economical situation and the child's physiological state may also influence testing scores. For instance, brain function is undoubtedly dependent on adequate nutrition, and even short-term variations in the amount and composition of nutrient intake in healthy individuals influence measures of cognitive function [63;64].

These arguments explain the dispersion mentioned above in the results of observed experiments that the single testing of objects caused it.

B. *The Future Translational Research Objectives*

For establishing metrological components of the computerized assessing method of cognitive development trajectory in preverbal children, the future bioengineering system research should explore the following elements:

(i) Method. The theoretical grounds about the construct of ShI, together with the math tools of its specification and changing prediction, would guarantee the method's validity and reliability in data collection, processing, and presentation to users.

(ii) Unit. The measurement unit should be defined by the structural and conceptual data formats connected with conventionally agreed reference quantities. The empirically proved reference to conventionally agreed physiological units would be the possible solution for ShI magnitude units.

(iii) "Zero". Calibration would standardize a universal correlation of all assessment outcomes in practice. This process needs the theoretical interpretation and empirical evidence of "zero" in the measurement scale of ShI magnitude in the certain dyad.

(iv) Algorithm. The caregiver-child dyad is a dynamic biological system. Therefore, the assessing system of ShI magnitude should accomplish dynamic input of the child's data at least three times on different days. The algorithm for monitoring a dynamic biological system processes the repeating assessment procedure to adapt the input data due to the difference in factors affecting the measured variables between the states of the biological system. The collection of three-time repeating inputs regulates the complexity of the data treatment (across different spatio-temporal scales) for invariance of processes across these scales in defining the medium value of ShI of the particular biological system. At the same time, this algorithm provides data standardization by contributing to the design of the universal measurement scale. This would be the way to introduce the universal measurement scale of assessing children's cognitive development with the standard measurement unit and a universal "zero". The successful execution of research with a large sample size (with thousands of subjects) would establish a quantitative measurement method to satisfy dependability for assessing cognitive development in preverbal children.

The translational research objectives are three, giving the need to explore the elements mentioned above:

a) registering an increase in the coordinated activity of neurons in subjects during coordinated mental activity without sensory signals. The inter-brain coordinated activity of neurons would be registered by the EEG technique, providing evidence for the quantum phenomenon of entanglement particles.

b) providing evidence of the ShI evaluation method for developing a human-computer system of cognitive development trajectories assessment in preverbal children. An association of the shared intentionality scores with knowledge about children's diagnoses (comparing NeuroDivergent (ND) and NeuroTypical (NT) children data) contributes to the design of the scale for assessing cognitive development trajectories in children. A sample size of 1.000 dyads repeating the tests three times each allows for establishing the method's validity and reliability.

c) exploring an association of specific hormone concentration in caregivers with the data about cognitive development trajectories scores (from point b). This association of caregivers' oxytocin and cortisol concentrations and the scores of cognitive development trajectories allows for establishing metrological components for assessing cognitive development in preverbal children.

V. Conclusions

The article provided the empirical data analysis from the current experiment and recent research studies with a similar research design across 30 dyads with neurodivergent (ND) children and those with neurotypical (NT) children. These research studies assessed shared intentionality (ShI) in the human pairs by computerized intellectual testing in a bioengineering system. The article presented evidence of shared intentionality in dyads. ND and NT children correctly solved unintelligible tasks in more items than predicted by probability, being with their caregivers who knew the correct answers. The improved performance could mean that the bioengineering system (computer-dyad) can encourage shared intentionality in human pairs by modeling the mother-newborn biological system. The ND young children aged up to 33 months showed relatively low scores of ShI than their NT peers. On the contrary, after three years of age, although sensory interaction modalities in ND children lag behind their NT peers, their quality of ShI was higher. The article discussed four factors' domains that contribute to facilitating or depressing ShI during the assessment. For establishing metrological components of the computerized assessing method of cognitive development trajectory in preverbal children, the article proposed three directions for future translational research in bioengineering: (i) evidence of shared intentionality occurring due to entangled protein molecules of neurons in the inter-brain study; (ii) proof of a shared intentionality assessment method validity, (iii) conditions for quantitative measurement to satisfy dependability in the cognitive development assessment.

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